ERRATA.

'PHIL. TRANS.,' 1890, A.

Bakerian Lecture.

Page 260, *for* $N = H_c \cos \delta_c - H \cos \delta$ *read* $N = H \cos \delta - H_c \cos \delta_c$.

A similar correction should be made in the two following equations.

Page 290, in fig. 21 the direction of the horizontal disturbing force at St. Leonards should be as in Plate 13.

Plate 13. The angle made by the horizontal disturbing force at Campbelton with the geographical meridian is $+136°$ not $-136°$.

'PHIL. TRANS.,' 1889, A.

G. H. BRYAN *on a Rotating Liquid Spheroid.*

Pages 214, 216, equations (96), (103),

$$\textit{for} \quad K_n(\zeta) - \frac{4q_2(\zeta)}{n(n+1)} \quad \textit{read} \quad K_n(\zeta) + \frac{4q_2(\zeta)}{n(n+1)},$$

and in equation (97) remove the sign $-$ on the right hand.

III. THE BAKERIAN LECTURE.—*A Magnetic Survey of the British Isles for the Epoch January 1, 1886.*

By A. W. RÜCKER, *M.A., F.R.S., and* T. E. THORPE, *B.Sc., Ph.D., F.R.S.*

Lecture delivered April 11,—MS. received June 6, 1889.

[PLATES 1–14.]

CONTENTS.

		Page.
Introduction—References to Former Surveys		55
Defects of Former Surveys		55
Scope of the Survey; Choice of Stations		56
Epoch		56
Instruments used		56
Kew as Base Station		57
Comparison of Kew and Survey Instruments		58, 59
Units employed		59
Comparison of Survey Instruments under Normal Conditions in Field		60
Chronometers and Method of Determining Rates		61
Number of Stations; Average distance apart		62
Method of Taking the Observations (Adjustment of Mirror, &c.)		63, 64
Discussion of Diurnal Variation and Disturbance		64–69
Method of Tabulating the Observations		69–76
Meaning of Symbols used	70	
Example of Declination Form	71	
Horizontal Force: Independent Results	72, 73	
,, ,, Specimen Form	74	
Inclination	76	
Errors of Experiment		76–80
Declination	78	
Horizontal Force	78	
Inclination	79, 80	
Secular Corrections		81–93
In Dip	81–87	
In Declination	87–91	
In Horizontal Force	91–93	
Form of Presenting Results of Observations		93–95
Description of, and Results at, each Individual Station		95–232
Calculation of the Isomagnetic Lines:—		
The Isogonal Lines		233–244
Terrestrial and True Isomagnetics	233	
Three Classes of Disturbances	233	

	Page.	Page.
Method of obtaining Equations to Isomagnetic Lines	234, 235	
Objections to Method of Least Squares	236	
"Central Stations"	237	
Declinations calculated from the District Lines for Points Uniformly Distributed over the Area of the Survey (Table)	238, 239	
Formula for calculating Declinations	240	
Discussion of Isogonals on Borders of English and French Surveys	241–244	
The Isoclinal Lines		244–246
Formula for calculating ditto	245	
The Isodynamic Lines		247–250
Necessity for Two Formulæ	243	
Formulæ for calculating Horizontal Force	250	
Summary of Elements and Disturbances		251–258
Scotland	251, 252	
England and Wales	253–256	
Ireland	257, 258	
Supplementary Stations	258	
Discussion of Local and Regional Disturbances:—		
Methods of deducing Disturbances		259–269
Effect of Disturbing Centre on Isogonals	261, 262	
,, ,, ,, other Lines	263, 264	
"Ridge" and "Valley" Lines	265	
Meaning of Vertical Force Disturbances Doubtful	266	
Results at Different Stations at Different Times	267–269	
Table of Disturbing Forces		270–273
Surveys of Selected Districts		274–292
The Malvern Hills	274–276	
The Island of Canna	276–279	
The E. and S.E. Counties	280–286	
The Wash	286–288	
The Leicestershire District	288–292	
General Results of Investigation of Disturbances		292–314
Methods of Testing Conclusions	292	
Comparison with Mr. WELSH'S Survey	293	
Declination at Stations common to the Surveys of 1857 and 1886	294–296	
Disturbing Forces in Scotland (WELSH)	297–299	
The Highland District	299–302	
The Scotch Coalfield District	302, 303	
N.W. England, N. Wales, and Galloway	304–306	
N.E. England	306–308	
The Southern District	308, 309	
Ireland	309, 310	
Magnetic Map of United Kingdom	310	
Relation between Magnetic and Geological Constitutions of Districts	310–314	
The Causes of Local and Regional Magnetic Forces		314–320
Dr. NAUMANN'S Views	314	
Earth-currents	315	
Insufficiency of observed Earth-currents to Produce Effects	316–318	
Insufficiency of Geological Faults	318	

	Page.	Page.
Summary		320, 321
Tables for the Calculation of the Magnetic Elements		322
Table VIII. Declination.		
,, IX. Horizontal Force.		
,, X. Dip.		
Rate of Secular Change		323–326
Table XII. Rates of Secular Change	325	

Two Magnetic Surveys of the British Isles have been made previous to that of which an account is given in this paper. The observations necessary for these were taken between the years 1834–38 and 1857–62, and the results were reduced to the epoch 1842–5 by Sir E. SABINE, in a paper published in the 'Philosophical Transactions' for 1870 ('Phil. Trans.,' vol. 160, 1870, p. 265). As a full account of both surveys is given in that paper, it is unnecessary to describe them in detail here. The first was made by five observers, viz., Sir E. SABINE, Captain J. C. ROSS, Mr. R. W. FOX, and Professors LLOYD and JOHN PHILLIPS. In the second survey (1857–58), Mr. WELSH, Superintendent of the Kew Observatory, made an admirable series of observations in Scotland, though, unfortunately, the exposure to which he was subjected brought on an illness which terminated in his death. Sir EDWARD SABINE made observations on the Force and Dip at 24 stations in England, and some declinations determined by several naval officers between the years 1855 and 1861, were utilized. Altogether observations were made at 243 stations. ('Phil. Trans.,' vol. 162, 1872, p. 319.)

It has, we believe, for some time been thought by those interested in terrestrial magnetism, that another survey of the United Kingdom should be undertaken, and we ourselves drew attention to the matter in a paper "On the Irregularities in Magnetic Inclination on the West Coast of Scotland" ('Roy. Soc. Proc.,' vol. 36, 1884, p. 10). Not only was this desirable in order that the secular changes in the direction of the lines of equal Inclination, Force, and Declination might be re-determined, but also because the earlier surveys left much to be desired with regard to the distribution of the stations and the number of the Declination observations. Thus the Declination was determined about the epochs 1836 and 1857 at 84 stations only, of which 11 were common to the two surveys. The maps given by Sir E. SABINE in the paper already referred to show that different districts have received very different degrees of attention. Stations where the Dip has been determined cluster thickly about the coast of Scotland to the south of Oban, about the English lakes, and the south coast of England, and are thinly distributed in the North of Scotland, in the eastern counties of England, and in the centre of Ireland. In like manner, while (owing chiefly to the labours of Mr. WELSH) the Declination had been measured at 40 places in Scotland, it had been observed with adequate instruments at only 28 stations in England, and 16 in Ireland. We have therefore undertaken, and, in the course of the five years 1884–88, both inclusive, have completed a new magnetic survey of the British Isles.

In our opinion, it would probably have been better if a larger number of observers had been engaged in the task, so that it could have been finished in a shorter time. In fact, we originally made a proposal in this sense which was, we believe, brought before the Kew Committee of the Royal Society. It was considered that the objections to the employment of many instruments and observers were sufficient to prevent the acceptance of such a scheme. With proper organisation, we believe that the errors thus introduced would have been much less serious than those due to the uncertainty as to the true secular corrections at any particular station. As, however, it was more important that the survey should be made than that it should be made under the best possible conditions, we have in undertaking the task ourselves devoted most of our vacations and spare time to it, so that there should be as little delay as possible, and have collected all the facts which throw light on the value of the secular corrections.

Although the re-determination of the lines of equal magnetic Declination, Force, and Dip has been the main object of our investigation, a number of other questions have naturally come under consideration. We have made some alterations in the Kew magnetometer which have been described to the Physical Society ('Phil. Mag.,' August, 1888, p. 122); the method of presenting the results of the experiments has been modified so as to afford a greater test of their accuracy; the validity of the method of correcting for diurnal variation and disturbance, especially at places far distant from the base station, has been reconsidered, and finally, and perhaps chiefly, we have given more attention than our predecessors have done to the distribution and causes of "local magnetic attraction." In view of the difficulties caused by such disturbances, we have taken special pains to indicate the position of our stations as accurately as possible. This has been done, not merely by verbal description, but by taking out the latitudes and longitudes from the inch Ordnance maps or the Admiralty charts, with far greater accuracy than is necessary for the calculations in which these quantities are afterwards employed. For similar reasons we have selected, when possible, public parks, open commons, or other situations which are likely to be still available when the survey is repeated. It must, however, be remarked that, at some places which were not included in our original programme, observations have been made mainly because a favourable opportunity presented itself, and that, in such cases, it was not always possible to exercise the same care in the selection of a site.

Epoch.

The epoch of the survey is January 1, 1886, to which date all the observations have been reduced.

Instruments.

The survey of Scotland was mainly made with a set of instruments which belong to Professor RÜCKER. They are a Kew Magnetometer by ELLIOTT BROS., No. 60, and a

Dip Circle by Dover, No. 74. These instruments were also used by Professor RÜCKER in his portion of the surveys of England, Wales, and Ireland. The instruments employed by Dr. THORPE in these countries are the property of the Science and Art Department. They are of the same patterns and by the same makers; the Magnetometer and Dip Circle are numbered 61 and 83 respectively.

Arrangements have been made for placing this latter set of instruments in the Collection of Scientific Apparatus at South Kensington. They will be kept for surveying only, and will be available for comparison with instruments which may be used by future observers.

Base Station.

Our base station is the Kew Observatory. Both sets of instruments were tested there before they came into our possession, and we have also made numerous comparisons with the Kew instruments during the progress of the survey. We take this opportunity of expressing the great obligation we are under to Mr. G. M. WHIPPLE, the Superintendent, and to Mr. T. BAKER, the First Assistant in the Observatory, who, with the approval of the Kew Committee, rendered us every assistance in their power. Our frequent visits and requests for information as to diurnal variation and disturbance have imposed much additional labour on these gentlemen. The help we required has, however, invariably been given with a readiness and heartiness which merit our grateful acknowledgments.

We tested our instruments at Kew in 1884, 1886, and 1887.

A very large magnetic disturbance set in on March 30, 1886, the 31st was also much disturbed and the effects were still to be distinguished on April 1. We have, therefore, neglected the observations made on that day, but, with this exception, the following tables contain all the determinations made by us in the Magnetic House.

The first three columns give the date, instrument, and observer, and that headed S the value of the element obtained.

The numbers given are not corrected either for diurnal variation or disturbance.

In the column headed K is the corresponding value read off from the curves of the continuously recording instruments at Kew, standardised by means of the monthly observations which are taken there.

The differences are given in the next column. They are very nearly constant, but are rather larger than we should *a priori* have expected. Our own instruments are evidently in accord.

Subtracting the mean difference from the Kew values, we should, if both sets of observations were perfect, reproduce our own numbers, so that a comparison between columns S and $K-\beta$ gives the error of experiment and comparison which is tabulated in the last column.

Observations in the Kew Magnetic House.

Declination.

Date.	Instrument.	Observer.	S (Survey Instrument.)	K (Kew Instrument.)	K − S = β.	K − β = K′.	S − K′.
1884.			° ′	° ′	′	° ′	′
July 17 . .	60	T	18 26·3	18 28·6	2·3	18 26·1	+ 0·2
„ 18 . .	60	R	18 27·4	18 29·9	2·5	18 27·4	0·0
1886.							
April 2 . .	61	T	18 12·1	18 14·4	2·3	18 11·9	+ 0·2
1887.							
Sept. 30 . .	60	R	18 8·8	18 13·1	4·3	18 10·6	− 1·8
			18 5·5	18 9·4	3·9	18 6·9	− 1·4
Oct. 11 . .	61	T	18 6·0	18 8·7	2·7	18 6·2	− 0·2
			18 6·9	18 10·4	3·5	18 7·9	− 1·0
„ 12 . .	60	R	18 9·5	18 11·9	2·4	18 9·4	+ 0·1
			18 11·1	18 13·4	2·3	18 10·9	+ 0·2
„ 13 . .	61	T	18 5·8	18 6·7	0·9	18 4·2	+ 1·6
			18 8·6	18 8·8	0·2	18 6·3	+ 2·3
„ 18 . .	61	T	18 6·3	18 8·4	2·1	18 5·9	+ 0·4
			18 6·0	18 10·4	4·4	18 7·9	− 1·9
„ 19 . .	60	R	18 8·1	18 10·3	2·2	18 7·8	+ 0·3
			18 6·9	18 8·7	1·8	18 6·2	+ 0·7
					β = 2·5	Mean .	= ± 0·82

Horizontal Force.

Date.	Instrument.	Observer.	S (Survey Instrument.)	K (Kew Instrument.)	K − S = β.	K − β = K′.	S − K′ = 0·000.
1884.							
July 17 . .	60	T	1·8080	1·8055	− 0·0025	1·8084	− 4
1886.							
April 2 . .	61	T	1·8091	1·8070	− 0·0021	1·8099	− 8
	60	R	1·8107	1·8072	− 0·0035	1·8101	+ 6
„ 22 . .	60	R	1·8110	1·8082	− 0·0028	1·8111	− 1
1887.							
Sept. 30 . .	60	R	1·8117	1·8087	− 0·0030	1·8116	+ 1
Oct. 11 . .	61	T	1·8114	1·8084	− 0·0030	1·8113	+ 1
„ 12 . .	60	R	1·8096	1·8070	− 0·0026	1·8099	− 3
„ 13 . .	61	T	1·8092	1·8062	− 0·0030	1·8091	+ 1
„ 18 . .	61	T	1·8114	1·8088	− 0·0026	1·8117	− 3
			1·8117	1·8088	− 0·0029	1·8117	0
„ 19 . .	60	R	1·8113	1·8074	− 0·0039	1·8103	+ 10
					β = − 0·0029	Mean .	± 3·5

To obviate, as far as possible, the use of decimals, the Forces are throughout this paper expressed in terms of metric units (metre, gram, second), and all numerical values of Forces can be reduced to C.G.S. units by dividing by 10.

In the case of the Dips, of which no continuous record is kept, the following plan was adopted. We give, under the column S, our results corrected for diurnal variation and disturbance as hereafter described, each being the mean of the two needles. In column K are the values obtained at Kew at the nearest date to the time of our observations taken from the published record. The dates in question are July 28 and 31, 1884, Sept. 22, 24, and October 25, 26, 1887. The mean of the last two is taken as applying to the whole period of the 1887 observations.

INCLINATION.

Date.	Instrument.	Observer.	S (Survey Instrument).	K (Kew Instrument).	K − S = β.	K − β = K′.	S − K′.
July 17, 1884 .	74	R	67° 36′·0	67° 38′·8	2′·8	67° 36′·1	− 0′·1
„ 18, „ .	„	T	67 35·8	..	3·0	..	− 0·3
„ 19, „ .	„	R	67 36·4	..	2·4	..	+ 0·3
Sept. 30, 1887 .	„	„	67 34·9	67 37·5	2·6	67 34·8	+ 0·1
Oct. 11, „ .	83	T	67 34·8	..	2·7	..	0·0
„ 13, „ .	„	„	67 35·0	..	2·5	..	+ 0·2
„ 18, „ .	„	„	67 34·2	..	3·3	..	− 0·6
„ 19, „ .	74	R	67 34·9	..	2·6	..	+ 0·1
					β = 2·7	Mean . .	± 0·2

The mirrors used to form an image of the Sun which can be viewed through the telescope were tested independently. We were, however, unfortunate in that on most of the days when we observed at Kew the Sun was invisible. The meridian mark also, which is used in the Kew measurements, cannot be seen from the lawn immediately in front of the Magnetic House, and we were, therefore, obliged to use a rod which was fixed at some distance, as nearly as might be in the meridian line in which the instrument was also placed. On one occasion (October 11, 1887) the latter adjustment was inaccurate, and a correction was applied deduced from the angle subtended at the pillar in the magnetic house by the centre of the tripod and the rod, and from the distances of the tripod and pillar from the rod. At Parsonstown the instrument was placed in the meridian line used for the Observatory of the Earl of ROSSE, and a check on the declinometer was thus obtained. From what has been said it will have been seen that the determinations of the geographical meridian at Kew were not made under the most favourable conditions, but the following Table is sufficient to show that no important error attached to the indications of the instruments.

AZIMUTH of Kew Meridian Mark from Sun Observations.

Date.	Instrument.	Observer.	Azimuth.
			° ′
April 22, 1886	60	R	2 48·4
Oct. 11, 1887	61	T	2 49·9
" 12, "	60	R	2 48·0
" 12, "	"	"	2 50·1
" 19, "	"	"	2 48·2
Mean	..	..	2 48·9
Value employed at Kew	..	..	2 48·7

At Parsonstown the difference between the reading for the fixed mark and the meridian, as calculated from a sun observation, was 1′·1.

We also thought that it would be desirable to compare the instruments under the normal conditions of use in the field. We therefore made three sets of observations at Ard Point, Stornoway; at Bunnahabhain, in the Sound of Islay; and at Stranraer. At the first station the results of the individual experiments made with each instrument were in good accord, but, as the declinations differed from each other by an amount very much greater than any possible error of experiment, viz., 18′, it was obvious that the station was affected by local magnetism. At Bunnahabhain we took the precaution to exchange positions; these observations were made on a patch of limestone, and were in agreement. At Stranraer the sky became overcast, and it was impossible to move the instruments after the first determination of the geographical meridian. The results show that the station was a good one, and we therefore give here the declinations obtained at Bunnahabhain and Stranraer. As we shall have to refer to them again, we reproduce only the data which bear upon the point under discussion. At Bunnahabhain the thread of instrument 61 was broken, and had to be replaced in the field, which accounts for the fact that the first observation made with it is not in very good accord with the others. The Greenwich mean time is reckoned throughout from midnight.

BUNNAHABHAIN.—Aug. 25, 1888.

G. M. T.	Station.	Instrument.	Observer.	Declination.
h. m.				° ′
10 55	1	61	T.	22 44·0
11 36	2	"	"	22 46·0
10 29	2	60	R.	22 46·0
12 25	1	"	"	22 47·3
14 30	1	"	"	22 47·9
15 9	1	"	"	22 47·3

STRANRAER.—Aug. 28, 1888.

G. M. T.	Station.	Instrument.	Observer.	Declination.
h. m.				° ′
11 35	1	61	T.	21 13·7
10 54	2	60	R.	21 12·5
13 6	2	„	„	21 13·0

During the survey we employed various chronometers, some of which were hired from Messrs. DENT, and others were lent to us by the late Professor BALFOUR STEWART, F.R.S., and by Captain WHARTON, R.N., F.R.S., Chief Hydrographer to the Admiralty, to whom our thanks are due.

We enjoyed an important advantage over our predecessors in that we were able to determine the rates of our chronometers frequently by comparison with Greenwich, by means of the 10 A.M. and 1 P.M. telegraphic signals, of which the former is sent to all post-offices in the kingdom. We have to thank Mr. PREECE, F.R.S., Chief Electrician to the General Post-office, and Mr. J. C. LAMB, the Head of the Telegraph Department, for their kindness in giving or obtaining for us permission to receive the signals. Many of the local post-office officials not only afforded us every facility for correcting our chronometers in accordance with their instructions, but gave us additional help in the selection of suitable stations. When possible, we received the signal every day, and rarely omitted more than two consecutive days. At places where the signal had undergone one or more re-transmissions, an error on this account was inevitable. By the kindness of the Earl of ROSSE, we were able to determine its magnitude on the occasion of our visit to Parsonstown. The time signal was observed both by Professor RÜCKER and Herr BÖDDEKKER, the Superintendent of Lord ROSSE'S Observatory, who agreed exactly as to the apparent error of the chronometer. The value thus obtained differed by 4 sec. from that given by the observatory clock, the error of which was known from star observations. We are inclined to think that this amount was rarely exceeded, or the rates would have varied more widely than was actually the case. No special precautions against error had been taken at Parsonstown, whereas in many districts we had, when practicable, made arrangements at the central office that particular care should be taken on those mornings when we informed the authorities that we intended to receive the signal. We have on several occasions received at the same post-office signals sent by two different routes, involving re-transmission, and have never detected any appreciable difference.

When visiting outlying stations at sea we kept one chronometer on board in a fixed position. This served as the standard. Another instrument, which was frequently compared with it, was used for making the comparisons with Greenwich and for the work of the actual observations. At these periods of our survey longer intervals necessarily elapsed between successive receptions of the time signal, during which we depended on the standard. With the exception of two or three cases, which are referred to in the detailed account of the observations at the stations affected, we do not think that any error exceeding a minute of arc can have been introduced into the declinations from uncertainty as to the true time.

Selection of Stations.

In selecting stations we have aimed at uniformity of distribution over the whole area under investigation, and, subject to this condition, have chosen places at which observations have previously been made. We have also avoided situations where disturbance by so-called local attraction was known to be great, except in special cases to be discussed hereafter. On many tours we have carried geological maps which have aided us in choosing sites.

In all we have made observations at 54 stations in Scotland, 102 in England, Wales,* and the Channel Isles, and 44 in Ireland. At many of these places which are counted as a single station our instruments have been set up in different localities in order to study or eliminate the local effects of magnetic rocks. These sub-stations were in some instances only a few yards and in others several miles apart. The more important of them are indicated by letters in the lists given hereafter, and if these are added they bring the number of stations up to 213. In addition to these we observed on the island of Canna at 23 places. If we took minor changes of position into account this total would be considerably increased, and as we have been able to use the observations made at Greenwich and Stonyhurst, and the data for Cherbourg and Berck-sur-Mer, furnished by the survey of France, recently completed by M. MOUREAUX ("Détermination des Éléments Magnétiques en France," par M. TH. MOUREAUX. Paris: GAUTHIER-VILLARS, 1886), our conclusions are based upon observations made at about 250 different places.

The average distance apart in normal districts is about 30 miles. At most of the principal stations we made two Dip observations, one with each needle, and a complete set of measurements for the determination of the Declination and Horizontal Force. At many places we determined the Declination twice, making two independent sets of observations on the Sun and the needle. In some cases only the geographical meridian or only the direction of the magnetic axis of the needle was re-determined. When time was short or the weather unfavourable the deflection experiment was omitted. The following Table shows the total number of observations made. By magnetic meridian we mean determination of the direction of the magnetic axis, which, when combined with the Sun observations or geographical meridian, gives the Declination. We do not include 23 Declinations taken on Canna by means of an azimuth compass and chart.

* Exclusive of five supplementary stations along the valley of the Wye, at which Dip observations only were made in 1889 (*vide* p. 84).

	Stations.	Dips.	Deflections.	Vibrations.	Geographical meridian.	Magnetic meridian.
Scotland	54	120	57	66	89	93
England and Wales	102	213	94	135	171	185
Ireland	44	89	35	58	84	84
Total . . .	200	422	186	259	344	362

Most of these observations were taken by one or other of us. We have, however, to thank Mr. A. P. LAURIE, now Fellow of King's College, Cambridge, for observations of Dip at 8 stations in Scotland. The stations on the West Coast of Scotland were, for the most part, visited in Dr. THORPE'S yacht "Coventina." During the first year (1884) we generally observed together. Afterwards, in order to save time, we travelled separately.

Method of Taking the Observations.

The conditions and time of the observations necessarily varied, but the greatest number were made as follows:—Shortly before 10 A.M. we visited the post-office to correct our chronometers by the time signal from Greenwich. We then drove to the station which had been selected the night before or earlier in the morning. The first observation taken was the solar azimuth, which was finished about an hour before noon. This was followed by the declination, vibration, and deflection in this order. The dip was then determined, and, if time and weather allowed, we often repeated the azimuth and declination. The Sun observations were hardly ever taken within an hour of noon.

In a variable climate like that of the United Kingdom the weather often presents a serious difficulty. We carried with us a small tent, in which the dip and vibration observations could be made, and we were also provided with waterproof covers for the Magnetometer and Dip Circle. We were thus able to make the Dip observations, for example, during showers, while the Magnetometer, though outside the tent, was protected by its covering. The case containing the dip needles was carried in a box filled with soda-lime to prevent the axles being injured by rust.

During sunshine we shaded the deflecting magnet in the deflection experiment by a cardboard case, or by throwing a light piece of cloth over it. At 42 principal and subsidiary stations the force was determined by means of the vibration experiment only, the deflection being omitted and the moment of the magnet deduced from the values obtained at neighbouring stations.

The only part of the observations which requires special comment is the use of the mirror employed in the sun observations. The adjustment can be effected by means of the reflected image of the cross wires in the telescope. We found, however, that in practice in the field this method is troublesome. It is difficult to see the image unless the mirror is very bright, and there is fairly strong sunshine. On days when the weather and sunshine are uncertain it is very annoying to have to spend time when the sun is visible in making preliminary adjustments. From and after our visit to Stornoway in 1884, *i.e.*, after observations had been made at about a dozen stations, we adopted a different plan. The mirror was frequently adjusted either indoors in accordance with the directions of the Admiralty 'Manual,' or by means of some elevated object in the field. In the latter case the error of parallelism was first got rid of by observing the object when the observer's back was turned towards it, and the mirror was nearly vertical. The mirorr was adjusted until the image appeared in the same position as before when it was reversed in its bearings. The object was then viewed by reflection when the instrument was turned through 180°, *i.e.*, when the mirror was nearly horizontal and the axis of the mirror was made perpendicular to the axis of the telescope. By repeating these processes twice or thrice a perfect adjustment was obtained, and it was found that under ordinary circumstances the instrument could be carried about from place to place for some time without this adjustment being seriously affected. To make certain, however, that all was right, we always (when possible) took observations of the sun both in the "front" and "back" positions, *i.e.*, with the mirror approximately horizontal and vertical and reversed the mirror in its bearings in both positions. By the latter precaution the error of parallelism (if any existed) was eliminated, and the observation thus afforded data for the calculation of the error of collimation, and for the corrections which in consequence of this error must be applied to the "front" observations.

By this method the actual adjustment of the mirror could be made at any time or place. If the time at our disposal was short, or the weather uncertain, the instrument was regarded as ready for use as soon as it was set up in the field, and thus no time was lost, but the observations were so taken that any error of adjustment could be calculated and allowed for. Lastly the agreement of the measurements made in the front and back positions gives a valuable test both of the adjustments and observations.

In the case of the observations made in 1888 with Magnetometer No. 60, the method of correcting the mirror by the image of the cross wires was again resorted to. Some modifications of the instrument which we have introduced (*loc. cit.*) now make this method practicable, and it was found to work well under the new conditions.

Diurnal Variation and Disturbance.

In the survey of 1857 corrections for diurnal variation and disturbance were applied to the declination observations only. These two quantities are intimately connected. The total deflections of the continuously recording instruments at any instant are the sums of the normal diurnal variations and the disturbances. If the latter are assumed to occur simultaneously and in equal intensity over an area such as that of the United

Kingdom, and if the G.M.T. at which the observations were made is known they may be determined from the curves obtained at Kew. On the other hand the magnitude of the diurnal variation at a given instant depends on the local time, and in the case of stations so far apart as Kew and Valentia, the diurnal variation of the declination would, between 10 and 11 a.m. G.M.T., differ by several minutes of arc.

We have therefore taken out from the Kew curves the deviations from the mean at the G.M.T. of our observations, and subtracting the corresponding value of the diurnal variations at Kew, have called these differences the temporary disturbances at the time of the observations.

We have assumed further, that the Kew mean curves of diurnal variations may be taken as applying to the whole of the United Kingdom, but we have, in all cases, used the correction corresponding to the local time. Thus the total correction is the algebraic sum of the diurnal variation at the local time, and of the disturbance registered at Kew at the G.M.T. at which the observations were taken.

As proof of the validity of this method, we have picked out all the stations in Ireland at which two or more observations were made at times when the diurnal variations differed by more than four minutes.

As full particulars are given later on, it is only necessary here to tabulate the corrections for diurnal variation and disturbance in addition to the final results. It may, however, be remarked that in the majority of cases the determinations of the geographical, as well as of the magnetic meridian, are quite independent, and that at Athlone, Gort, and Westport, the results given were obtained on different days. The letters v and Δ are used throughout this memoir to indicate the departure from the mean value of the element at the time of experiment, due to diurnal variation and to temporary disturbance respectively.

Station.	v.	Δ.	Corrected Declination.
		′	° ′
Athlone	+ 6·3	+ 1·5	22 16·5
	− 3·9	0·0	22 16·8
Cavan	− 3·7	+ 1·5	22 26·1
	+ 6·2	− 4·0	22 26·7
	+ 3·5	− 5·0	22 27·4
Charleville	+ 4·9	+ 1·0	22 19·4
	+ 0·7	+ 2·5	22 19·1
Cork	0·0	0·0	22 3·8
	+ 5·8	− 1·0	22 1·7
Gort	+ 3·9	− 1·0	22 38·2
	− 4·2	+ 1·0	22 39·1
Lismore	− 1·0	0·0	21 54·1
	+ 6·4	+ 3·5	21 54·0
Westport	+ 0·7	0·0	23 5·5
	+ 1·8	− 0·5	23 4·2
	+ 6·3	+ 2·0	23 5·4

The following are the best stations for the application of a similar test to Scotland. The two sets of observations at Scarnish and Portree were taken on two different days. Those at Stornoway were on the same day, but at different stations. The observations at Bunnahabhain and Stranraer, which have been already discussed, are here arranged in order of time without reference to the station or instrument :—

Station.	v.	Δ.	Corrected Declination.
	′	′	° ′
Scarnish	+ 2·4	. .	24 49·8
	− 3·6	+ 3·0	24 51·8
Portree (2)	+ 3·3	+ 2·0	22 21·6
	+ 3·7	− 2·0	22 22·7
Stornoway, Ard Point (1)	+ 2·0	− 2·0	23 50·7
	+ 6·3	− 1·0	23 48·4
	+ 4·4	. .	23 50·7
Ard Point (2) . . .	+ 2·4	− 3·0	24 8·7
	+ 6·4	− 1·0	24 7·9
	+ 4·4	. .	24 8·3
Bunnahabhain . . .	− 0·1	. .	22 46·0
	+ 1·7	. .	22 44·0
	+ 4·3	− 2·0	22 46·0
	+ 6·3	− 1·0	22 47·3
	+ 5·7	. .	22 47·9
	+ 4·6	. .	22 47·3
Stranraer	+ 1·9	− 2·0	21 12·5
	+ 4·6	− 3·0	21 13·7
	+ 6·4	− 1·0	21 13·0

In some cases where there is an appearance of a regular change, such as would be caused if the diurnal variation was not properly estimated, it can be otherwise accounted for. Thus the first four observations at Bunnahabhain were independent in every particular, but the last two depend upon the same Sun observation as the fourth. This probably accounts for the somewhat closer agreement in these cases. The magnitude of the errors which would be introduced if the disturbance corrections were omitted can be estimated by noting that at Cavan the first and last observations when uncorrected give 22° 27′·6 and 22° 22′·4, those at Portree 22° 23′·6 and 22° 20′·7, and those at Scarnish 24° 49′·8 and 24° 54′·8 respectively, instead of the much more accordant numbers entered in the Table.

These results when corrected are quite as good as those we obtained when observing at Kew, and furnish a complete *a posteriori* justification of the method of correction.

The values of the diurnal variation employed for the year 1884–5 were furnished to us by Mr. WHIPPLE. For 1885–6 and 1886–7 we used the Tables given in the reports of the Kew Committee for those years ('Roy. Soc. Proc.,' vol. 41, p. 415, and vol. 43, p. 226).

These differed rather markedly as to the magnitude of the maximum variation from the curve employed for 1884–5, the difference amounting to about 1′·5. As the report of the Kew Committee for 1887–8 was not published when the observations made in 1888 were reduced, we used the same Table as for the 1887 observations.

The question as to whether we should apply similar corrections to the other elements has been carefully considered, and we have on the whole decided to do so.

Though we have worked up the observations on the Horizontal Force so that each experiment gives two nearly independent results, the times at which these have been taken are practically identical, and they do not serve as a test of the advantage of applying corrections. In 18 cases we have repeated either the deflection or the vibration experiment (generally the latter) in the field on the same day. The differences between the results when uncorrected and corrected for diurnal variations and disturbance are as follows. They are expressed in terms of 0·0001 metric or 0·00001 C.G.S. unit.

TABLE I.

Station.	Uncorrected.	Corrected.
Loch Aylort	− 5	0
Ayr	− 4	− 4
Stornoway	− 3	− 5
	+ 3	+ 2
Cambridge	+ 1	+ 1
Northampton	+18	− 7
Stoke	− 5	− 6
Swansea	+ 3	− 1
Taunton	+17	+16
Thirsk	0	+ 1
Tunbridge Wells	+17	− 3
Worthing	+ 8	− 2
Ballywilliam	0	− 1
Bangor	+ 4	− 6
Coleraine	− 7	−11
Drogheda	+ 9	+ 3
Kildare	−10	+ 5
Londonderry	+ 6	+ 5
Probable difference { Uncorrected . . 5·9		
Probable difference { Corrected . . . 4·0		

The values of H obtained by us at Kew in 1887 also afford a test of the method of correction. The diurnal variation and disturbance are expressed in the following Table in terms of 0·0001 metric unit :—

Date.	Deflection.		Vibration.		H.	
	v_1.	Δ_1.	v_2.	Δ_2.	Observed.	Corrected.
September 30	+ 7	0	+ 3	0	1·8117	1·8112
October 11	2	0	− 2	0	1·8114	1·8114
„ 12	3	− 20	− 1	− 20	1·8096	1·8115
„ 13	− 5	− 20	− 10	− 10	1·8092	1·8114
„ 18	− 5	0	− 13	0	1·8114	1·8123
, 18	− 5	0	− 11	0	1·8117	1·8125
„ 19	− 4	− 10	− 10	0	1·8113	1·8125

As then the diurnal variation between the hours at which our observations were generally taken amounts to 0·0025 metric unit, and as the probable difference between the corrected semi-independent results at the stations referred to in Table I., p. 67, is ·0004 (the probable error being half that quantity), and as the probable error of the seven Kew observations is less than ·0004, there seems no doubt that the correction ought to be applied.

In the case of the Dip the diurnal range (which is more than 2′) exceeds the error of experiment, but the application of a correction for disturbance is more difficult and uncertain. It has to be deduced from the Vertical and Horizontal Force magnetograms and thus the chances of error are increased. The quantities to be dealt with are generally small, and the uncertainty of the readings taken from the curves unquestionably affects the results. We have not many data which furnish any *a posteriori* arguments of importance, as in most cases the times at which the two Dip observations were taken were separated by too short an interval for the diurnal variation to have altered much. The observations made at Kew in 1887 are, however, decidedly improved by correction.

Date.	Instrument.	Needle.	Dip observed.	v.	Δ.	Dip corrected.
			° ′	′	′	° ′
September 30	74	1	67 35·4	− 0·7	+ 0·7	67 35·4
	74	2	34·7	− 0·8	+ 1·3	34·2
October 11	83	1	67 33·8	− 0·4	0	67 34·2
	83	2	34·9	− 0·5	0	35·4
„ 13	83	1	67 36·0	− 0·4	+ 1·4	67 35·0
	83	2	36·1	− 0·5	+ 1·6	35·0
„ 18	83	1	67 34·2	− 0·3	+ 0·3	67 34·2
	83	2	34·2	− 0·4	+ 0·3	34·3
„ 19	74	1	67 35·0	− 0·3	0	67 35·3
	74	2	33·5	− 0·3	− 0·7	34·5

The greatest differences in the corrected and uncorrected results are 1′·2 and 2′·6 respectively.

On the whole, then, we think the application of the correction for diurnal range is advantageous, but the correction for disturbance appears to be somewhat uncertain in its effect as applied to the field observations, and we have retained it chiefly for the sake of uniformity with our treatment of the other elements.

The formulæ used in the application of the corrections to the Horizontal Force and Dip were as follows: —

If H′, m' and H, m be the values of the Horizontal Force and the moment of the magnet deduced from the uncorrected and corrected observations respectively, and if ϕ and ψ be the total increments of the Horizontal Force due to diurnal variation and disturbance at the times when the deflection and vibration experiments are made,

$$H = H' - (\phi + \psi) / 2;$$
$$m = m' \{1 + (\phi - \psi) / 2H'\}.$$

As the disturbances of the Dips have to be deduced from those of the Horizontal and Vertical Forces, the calculations involved are rather troublesome.

If $d\theta$ be the change, expressed in minutes of arc, produced by increments dV and dH in the Vertical and Horizontal Forces respectively,

$$d\theta = a dV - b dH,$$

where a and b are quantities which depend on the Dip and Horizontal Force at the station. Tables were prepared in which the values of these were entered for each complete degree between 66° and 72°, and for each tenth of a unit of Horizontal Force between 1·4 and 1·8. As they vary slowly, the value corresponding to any given Dip or Force could be readily determined, and the value of $d\theta$ was thus deduced.

Method of Tabulating the Observations.

We have ventured to modify considerably the methods ordinarily adopted of presenting the results of a survey such as our own. It is often very difficult for any one who studies the records of magnetic observations to learn anything as to whether the instruments were in good or bad adjustment, or whether the actual observations were careful or careless. Sometimes superfluous data are given which supply no information on these points. Thus, the quantities log mX and log m/X, or mX and m/X, which are sometimes tabulated in records of Force observations, add but little to their value. In an observatory, indeed, they ought to be nearly constant from month to month; but as, in both of them, the changes in the value of the moment of the magnet and those in the Force are mixed up with the error of experiment, it is not easy to draw any definite conclusion from them. To test the observations, we should compare quantities the difference between which ought theoretically to vanish. In the case of a survey, log mX and log m/X must vary largely from station to station, and they are, therefore, quite worthless as tests of the observations.

There are now five British magnetic observatories working with instruments of substantially the same patterns, and we think it would be very desirable if an agreement could be come to as to the form in which the results of the observations are published. In our own case we have been anxious to check the numbers given by experiment in every way, as it is only thus that we are able to determine what reliance may be placed on observations at stations where time or weather prevented the repetition of one or more of the measurements.

The following is an example of the method of tabulation adopted in the case of the Declinations :—

Σ is the interval between the southing of the Sun and the mean of the times at which the "front" observations were made on the Sun's azimuth. It is taken as positive if the observations were made after noon.

Alt. signifies the altitude of the Sun above the horizon at the same time.

μ is the correction made by means of the "back" observations to the geographical meridian determined from the front observations alone. This quantity serves to indicate the order of the error that may have been introduced by the omission of the back readings on some occasions.

G.M. is the reading on the horizontal circle which corresponds to the geographical meridian. In most cases two determinations of the geographical and magnetic meridians were made at an interval of some hours. In this time the tripod may have shifted slightly, owing to unequal sinking of the ground, warping of the legs, &c. Hence, if no fixed mark was read, each geographical meridian must be regarded as corresponding only to the magnetic meridian which was observed nearly at the same time as itself. As it is often difficult to select a suitable fixed mark, we have, whether a fixed mark was observed or not, regarded each reading for the geographical meridian as corresponding to that for the magnetic meridian which was nearest to it in point of time.

In the case of the magnetic meridian (the reading for which is indicated by M.M.) we tabulate the following data :

(1) The G.M.T. at which the observation was made reckoned from midnight.

(2) Half the difference between the readings when the magnet is erect and inverted is the angle between the magnetic and geometrical axes of the magnet. If then from this quantity (ξ) we subtract its mean value as determined from all the observations made in the same year (ξ_0), we obtain a measure of the error due to inaccuracy of reading or adjustment, and to imperfect compensation of the diurnal variation or of any disturbance which may have been occurring at the time.

(3) ω is the error which would have been caused had the torsion of the thread not been allowed for.

(4) v and Δ are the deviations of the element from its mean value due to diurnal variation and disturbance respectively. The first, as has been already explained, is calculated for local time from the Kew curves of diurnal variation, the latter is the

disturbance registered by the Kew curves at the same G.M.T. as that at which the observations were taken.

(5) δ (obs.) is the value of the Declination obtained by subtracting the reading for the magnetic from that for the corresponding geographical meridian.

(6) σ is the secular correction to Jan. 1, 1886, obtained as is hereafter explained.

(7) δ (red.) is the mean value of the Declination reduced to the epoch of the survey.

As an example we take Athlone, where observations were made on two different days. On May 8, no back observations were taken, so that μ could not be calculated.

DECLINATION. Athlone. Observer, T. E. T. Magnetometer 61.

Geographical Meridian.

Date, 1887.	Σ.	Alt.	μ.	G.M.
	h. m. s.	° ′	′	° ′
May 8	+1 40 59	48 42	..	338 38·1
„ 9	−3 43 58	33 51	− 0·2	210 31·2

Magnetic Meridian.

Date.	G.M.T.	$\xi - \xi_0$.	w.	v.	Δ.	M.M.
	h. m.	′	′	′	′	° ′
May 8	12 39	+0·2	−0·1	+6·3	+1·5	316 21·6
„ 9	9 9	−0·4	0·0	−3·9	0·0	188 14·4

Declination.

δ (obs.).	Mean.	σ.	δ (red.).
° ′	° ′	′	° ′
22 16·5 22 16·8	22 16·6	+10·1	22 26·7

In the case of the Horizontal Force observations the deflections were always taken when the distances between the centres of the magnets were 0·3 and 0·4 metre. If then l_1 and l_2 are the common logarithms of the values of m/H obtained at the two distances, the factor P used in the corrections may be calculated by the formula

$$P = 0{\cdot}4737\,(l_1 - l_2) - 1{\cdot}947\,(l_1 - l_2)^2$$

of which the second term is very small. ('Nature,' Aug. 13, 1887, p. 366; Sept. 29, p. 508; Dec. 8, p. 127; and Jan. 19, 1888, p. 272).

The following table gives the mean values of P obtained for each year during the survey.

	Magnetometer.	
	60	61
1884	0·000817	. .
1885	0·000866	. .
1886	0·000828	0·000753
1887	0·000809	0·000692
1888	0·000800	0·000706

The ordinary method of determining the Inclination with two needles gives two independent values, the agreement of which furnishes a test of the accuracy of the observations. It is, however, usual to give only one value of the Horizontal Force deduced from the means of the values of m/H and $m\mathrm{H}$ calculated from the deflection and vibration experiments. The constancy or regular change of the value of m affords a means of determining whether the observations are sufficiently good, but it seems to us that nothing is for this purpose so satisfactory as the agreement or disagreement between two independent experiments. The results of the ordinary deflection and vibration observations can readily be presented in such a form as to satisfy this condition with only an insignificant addition to the labour of reduction.

The vibration experiment furnishes twelve independent determinations of the time of 100 vibrations, six of which are taken when the scale of the vibrating magnet is apparently moving to the right, and six when it appears to be moving to the left. If we take the mean of the six observations furnished by the first and last three of each of these groups, we have two independent determinations of the vibration period, based in each case on six observations, of which three were taken when the movement appeared to be to the right, and three when it appeared to the left.

If we agree always to combine the first and second of these groups with the values of m/H obtained when the distance between the magnets is 0·3 and 0·4 metre respectively, we obtain from each experiment two values of m and H. Except in so far as errors may arise in the determination of the temperature, or in the adjustment of the instrument (levelling, &c.), these are absolutely independent, and thus furnish a satisfactory check on the accuracy of the observations. It would, however, be hardly worth while for the sake of this advantage to go through the labour of repeating the reduction of the vibrations. As the two vibration periods are very nearly the same, this is unnecessary. Let T be the time deduced from all the observations, and $\mathrm{T} \pm d\mathrm{T}$ the times given by the first and second groups of observations selected as above described. Then if D be the value of m/H given by the deflection experiment,

$$H = \sqrt{\frac{\pi^2 K}{T^2} \div D},$$

$$\frac{dH}{H} = -\frac{dT}{T},$$

and in like manner

$$\frac{dm}{m} = -\frac{dT}{T}.$$

Thus, if we use the mean of the times for deducing two values of H and m from the two deflection experiments (as is done in the ordinary method of reduction) we may obtain the independent values of H and m by altering the means in the ratio of the independent to the mean times.

Thus, at Horsham, the mean time of vibration was $4^{s}\cdot1650$, and using this the deflections at the two distances gave

$$H = 1\cdot8365 \text{ and } 1\cdot8366$$

and

$$m = 0\cdot0091956 \text{ and } 0\cdot0091952$$

respectively.

The actual periods of vibration for 100 oscillations observed were—

Apparently—	
Moving to right.	Moving to left.
m. s.	m. s.
6 56·6	6 56·6
56·5	56·6
56·5	56·5
56·5	56·6
56·3	56·4
56·4	56·5

Taking the means of the observations recorded above and below the line we get for the time of one oscillation

$$4^{s}\cdot1655 \qquad \text{and} \qquad 4^{s}\cdot1645.$$

These independent times differ from the mean by 0·012 and − 0·012 per cent. respectively.

Hence, altering the values of H and m in the same proportion, but in the opposite direction to that indicated by the signs of these quantities, we get

$$H = 1\cdot8363 \qquad \text{and} \qquad 1\cdot8368,$$

and

$$m = 0\cdot0091945 \qquad \text{and} \qquad 0\cdot0091963.$$

These quantities are quite independent, except as regards the temperature corrections and instrumental adjustments, and their difference is a measure of the errors of observation and imperfect compensation of the diurnal variation and disturbance. In tabulating the Force observations we give the G.M.T. at which the deflection and vibration observations were made, and the extreme temperatures during the progress of the experiments, the observed deflections and the independent times calculated as above described.

The agreement of the times of vibration serves to test the vibration experiments. As a measure of the accuracy of the deflections we take the ratio of the two values of m/H calculated by combining the mean time of vibration with each of the two deflections.

The logarithms of these two quantities occur in the calculations, and all that is necessary is to subtract them and look out the corresponding natural number. As this quantity is very nearly unity we multiply by 100 and give the fractional part only. The symbol ϵ is thus the percentage difference between the results given by the two deflections when combined with the mean time of vibration.

The following form, which is that which has been used, explains itself.

The results of the deflections differed by 0·008 per cent., the times of vibration by 0^s·001. There was no disturbance, and the Horizontal Force, owing to diurnal variation, was 0·0007 and 0·0003 metric unit above the average, at the times which correspond to the middle of the deflection and vibration experiments respectively.

The corrected values are obtained from the mean values by applying the corrections for diurnal variation and disturbance.

HORIZONTAL FORCE. Horsham. Observer, A. W. R. Magnetometer 60.

Deflection.

Date, 1888.	G.M.T.	t.	Observed deflection.	ϵ.	v_1.	Δ_1.
	h. m.	°	° ′ ″			
April 21	14 44	11·8 to 10·7	21 51 55 9 0 8	+ 0·008	+ 0·0007	0

Vibration.

Date.	G.M.T.	t.	T.	v_2.	Δ_2.
	h. m.	°	s.		
April 21	13 34	16·5 to 17·4	4·1655 4·1645	+ 0·0003	0

Values of m.

Observed.	Mean.	Corrected.
0·0091945 0·0091963	0·0091954	0·0091965

Values of H.

Observed.	Mean.	Corrected.	σ.	Reduced.
1·8363 1·8368	1·8365	1·8360	− 0·0051	1·8309

At places where the deflection experiment was not made, the moment of the magnet was calculated from the other moments observed during the same tour. It was assumed that the strength of the magnet diminished regularly, and a linear expression was determined by equations of condition which gave the rate of decrease. A careful analysis of the Scotch observations, which were the first reduced, proved that this method was satisfactory.

The greatest difference between observation and calculation occurred at Kirkwall, and amounted to 0·234 per cent. It is certain that in this case the difference is not due to errors of experiment, but to a real change in the moment, as the observations obtained at the next station (Lerwick) confirmed it. We are also able to assign a probable cause for the alteration, as the "Coventina" was caught in a "roost" off Stromness, and experienced rather rough treatment, during which the magnet may have been jarred.

The mean difference (irrespective of sign) at all the stations was 0·057 per cent.; and if we put aside about one-fifth of the whole number of stations at which, owing to bad meteorological or magnetic weather, or some similar cause, the conditions under which the observations were taken were not very favourable, the mean difference at the remainder was 0·028 per cent.

It must, of course, be remembered that this quantity is not a measure of the error of experiment, but of the algebraical sum of that error, and of the deviation of the rate of decrease of the moment of the magnet from perfect uniformity. The conclusion we came to from the discussion of the Scotch observations was that if the observed moment differed from that calculated by the linear formula by 0·1 per cent., either a real change had taken place in the magnet or the observation had been affected by some disturbing cause, which it was in general easy to specify. In the later tours the moments of the magnets changed very slowly, and it was sufficient to take the mean of the moments obtained at one or two stations immediately preceding and following that at which the deflection experiment had been omitted. The total number of stations at which vibrations only were observed was 42.

In the case of the Dip observations the correction for diurnal variation was deduced from the Kew curves for the diurnal variation of the Horizontal and Vertical Forces, which were supplied to us by Mr. WHIPPLE.

The disturbance corrections were calculated as previously described.

The following form was used in working up the results :—

INCLINATION. Bunnahabhain. Observers: Needle 1, A. W. R.; Needle 2, T. E. T. Dip Circle, DOVER, 83.

Date 1888.	Needle.	G. M. T.	Observed.	v.	Δ.	Corrected.
		h. m.	° ′	′	′	° ′
Aug. 25 . .	1	12 46	70 40·2	+ 0·1	+ 0·7	70 39·4
	2	14 38	70 39·4	− 0·4	. .	70 39·8

Mean.	σ.	Reduced.
70° 39′·6	+ 3′·4	70° 43′·0

All the observations were tabulated in these forms, and we propose to deposit copies of them with the Royal Society. In this paper we give fewer data. It will, however, be more convenient to describe these under the heading "Results of the Observations," p. 93, and we now proceed to use the tabulated results in a discussion of the accuracy of our work.

Errors of Experiment.

The completion of so large a number of observations as those involved in our survey, carried out for the most part by two observers with different sets of instruments, affords a good opportunity of testing the accuracy of experiment in the field, especially as we have followed a regular practice of determining both the geographical and magnetic meridians by means of independent experiments made at an interval of several hours. Again, our method of tabulating the results of the Force observations furnishes a good test of the various parts of the experiments, and, as will be seen hereafter, we are able, in the case of the Dip observations, to arrive at conclusions as to the small errors due to the imperfections even of the excellent needles supplied by Mr. DOVER.

In the first place then, we take as the error of a Declination, the difference from the mean of the values obtained at the same station at an interval so small that the secular correction is not involved (*i.e.*, a few hours or days), when both the geographical and magnetic meridians are determined independently.

The error of a Force observation is taken as half the difference between the two *independent values*, calculated as above described.

Lastly, the error of a Dip observation is half the difference between the results given with needles 1 and 2. In the case of the last two, it is evident that both quantities may be affected with small errors which are not thus detected, such as that due to uncertainty as to temperature, in the case of the Forces, and errors of setting in the magnetic meridian, in that of the Dips.

Taking, however, these quantities and treating them as though all the results in each group were measures of the same quantity, we get the following values of the probable error :—

	Number of observations.	Probable error.
Declination	97·5	0′·699
Horizontal Force . . .	196	0·00028 (M.U.)
Dip	190	0′·15

In this Table, we count each double observation as one. The fraction, in the case of the Declination, is due to the fact that, at some stations, an odd number of observations was made.

It is useful to analyse the observations still further. In so doing, we have generally treated Scotland as a whole. During our earlier tours we observed together, and sometimes one observer would take the geographical and the other the magnetic meridian, one would observe the deflection and the other the time of vibration. It is, therefore, difficult to separate the results. In England and Ireland we always observed apart; and, with the exception of a short tour in 1886, when Dr. THORPE used Dip Circle No. 74, we always used different instruments. The mean values of the quantities are taken *irrespective* of *sign*, so that they indicate the average value whether positive or negative.

The definitions of the quantities used as tests, are given on p. 70. The symbol dS indicates the mean error of the element.

DECLINATION Observations.

	Observer.	Instrument.	Mean values of			
			μ.	$\xi - \xi_0$.	ω.	dS.
			′	′	′	′
Scotland	R. and T.	60 and 61	±0·31	±0·39	±0·75	±0·77
England	T.	61	±0·39	±0·32	±0·28	±0·71
	R.	60	±0·45	±0·35	±0·39	±0·85
Ireland	T.	61	±0·48	±0·24	±0·37	±0·51
	R.	60	±0·39	±0·32	±0·42	±0·63

Roughly then, the average errors due to imperfect adjustment of the mirror, to inaccuracy in determining the magnetic axis of the magnet, and to torsion, ought not, in each case, to exceed about 0·4 of a minute of arc, assuming that no correction was attempted, as would be the case, for instance, with regard to μ, if no back observations of the sun were taken. As in the great majority of cases, all three were corrected by front and back observations on the sun, by observing the magnet erect and inverted, and by determining the torsion, we may be sure that the actual errors were much below these amounts. It seems, therefore, probable that the observations are affected with small errors which are not so capable of correction, for the mean and probable values of dS appear to prove that it is an even chance that each of two independent declinations differ from their mean by more than 0′·7.

In the following Table we give a similar analysis of the Force observations. The quantity $\epsilon/2$ is the percentage difference of either deflection experiment from their mean.

dT is the average difference in seconds between each "independent" determination of the time of a single oscillation (as defined on p. 73) and their mean.

dH is the average difference between each independent determination of the Horizontal Forces and the mean of the two involved in each complete experiment. In all cases the averages are, of course, taken without reference to sign.

HORIZONTAL Force.

	Observer.	Instrument.	Mean values of		
			$\epsilon/2$.	dT.	dH.
			Per cent.	s.	M.U.
Scotland . .	R. and T.	60 and 61	± 0·041	± 0·00043	± 0·00033
England . .	T.	61	0·031	0·00040	0·00030
	R.	60	0·023	0·00035	0·00025
Ireland . .	T.	61	0·033	0·00032	0·00028
	R.	60	0·017	0·00040	0·00022

We have analysed the dips in a somewhat different way.

If one needle tends to give a slightly higher or lower result than the other, the mean value of the difference of the results, always taken in the same order—viz., dip given by Needle 1, minus dip given by Needle 2—ought to give the bias or measure of the difference due to imperfections in their construction. If this quantity be subtracted from the difference of the results in each observation, we get the error of experiment, which is the difference due to imperfection in observing and correcting. The mean of the last quantities, taken without reference to sign, is the mean error of experiment.

Thus, if we take the difference as positive when Needle 1 is the higher, out of 23 stations in Ireland at which observations were made with the same instrument (74), it was positive at 15 and negative at 8. The mean of all the differences showed that, on the average, Needle 1 gave results 0′·31 higher, and Needle 2 results 0′·31 lower, than the mean of the two needles; so that there is evidence of a *bias* which would make Needle 1 give results 0′·6 higher than Needle 2. That this number is worthy of credit is shown by the close agreement of the values obtained with the same instrument in England, and by the practical identity of all the numbers obtained for Dip Circle 83 in England, Scotland, and Ireland.

The axles of the needles of Dip Circle No. 74 appear to have undergone some slight alteration between the end of 1885 and the beginning of 1886, but there seems no doubt that since that date Needles No. 1 in the two instruments have read about 0′·3 and 0′·2 respectively above the mean of the two needles.

The following Table gives a summary of the results :—

INSTRUMENT 74.

	Observers.	Number of stations, with difference.		Bias. Upper sign, Needle 1. Lower sign, Needle 2.
		Positive.	Negative.	
Scotland . .	T., R., and L.	18	31	∓ 0′·25
England . .	T.	8	2	± 0·25
	R.	24	12	± 0·33
Ireland . .	R.	15	8	± 0·31

INSTRUMENT 83.

	Observers.	Number of stations, with difference.		Bias. Upper sign, Needle 1. Lower sign, Needle 2.
		Positive.	Negative.	
Scotland . .	T. and R.	6	3	$\pm 0'{\cdot}19$
England . .	T.	25	16	$\pm 0{\cdot}20$
Ireland . . .	T.	11	7	$\pm 0{\cdot}20$

An analysis of the errors and corrections such as we have carried out appears to constitute a very delicate test of the observer and instrument combined. Thus it is curious to note that (although the differences are small) one of us has on the whole been more successful with the Declinations and the other with the Force observations. As has already been remarked, the observations in Scotland were often divided between us, so that we do not attempt to analyse them, but both in England and Ireland Dr. THORPE'S Declinations agree the better by about 0'·26, and Professor RÜCKER'S Forces by about 0·00011 metric unit. The facts that in Ireland Professor RÜCKER'S mirror appears to have been generally in the better adjustment, and that in England Dr. THORPE'S observations of the period of oscillation of the needle were the better, indicate that the causes of the differences in the results were probably a more perfect management of the torsion of the thread in the Declination observations, and a slight superiority in the deflection observations in the Force measurements.

It will, we think, be granted that in all cases the observations are as good as the occasion requires, and we discuss these minute differences not because we think they produce any appreciable effect on the results of our survey, but as an illustration of the fact that our method of tabulating the observations, conveys information as to the personal equations of the observers which is not afforded by the results as ordinarily presented.

We think it possible that if we had been able to carry out the work in a more leisurely manner, to observe azimuths only when the Sun was low in the heavens, and to wait for fine weather, the results might have been in closer accord, but on the other hand we do not think that any improvement so obtained would have been of practical importance. The uncertainty of the value of the secular correction at any given station, and the changes produced in disturbed districts by a slight alteration in the position of the instruments, are far more important than any residual errors by which our observations may possibly be affected.

Secular Corrections.

The secular correction is often appreciably different at neighbouring stations. Thus the annual change in the Dip in the years 1883–4 and 1884–5 was 1′·8 and 1′·7 at Greenwich, and 1′·4 and 1′·2 at Kew.

The differences in the Declination change are still more marked, as the following Table shows.

Year.	Declination.		Annual variation.	
	Greenwich.	Kew.	Greenwich.	Kew.
1880	18° 32′·6	18° 59′·0	5′·5	8′·5
1881	27·1	50·5	4·8	5·7
1882	22·3	44·8	7·3	4·8
1883	15·0	40·0	7·4	8·0
1884	7·6	32·0	5·9	7·3
1885	1·7	24·7	. .	. .

It will be noted that the annual variations differed in 1880 by 3′·0, and that the average difference irrespective of sign is 1′·4.

It does not therefore appear advisable to reduce the observations to one epoch by means of the annual variations as determined at a single observatory.

On the whole a better result will probably be attained if we collect all the evidence at our disposal and deduce from it an average secular change.

The comparison of our own observations with those of Mr. WELSH affords the means of determining this quantity for Scotland, and proves that the rate of decrease of the Dip is less in the northern than in the southern stations, a result which is in accord with previous observations.

The mean decrease in Scotland between 1837 and 1857 was 1′·94. ('Brit. Assoc. Rep.,' 1859, p. 169.) In the nearly corresponding interval between 1837 and 1860 it was 2′·05 on the northern border of England and 2′·68 on the south coast. ('Brit. Assoc. Rep.,' 1861, p. 260.)

Unfortunately very few Dip observations were made in England and none were made in Ireland in the 1857 survey, but there are a number of stations common to the surveys of 1837 and 1886. We can thus determine the secular decrease during the last 50 years. In the following Table the stations are grouped according to their geographical distribution, the districts being North and South Scotland, North, Central, and South England and Wales, and North and South Ireland.

The data for the 1837 survey are taken from the paper by the late Sir EDWARD SABINE, already cited ('Phil. Trans.,' 1870, Vol. 160, p. 271).

TABLE II.—Mean Annual Decrease of Inclination between 1837 and 1886.

Station.	Mean Annual Decrease.	Station.	Mean Annual Decrease.
Lerwick	1′·22	Malvern	2′·33
Aberdeen	1·58	Brecon	2·24
Kirkwall	1·41	Aberystwith	2·27
Wick	1·47	Harwich	2·02
Golspie	1·48	Clifton	2·25
Inverness	1·57	Swansea	2·22
Fort Augustus	1·44		
		Kew	2·04
Edinburgh	1·43	Ilfracombe	2·04
Glasgow	1·53	Salisbury	2·28
Helensburgh	1·38	Dover	2·10
Campbelton	1·70	Exeter	2·06
Cumbrae	1·23	Ryde	2·26
Berwick	1·77	Weymouth	2·32
		Plymouth	2·26
Alnwick	1·67	Falmouth	2·46
Newcastle	1·75		
Carlisle	1·96	Londonderry	2·04
Whitehaven	1·77	Strabane	1·87
Thirsk	1·88	Bangor	1·98
Scarborough	1·80	Armagh	2·09
Manchester	2·10	Enniskillen	2·04
Birkenhead	1·98	Ballina	2·06
Holyhead	2·02	Westport	2·12
		Clifden	2·13
Cromer	1·81		
King's Lynn	1·96	Galway	1·99
Nottingham	2·06	Dublin	2·06
Pwllheli	2·04	Limerick	2·21
Shrewsbury	1·70	Waterford	2·31
Birmingham	2·10	Killarney	2·45
Cambridge	2·02	Cork	2·32
Lowestoft	1·84	Valentia	2·50

There is a steady increase as we pass from north to south, and from east to west. This is brought out in the next table, in which the mean decrease is given for each district, and also for the stations in the easterly and westerly parts of it.

District.	Number of Stations.	Mean annual decrease of inclination between 1837–1886 for		
		Whole district.	Western half.	Eastern half.
North of Scotland	7	1′·45	1′·49	1′·42
South of Scotland	6	1·51	..	..
North of England and North Wales	9	1·88	1·97	1·77
Midlands and Wales	14	2·05	2·10	2·00
South of England	9	2·20	2·24	2·17
North of Ireland	8	2·04	2·07	1·98
South of Ireland	7	2·26	2·37	2·15

In the case of twelve Scotch and six English stations we are able to compare the rate of change in the two periods 1837–1857 and 1857–1886. The data are taken from the sources above described.

Station.	Mean annual decrease of inclination.		Ratio.
	1837–1857.	1857–1888.	
Lerwick	1′·65	0′·96	1·72
Aberdeen	2·02	1·33	1·52
Kirkwall	1·97	1·07	1·84
Wick	2·02	1·11	1·82
Golspie	1·68	1·38	1·22
Inverness	1·92	1·37	1·40
Fort Augustus	1·80	1·21	1·49
Edinburgh	1·82	1·14	1·60
Glasgow	1·80	1·42	1·27
Helensburgh	1·48	1·32	1·12
Campbelton	1·99	1·39	1·43
Cumbrae	1·53	0·94	1·63
Berwick	2·48	1·33	1·87
Scarborough	2·02	1·63	1·24
Stonyhurst	..	1·75	..
Cromer	2·22	1·44	1·54
Cambridge	2·50	1·58	1·58
Lowestoft	2·17	1·54	1·41
Kew	2·65	1·62	1·63
St. Leonards	..	1·82	..
Plymouth	2·73	1·89	1·44

The mean ratio for North Scotland is 1·57, for South Scotland 1·49, and for England 1·47.

These figures prove that the ratio of the mean annual decrease, in the intervals 1837–57 and 1857–87 has been nearly constant all over Great Britain, but that the rate of change has been rather more rapid in the north.

If we assume that the ratio has been 1·5 for England and Ireland, we may deduce x, the mean annual decrease between 1857–87, from the corresponding quantity given in Table II., p. 82, for the interval 1837–87, by the formula

$$1{\cdot}5 \times 20x + 30x = 50d,$$
$$x = 5d/6.$$

The same quantity is determined for stations in Scotland by direct experiment by the comparison of our own observations with those of Mr. Welsh. The results are given in the following Table.

MEAN Annual Decrease of Inclination in Scotland between 1857 and 1884–8.

Station.	Mean annual decrease.	Station.	Mean annual decrease.
	′		′
Lerwick	0·96	Fort Augustus	1·21
Kirkwall	1·07	Aberdeen	1·33
Stromness	1·27	Pitlochrie	1·40
Thurso	1·15	Oban	1·27
Wick	1·11	Port Askaig	1·38
Loch Inver	1·32	Lochgoilhead	1·12
Stornoway	0·90	Edinburgh	1·14
Callernish	0·99	Glasgow	1·42
Golspie	1·38	Berwick	1·33
Banff	1·33	Cumbrae	0·94
Elgin	1·30	Campbelton	1·39
Inverness	1·37	Ayr	1·56
Kyle Akin	1·12	Dumfries	1·45
Dalwhinnie	1·41	Stranraer	1·54

Using these figures and the numbers calculated as above described from Table II., p. 82, we get the mean annual decrease between 1857 and 1886 in different parts of the United Kingdom, as follows :—

District.	Mean annual decrease between 1857–8 and 1884–7.
N. of Scotland	1′·20
S. of Scotland	1·36
N. of England and N. Wales	1·57
Midlands and Wales	1·71
S. of England	1·84
N. of Ireland	1·68
S. of Ireland	1·90

Although we give these numbers as showing the mean results for districts of considerable size, the figures obtained at the individual stations appear worthy of careful study.

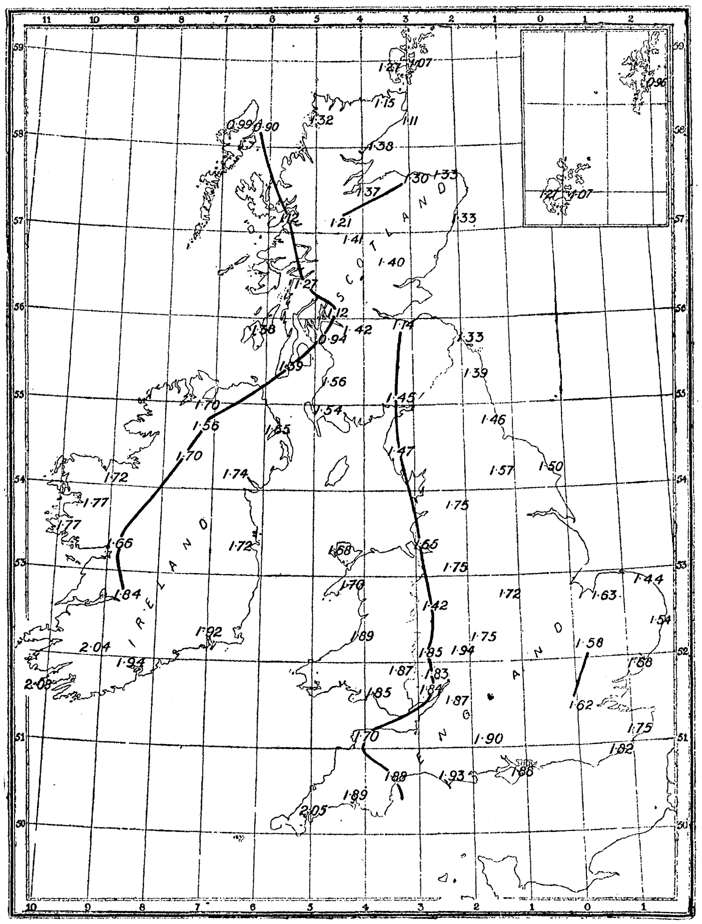
The observed values of the annual decrease for 1857–87 for Scotland, and those calculated for the same period for England and Ireland from the 1837–87 surveys are inserted in the accompanying map (fig. 1).

The general increase from east to west is evident, but in Great Britain there are some stations the annual decrease at which is less than at those which are nearest to them on the eastern side.

To test whether the differences were accidental a number of supplementary stations were taken on the Wye.

At Malvern and Brecon the calculated secular rates between 1857 and 1886 are $-$ 1′·94 and $-$ 1′·87, and at Clifton and Cardiff $-$ 1′·87 and $-$ 1′·85. In each case the smaller value occurs at the western station. Between them lie Hereford, Ross, and Chepstow, and the rates obtained from observations at these in April, 1889, are $-1'{\cdot}85$, $-1'{\cdot}83$, and $-1'{\cdot}84$, which are in all cases less than those at Malvern and Clifton. These observations then support the view that there is a real maximum followed by a minimum rate of change of Dip in this neighbourhood.

Fig. 1.



Secular change of Dip, 1858–86.

This induces us to show in fig. 1 that if all stations at which there is a maximum rate of change are joined, we get two long lines running from Edinburgh to Exeter, and from Stornoway to Limerick. The stations are not sufficiently numerous to enable us to draw any certain conclusions about them, but the point ought not to be lost sight of when the survey is repeated.

For the present we note only that of the three pairs of neighbouring abnormal stations at which observations were made in all three surveys, all three are abnormal (in the sense that the rate of change is greater at the easterly station) whether we take the interval 1837–87 or 1857–87. In both cases the rate at Inverness is greater than at Fort Augustus, at Glasgow than at Cumbrae, and at Berwick than at Edinburgh.

The distribution of these stations affords, at all events, *prima facie* evidence that the differences between them are not accidental. That they cannot be due to errors of measurement is evident when we remember that an error of 0′·1 in the annual rate of change determined from experiments separated by an interval of fifty years would require an error of 5′ in one or other of the observations, or of 2′·5 in both. We therefore decided to regard the figures in fig. 1 as giving the true rate of secular change of Dip between 1857 and 1887 at the stations indicated.

The determination of the mean rate of decrease of Dip between the years 1857 and 1887 does not, however, give the value of that quantity during the period of our survey. As the rate is diminishing it would be less in recent than in earlier years.

The evidence we are able to collect on this head is confined to data from Greenwich, Kew, and Stonyhurst, and to a few stations at which we observed both near the beginning and near the end of our survey. In the following Table we have entered such facts as were known to us at the time when the progress of the reductions made it necessary to come to a decision on this point.

Our own observations and those taken at Stonyhurst are corrected for diurnal variation and disturbance. The Table illustrates the importance of these corrections when conclusions are to be drawn from observations between which the interval of time is small.

TABLE III.

Station.	Date.	Dip.	Date.	Dip.	Interval in years.	Secular rate of change.	Assumed rate.
Loch Aylort .	Sept., 1884	71° 24′·0	Aug., 1888	71° 22′·3	4	− 0′·4	− 1′·0
Kerrera . . .	Aug., 1884	70 51·1	Aug., 1885	70 48·7	1	− 2·4	− 1·2
Stranraer . .	Sept., 1884	70 14·1	Aug., 1888	70 11·1	4	− 0·8	− 1·4
Stonyhurst .	1884	69 16·2	1887	69 9·0	3	− 2·4	− 1·6
Kew	1884	67 39·5	1888	67 36·4	4	− 0·8	− 1·5
Greenwich . .	1884	67 30·2	1886	67 27·0	2	− 1·6	− 1·5
Leeds . . .	Sept., 1886	69 9·7	Dec., 1888	69 6·9	2·2	− 1·3	− 1·5
					Mean .	− 1·4	− 1·4

NOTE.—Stornoway is omitted because the observations were made in 1884 in the Castle grounds and in 1888 on Ard Point.

These figures illustrate the fact that there may be a considerable discrepancy at any particular station between the actual secular change at a given time and that deduced from the mean taken over a long series of years. On the whole, we think it probable that the present rate of change of Dip is somewhat less than its mean value between 1857–87, and we have, therefore, reduced the numbers for that period by one tenth, neglecting fractions of a tenth of a minute. This *assumed rate* gives a correct mean rate for the stations referred to above in Table III., though it is considerably too high for some and too low for others. It is probable that in the case of Kerrera the observed rate of change is not quite correct. The site is subject to local attraction, and a single pair of observations made at so short an interval as a year is hardly sufficient to rely on. The results from Stonyhurst, however, prove that the assumed and actual rates of change may differ by 0′·8, and that, thus, Dips reduced to January 1, 1886, from the end of 1888, may be about 2′·5 wrong. To prevent, as far as possible, any effect on the general run of the isoclinal lines from this uncertainty, we put down on a map all the assumed rates at places for which they could be determined, and took the rate at any other place to be that given by the nearest of these stations.

The rates of decrease thus obtained for the south of England are considerably less than those assumed by M. MOUREAUX for the north of France, which do not differ much from − 2′·7. These values are obtained for the interval 1858–1885 by comparing M. MOUREAUX's observations with LAMONT's map. We think, however, that the observations of the Rev. S. J. PERRY, F.R.S., reduced to the epoch, January 1, 1869, prove that in France as in England the rate of change of Dip has been diminishing.

Twelve stations were common to Father PERRY and M. MOUREAUX; at one of these, Marseilles, the station of the earlier observer was no doubt seriously affected by local disturbance. The rate of change for the epoch 1858–69 is much larger than for any other station, and for 1869–85 it is much too small. Rejecting this observation we think the following table shows that M. MOUREAUX's numbers are too large.

SECULAR Change of Dip in France.

Station.	Jan. 1, 1869.	Jan. 1, 1885.	Secular variation.	
			1869–85.	1859-85.
	° ′	° ′	′	′
Amiens	66 40·3	66 8·0	− 2·0	− 2·7
Bordeaux	63 23·0	62 41·8	− 2·6	− 3·1
Clermont	63 36·4	62 52·1	− 2·8	− 2·8
Dijon	64 24·5	63 53·4	− 1·9	− 2·7
Grenoble	62 54·2	62 6·9	− 2·9	− 2·6
Monaco	61 22·1	60 41·2	− 2·5	− 2·8
Moulins	64 4·9	63 30·1	− 2·2	− 2·7
Paris	65 52·5	65 17·3	− 2·2	− 2·8
Périgueux	63 23·9	62 44·9	− 2·4	− 3·1
Poitiers	64 28·1	63 55·6	− 2·0	− 2·8
Toulouse	62 1·1	61 23·9	− 2·3	− 3·2
Mean	..	..	− 2·35	− 2·85

We turn next to the secular change of the Declination.

A number of stations are common to our own survey and those of 1837 and 1857, and we have also observed at several places where the Declination was determined in 1872. The mean annual decrease calculated for the observations is exhibited in the following table :—

TABLE IV.—Table of Mean Annual Decrease of Declination.

Station.	1837 to 1886.	1857 to 1886.	1872 to 1886.
Lerwick	8·4	10·5	8·2
Kirkwall	7·9	10·5	..
Thurso	..	10·6	9·9
Loch Eriboll	..	10·1	9·4
Wick	8·1	10·5	9·3
Stornoway	..	8·2	..
Callernish	..	9·8	..
Loch Inver	..	11·8	..
Golspie	8·1	10·4	..
Elgin	..	8·8	..
Banff	..	8·9	..
Loch Maddy	..	9·8	..
Kyle Akin	..	8·8	8·9
Inverness	7·9	9·0	..
Aberdeen	7·7	8·9	8·9
Loch Boisdale	..	..	12·0
Fort Augustus	..	9·1	..
Dalwhinnie	..	8·8	..
Pitlochrie	..	8·9	..
Oban	..	8·1	12·9
Lochgoilhead	..	..	..
Edinburgh	..	9·1	8·4
Glasgow	..	9·0	..
Cumbrae	..	..	..
Ayr	..	8·7	..
Campbelton	..	9·0	..
Dumfries	..	8·4	..
Stranraer	..	8·5	..
Liverpool	..	8·2	..
Cromer	7·3	..	7·0
King's Lynn	..	..	6·6
Lowestoft	7·1	..	..
Harwich	7·3	..	7·3
Kew	..	7·8	..
Greenwich	7·3	7·6	7·3
Milford	..	..	7·7
Plymouth	..	8·3	..
Falmouth	..	8·4	..
Jersey (St. Helier's)	..	7·6	..
Londonderry	7·7	..	..
Westport	7·6	..	..
Dublin	7·5	..	..
Limerick	6·9	..	..
Wexford	..	..	9·1
Waterford	6·7	..	..
Killarney	6·6	..	..
Valentia	6·9	..	8·4
Cork	6·2	..	..

These results indicate—(1) that the secular change is greater in the northern than in the southern parts of the United Kingdom; (2) that it was much larger between the years 1857–86 than during the interval 1837–57; and, lastly, (3) that, in the north at all events, the rate of annual decrease is again diminishing.

The first of these conclusions differs from that arrived at by Sir E. SABINE when collating the 1837 and 1857 surveys. He assumed ('Phil. Trans.,' vol. 160, 1870, p. 268) "an annual decrease of West Declination of approximately 5′·6 in Scotland and the north of England, increasing to 6′·2 in the middle and southern parts of England and to 6′ in Ireland."

Our conclusion that, at the present time, the rate is greater in the north is borne out by the values deduced by M. MOUREAUX from his own observations and the maps of LAMONT (*loc. cit.*, p. 162). The values he gives for stations on the Mediterranean and on the English Channel are about −6′·5 and −7′·7 respectively, which indicates an increase of about 0′·2 on the rate for each degree of latitude as we go north.

The truth of the second conclusion is rendered more apparent by calculating the annual rate for the epoch 1837–57 instead of 1857–86, as shown in the following Table for the Scotch stations, for which the requisite data are available:—

MEAN Annual Decrease of Declination.

Station.	1837 to 1857.	1857 to 1886.	Station.	1837 to 1857.	1857 to 1886.
Lerwick	−5′·5	−10′·5	Inverness	−6′·3	−9′·0
Kirkwall	−4·5	−10·5	Aberdeen	−6·8	−8·9
Wick	−4·8	−10·5	Loch Inver	−2·9 (?)	−11·8
Golspie	−5·0	−10·4			

The third conclusion is supported by a comparison of M. MOUREAUX's rates for the epoch 1859–1885 with those obtained by collating as before his results and those of the Rev. S. J. PERRY (*loc. cit.*).

Station.	Declination.		Secular rate of change.	
	Jan. 1, 1869.	Jan. 1, 1885.	1869–85.	1859–85.
Amiens	18° 19′·0	16° 34′·7	− 6′·5	− 7′·4
Bordeaux	18 12·5	16 45·7	− 5·4	− 7·0
Clermont	16 27·6	15 25·0	− 3·9	− 6·9
Dijon	16 36·7	14 45·2	− 7·0	− 7·2
Grenoble	15 49·3	14 11·0	− 6·1	− 6·8
Marseilles	15 41·5	14 0·0	− 6·3	− 6·7
Monaco	14 31·4	13 10·5	− 5 0	− 6·5
Moulins	16 29·2	15 25·6	− 4·0	− 6·9
Paris	17 50·5	16 10·2	− 6·3	− 7·4
Périgueux	17 40·9	16 8·6	− 5·8	− 7·0
Poitiers	18 18·4	16 40·8	− 6·1	− 7·1
Toulouse	17 7·3	15 41·4	− 5·4	− 6·8
Mean	..	..	− 5·6	− 7·0

This result—that the rate of decrease is diminishing—is in accord with the conclusions drawn by M. MOUREAUX himself from a comparison of his own observations with those on which a magnetic map of France for the epoch 1875 was based by M. MARIÉ-DAVY (*loc. cit.*, p. 166). He did not, however, make use of this fact, as the number of observations employed by MARIÉ-DAVY was small, and they were taken at stations irregularly distributed over France. He does not cite the observations of Father PERRY, which, as the above Table shows, strongly support the same view.

In the next Table we give such observations as were made at English observatories or by ourselves during the progress of the survey which bear on the question under discussion. No very definite conclusions can be drawn from them.

Two single observations at the interval of a year, as at Kerrera and Glasgow, are hardly sufficient for the purpose of deducing a secular rate. Loch Aylort and Stornoway are both disturbed stations and the results are thus less trustworthy. The general evidence that the secular change is greater in higher latitudes is opposed by the fact that Stonyhurst gives a less value than Kew and Greenwich. If the increase with latitude which obtains in France were maintained in England, the value at Paris being taken at − 6′·3, we could deduce − 6′·8 for London; − 7′·7 for Edinburgh; and − 8′·2 for Wick; of which the two latter are less than the values for the epoch 1872–86 given in Table IV., p. 88.

Station.	Date.	Declination.	Date.	Declination.	Interval in years.	Secular rate of change.
		° ′		° ′		′
Stornoway . . (Ard Point)	Sept., 1884	24 20·6	Aug., 1885	24 12·4	0·96	− 8·5
			Aug., 1888	23 49·9	4	− 7·7
Loch Aylort .	Sept., 1884	23 40·2	Aug., 1888	22 41·8	4	− 14·6
Kerrera . . .	Aug., 1884	22 25·4	Aug., 1885	22 15·2	1	− 10·2
Glasgow . .	Aug., 1884	21 21·3	Aug., 1885	21 18·2	1	− 3·1
Stranraer . .	Sept., 1884	21 46·2	Aug., 1888	21 13·1	4	− 8·2
Stonyhurst . .	1884	19 52·8	1887	19 35·2	3	− 5·9
Reading . .	April 30, 1886	18 13·1	May 30, 1888	17 53·9	2	− 9·6
Kew	1884	18 33·9	1888	18 9·3	4	− 6·1
Greenwich . .	1884	18 7·6	1888	17 40·0* (approx.)	4	− 6·9

From Table IV. we see that the rates at Greenwich for the three intervals, 1837–86, 1857–86, and 1872–86 are nearly the same, the differences between them and the mean rate during the period of our survey (6′·9) being 0′·4, 0′·7, and 0′·4 respectively. Assuming that if we subtract these numbers from the rates calculated for the same epochs for the other English stations in Table IV. we obtain the present rates at the stations, we find as a mean rate 7′·0, which agrees closely with that of Greenwich.

On the whole we decided to take a secular rate of − 7′·0 in England south of a line joining Redcar and Barrow, and also in Wales, and in Ireland south of a line joining Dublin and Donegal.

For the remainder of England and Ireland we have assumed the rate to be − 8′·0 per annum. At the time when most of the Scotch observations were reduced we had not M. Moureaux's results before us, and we hardly felt justified in departing from the rates given by the comparison of our observations with Mr. Welsh's, on the evidence of the small number of stations at which the Declination was determined in 1872. We, therefore, employed rates varying from − 10′·4 in the north of Scotland to − 8′·8 in the south, the change on the east coast being somewhat greater than on the west. These may be a little too large but the error certainly does not exceed the variation which occurs between neighbouring stations. For the later Scotch observations we used a rate of − 9′·0.

The data for the determination of the secular change of the Horizontal Force are more scanty than in the case of the other elements.

At the time of the 1837 survey the measures were comparative only, and though Sir E. Sabine afterwards reduced them to absolute values by means of the known absolute value and secular rate at Kew, we do not think any useful end would be attained by discussing them.

M. Moureaux found that for the interval 1848–85, the secular variation in France attains its maximum + 0·0027 (M.U.) at Bordeaux and decreases slowly towards the

* From information kindly supplied by the Astronomer-Royal.

east, being ·0025 at Paris and + 0·0023 at Nice and Mezières (*loc. cit.*, p. 167). The mean value obtained by the Rev. S. J. Perry in 1869 by comparison with Lamont was 0·0023 ('Phil. Trans.,' Vol. 160, 1870, p. 48), which was increasing by about 0·000008 per annum and would correspond to 0·0025 at the present time.

By comparison of our own observations with those of Welsh we obtain 0·0018 as a mean for Scotland between 1857 and 1886.

The following Tables give these values and those which were obtained at the English observatories or by ourselves during our survey.

Secular Change in Horizontal Force.

Station.	Welsh.	R. and T.	Difference.	Interval.	Secular rate of change.
	Uncorrected for v and Δ.			Years.	
Dumfries	1·6006	1 6522	·0516	27	·0019
Stranraer	1·5853	1·6433	·0580	27	·0021
Ayr	1·5756	1 6317	·0561	$27\frac{3}{4}$	·0020
Oban	1·5451	1·6083	·0632	31	·0020
Fort Augustus	1·5134	1·5643	·0509	28	·0018
Inverness	1·5093	1·5653	·0560	28	·0020
Aberdeen	1·5166	1·5735	·0569	$27\frac{1}{2}$	·0021
Pitlochrie	1·5341	1·5926	·0585	$27\frac{3}{4}$	·0021
Dalwhinnie	1·5377	1·5926	·0549	$27\frac{3}{4}$	·0020
Edinburgh	1·5665	1·6162	·0497	$27\frac{1}{2}$	·0018
	1·5697	..	·0465	$26\frac{3}{4}$	·0017
Kyle Akin	1·5009	1·5407	·0398	..	·0015
Stornoway	{1·4773, 1·4783, 1·4794} 1·4783	1·5122	·0339	$26\frac{1}{12}$	·0013
Callernish	1·4731	1·5236	·0505	27	·0019
Loch Inver	1·4499	1·4956	·0457	$26\frac{1}{12}$	·0018
Thurso	1·4763	1·5209	·0446	$26\frac{3}{4}$	·0017
Lerwick	1·4313	1·4718	·0405	27	·0015
Kirkwall	{1·4669, 1·4725, 1·4753} 1·4716	1·5111	·0395	27	·0015
Wick	1·4706	1·5117	·0411	$26\frac{3}{4}$	·0015
Golspie	1·4893	1·5390	·0497	$26\frac{3}{4}$	·0019
Mean	.. ..	..	.. ..	..	·0018

Station.	Date.	H.	Date.	H.	Interval in years.	Secular rate of change.
Stornoway	Aug. 19, 1885	1·5200	Aug. 14, 1888	1 5220	3	+ ·0007
Loch Aylort	Sept. 12, 1884	1·5577	Aug. 2, 1888	1·5774	4	+ ·0049
Stranraer	Sept. 18, 1884	1·6423	Aug. 28, 1888	1·6470	4	+ ·0012
Stonyhurst	1884	1·6954	1887	1·7024	3	+ ·0023
Kew	1884	1.8056	1887	1·8091	3	+ ·0012
	1883	1·8023	1887	1·8091	4	+ ·0017
Greenwich	1883	1·8100	1885	1·8156	2	+ ·0028
	1883	1·8100	1886	1·8157	3	+ ·0019

The results at Kew and Greenwich show that the secular variation varies so much from year to year that it is practically impossible to draw any conclusions from so short a period as 2 or 3 years, and our own observations on Scotland show that if to this difficulty, that due to a slight variation in the position in a disturbed district is added, the results are still less trustworthy. At the time when the reductions were made the Greenwich results for 1886 and the Stonyhurst results for 1887 had not been published. We therefore took the mean of the values for Stonyhurst 1883–1886, Kew 1883–87, and Greenwich 1883–1885, or + 0·0022 the annual increase for England. This value is in fair accord with M. MOUREAUX's results. In Scotland we took the number given by the comparison of our own and WELSH's observations, viz., + 0·0018, and for Ireland + 0·0020.

Results of the Observations.

Having thus described the observations and the methods of correction and reduction to epoch, we now proceed to give a more detailed account of the results at each station. In doing this we have attempted to distinguish between facts which it is necessary to give for the information of most of those who may read our paper, and details which ought to be preserved, but which will nevertheless only be of interest to observers who may for any cause wish to undertake a detailed examination of our results. We have therefore decided to publish in this paper only a description of each station, the hours at which the observations were taken, the results corrected for diurnal variation and disturbance, and the mean reduced to epoch. As Magnetic Observatories and provincial Colleges are now rapidly multiplying, it is not too much to hope that special studies of the districts in their immediate neighbourhood may from time to time be made by those connected with such institutions. It is, therefore, we think, important that the descriptions of the stations should be readily accessible. In adding to these only the times at which the observations were taken, and the actual and reduced results, we are publishing far less than has been usual. Thus, in the case of the Rev. S. J. PERRY's survey of the east of France, he gave for the Force observations the date, hour, and temperature for both vibrations and deflections, the time of one vibration, log mX, the distances of the magnets in the deflection experiment, the observed deflections, and log m/X. M. MOUREAUX has not given quite so many details of the Force observations, but in the case of the Declination he gives the individual readings for the determination of the geographical meridian, &c., so that the description of his work at each station occupies about two quarto pages. For our own part we have no fault to find with the publication of these details; on the contrary, we have found them to be useful; but the large number of stations included in our survey would, we fear, make this paper inordinately long if we adopted a similar plan. We therefore purpose to place in the hands of the Royal Society bound copies of the details of the observations and calculations, and also of the forms described on pp. 71–74, in which the results are analysed and the corrections for diurnal and secular variation and disturbance are applied. It will thus be possible for those who may desire to do so to inspect these, and the data used in the preparation of the Tables on pp. 77–80 will be on record, while this paper will, we hope, contain sufficient to enable future observers who are not specially interested in the details of the calculations and reductions to find the positions where we observed, to know when we observed there, and to judge from the final results of the general accuracy of the observations. We have followed the plan adopted by M. MOUREAUX of giving all the facts with respect to each station together, which we think the most convenient. Tables are also given on pp. 251–258 in which the final results are entered in tabular form for comparison with the values obtained by calculation from formulæ to be hereafter discussed.

The stations are arranged in the following order:—Three groups are formed, comprising Scotland, England and Wales, and Ireland, this being the chronological order of the bulk of the observations in each of these countries. In each group the stations are arranged in alphabetical order, and they are numbered continuously throughout. These numbers are affixed to the positions of the stations as given on Plate I., which serves as an Index map.

The Scotch stations, from Aberdeen to Wick, are numbered from 1 to 54, and it should be mentioned that the name of a Loch is regarded as determining the initial letter. Thus East Loch Tarbert is found under T.

The English and Welsh stations, including the Isle of Man and the Channel Isles, from Aberystwith to Worthing, are numbered from 55 to 156.

The Irish stations, from Armagh to Wicklow, are numbered from 157 to 200.

Thus anyone desirous of looking up the observations at a particular place, can easily do so from a knowledge of its name, while the stations in any particular district can be found in Plate I., and then referred to by means of the corresponding numbers.

The data given in each case, are as follows :—

(1.) The number and name of the station.
(2.) Date of the observations.
(3.) Initials of the observer and numbers of the instruments.
(4.) Latitude and longitude of the station.
(5.) Verbal description of the station.

For the Declination we give :—

(1.) The time from the southing of the sun (Σ), at which the geographical meridian was determined by sun observations, a positive sign indicating the afternoon.
(2.) The G.M.T. of the determination of the magnetic meridian.
(3.) The observed Declinations with all corrections applied (δ).
(4.) The mean observed Declination reduced to the epoch, January 1, 1886 (δ_0).

For the Inclination we give :—

(1.) The number of the needle.
(2.) The G.M.T. at which the observation was made.
(3.) The observed Dip, with all corrections applied (θ).
(4.) The mean observed Dip reduced to epoch (θ_0).

For the Horizontal Force we give :—

(1.) The G.M.T. at which the deflection (D) and vibration (V) were observed.
(2.) The corrected independent forces found as described on p. 73 (H), but corrected for diurnal variation and disturbance.
(3.) The mean observed Horizontal Force reduced to epoch.

Longitudes are to be taken as west of Greenwich, unless the contrary is expressly stated.

Descriptions of Scotch Stations.

1. Aberdeen. April 6 and 7, 1885; A. W. R. and T. E. T. (60, 74). Lat. 57° 9′ 50″; Long. 2° 6′ 5″. In a field behind Professor Milligan's house, immediately opposite to King's College. Tower of King's College E.S.E.; hermitage in Miss Leslie's park W. by S., and the centre of the gate of Miss Leslie's lodge S.E. by S.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
April 6	..	14 49	20 24·3	20 16·3
„ 7	−2 42	9 53	20 21·6	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
April 6	1	14 46	71 12·4	71 12·3
	2	15 28	71 14·1	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
April 6	D	15 56	1·5724	1·5734
	V	14 10	1·5719	

2. ARINAGOWER (Coll). August 11, 1885; A. W. R. (60). Lat. 56° 37′ 5″; Long. 6° 31′ 12″. Near the landing-place on the west side of the bay. This observation was taken during an unexpected detention of the steamer. The declination was the only element determined.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. −0 52	h. m. 12 1	° ′ 23 44·2	° ′ 23 40·4

3. LOCH AYLORT (Gobbar Island). September 12, 1884; A. W. R. and T. E. T. (60, 74). August 2, 1888; T. E. T. (61, 83). Lat. 56° 51′ 5″; Long. 5° 47′ 0″. On the east side of the island.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
Sept. 12, 1884	+ 2 48	15 42	23 40·2	23 27·2
Aug. 2, 1888	+ 1 15	{ 12 16 13 24	22 40·5 22 43·1	23 5·9

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
Sept. 12, 1884	1	14 44	71 24·8	71 22·6
	2	15 46	71 23·2	
Aug. 2, 1888	1	12 38	71 22·0	71 25·4
	2	13 27	71 22·7	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
Sept. 12, 1884	D	16 39 17 14	1·5571 } 1·5583 }	1·5600
	V	15 9	1·5576 } 1·5578 }	1·5600
Aug. 2, 1888	D	14 28	1·5772	1·5727
	V	13 0	1·5776	

4. AYR. May 25, 1885; A. W. R. (60, 74). Lat. 55° 27′ 30″; Long. 4° 37′ 10″. On the low green about 150 yards from the Castle. Identical with Mr. WELSH's station.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
−3 55	8 55	21 23·0	21 17·9
−1 29		21 23·4	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 32	70 21·6	70 21·4
2	13 15	70 23·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	11 21	1·6337	1·6345
V	9 25	1·6336	
D	..	1·6331	
V	10 28	1·6334	

5. BALLATER. April 7 and 8, 1885; A. W. R. and T. E. T. (60, 74). Lat. 57° 2′ 53″; Long. 3° 2′ 6″. Fifty yards from the Invercauld Arms Hotel; near the river.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
April 7	+ 3 30	16 26	20 36·9	20 29·5
„ 8	− 2 51	..	20 36·1	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
April 7	1 2	h. m. 15 39 16 22	° ′ 71 14·9 71 17·8	° ′ 71 15·4

Horizontal Force.

Date.	G.M.T.		H.	H_0.
April 7	D V	h. m. 15 11 17 2	1·5703 1·5699	1·5714

6. BANAVIE. August 4, 1885. A. W. R. and A. P. L. (60, 74). Lat. 56° 51′ 0″; Long. 5° 5′ 40″. Field close to and on the North side of the Hotel.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. + 4 16	h. m. 17 39	° ′ 22 10·6	° ′ 22 6·7

Inclination.

Needle.	G.M.T.	θ.	θ_0.
1 2	h. m. 17 11 18 5	° ′ 71 11·7 71 12·1	° ′ 71 11·4

Horizontal Force.

G.M.T.		H.	H_0.
D V	h. m. 18 23 17 10	1·5928 1·5938	1·5940

7. BANFF. July 9, 1885; A. W. R. (60, 74). Lat. 57° 39′ 57″; Long. 2° 31′ 17″. In the grounds of the old Castle; on the lawn in front of the house formerly occupied by Dr. BREMNER, now by Sheriff SCOTT-MONCRIEFF. Same station as that at which Mr. WELSH observed.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. −2 40	h. m. 10 28	° ′ 21 8·8	° ′ 21 4·5

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 58	71 19·7	71 19·0
2	13 39	71 19·6	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	11 48	1·5669	1·5684
V	11 7	1·5681	

8. BERWICK. April 2, 1885; A. W. R. and T. E. T. (60, 74). Lat. 55° 46′ 4″; Long. 1° 59′ 52″. On a bastion. Powder-magazine distant about 150 yards N. Church, N.W., and works on sandspit at mouth of river S.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. −3 5	h. m. 9 50	° ′ 19 42·9	° ′ 19 36·4

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	10 57	70 15·8	70 15·9
2	11 34	70 17·8	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	11 35	1·6474	1·6483
V	10 28	1·6467	

9. Boat of Garten. July 31, 1885; A. W. R. and A. P. L. (60, 74). Lat. 57° 15′ 0″; Long. 3° 45′ 13″. On the Green to the North of the Station, about 200 yards from the Hotel.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.		
+ 3 37	15 31	22° 11′·7	22° 7′·7

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	15 51	71 15·0	71 16·3
2	18 0	71 19·3	
1	18 28	71 16·0	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	16 43	1·5776	1·5786
V	15 6	1·5781	

10. Loch Boisdale (S. Uist). August 31, 1884; A. W. R. and T. E. T. (60, 74). Lat. 57° 8′ 55″; Long. 7° 18′ 0″. In the Bay on the Island of Kisgay.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 51	11 19	23 7·1	22 53·3
+ 4 56	16 45	23 7·1	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	11 29	71 41·0	71 39·3
2	12 30	71 39·9	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 49	1·5284	1·5310
V	12 2	1·5288	

11. Bunnahabhain (Islay). August 25, 1888; A. W. R. and T. E. T. (60, 61, 83). Lat. 55° 53′ 0″; Long. 6° 8′ 0″. At the bottom of the road, 150 yards N. of the Distillery and about 10 yards from the beach.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
−2 32	10 55	22 44·0	
−1 12	11 36	22 46·0	
−2 29	10 29	22 46·0	23 10·3
	12 25	22 47·3	
−1 16	14 30	22 47·9	
	15 9	22 47·3	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 46	70 39·4	70 43·0
2	14 38	70 39·8	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	15 39	1·6292	1·6243
V	14 55	1·6291	

12. CALLERNISH (Lewis). August 20, 1885; T. E. T. (60, 74). Lat. 58° 11′ 0″; Long. 6° 42′ 0″. Fifty yards S.S.W. (magnetic) from front of Garynahine inn.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 5 2	18 3	23 44·1	23 40·6

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	7 26	72 7·5	72 7·1
2	8 1	72 7·4	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
V	18 21	1·5224	1·5231

13. CAMPBELTON. August 22, 1884; A. W. R. and T. E. T. (60, 74). Lat. 55° 25′ 30″; Long. 5° 36′ 5″. 200 yards N.E. from Lime Crags. 400 yards E.S.E. from old Parish Church. Same station as that at which Mr. WELSH observed.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 20		22 21·1	
− 1 13	14 36	22 21·0	22 8·1
+ 1 43		22 19·8	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 56	70 35·2	70 34·2
2	13 27	70 36·9	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 58	1·6236	1·6244
V	11 49	1·6204	

14. CANNA. August 30, 1884; A. W. R. and T. E. T. (60, 74). Lat. 57° 3′ 30″ Long. 6° 29′ 20″. On the high land N.E. of the Harbour, and S.W. of Compass Hill.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 4 35	8 12	21 21·8	21 8·4

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
2	8 38	72 46·3	72 45·0

Horizontal Force.

G.M.T.		H.	H_0
	h. m.		
D	9 10	1·5065	1·5092
V	8 30	1·5072	

15. CARSTAIRS. May 25 and 26, 1885; A. W. R. (60, 74). Lat. 55° 41′ 10″; Long. 3° 40′ 11″. In Mr. MONTEITH's grounds, about 400 yards from the station, and about 50 yards from the road leading from the station to the house. Nearly the same position as that at which Mr. WELSH observed.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
May 25	+ 5 55	18 35	20 57·6	20 52·2

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
May 26	1	9 49	70 16·4	70 15·7
	2	10 23	70 16·4	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
May 25	D	19 42	1·6434	1·6448
	V	19 5	1·6440	

16. CRIANLARICH. September 17, 1884; A. W. R. (60, 74). Lat. 56° 23′ 25″; Long. 4° 37′ 6″. Near the inn, about 80 yards from the roads to Dalmally and Loch Lomond.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 47 + 2 49	11 10	22 2·2 22 3·8	21 50·6

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1 2	8 31 9 8	70 54·5 70 53·1	70 52·5

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D V	12 52 11 32	1·5943 1·5971	1·5980

17. CRIEFF. July 28, 1885; A. W. R. and A. P. L. (60, 74). Lat. 56° 22′ 27″; Long. 3° 50′ 22″. In the grounds of MORRISON'S Academy, about half-way between the school and the gate.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	°
+ 1 46	14 48	21 37·6	21 33·6

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 36	70 53·4	70 53·6
2	14 49	70 54·8	

Horizontal Force.

G.M.T.		H.	H_0
	h. m.		
D	15 55	1·6071	1·6079
V	15 19	1·6072	

18. CUMBRAE. July 24, 1888; T. E. T. (61, 83). Lat. 55° 47′ 45″; Long. 4° 53′ 40″. Eight yards to the N. of the Monument to the "Shearwater's" midshipmen, at the N.E. end of the Island. Mr. WELSH's Station.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 4 19	17 0	21 13·2	21 37·2

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	17 41	71 1·0	71 2·3
2	18 0	70 59·7	

Horizontal Force.

G.M.T.		H.	H_0.
V.	h. m. 17 16	1·5957	1·5911

19. DALWHINNIE. July 30, 1885. A. W. R. and A. P. L. (60, 74). Lat. 56° 55′ 52″; Long. 4° 14′ 12″. About 150 yards from the Hotel; on the opposite side of the river.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. + 2 54	h. m. 16 10	° ′ 21 49·2	° ′ 21 45·5

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	16 9	70 59·7	71 0·1
2	17 35	71 1·6	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	14 42	1·5901	1·5909
V	15 49	1·5902	

20. DUMFRIES. September 20, 1884 and July 11, 1885. A. W. R. (60, 74). Lat. 55° 2′ 10″; Long. 3° 35′ 30″. On Mr. STOTT's farm at Lower Netherwood. In a field about 100 yards W. of the farm-house; 39 and 50 paces from the N. and E. walls of the field respectively. Nearly the same station as that of Mr. WELSH.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
July 11.	h. m. + 4 51	h. m. 16 33	° ′ 20 51·5	° ′ 20 47·4

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
Sept. 20.	1 2	h. m. 12 6 12 46	° ′ 70 4·2 70 4·5	° ′ 70 2·6

Horizontal Force.

Date.	G.M.T.		H.	H_0.
Sept. 20.	D V	h. m. 13 38 14 19	1·6524 1·6514	1·6542

21. DUNDEE. April 9, 1885; A. W. R. and T. E. T. (60, 74). Lat. 56° 28′ 17″; Long. 2° 56′ 58″. In the Baxter Park. The tower of Morgan's Hospital N. by W.; tower of lodge S.W. (100 yards); Park Pavilion N.N.E. (100 yards); Ogilvie Church N.W.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. +1 33	h. m. 12 45	° ′ 20 51·2	° ′ 20 44·5

Inclination.

Needle.	G.M.T.	θ.	θ_0.
1 2	h m. 11 56 12 38	° ′ 70 51·7 70 54·6	° ′ 70 52·2

Horizontal Force.

G.M.T.		H.	H_0.
D V	h. m. 11 31 12 16	1·5990 1·5989	1·6002

22. EDINBURGH. April 3, 1885; A. W. R. and T. E. T. (60, 74). Lat. 55° 57′ 52″. Long. 3° 12′ 28″. In the Arboretum of the Botanic Gardens. Inverleith House N.N.W. 100 yards. Cathedral S.W. by S. Melville College S.S.E. Donaldson's Hospital W.S.W. The small magnetic house in the gardens in which Mr. WELSH probably observed had been removed.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. +2 14	h. m. 13 56	° ′ 20 53·8	° ′ 20 47·2

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	11 57	70 37·2	
2	12 36	70 39·5	70 38·5
2	14 21	70 40·8	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 22	1·6175	1·6183
V	12 51	1·6165	

23. ELGIN. July 8, 1885; A. W. R. (60, 74). Lat. 57° 38′ 40″; Long. 3° 19′ 0″. In the grounds of North College, the residence of G. SMITH, Esq., 100 yards N.N.E. of the Cathedral Tower and 80 yards E.S.E. of the house.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. −1 33	h m. 12 29	° ′ 21 1·8	° ′ 20 57·5

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	14 26	71 32·5	71 32·0
2	15 2	71 32·7	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	13 8	1·5566	1·5577
V	12 11	1·5570	

24. LOCH ERIBOLL (Camas Bay). August 23, 1885; T. E. T. (60, 74). Lat. 58° 29′ 15″; Long. 4° 39′ 20″. Near the stream running into Camas Bay, ¼ mile N.E. (magnetic) from the ruin in the bight.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 3 31	14 52	22 21·7	22 18·1
+ 4 34			

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	11 40	72 9·4	72 9·4
2	12 13	72 10·3	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	13 7	1·5184	1·5198
V	14 29	1·5201	

25. Fairlie. August 14, 1884. A. W. R. and T. E. T. (60, 74). Lat. 55° 45′ 30″; Long. 4° 51′ 5″. In a field on the high ground to the rear of the village.

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	16 4	70 43·7	70 42·8
2	16 8	70 44·2	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 50	1·6150	1·6172
V	13 56	1·6143	

26. Fort Augustus. August 3, 1885. A. W. R. and A P. L. (60, 74). Lat. 57° 8′ 30″; Long. 4° 40′ 32″. In a field on the south side of the Abbey, and about 150 yards from the building.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 1 37	14 38	21 49·4	21 45·6

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	14 47	71 29·4	71 27·7
2	15 51	71 27·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
V	15 47	1·5634	1·5641

27. GAIRLOCH. September 9, 1884; A. W. R. and T. E. T. (60, 74). Lat. 57° 42′ 40″; Long. 5° 40′ 55.″ On the rising ground behind the pier in Flowerdale Bay.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. + 3 23	h. m. 16 33	° ′ 22 28·0	° ′ 22 14·4

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	16 39	71 45·9	71 44·3
2	17 36	71 45·3	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	17 37	1·5323	1·5353
V	17 2	1·5336	

28. GLASGOW. August 13, 1884, and July 27, 1885; A. W. R. (60, 74). Lat. 55° 52′ 43″; Long. 4° 17′ 39″. In a field to the West of the Observatory; 48 paces from the building.

Declination.

Date.		G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
Aug. 13, 1884	+ 3 47	16 53	21 21·3	21 11·5
July 27, 1885	+ 2 43	15 54	21 18·2	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
Aug. 13, 1884	1	12 12	70 44·6	70 44·7
	2	12 18	70 48·4	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
Aug. 13, 1884	D	14 17	1·6038	1·6064
	V	15 5	1·6038	

29. Golspie. July 4, 1885; A. W. R. (60, 74). Lat. 57° 58′ 20″; Long. 3° 58′ 15″. The Dips were taken in a field by the road in front of the Sutherland Arms Hotel and about 50 yards to the West of it. The other observations in a field behind the Hotel about 80 yards S.W. of some cottages and 50 yards N.N.W. of the Bank.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 2 9	15 33	21 34·9	21 30·2
+ 2 39		21 35·6	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 20	71 46·8	71 46·7
2	12 55	71 47·8	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	16 37	1·5372	1·5382
V	16 1	1·5374	

30. Hawick. March 31 and April 1, 1885; A. W. R. and T. E. T. (60, 74). Lat. 55° 25′ 58″; Long. 2° 47′ 58″. In the Park of Sillerbit Hall (T. Laidlaw, Esq.) to the N. of the town. The Hall bears 400 yards E.N.E. and the Lodge 120 yards S.S.E.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
March 31 . .	. .	12 43	20 21·5	20 16·0
April 1 . . .	+ 1 50	13 34	20 23·5	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
March 31 . .	1	11 15	70 7·5	70 7·3
	2	11 54	70 9·0	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
March 31 . .	D	11 14	1·6473	1·6487
	V	12 1	1·6476	

31. Loch Inver. September 6, 1884; A. W. R. and T. E. T. (60, 74). Lat. 58° 9′ 30″; Long. 5° 14′ 40″. Near the Coast-guard Station, on the bank of the River Inver.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 2 53	14 2	22 21·8	22 7·4

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 48	72 2·6	72 0·2
2	13 46	72 1·0	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	13 14	1·4968	1·4990
V	13 25	1·4965	

32. INVERNESS. August 1, 1885; A. W. R. and A. P. L. (60, 74). Lat. 57° 28′ 30″; Long. 4° 13′ 20″. In the garden of Mr. MITCHELL's house, near the Castle. Mr WELSH's station.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+2 32	16 18	21 47·2	21 43·3

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	15 44	71 30·0	71 31·1
2	16 45	71 33·2	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	16 56	1·5638	1·5642
V	15 50	1·5631	

33. IONA. September 15 and 16, 1884; A. W. R. (60, 74). Lat. 56° 20′ 0″; Long. 6° 23′ 40″. In a field behind the Inn, and about 50 yards from it.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
Sept. 15 . .	+ 4 6	17 4	23 41·0	23 28·6

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
Sept. 16 . .	1	9 35	70 57·1	70 55·8
	2	10 10	70 57·5	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
Sept. 15 . .	V	17 47	1·6162	1·6185

34. KIRKWALL. August 27, 1885; T. E. T. (60, 74). Lat. 58° 59′ 12″; Long. 2° 57′ 15″. At Battery Point and close to the road. Cathedral tower bearing S.W. by W Cairn on Wideford Hill, bearing W.N.W.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 1 46	12 19	21 32·9	21 29·3
+ 4 31	. .	21 32·7	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	14 31	72 12·4	72 12·8
2	14 59	72 13·8	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	15 55	1·5104	1·5108
V	11 51	1·5100	

35. KYLE AKIN. September 11, 1884; A.W.R. and T.E.T. (60, 74). Lat. 57° 16′ 35″; Long. 5° 44′ 0″. Near the shore; between the Inn and Kyle House.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 2 49	10 29	23 23·4	23 10·4

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	10 15	71 40·9	71 38·5
2	11 1	71 38·8	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	8 56	1·5432	1·5465
V	11 21	1·5452	

36. Lairg. July 6, 1885; A. W. R. (60, 74). Lat. 58° 1′ 30″; Long. 4° 24′ 0″. 40 yards S.W. of Church, and about 200 yards N.E. of the Hotel.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. + 1 44	h. m. 15 56	° ′ 21 55·2	° ′ 21 50·3

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	15 13	71 51·0	71 50·3
2	18 5	71 50·8	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	17 7	1·5347	1·5356
V	16 23		

37. Lerwick. August 30, 1885; T. E. T. (60, 74). Lat. 60° 8′ 53″; Long. 1° 7′ 47″. Towards the South Ness, ½ mile due S. (mag.) from Fort Charlotte. Mr. Welsh's station.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. + 1 53	h. m. 12 38	° ′ 20 33·1	° ′ 20 29·7

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	15 36	72 46·7	72 47·1
2	16 3	72 48·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	14 39	1·4712	1·4710
V	13 34	1·4696	

38. LOCHGOILHEAD. July 21, 1888; T. E. T. (61, 83). Lat. 56° 10′ 20″; Long. 4° 54′ 0″. In a field about 80 yards N.E. of the Church. Mr. WELSH's station.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 4 40	15 48	21 29·2	21 54·2
	18 6	21 30·8	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	17 32	70 42·4	70 46·1
2	17 48	70 43·6	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	16 29	1·6069	1·6021
V	16 4	1·6065	

39. LOCH MADDY (N. Uist); September 1 and 2, 1884; A. W. R. and T. E. T. (60, 74). Lat. 57° 35′ 50″; Long. 7° 9′ 0″. On the most westerly of the Reelee Islands.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
Sept. 1	. .	18 34	23 31·3	23 18·0
„ 2	−3 14	10 29	23 32·3	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
Sept. 1	2	18 55	71 53·3	71 52·1

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
Sept. 2	D	12 26	1·5346	1·5365
„ 1	V	19 13	1·5336	

40A. OBAN. August 13, 1885, and July 30, 1888; T. E. T. (60, 61, 83). Lat. 56° 25′ 9″; Long. 5° 28′ 30″. Same station as that of Mr. WELSH.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
Aug. 13, 1885	+3 38	16 37	22 12·0	22 8·7
July 30, 1888	−1 41	11 20	21 47·3	22 10·2
		12 59	21 45·2	

Inclination.

Date.	Needle.	G.M.T.	θ.	$θ_0$.
		h. m.	° ′	° ′
July 30	1	12 43	70 50·7	70 53·2
	2	13 7	70 49·5	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
July 30	D	12 24	1·6090	1·6044
	V	11 38	1·6091	

40B.—OBAN (Kerrera). August 26, 1884, and August 6, 1885. A. W. R. and T. E. T. (60, 74). Lat. 56° 25′ 20″; Long. 5° 30′ 0″. Near the shore of Ardentraive Bay.

Declination.

Date.	Σ.	G.M.T.	δ.	$δ_0$.
	h. m.	h. m.	° ′	° ′
Aug. 26, 1884	+ 2 5	15 32	22 25·4	22 12·4
	+ 3 55	..	22 25·5	22 11·4
,, 6, 1885	− 1 25	12 32	22 15·2	

Inclination.

Date.	Needle.	G.M.T.	θ.	$θ_0$.
		h. m.	° ′	° ′
Aug. 26, 1884	1	15 18	70 50·5	70 49·5
	2	15 47	70 51·8	
,, 6, 1885	1	13 14	70 49·1	70 48·2
	2	14 11	70 48·3	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
Aug. 26, 1884	D	17 30	1·6066	1·6092
	V	16 44	1·6071	
,, 6, 1885	D	13 30	1·6110	1·6114
	V	12 13	1·6105	

41. PITLOCHRIE. July 29, 1885; A. W. R and A. P. L. (60, 74). Lat. 56° 42′ 7″; Long. 3° 43′ 26″. In the grounds of the Hydropathic Establishment, about 100 yards S.S.W. of the building; near the lower road through the grounds.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. +3 9	h. m. 16 35	° ′ 21 12·2	° ′ 21 8·3

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	17 55	70 58·7	70 57·4
2	16 58	70 57·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	17 10	1·5891	1·5899
V	16 11	1·5891	

42. PORT ASKAIG (Islay). August 25, 1884; A. W. R. and T. E. T. (60, 74). Lat. 55° 50′ 40″; Long. 6° 6′ 55″. Between the Inn and the Quay.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. −2 44	h. m. 10 18	° ′ 23 13·7	° ′ 23 0·7

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 23	70 37·9	70 36·2
2	12 22	70 38·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 2	1·6313	1·6340
V	10 38	1 6319	

43. Portree. T. E. T. (61, 83).

(*a*) August 9, 1888; Lat. 57° 24′ 35″, Long. 6° 11′ 40″. On the N. shore of the bay. Boat-house 20° W.

(*b*) August 9 and 10, 1888. Lat. 57° 24′ 10″, Long. 6° 11′ 5″. On the S. side of the bay, on a rock close to the shore. Portree Landing Stage 12° W. of N. (mag.). School-house 35° W. of N. Station (*a*) 22° E. of N.

(*c*) August 10, 1888. Lat. 57° 24′ 15″, Long. 6° 11′ 50″. On the edge of the bay; S. of the town, and within a dozen yards of the shore. Station (*b*) bearing 100° E. of N.; School-house 2° E. of N.; Station (*a*) bearing 57° E. of N. (approx.); St. Columba's Church steeple 24° E. of N.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
Aug. 9 (*a*)	−2 30	10 26	24 37·6	22 42·3
„ 9 (*b*)	+4 24	15 50	22 21·6	
„ 10 (*b*)	−2 42	11 25	22 22·7	
„ 10 (*c*)	+1 12	13 24	19 50·8	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
Aug. 9 (*a*)	1	13 2	72 16·3	72 1·2
	2	13 21	72 14·7	
„ 10 (*b*)	1	10 34	71 5·9	
	2	10 51	71 5·5	
„ 10 (*c*)	1	14 31	72 33·9	
	2	14 56	72 33·6	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
Aug. 9.	D	(a) 12 9	1·5223	1·5177
	V	(a) 11 10	1·5226	
„ 10.	D	(c) 12 38	1·5265	1·5211
	V	(c) 13 10	1·5252	
„ 9.	V	(b) 15 36	1·5906	1·5859
„ 10.	V	(b) 11 16	1·5941	1·5894

NOTE.—The ground at Portree was known to be extremely bad as there is much basaltic rock in the neighbourhood. The observations were made with a view of gaining information as to the magnitude of the disturbing forces.

44. Row (Gairloch). July 23, 1888; T. E. T. (61, 83). Lat. 56° 1′ 0″; Long. 4° 46′ 50″. Near the shore of the loch; Pier end bears due W. (mag.); Roseneath House 37° W. of S.; and Roseneath Point 17° W. of S. (mag.).

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 2 23	10 24	21 24·4	21 47·7
	12 0	21 22·6	
+ 1 16	13 13	21 24·0	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 28	70 48·4	70 51·0
2	12 52	70 47·5	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	11 31	1·6025	1·5978
V	10 53	1·6023	

45. SCARNISH (Tiree). August 8 and 10, 1885; A. W. R. and A. P. L. (60, 74). Lat. 56° 30′ 12″; Long. 6° 47′ 20″. Dips about 15 yards in front of Hotel. Declinations: Station I. 30 yards W.S.W. of Inn. Station II. Inn bears S.W. by S. (200 yards); Harbour Mouth bears S. Station III. Inn bears S.W. by S. (250 yards). On returning to Oban, when a comparison could be made with Greenwich time, the rate of the chronometer was found to have altered suddenly during the visit to Tiree. The difference between the values of the declinations obtained at Stations I. and II. on the 8th and 10th is probably due to this fact.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
Aug. 8 (1)	− 1 43	11 36	24 49·8	24 46·9
„ 10 (1)	− 2 49	9 24	24 51·8	
„ 10 (3)	+ 5 57	17 0	24 52·4	24 47·3
	..	18 51	24 50·0	
„ 8 (2)	+ 3 27	16 34	23 52·1	23 49·6
„ 10 (2)	+ 4 13	16 30	23 54·9	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
Aug. 8	1	11 43	71 20·0	71 19·4
	2	12 50	71 19·9	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
Aug. 8	D	13 6	1·5898	1·5909
	V	12 9	1·5907	

46. SOA (Skye). August 29, 1884; A. W. R. and T. E. T. (60, 74). Lat. 57° 9′ 45″; Long. 6° 10′ 12″. On the N.E. point; about 300 yards E. of the anchorage, and near the Ru Mhoil Dearg.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 4 41	8 38	23 28·3	23 14·9

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	8 48	72 0·4	71 59·6
2	9 31	72 1·5	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	10 16	1·5051	1·5072
V	9 21	1·5045	

47. STIRLING. July 10, 1885; A. W. R. (60, 74). Lat. 56° 7′ 2″; Long. 3° 56′ 55″. In the King's Park; in the centre of the plain to the S. of the Castle.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+1 42	14 53	21 33·0	21 28·6

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	15 54	70 53·7	70 53·3
2	16 26	70 54·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	17 11	1·5938	1·5945
V	14 32	1·5935	

48A. Stornoway (Ard Point). September 4 and 5, 1884, and August 19, 1885, A. W. R. and T. E. T. (60, 74); and August 14, 1888, T. E. T. (61, 83), A. W. R. (60, 74). Lat. 58° 12′ 10″; Long. 6° 23′ 40″. On the top of the hillock on the Point. The Declinations taken on this spot agreed well with that obtained in the Castle Grounds, and were therefore regarded as normal. In 1888, simultaneous observations were made by both of us, which agree among themselves but differ considerably from each other. Dr. Thorpe occupied the old station near the top of the hillock, Professor Rücker was about 50 yards distant on lower ground and nearer the mainland. There can be little doubt that the station is disturbed.

Declination.

Date.	Σ.	G.M.T.		δ.	δ_0.
	h. m.	h. m.		° ′	° ′
Sept. 4, 1884	− 2 22	10 54		24 21·0	24 9·8
„ 5, „	− 1 42	11 3		24 20·2	
Aug. 19, 1885	+ 3 11	14 7		24 12·4	24 9·5
„ 14, 1888	− 1 52	11 2	T	23 50·7	24 13·9
		12 28	T	23 48·4	
	+ 3 24	15 15	T	23 50·7	
	− 1 45	11 8	R	24 8·7	24 32.3
		12 37	R	24 7·9	
	+ 3 23	15 15	R	24 8·3	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
Aug. 14, 1888	1	13 3	72 8·4	72 10·5
	2	13 31	72 8·5	

Horizontal Force.

Date.	G.M.T.		H.		H_0.
		h. m.			
Aug. 19, 1885	D	16 44	1·5197		1·5210
	V	15 13	1·5210		
	V	17 42	1·5191		1·5205
Aug. 14, 1888	D	12 1	1·5205		
	V	11 25	1·5242	R	1·5195
	D	12 0	1·5243	R	
	V	11 20	1·5222	T	1·5173
			1·5218	T	

48B. STORNOWAY. September 4, 1884, A. W. R. and T. E. T. (60, 74). Lat. 58° 12′ 40″; Long. 6° 23′ 35″. In the Castle Grounds.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. + 2 32	h. m. 14 20	° ′ 24 18·4	° ′ 24 7·6

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 21	72 9·4	72 9·1
2	12 54	72 11·0	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	13 5	1·5119 1·5124	1·5145
V	13 44 13 59	1·5122 1·5125	1·5147

49. STRACHUR. August 16 and 17, 1884; A. W. R. and T. E. T. (60, 74). Lat. 56° 10′ 20″; Long. 5° 4′ 40″. On the lawn in front of Strachur House.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
Aug. 17	h. m. − 4 4	h. m. 8 59	° ′ 22 1·5	° ′ 21 48·9

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
Aug. 16	1	12 17	70 44·4	70 42·9
	2	12 19	70 44·9	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
Aug. 16	D	15 38	1·6068	1·6095
	V	16 19	1·6073	

50. STRANRAER. September 18, 1884; A. W. R. (60, 74); and August 28, 1888; A. W. R. (60, 83), and T. E. T. (61, 83). Lat. 54° 54′ 25″; Long. 5° 2′ 10″. In a field 300 yards N.W. by W. of Schuchan Church. The same position was occupied on both occasions. Near Mr. WELSH's station.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
Sept. 18, 1884	+ 2 7	16 14	21 46·2	21 35·0
Aug. 28, 1888	− 1 30	11 35	21 13·7	21 37·6 T
	− 2 10	10 54	21 12·5	21 36·6 R
		13 6	21 13·0	

Inclination.

Date.	Needle.	G.M.T.	θ	θ_0
		h. m.	° ′	° ′
Sept. 18, 1884	1	15 1	70 14·6	70 12·3
	2	15 37	70 13·7	
Aug. 28, 1888	1	11 16	70 11·7	70 14·8
	2	12 43	70 10·5	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
Sept. 18, 1884	D	17 25	1·6421	1·6446
	V	16 39	1·6426	
Aug. 28, 1888	D	11 50	1·6466 } R	1·6420
	V	11 21	1·6471 } R	
	D	12 37	1·6473 } T	1·6425
	V	12 3	1·6473 } T	

51. STROMNESS (Orkneys). August 25, 1885; T. E. T. (60, 74). Lat. 58° 57′ 30″; Long. 3° 17′ 12″. 60 yards S.E. from the door of the house on Holm of Stromness.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. + 1 9	h. m. 12 29	° ′ 21 31·5	° ′ 21 27·9

Inclination.

Needle.	G.M.T.	θ.	θ_0.
1 2	h. m. 15 1 14 28	° ′ 72 12·3 72 11·9	° ′ 72 11·7

Horizontal Force.

G.M.T.		H.	H_0.
V	h. m. 12 8	1·5143	1·5149

52. E. LOCH TARBERT (Loch Fyne). August 19 and 20, 1884; A. W. R. and T. E. T. (60, 74). Lat. 55° 51′ 56″; Long. 5° 24′ 25″. At the back of the town, near the Castle.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
Aug. 19 ,, 20	h. m. + 5 43 − 3 20	h. m. 18 50 9 46	° ′ 22 14·4 22 19·3	° ′ 22 4·3

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
Aug. 20	1	10 2	70 47·8	70 46·8
	2	10 26	70 49·5	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
Aug. 20	D	11 33	1·6027	1·6053
	V	10 22	1·6031	

53. THURSO. July 3, 1885; A. W. R. (60, 74). Lat. 58° 35′ 30″; Long. 3° 31′ 15″; On the green by the right bank of the river, about 30 yards above the bridge. The station occupied by Mr. WELSH had been built over.

Declination.

Σ.	G.M.T.	δ.	δ.
h. m.	h. m.	° ′	° ′
− 1 44	11 11	21 43·5	21 38·4

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 7	72 2·9	72 1·1
2	13 43	72 0·6	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	14 38	1·5208	1·5217
V	11 54		

54. WICK. July 2, 1885; A. W. R. (60, 74). Lat. 58° 26′ 20″; Long. 3° 5′ 45″
On the lawn in front of Rosebank. Same station as that of Mr. WELSH.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. − 2 52	h. m. 11 6	° ′ 21 20·4	° ′ 21 15·3

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 25	72 10·1	72 9·8
2	14 0	72 10·7	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	11 56	1·5139	1·5144
V	10 44	1·5131	

DESCRIPTIONS OF ENGLISH STATIONS.

55. ABERYSTWITH. May 18, 1886; A. W. R. (60, 74). Lat. 52° 23′ 51″; Long. 4° 5′ 13″. About a mile to the South of the town, between the River Ystwith and the sea, near the point marked Pen-y-ro on the Ordnance map.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 19	11 19	19 54·6	19 56·5
	13 42	19 51·7	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	18 2	68 34·4	68 34·7
2	13 4	68 33·9	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
V	12 16	1·7508	1·7500
V	12 34	1·7485	1·7477

56. ALDERNEY. April 3 and 4, 1888; T. E. T. (61, 83). Lat. 49° 43′ 10″; Long. 2° 11′ 0″. In the N.E. corner of the garden of Scott's Hotel; about 70 yards from the house.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
April 3	+ 1 54	12 56	17 46·1	18 2·8
	..	15 9	17 46·5	
	+ 4 27	16 48	17 45·1	
,, 4	− 4 2	7 54	17 49·3	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ₀.
		h. m.	° ′	° ′
April 3	1	16 1	66 35·2	66 38·9
	2	16 23	66 33·7	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
April 3	D	14 45	1·8755	1·8705
	V	13 41	1·8756	
			1·8719	1·8677
	V	15 21	1·8735	

57. Alnwick. September 16, 1886. A. W. R. Lat. 55° 25′ 19″; Long. 1° 43′ 53″. In the Deer Park; on the N. side of the drive, and about one-third of a mile from the reservoir. Alnwick Church S.E. by E. Castle E. by S.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 7	11 26	19 39·4	19 45·0

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 1	70 2·1	70 3·6
2	13 32	70 3·3	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
P	14 20	1·6529	1·6511
V	11 50	1·6526	

58. ALRESFORD. April 28, 1888; A. W. R. (60, 74). Lat. 51° 4′ 46″; Long. 1° 9′ 56″. On Tichborne Down.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 2 39	13 16	17 52·8	18 9·7
3 45	16 19·5	17 53·2	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	15 26	67 17·8	67 22·3
2	16 2	67 19·0	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	14 42	1·8292	1·8241
V	14 2	1·8293	

59. APPLEBY. September 15, 1886; A. W. R. (60, 74). Lat. 54° 34′ 10″; Long. 2° 29′ 3″. On the Holme, a common close to the Eden, to the S. of the town.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
−1 1	11 47	20 1·5	20 5·8
+2 7	13 51	19 59·0	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 46	69 43·7	69 44·9
2	13 15	69 44·1	

Horizontal Force.

G.M.T.		H.	H_0.
V	h. m. 12 2	1·6706	1·6690

60. Barrow. August 25, 1886; A. W. R. (60, 74). Lat. 54° 7′ 24″; Long. 3° 13′ 0″. In a field about 200 yards W. from the road which leads to Barrow from Furness Abbey. About 1½ miles from the Abbey on the brow of the hill above Barrow.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. +2 15 +5 18	h. m. 14 52 17 5	° ′ 20 4·6 20 2·9	° ′ 20 9·3

Inclination.

Needle.	G.M.T.	θ.	θ_0.
1 2	h. m. 16 3 16 32	° ′ 69 29·5 69 29·7	° ′ 69 30·6

Horizontal Force.

G.M.T.		H.	H_0.
D V	h. m. 17 59 15 13	1·6886 1·6892	1·6875

61. Bedford. April 21, 1888; T. E. T. (61, 83). Lat. 52° 8′ 3″; Long. 0° 26′ 51″. On a road on the Bower estate, half-a-mile to the E. of the town-bridge, and about 80 yards from the river.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. −1 24	h. m. 9 51	° ′ 18 10·9	° ′ 18 27·4

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	11 13	68 4·4	68 7·3
2	11 30	68 3·3	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
V	10 8	1·7756	1·7705

62. Birkenhead. August 23, 1886; A. W. R. (60, 74). Lat. 53° 24′ 4″; Long. 3° 4′ 18″. 1st station, 130 yards S. of Observatory; 2nd station, 100 yards S. of Observatory.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
−1 1	(1) 12 23	19 54·8	19 58·3
+5 2	(2) 17 32	19 52·1	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	15 37	69 4·0	69 4·3
2	16 4	69 2·6	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	13 29	1·7188	1·7176
V	12 50	1·7192	

63. Birmingham. May 7, 1886; A. W. R. (60, 74). Lat. 52° 27′ 37″; Long. 1° 53′ 40″. In Calthorpe Park, at the S. end. About 50 yards from the East, and 200 yards from the South railings.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 14	11 15	18 42·1	18 44·0
+ 2 44	14 29	18 39·7	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 24	68 21·3	68 21·3
2	13 55	68 20·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 22	1·7672	1·7669
V	11 37	1·7683	

64. Braintree. September 22, 1888; T. E. T. (61, 83). Lat. 51° 52′ 41″; Long. 0° 32′ 40″ E. In a field to the W. of the Church, distant 400 yards; 400 yards N. of the Railway to Dunmow.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 3 34	15 51	17 36·4	17 55·4

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	17 16	67 41·8	67 45·4
2	17 32	67 40·8	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	16 40	1·8005	1·7942
V	16 15	1·7999	

65. Brecon. May 26, 1886; A. W. R. (60, 74). Lat. 51° 56′ 56″; Long. 3° 24′ 42″. In the fields (Newton Port) to the W. of the town, and close to the river. Church in centre of town S.E. by E. About ¾ of a mile E. by N. of Castle Hotel.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 4 42	17 50	19 35·1	19 38·6

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
2	19 12	68 15·1	68 15·8

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	18 28	1·7710	1·7701
V	17 51	1·7710	

66. Bude Haven. T. E. T. (61, 83).

(*a*) April 11 and 15, 1887; Lat. 50° 49′ 34″; Long. 4° 32′ 37″. On the upper walk of the kitchen garden of the Falcon Hotel, and on the W. front of the house.

(*b*) April 12, 1887; Lat. 50° 49′ 42″; Long. 4° 32′ 54″. On Efford Down near the Compass Tower, which bore 75° W. of N. (mag.). Belfry of Efford House 10° E. of S. (mag.). Entrance lock to Bude Canal 68° E. of N. (mag.).

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
April 11 . .	− 1 46	11 2	19 50·1	20 0·1
	+ 3 7	15 2	19 52·2	
" 22 . .	− 1 32	11 13	19 43·9	
	+ 2 44	14 41	19 43·5	19 52·9
" 15 . .	− 0 20	12 26	19 44·2	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
April 11 . .	1	15 58	67 44·8	
	2	14 31	67 40·2	67 44·2
" 12 . .	1	13 46	67 41·8	
	2	14 16	67 41·1	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
April 11 . .	D	12 14	1·8126	1·8085
	V	11 47	1·8100	
12 . .	D	12 2	1·8103	1·8075
	V	11 36	1·8104	

67. CAMBRIDGE. T. E. T. (61, 83).

May 18, 1886; Lat. 52° 11′ 40″; Long. 0° 7′ 17″ E. In the lane off the Trumpington Road, past the Botanic Gardens, and on the right hand side.

May 19 and 20, 1886; Lat. 52° 11′ 23″; Long. 0° 7′ 16″ E. In the Leys School Grounds.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
May 18.	+2 28			
	+2 37			
„ 19.	..	11 47	18 2·1	
	..	15 35	18 0·5	18 5·0
„ 20.	−1 51	10 34	18 2·1	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
May 18.	1	16 39	68 1·8	68 2·4
	2	17 11	68 1·9	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
May 19.	D	12 37	1·7799	1·7784
	V	11 11	1·7786	
„ 20.	V	10 58	1·7797	1·7785
			1·7790	

68. CARDIFF. May 25, 1886; A. W. R. (60, 74). Lat. 51° 29′ 36″; Long. 3° 10′ 33″. In a field W. of the town, on Crwys Farm. House E.N.E., about 80 yards distant; gate of barracks, 200 yards N. by W.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+3 0	16 1	19 16·6	19 19·7
+4 33	17 5	19 15·9	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	17 38	67 52·8	67 52·3
2	18 3	67 50·5	

Horizontal Force.

G.M.T.		H.	H_0.
V	h. m. 16 22	1·7953	1·7944

69. CARDIGAN. May 29, 1886; A. W. R. (60, 74). Lat. 52° 5′ 20″; Long. 4° 40′ 9″. In a field about half a mile to the west of the town.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 1 12	12 15	20 22·2	20 25·8

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 6	68 30·3	68 31·3
2	11 43	68 31·0	

Horizontal Force.

G.M.T.		H.	H_0.
V	h. m. 13 47	1·7544	1·7535

70. CARLISLE. August 28, 1886; A. W. R. (60, 74). Lat. 54° 53′ 55″; Long. 2° 55′ 40″. On the Swifts, about 100 yards from the footpath on the S. side, and 250 yards E. by S. of the Grand Stand. Cathedral bore W.S.W. ½ S.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 0 41	12 1	20 20·5	20 25·8
+ 1 30	14 41	20 19·8	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 17	69 52·1	69 54·0
2	14 14	69 54·0	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
V	12 25	1·6640	1·6625

71. CHESTERFIELD. September 14 and 15, 1887; A. W. R. (60, 74). Lat. 53° 14′ 3″; Long. 1° 24′ 37″. In a field on Mr. PENISTONE'S farm to the N. of the main road. Church bearing W.N.W. about a mile distant. Cemetery S.W. by W. about half a mile.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
Sept. 15	− 2 36	10 19	19 0·3	19 11·9
	− 2 10	..	18 59·8	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
Sept. 14	1	11 40	68 47·1	68 48·5
	2	12 10	68 44·5	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
Sept. 14	D	14 16	1·7383	1·7351
	V	13 26	1·7393	

72. CHICHESTER. September 18, 1888; T. E. T. (61, 83). Lat. 50° 50′ 0″; Long. 0° 47′ 2″. In the meadows between the Cathedral and the Railway Station; close to the ditch. Railway Station bearing S.E. Cathedral tower N.E., distant a quarter of a mile.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 0 52	11 32	17 46·6	18 5·5

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 27	67 7·6	67 11·6
2	13 43	67 7·0	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 36	1·8456	1·8395
V	11 54	1·8455	

73. CLENCHWARTON. August 2, 1888; A. W. R. (60, 74). Lat. 52° 45′ 20″; Long. 0° 21′ 20″ E. In the grounds of a house on the road from King's Lynn to Sutton Bridge. Not quite 3 miles from King's Lynn.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. −0 29	h. m. 11 58	° ′ 17 51·4	° ′ 18 10·3

Inclination.

Needle.	G.M.T.	θ.	θ_0.
1	h. m. 13 45	° ′ 68 14·3	° ′ 68 17·9

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 49	1·7722	1·7662
V	12 16	1·7717	

74. CLIFTON. April 22, 1886; T. E. T. (61, 74). Lat. 51° 27′ 15″; Long. 2° 37′ 4″. On the Down; on the N. side of the Stoke road, about 60 yards from it, and about ¼ mile from the Clifton Cricket Club Pavilion. Steeple of Christ Church Congregational Chapel bearing E. Pumping station S.E. about 150 yards.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. +0 15	h. m. 11 56	° ′ 19 8·6	° ′ 19 10·7

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 12	67 48·9	67 48·7
2	13 47	67 47·6	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	14 49	1·8001	1·7996
V	11 30	1·8006	

75. Clovelly. April 16, 1887; T. E. T. (61, 83). Lat. 50° 59′ 48″; Long. 4° 23′ 50″. To the W. of the village; between it and Clovelly Court.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 0 33	12 9	19 44·2	19 53·8
+ 3 4	15 45	19 45·5	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	14 23	67 47·8	67 49·9
2	14 57	67 47·6	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	11 27	1·8027	1·8000
V	12 44	1·8030	

76. Coalville. April 30, 1888; T. E. T. (61, 83). Lat. 52° 43′ 41″; Long. 1° 21′ 18″. In a field about 100 yards E. of Coalville Station (L. and N.W. Railway), and E. of town.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. + 1 26	h. m. 14 28	° ′ 18 24·6	° ′ 18 41·4

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	11 58	68 20·3	68 24·1
2	12 17	68 20·6	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	13 1	1·7583	1·7534
V	14 15	1·7587	

77. Colchester. September 24, 1888; T. E. T. (61, 83). Lat. 51° 53′ 30″; Long. 0° 54′ 0″ E. In the Castle grounds; to the S. of the main tower, distant 20 yards.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 13	10 52	17 36·2	17 55·2
+ 1 18	12 52	17 36·2	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	11 21	67 31·3	67 35·3
2	11 37	67 31·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 28	1·8078	1·8012
V	12 2	1·8066	

78. CROMER. May 10, 1886; T. E. T. (61, 83). Lat. 52° 55′ 20″; Long. 1° 18′ 24″ E. In a field S.S.W. of the Lighthouse; Railway Station about three-quarters of a mile away bearing W.; town bearing N.W. by N.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 1 0	13 21	17 32·7	17 35·8

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	14 26	68 19·6	68 20·0
2	14 53	68 19·2	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
V.	13 40	1·7611	1·7603

79. DOVER. September 28, 1887; T. E. T. (61, 83). Lat. 51° 6′ 53″; Long. 1° 17′ 52″ E. In the Public Recreation Ground, near Archcliff Fort; between the town and Shakespeare Cliff. End of Dover Breakwater 63° E. of S. (mag.); Flagstaff on Shakespeare Cliff 65° W. of S. (mag.).

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 58	10 20	16 44·1	16 57·2
+ 0 56	12 26	16 46·2	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	11 15	67 5·8	67 8·0
2	11 31	67 4·7	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	11 59	1·8377	1·8336
V	10 34	1·8372	

80. FALMOUTH. April 8, 1887; T. E. T. (61, 83). Lat. 50° 8′ 47″; Long. 5° 4′ 21″. At the Observatory.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
−1 51	11 10	19 43·3	19 53·4
+2 39	15 42	19 45·8	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	14 31	67 12·3	67 15·0
2	13 45	67 13·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	11 59	1·8354	1·8323
V	11 35	1·8348	

81. GAINSBOROUGH. September 19, 1887; A. W. R. (60, 74). Lat. 53° 23′ 23″; Long. 0° 44′ 51″. In a field to the W. of the Upton Road, and about 1 mile S. (mag.) of the town.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. +3 56	h. m. 16 16	° ′ 18 24·5	° ′ 18 36·4

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	17 53	68 46·4	68 49·3
2	18 12	68 46·7	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	17 14	1·7362	1·7321
V	16 31	1·7356	

82. GIGGLESWICK. September 14, 1886; A. W. R. (60, 74). Lat. 54° 4′ 18″; Long. 2° 17′ 48″. In the cricket field of Giggleswick School, 150 yards N.W. of the Pavilion, and near the W. end of the field.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+1 33	12 2	19 31·2	19 35·3
+3 16	15 8	19 29·8	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	10 59	69 21·4	69 22·3
2	11 19	69 21·0	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	13 16	1·6976	1·6962
V	12 37	1·6979	

83. Gloucester. May 24, 1886; A. W. R. (60, 74). Lat. 51° 52′ 12″; Long. 2° 14′ 50″. In the fields to the E. of the town, about 300 yards E. by N. of Alexandra Terrace; Cathedral bearing W.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+1 12	..	19 9·4	19 12·9
+3 26	16 4	19 9·7	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 46	68 4·5	68 4·3
2	14 19	68 2·8	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	15 1	1·7823	1·7811
V	12 46	1·7817	

84. GRANTHAM. May 22, 1886; T. E. T. (61, 83). Lat. 52° 54′ 54″; Long. 0° 37′ 46″ W. In a field to the E. of the town, and across the river. The Church bore about S.W.; distant 400 yards.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. +1 36	h. m. 13 13	° ′ 18 25·6	° ′ 18 29·0

Inclination.

Needle.	G.M.T.	θ.	θ_0.
1	h. m. 14 9	° ′ 68 26·6	° ′ 68 28·0
2	14 30	68 28·3	

Horizontal Force.

G.M.T.		H.	H_0.
V	h. m. 12 56	1·7536	1·7527

85 and 86. GUERNSEY. T. E. T. (61, 83).

85. L'ERÉE. Lat. 49° 27′ 50″; Long. 2° 35′ 40″. Fifty yards due S. of L'Erée Hotel, and about 15 yards from the road to Roquaine Castle.

86. PETER PORT. Lat. 49° 27′ 45″; Long. 2° 31′ 45″. In the Gardens behind the Royal Hotel, and about 60 yards from the house.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
April 2 . . .	+ 2 32	14 22	18 16·6	18 32·7
" 4 . . .	+ 2 43	14 19	18 2·3	18 18·4

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
April 2 . . .	1	13 2	66 28·9	66 34·1
	2	13 38	66 30·3	
„ 4 . . .	1	16 2	66 29·0	66 32·4
	2	16 17	66 26·8	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
April 2 . . .	D	15 20	1·8798	1·8746
	V	14 10	1·8795	
„ 4 . . .	D	15 28	1·8843	1·8796
	V	14 37	1·8849	

87. HARWICH. May 8, 1886; T. E. T. (61, 83). Lat. 51° 56′ 48″; Long. 1° 17′ 5″ E. In a field to the W. of the town; Harwich Church bearing E. by N.; Great Eastern Hotel, N.E., and Railway Station, E.S.E.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 10	11 38	17 15·5	17 18·8
	13 41	17 16·0	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 30	67 37·0	67 38·4
2	13 6	67 38·7	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	14 17	1·8040	1·8031
V	11 13	1·8039	

88. HARPENDEN. October 5 and 6, 1887, and May 1, 1888; T. E. T. (61, 83). Lat. 51° 47′ 27″; Long. 0° 21′ 15″. 1st Station. At the N. end of the Common; 200 yards S. of the Railway Hotel, and W. of the Railway Station. 2nd Station. In Dr. GILBERT's garden. To the W. of the lower Common.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
May 1, 1888	+ 5 13	14 33	17 59·6	18 16·5

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
Oct. 6, 1887	1	16 13	67 53·4	67 53·5
	2	16 32	67 48·4	
May 1, 1888	1	18 7	67 48·2	67 51·4
	2	17 48	67 47·6	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
Oct. 5, 1887	D	15 36	1·7961 }	1·7926
	V	15 13	1·7970 }	
May 1, 1888	V	14 50	1·7971	1·7920
	V	15 6	1·7960	1·7909

89. HASLEMERE. September 30, 1887; T. E. T. (61, 83). Lat. 51° 6′ 4″; Long. 0° 44′ 40″. On the tennis-lawn of Professor WILLIAMSON's house, High Pitfold, and about 50 yards S. of it. About 600 feet above sea level.

Declination.

Σ	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
—1 6	11 12	17 55·6	18 7·7

Inclination.

Needle.	G.M.T.	θ.	$θ_0$.
	h. m.	° ′	° ′
1	12 57	67 17·8	67 20·6

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 17	1·8321	1·8282
V	11 46	1·8319	

90. HOLYHEAD. May 4, 1887; T. E. T. (61, 83). Lat. 53° 17′ 53″; Long. 4° 38′ 22″. On the road to Porth Dafarch, 20 yards from the roadside, and about a mile from the Railway Station which bore 50° E. of N.; Monument on Black Bridge, 55° E. of N.; Spire of New Church, 30° E. of N.; Windmill, 80° E. of N.; Summit of Holyhead Mountain, 30° W. of N.

Declination.

Σ.	G.M.T.	δ.	$δ_0$.
h. m.	h. m.	° ′	° ′
−1 51	10 50	20 40·3	20 51·1
+1 42	13 42	20 41·8	
+2 0			

Inclination.

Needle.	G.M.T.	θ.	$θ_0$.
	h. m.	° ′	° ′
1	12 46	69 22·2	69 23·1
2	13 10	69 20·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	11 50	1·6988	1·6958
V	11 11	1·6986	

91. HORSHAM. April 21, 1888; A. W. R. (60, 74). Lat. 51° 4′ 16″; Long. 0° 21′ 54″. In a field on the N.W. side of Barber's Green, 1½ miles W. of Horsham.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 0 44	13 14	17 47·0	
+ 3 16	15 37	17 47·3	18 3·3
+ 5 4	17 26	17 46·1	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	16 17	67 11·6	67 15·2
2	16 39	67 11·4	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	14 44	1·8358	1·8309
V	13 34	1·8363	

92. HULL. Sept. 16 and 17, 1887; A. W. R. (60, 74). Lat. 53° 44′ 40″; Long. 0° 22′ 5″. In the Botanic Gardens.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
Sept. 16 . .	+ 5 38	18 1	18 45·7	18 57·8
„ 17 . .	− 3 3	9 20	18 46·2	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
Sept. 16 . .	1	16 1	69 1·8	69 3·9
	2	16 44	69 1·3	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
Sept. 16 . .	V	17 18	1·7163	1·7125

93. Ilfracombe. April 25, 1886; T. E. T. (61, 83). Lat. 51° 12′ 38″; Long. 4° 7′ 36″. In a field near the Torr's Walk, between the town and the sea. Parish Church, bearing S. by E. (½ mile). Ilfracombe Hotel, E. by N.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	h. m.	° ′
− 1 32	11 12	19 45·5	19 46·5
+ 1 51	13 48	19 43·3	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 15	67 53·3	67 53·8

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	14 48	1·7962	1·7952
V	11 33	1·7957	

94, 95, 96. JERSEY. T. E. T. (61, 83).

94. Grouville. Lat. 49° 12′ 5″; Long. 2° 1′ 20″. In the eastern ditch of the Fort. Railway Station bore about W.

95. S. Louis. Lat. 49° 12′ 0″; Long. 2° 5′ 40″.

96. S. Owen. Lat. 49° 13′ 30″; Long. 2° 12′ 5″. Within 300 yards of the shore, on the flat ground near the Marée. Corbière Lighthouse, 40° W. of S. (mag.).

Declination.

Date.		Σ.	G.M.T.	δ.	δ_0.
		h. m.	h. m.	° ′	° ′
Grouville	March 30	+1 19	13 16	18 19·9	18 36·0
		+2 20	14 24	18 19·9	
S. Louis	„ 31	+1 20	12 12	17 34·4	17 49·7
		..	13 56	17 32·9	
S. Owen	April 1	+2 21	12 37	18 7·6	18 24·7
		..	15 1	18 9·7	

Inclination.

Date.		Needle.	G.M.T.	θ.	θ_0.
			h. m.	° ′	° ′
Grouville	March 31	1	9 49	66 3·4	66 8·7
		2	9 9	66 5·1	
S. Louis	„ 31	1	14 32	66 7·8	66 13·0
		2	15 0	66 9·2	
S. Owen	April 1	1	14 4	66 9·8	66 15·5
		2	14 20	66 12·2	

Horizontal Force.

Date.		G.M.T.		H.	H_0.
			h. m.		
Grouville	March 30	D	15 13	1·9099	1·9053
		V	14 7	1·9106	
S. Louis	„ 31	D	13 6	1·8938	1·8887
		V	12 28	1·8934	
S. Owen	April 1	D	13 28	1·8952	1·8904
		V	12 51	1·8955	

97. KENILWORTH. April 16, 1888; T. E. T. (61, 83). Lat. 52° 20′ 51″; Long. 1° 34′ 43″. In a field near the Abbey Hotel, 60 yards from the road; Castle bearing 65° W. of N., and S. Nicholas' Church steeple 24° W. of N. (all magnetic).

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
−1 23	11 9	18 45·2	19 1·4
+1 16	13 42	18 44·8	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 47	68 24·1	68 28·8
2	13 5	68 26·2	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 4	1·7628	1·7576
V	11 28	1·7624	

98. KETTERING. May 1, 1888; T. E. T. (61, 83). Lat. 52° 23′ 44″; Long. 0° 44′ 10″. In the second field past the Railway Arch, W. of the Church, and 70 yards from the Northampton Road.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 2 37	9 40	18 19·1	18 36·0

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	10 56	68 7·7	68 10·7
2	11 12	68 6·3	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
V	10 0	1·7707	1·7656

99. KEW. Lat. 51° 28′ 6″; Long. 0° 18′ 45″. In the Magnetic House at the Observatory.

Declination.

Date.	Observer.	Instrument.	G.M.T.	δ.	δ_0.
			h. m.	° ′	° ′
July 17, 1884	T.	60	16 9	18 23·7	18 15·8
„ 18, „	R.	60	11 59	18 21·9	18 14·0
April 2, 1886	T.	61	17 14	18 11·0	18 12·5
September 30, 1887 . .	R.	60	12 33	18 3·4	18 14·0
			15 38	18 5·1	18 15·7
October 11, 1887 . . .	T.	61	12 11	18 3·9	18 13·8
			15 33	18 4·0	18 13·9
„ 12, „ . . .	R.	60	12 14	18 4·8	18 14·7
			14 21	18 4·3	18 14·2
„ 13, „ . . .	T.	61	10 33	18 5·3	18 15·2
			15 30	18 4·6	18 14·5
„ 18, „ . . .	T.	61	10 47	18 4·1	18 14·0
			14 56	18 2·6	18 12·5
„ 19, „ . . .	R.	60	11 9	18 4·8	18 14·7
			16 1	18 6·7	18 16·6
				Mean . .	18 14·4

It will be observed that the differences between these results are not exactly in accord with those which would be deduced from the table on p. 58.

This is due to the fact that in the above table the observations have been treated as though Kew were an ordinary station, whereas, on p. 58, the corrections have been applied in the most accurate way.

In the first place, no attempt is made on p. 58 to reduce the observations to epoch, whereas in the above table they are reduced by the mean coefficient of secular change at Kew (6′·1) during the period of the survey, together with a mean correction for monthly variation.

In the next place in the reduction on p. 58, no distinction was made between the diurnal variation and disturbance, the total divergence from the mean being read off directly. The corrections applied in the above table were obtained by reading off the disturbances only and afterwards adding the value of the diurnal variation.

The differences are a little larger than we should have expected, but this is probably due to the fact that, as the corrections were wanted quickly, the constants of the curves were only determined provisionally.

That the accuracy attained was practically sufficient is proved by a comparison of the numbers in the above table with those on p. 58.

The mean difference between our results and those given by curves treated as accurately as possible is $\pm$ 0′·81, while the mean difference between the numbers given above and their mean is $\pm$ 0′·83.

The Kew value for January, 1886, is 18° 16′·3, and ours, from the above table when reduced to the Kew instrument by adding the mean difference, is 18° 14′·4 + 2′·5 = 18° 16′·9.

If from each of our uncorrected observations given on p. 58, we subtract the difference between the corresponding Kew value and 18° 16′·3, we reduce to January, 1886, by one operation, in which no distinction is made between disturbance and the diurnal, monthly, and secular variations. The largest of the numbers so obtained is 18° 16′·1, and the smallest 18° 11′·9, while the largest and smallest in the above table are 18° 16′·6 and 18° 12′·5. Thus, not only are the mean results obtained by the two methods in close accord, but the range of variation of the results is in each case practically identical; in other words, they agree to within the limits of the error of experiment.

Horizontal Force.

Date.	Observer.	Instrument.	H.	H_0.
July 17, 1884	R.	60	1·8075	1·8100
April 2, 1886	T.	61	1·8082	1·8078
" 2, "	R.	60	1·8098	1·8094
" 22, "	R.	60	1·8101	1·8096
September 30, 1887 . . .	R.	60	1·8112	1·8082
October 11, 1887	T.	61	1·8114	1·8084
" 12, "	R.	60	1·8115	1·8085
" 13, "	T.	61	1·8114	1·8084
" 18, "	T.	61	1·8123	1·8092
" 18, "	T.	61	1·8125	1·8094
" 19, "	R.	60	1·8125	1·8094
			Mean . . .	1·8089

Inclination.

Date.	Needle.	Observer.	Dip Circle.	G.M.T.	θ.	θ_0.
				h. m.	° ′	° ′
July 17, 1884 . .	1	R.	74	15 38	67 36·0	67 34·8
„ 18, „ . .	1	T.	74	12 9	67 35·7	67 34·5
	2	T.	74	12 38	67 36·0	67 34·8
„ 19, „ . .	1	R.	74	12 12	67 36·7	67 35·5
	2	R.	74	12 47	67 36·1	67 34·9
September 30, 1887	1	R.	74	16 43	67 35·4	67 36·8
	2	R.	74	17 10	67 34·2	67 35·6
October 11, 1887 .	1	T.	83	14 33	67 34·2	67 35·6
	2	T.	83	15 7	67 35·4	67 36·8
„ 13, „ .	1	T.	83	14 27	67 35·0	67 36·4
	2	T.	83	15 0	67 35·0	67 36·4
„ 18, „ .	1	T.	83	13 52	67 34·2	67 35·6
	2	T.	83	14 28	67 34·3	67 35·7
„ 19, „ .	1	R.	74	13 38	67 35·3	67 36·7
	2	R.	74	14 2	67 34·5	67 35·9
					Mean . .	67 35·8

In the following Table the values for January 1, 1886, deduced above from the survey instruments, are given in Column I. In Column II. are the mean differences between the survey and Kew instruments (see p. 58), and hence in Column III. the Kew (calculated) values are deduced. In Column IV. are the published elements for that epoch ('Roy. Soc. Proc.,' vol. 41, 1887, p. 416), the Declination being corrected for diurnal variation.

I.	II.	III.	IV.
18° 14′·4	+ 2′·5	18° 16′·9	18° 16′·3
1·8089	− 0·0029	1·8060	1·8093
67° 35′·8	+ 2′·7	67° 38′·5	67° 37′·4

The agreement between Columns III. and IV. is satisfactory in the cases of the Declination and Dip. In that of the Horizontal Force the actual value in January, 1886, seems to have been rather high. As a good deal will hereafter be said about the relative values of the elements at Kew and Greenwich, and as we have not compared our instruments with those at Greenwich, it has been thought better to treat both these observatories in the same way, and therefore to use the numbers in Column IV. as the Kew values.

100. KING'S LYNN.

(*a*) May 20, 1886; T. E. T. (61, 83). Lat. 52° 45′ 43″; Long. 0° 24′ 30″ E. In a field to the E. of the town; S. Nicholas' Church half-a-mile away, bearing W.S.W.; Waterworks, S.W., quarter of a mile away.

(*b*) August 2, 1888; A. W. R. (60, 74). Lat. 52° 45′ 20″; Long. 0° 26′ 0″ E. In a field on the S. side of the road from Gaywood to Gayton Road Station. About half a mile from the village of Gaywood.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
May 20, 1886	+5 12	16 14	17 54·5	17 57·9
(Gaywood) Aug. 2, 1888	+3 26	15 47	17 42·8	18 1·7

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
May 20, 1886	2	17 15	68 17·3	68 17·8
Aug. 2, 1888	1	16 39	68 13·2	68 16·8

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
May 20, 1886	V	15 51	1·7664	1·7656
Aug. 2, 1888	V	16 5	1·7703	1·7646

101. KING'S SUTTON. April 14, 1888; T. E. T. (61, 83). Lat. 52° 1′ 9″; Long. 1° 16′ 19″. In a field 25 yards E. of the road to Aynho, and parallel to the Great Western line; King's Sutton Church bearing 35° W. of N., and distant 300 yards.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+1 27	13 45	18 35·4	18 51·8

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	15 35	68 2·6	68 6·4
2	16 1	68 2·4	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	14 55	1·7825	1·7778
V	14 23	1·7832	

102. Lampeter. May 31, 1886; A. W. R. (60, 74). Lat. 52° 6′ 38″; Long. 4° 4′ 36″. In a field to the S. of the town. Church bearing a little to the W. of N. Distance from the Church, about two-thirds of that between it and the river; 250 yards from the nearest point of a bend in the river.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
−1 35	11 2	19 51·7	19 55·3

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 34	68 24·6	68 25·5
2	12 59	68 25·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	13 38	1·7569	1·7559
V	11 26	1·7567	

103. LEEDS. September 22 and 24, 1886; A. W. R. (60, 74). Lat. 53° 50′ 58″; Long. 1° 35′ 3″. In the centre of a field behind St. Helen's, the residence of O. Eddison, Esq., at Adel. The Dip observations were repeated in the same position on December 31, 1888.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
Sept. 22, 1886	+ 4 2	16 38	19 3·9	19 8·9

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
Sept. 24, 1886	1	9 58	69 10·7	69 10·8
	2	10 21	69 8·8	
Dec. 31, 1888	1	10 57	69 7·5	69 11·4
	2	11 30	69 6·3	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
Sept. 22, 1886	V	16 51	1·7098	1·7082

104. LEICESTER. June 19, 1886; T. E. T. (61, 83). Lat. 52° 37′ 38″; Long. 1° 6′ 41″. Twenty yards E. of Evington Road; Evington, 1½ mile away, bearing S.E. Railway Station (Midland) ¾ of a mile away, bearing N.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+1 57	13 4	18 18·0	18 23·6
	16 42	18 21·0	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	15 48	68 23·0	68 24·0
2	16 16	68 23·5	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	14 46	1·7548	1·7538
V	13 42		

105. LINCOLN. April 26, 1888; T. E. T. (61, 83). Lat. 53° 12′ 27″; Long. 0° 31′ 14″. On the South Common, S. of the Cathedral, and about 60 yards from the road.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+3 39	15 35	18 2·2	18 18·9

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	16 43	68 40·3	68 43
2	16 57	68 38·3	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
V	16 0	1·7446	1·7395

106. LLANDUDNO. May 14, 1886; A. W. R. (60, 74). Lat. 53° 19′ 5″; Long. 3° 50′ 23″. Near the Beach to the W. of the Town, steeple bearing E. by N. In a little Bay about 300 yards S. of the road round Great Orme's Head.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 2 45	9 1	20 49·5	20 51·5
+ 1 37	14 2	20 46·9	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 36	69 12·5	69 12·0
2	13 8	69 10·4	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	11 15	1·7087	1·7084
V	10 29	1·7098	

107. LLANGOLLEN. May 10, 1886; A. W. R. (60, 74). Lat. 52° 58′ 23″; Long. 3° 10′ 13″. On a hillock in a field on the N. of the town, near the road which runs parallel to the canal, and through which the footpath to Castle Dinas Bran passes. Llangollen Church bearing S. Bridge over Canal S. by E. (80 yards distant). Castle Dinas Bran N.E. by N.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 30	11 15	20 5·3	20 8·4

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.		° ′
1	13 39	68 50·5	68 49·4
2	14 9	68 47·3	

Horizontal Force.

G.T.M.		H.	H_0.
	h. m.		
D	12 40	1·7338	1·7331
V	11 51	1·7340	

108. LLANIDLOES. May 19, 1886; A. W. R. (60, 74). Lat. 52° 56′ 57″; Long. 3° 32′ 20″. In the garden of the Inn.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 2 31	9 57	19 52·2	19 53·8
+ 2 21	14 53	19 48·7	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	7 3	68 33·2	68 33·8

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	17 56	1·7504	1·7501
V	15 13	1·7515	

109. LOUGHBOROUGH. April 30, 1888; T. E. T. (61, 83). Lat. 52° 46′ 37″; Long. 1° 13′ 3″. In a field to the N. of the London and North-Western Railway Station, distant 100 yards.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. − 2 22	h. m. 10 3	° ′ 18 2·4	° ′ 18 18·7

Inclination.

Needle.	G.M.T.	θ.	θ_0.
1	h. m. 10 47	° ′ 68 24·0	° ′ 68 27·7

Horizontal Force.

G.M.T.		H.	H_0.
V	h. m. 10 16	1·7582	1·7531

110. LOWESTOFT. May 9, 1886; T. E. T. (61, 83). Lat. 52° 27′ 54″; Long. 1° 43′ 56″ E. In a field W.S.W. of the town 1¼ mile away. S. John's Church, S. Lowestoft bore E.N.E. Kirkley Old Church, E. by S.; Cemetery, half a mile away, S.E. by E.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. −1 13 +2 2	h. m. 11 3 13 34	° ′ 17 21·4 17 20·5	° ′ 17 24·0

Inclination.

Needle.	G.M.T.	θ.	θ_0.
1 2	h. m. 12 21 12 53	° ′ 68 00·0 67 59·7	° ′ 68 00·4

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	14 28	1·7804	1·7797
V	11 22	1·7806	

111. MABLETHORPE. May 23, 1886; T. E. T. (61, 83). Lat. 53° 20′ 20″; Long. 0° 15′ 41″ E. In a field 60 yards from the Victoria Road, and 400 yards S. of the "Book in Hand" Hotel. Flagstaff of coastguard station bearing N.E. (mag.). Convalescent Home bearing S.E. by S. (mag.). Railway Station bearing N.W. (mag.).

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
−1 20	11 0	18 13·5	18 16·5
+2 15	13 53	18 12·7	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 59	68 42·0	68 42·7
2	13 28	68 42·5	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 5	1·7381	1·7370
V	11 20	1·7378	

112. MALVERN. A. W. R. (60, 74).

(*a*) Colwall Green, May 22, 1886; Lat. 52° 4′ 0″; Long. 2° 21′ 40″. About 250 yards S. of the bridge over the railway, in the space between two roads which bifurcate about 100 yards away.

(*b*) Great Malvern, May 21, 1886; Lat. 52° 6′ 22″; Long. 2° 18′ 10″. At the west end of Barnard's Green, about 20 yards S. of the south side of a triangle formed by three roads; near a pond.

(*c*) Malvern Wells, May 22, 1886; Lat. 52° 4″ 49″; Long. 2° 18′ 30″. In a field to the N. of the Hanley Road from Malvern Wells; and N.W. of the cross-roads which are E. of the Midland Station; about 10 yards from the road.

(*d*) Mathon, May 22, 1886; Lat. 52° 6′ 40″; Long. 2° 22′ 6″. In a field to the S. of the road to Mathon; a large pond on the other side of the road, 250 yards N.E. by N.; small church at West Malvern nearly due E.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
May 21 Great Malvern. . . .	+ 1 33	12 40	19 31·3 }	19 33 0
	+ 4 11	16 57	19 28·0 }	
„ 22 Mathon	+ 1 19	12 45	18 43·1	18 46·5
„ 22 Colwall Green	+ 2 9	14 37	19 0·3 }	19 3·6
	+ 3 5		19 0·1 }	
„ 22 Malvern Wells. . . .	+ 4 12	16 32	19 19·0	19 22·4

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
May 21 Great Malvern. . . .	1	12 57	68 14·8	68 14·2
	2	16 34	68 12·3	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
May 21 Great Malvern. . . .	D	14 28	1·7691	1·7687
	V	13 12	1·7700	
„ 22 Mathon	V	13 1	1 7664	1·7655
„ 22 Colwall Green	V	14 53	1·7636	1·7627
„ 22 Malvern Wells. . . .	V	16 47	1·7691	1·7682

113. MANCHESTER. June 20 and 21, 1886; T. E. T. (61, 83). Lat. 53° 27′ 40″; Long. 2° 16′ 54″. Old Trafford. On the lawn of the Royal Botanic Gardens, near the Winter House. Second series of Dip Observations, close to the lake, and about 100 yards S.E. of the first station.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
June 20	+ 2 25	14 13	19 12·5	19 16·7

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
June 20	1 2	13 3 12 13	69 3·2 69 3·0	69 3·9

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
June 21 ,, 20 ,, 21	D V V	16 33 13 51 17 8	1·7138 1·7133	1·7128 1·7123

114. MANTON. April 21, 1888; T. E. T. (61, 83). Lat. 52° 37′ 32″; Long. 0° 41′ 51″. On the hill about 400 yards from the Railway Station.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 3 16	15 13	18 5·2	18 21·7

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	17 1	68 13·8	68 17·1
2	16 46	68 13·0	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	16 15	1·7711	1·7661
V	15 34	1·7714	

115. MARCH. July 27, 1888; A. W. R. (60, 74). Lat. 52° 32′ 0″; Long. 0° 4′ 0″ E. About a mile from March Church, on the south side of the road which runs west towards Barrow Moor.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	′
+3 10	15 36	17 43·9	18 2·8

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	17 46	68 6·8	68 10·3
2	18 14	68 6·0	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	16 36	1·7780	1·7719
V	15 53	1·7772	

116. Melton Mowbray. T. E. T. (61, 83).

(*a*) April 22, 1888; Lat. 52° 44′ 54″; Long. 0° 52′ 46″. In a field about a mile S. (mag.) of the Midland Station. 20 yards E. of the Sandy Road.

(*b*) April 30, 1888; Lat. 52° 45′ 47″; Long. 0° 53′ 20″. In a field by the river, 400 yards W. of the Church. Egerton Lodge bearing about N.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
April 22	− 0 30	11 2	18 55·0	
	− 0 12	11 2	18 54·3	19 10·9
	− 0 5	13 8	18 53·7	
„ 30	+ 5 22	17 44	18 47·5	19 4·2

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
April 22	1	13 43	68 29·0	68 31·5
	2	14 0	68 26·7	
„ 30	1	18 20	68 36·1	68 39·7
	2	18 32	68 36·0	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
April 22	D	12 26	1·7673 }	1·7620
	V	11 17	1·7670 }	
	V	12 55	1·7669 } 1·7674 }	1·7620
„ 30	V	17 55	1·7466	1·7415

117. MILFORD HAVEN. July 29, 1887; A. W. R. (60, 74). Lat. 51° 42′ 24″; Long. 4° 56′ 47″. In a field belonging to Mr. CARON. 100 yards S.W. by W. of the main road which leads inland, and about 50 yards N.W. of a short lane leading to Mr. CARON'S house. Barracks due S. on the other side of the inlet; about ⅓ of a mile N.N.W. of the quay.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. − 1 13 + 1 51	h. m. 10 29 13 58	° ′ 19 56·5 19 56·8	° ′ 20 8·8

Inclination.

Needle.	G.M.T.	θ.	θ_0.
1 2	h. m. 11 46 12 12	° ′ 68 7·9 68 6·6	° ′ 68 9·9

Horizontal Force.

G.M.T.		H.	H_0.
D V	h. m. 12 58 13 41	1·7844 1·7843	1·7808

118. NEWARK. April 27, 1888; T. E. T. (61, 83). Lat. 53° 4′ 35″; Long. 0° 48′ 43″. In the middle of the Castle grounds.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. + 1 29	h. m. 14 18	° ′ 18 29·5	° ′ 18 46·2

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 8	68 30·5	68 33·4
2	12 25	68 28·9	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	13 1	1·7505	1·7464
V	14 0	1·7525	

119. NEWCASTLE. September 17, 1886; A. W. R. (60, 74). Lat. 54° 59′ 25″; Long. 1° 39′ 44″. At the W. end of the moor, about 200 yards from the road. First Station about 150 yards from a Colliery; second, about 200.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
−0 59	11 37	19 25·6	19 30·3
+1 44	13 32	19 23·9	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 10	69 48·0	69 49·5
2	14 17	69 49·0	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
V	12 22	1·6681	1·6665

120. NORTHAMPTON. October 7, 1887; T. E. T. (61, 83). Lat. 52° 13′ 1″; Long. 0° 53′ 52″. In a field on the W. side of the High Road, and nearly opposite Queen Eleanor's Cross, distant about 30 yards.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 48	10 27	18 29·7	18 41·7
+ 1 25	13 37	18 30·5	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 15	68 6·3	68 9·4
2	12 47	68 7·2	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	11 22	1·7708	1·7671
V	10 46	1·7713	
V	13 51	1·7701 1·7705	1·7664

121. NOTTINGHAM. April 28, 1888; T. E. T. (61, 83). Lat. 52° 57′ 0″; Long. 1° 9′ 20″. To the W. of Tunnel Road, due W. of the Castle, towards the Bowling Green.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 0 28	9 35	18 27·1	18 44·9
+ 3 20	15 9	18 29·4	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	15 52	68 33·7	68 37·6
2	16 9	68 34·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	11 0	1·7520	1·7471
V	9 54	1·7524	
V	10 24	1·7515	1·7468
		1·7524	

122. OXFORD. May 5 and 6, 1886; A. W. R. (60, 74). Lat. 51° 45′ 34″; Long. 1° 15′ 6″. In the Parks, near the Physical Laboratory. Ventilating flue in the middle of the Physical Lecture Room bears magnetic S.; Cricket Pavilion E. by N.; 29 paces W. from Plantation.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
May 5.	+5 15	17 51	18 29·0	18 33·7
„ 6.	−1 15	11 5	18 32·2	

Inclination.

Date.	Needle.	G.M.T.	.	θ_0.
		h. m.	° ′	° ′
May 6.	1	14 24	67 57·1	67 57·5
	2	14 55	67 56·8	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
May 6.	D	12 18	1·7900	1·7890
	V	11 34	1·7894	

123. PETERBOROUGH. May 21, 1886; T. E. T. (61, 83). Lat. 52° 34′ 16″; Long. 0° 15′ 57″. In the meadows to the W. of G.N. Railway Station, and about three quarters of a mile from it; 200 yards N. of the River Nen, and 50 yards S. of the Thorpe Road.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. +1 23 +4 10	h. m. 12 30 15 40	° ′ 18 18·6 18 18·5	° ′ 18 21·9

Inclination.

Needle.	G.M.T.	θ.	θ_0.
1 2	h. m. 14 50 15 18	° ′ 68 14·3 68 14·1	° ′ 68 14·8

Horizontal Force.

G.M.T.		H.	H_0.
D V	h. m. 13 56 12 52	1·7692 1·7708	1·7692

124. PLYMOUTH. April 7, 1887, T. E. T. (61, 83). Lat. 50° 21′ 59″; Long. 4° 8′ 35″. On the West Hoe, S. of the Drake Monument. W. end of Breakwater, 40° W. of S.; E. end of Breakwater, 10° W. of S. Old Eddystone Tower, 42° E. of S., 70 yards away. Grand Hotel, 55° W. of N.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. −1 33	h. m. 11 13 14 25	° ′ 19 22·6 19 22·8	° ′ 19 31·6

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 27	67 12·9	67 14·7
2	13 56	67 12·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 5	1·8343	1·8309
V	11 39	1·8331	

125. PORT ERIN (Isle of Man). August 8, 1887; T. E. T. (61, 83). Lat. 54° 5′ 4″; Long. 4° 46′ 7″. On the S. side of the Harbour near the Breakwater.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 5	11 46	20 40·3	20 55·4
+ 2 37	13 47	20 44·2	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	14 26	69 46·2	69 48·1
2	14 45	69 45·7	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	15 36	1·6714	1·6678
V	12 38	1·6712	

126. PRESTON. August 24, 1886; A. W. R. (60, 74). Lat. 53° 42′ 46″; Long. 2° 43′ 18″. On Farrington Moor, about 2 miles S.W. of the town, and 200 yards from a railway crossing. Close to cross-roads running N. and S. and E. and W. Spire of St. James' Layland, S. by W., ½ W. Farrington Factory, E.S.E.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 1 45	14 25	19 49·7	19 52·3
+ 4 48	17 24	19 45·2	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	16 29	69 13·7	69 14·7

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	15 30	1·7070	1·7053
V	14 48	1·7064	

127. PURFLEET. April 14, 1888; A. W. R. (60, 74). Lat. 51° 29′ 7″; Long. 0° 14′ 58″ E. Near a footpath which leads to the woods behind the village.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 1 32	15 30	17 38·9	17 54·5
+ 4 44	16 55	17 37·4	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	14 40	67 27·2	67 30·9
2	15 6	67 27·8	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	16 21	1·8178	1·8134
V	15 48	1·8190	

128. PWLLHELI. May 15, 1886; A. W. R. (60, 74). Lat. 52° 52′ 55″; Long. 4° 24′ 35″. On the beach to the S. of the town and harbour. About 100 yards E. of the road which leads to the beach. The first declination was taken on the shore of the harbour about 100 yards off.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 46	11 0	20 40·3	20 41·9
+ 2 9	14 6	20 36·9	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 15	68 49·7	68 50·9
2	12 48	68 51·0	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
V	13 54	1·7415	1·7407

129. RAMSEY (Isle of Man). August 3, 1887; T. E. T. (61, 83). Lat. 54° 19′ 22″; Long. 4° 22′ 48″. On the N. shore of the harbour and about 60 yards W.S.W. of the end of the pier. Ramsey Church bearing due S.; end of North pier bearing E.S.E.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 31	11 19	20 40·9	20 54·9
+ 1 52	13 54	20 42·8	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 22	69 54·0	69 55·0
2	12 44	69 51·6	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	14 47	1·6653	1·6617
V	11 40	1·6651	

130. RANMORE. May 21, 1888; T. E. T. (61, 83). Lat. 51° 14′ 38″; Long. 0° 21′ 36″. On Ranmore Common, half-way between the Post Office and the Church, and 20 yards N. of the road.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 0 57	11 20	17 53·1	18 8·9
+ 1 18	13 6	17 49·9	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	9 10	67 16·7	67 20·0
2	10 27	67 16·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 11	1·8310	1·8261
V	11 36	1·8318	

131. Reading. T. E. T. (61, 74).

(*a*) April 20, 1886. Lat. 51° 27′ 57″; Long. 0° 58′ 46″. On the river-bank opposite Caversham Church.

(*b*) May 30, 1888. Lat. 51° 27′ 56″; Long. 0° 58′ 50″. Close to the former station.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
April 20, 1886	− 1 21	11 14	18 13·6	18 15·2
	+ 2 24	14 1	18 12·7	
	+ 4 12			
May 30, 1888	+ 1 4	12 1	17 53·9	18 11·6

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
April 20	1	15 47	67 41·6	67 40·7
	2	16 45	67 38·9	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
April 20	D	12 40	1·8112	1·8110
	V	13 27	1·8121	
May 30	V	12 15	1·8194	1·8141

132. REDCAR. September 18, 1886; A. W. R. (60, 74).

(*a*) Lat. 54° 34′ 33″; Long. 1° 0′ 22″. In a field on the spur of the hills due S. of Marske Church, and about three-quarters of a mile from it; about 20 yards E. of the road which runs inland from Marske.

(*b*) Lat. 54° 35′ 46″; Long. 1° 1′ 15″. In a straight line between Marske Church and the Sea. About 250 yards from the Church.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 1 21	11 22	19 2·0	19 5·6
+ 3 45	15 11	18 58·0	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	14 2	69 30·5	69 31·5

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 15	1·6865	1·6847
V	11 42	1·6861	

133. RYDE. April 28, 1886; T. E. T. (61, 74). Lat. 50° 43′ 13″; Long. 1° 10′ 44″. In a field W. of Pellshurst, near Ryde. Parish Church bore E. by N., Mr. Hunter's house W.N.W. About 40 yards N. of the road.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 29	11 4	18 1·1	18 1·6
+ 2 6	13 50	17 57·8	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 24	67 6·1	67 7·8
2	12 58	67 8·5	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	14 39	1·8398	1·8391
V	11 22	1·8399	

134. St. Cyres. April 26, 1886; T. E. T. (61, 74). Lat. 50° 46′ 30″; Long. 3° 35′ 26″. In the middle of a field to the S. of the S.W. Railway, near the road, and N. of the river Avon.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 2 43	13 25	19 26·4	19 28·6

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	14 27	67 26·4	67 26·2
2	14 6	67 25·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	15 27	1·8269	1·8260
V	13 10	1·8266	

135. St. Leonards. August 9, 1886; A. W. R. (60, 74). Lat. 50° 50′ 56″; Long. 0° 31′ 5″ E. On the Common N. of the road three-quarters of a mile W. of Bo Peep Station. About 100 yards N.W. of Coastguard Station.

Declination.

Σ.	G.M.T.	δ.	δ_0.
	h. m.	° ′	° ′
+ 2 41	15 13	17 21·4	17 24·8
+ 5 35		17 19·0	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	17 21	66 59·1	66 58·9
2	17 58	66 56·7	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	16 17	1·8452	1·8437
V	15 37	1·8449	

136. Salisbury. April 27, 1886; T. E. T. (61, 74); Lat. 51° 5′ 3″; Long. 1° 48′ 6″. To the N. of the town, and S. of Old Sarum, in a field E. of the Avon; 60 yards from the Old Castle or Stratford Road.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 3	10 46	18 22·5	18 23·9
+ 1 59	13 46	18 21·0	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 38	67 25·9	67 25·6
2	13 15	67 24·4	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	14 35	1·8253	1·8242
V	11 34	1·8246	

137. SCARBOROUGH. September 21, 1886; A. W. R. (60, 74); Lat. 54° 15′ 55″; Long. 0° 23′ 24″. In a field near the edge of the cliff on the south side of the town. About 200 yards from the residence of Alderson Smith, Esq.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 2 57	13 17	18 43·4	18 48·3

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	16 31	69 14·3	69 15·6
2	17 9	69 15·2	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 38	1·7032	1·7017
V	14 19	1·7035	

138. SHREWSBURY. May 8, 1886; A. W. R. (60, 74). Lat. 52° 42′ 11″; Long. 2° 45′ 36″. In the School Grounds, about 100 yards S.W. by W. of the new buildings. On grass W. of road and E. of the Cricket Ground.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. − 1 26	h. m. 11 7	° ′ 19 38·1	° ′ 19 41·2

Inclination.

Needle.	G.M.T.	θ.	θ_0.
1	h. m. 12 40	° ′ 68 35·9	° ′ 68 36·4

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
V	11 27	1·7352	1·7344
V	11 53	1·7349	1·7341

139. SOUTHEND. May 24, 1887; T. E. T. (61, 83) Lat. 51° 32′ 49″; Long. 0° 43′ 11″ E. In a field, about 20 yards from the point where the Sutton Road bends at right angles towards Prittlewell, half a mile N. of Southend Station, and about half a mile E. of Prittlewell Church.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. +2 32	h. m. 14 3	° ′ 17 34·0	° 17 44·4

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	15 12	67 28·9	67 30·8
2	14 56	67 28·5	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	13 12	1·8135	1·8112
V	13 46	1·8152	

140. SPALDING. April 26, 1888; T. E. T. (61, 83). Lat. 52° 47′ 5″; Long. 0° 8′ 48″. Seventy yards W. of the church.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
−1 5	11 10·5	17 34·9	17 51·6

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 36	68 19·9	68 23·1
2	12 50	68 19·4	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 0	1·7576 }	1·7512
V	11 25	1·7541 }	
V	11 25	1·7487	1·7436

141. Stoke-on-Trent. September 13, 1887; A. W. R. (60, 74). Lat. 52° 57′ 47″; Long. 2° 12′ 20″. In Trentham Park, about 350 yards S.W. of the house.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+2 29	11 22 14 14	19 11·8 19 10·0	19 22·7

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1 2	13 33 13 58	68 41·4 68 40·5	68 43·6

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 35	1·7443 1·7439	1·7404
V V	11 37 11 55	1·7435 1·7436	1·7398

142. Sutton Bridge. July 31, 1888; A. W. R. (60, 74). Lat. 52° 45′ 40″; Long. 0° 11′ 50″ E. In a field on the E. bank of the River, about a quarter of a mile from the Railway.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+1 39 +5 34	14 8 17 24	17 36·2 17 34·3	17 54·1

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	15 30	68 18·2	68 21·1
2	15 54	68 16·8	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
V	14 29	1·7677	1·7620

143. SWANSEA. May 28, 1886; A. W. R. (60, 74). Lat. 51° 36′ 50″; Long. 3° 58′ 57″. In Cwmdonkin Park, one and a half mile N.W. of the town, and 150 yards N.W. of the Reservoir.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
−1 4	11 39	19 43·2	19 45·6
+2 22	13 15	19 41·0	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	16 22	67 59·5	67 59·7
2	16 59	67 58·6	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	14 0	1·7939 } 1·7943 }	1·7932
V	12 26	1·7939 }	1 7931
V	13 0	1·7941 }	

144. SWINDON. April 21, 1886; T. E. T. (61, 74). Lat. 51° 34′ 12″; Long. 1° 46′ 54″. In a field N.N.E. (mag.) of railway station, about a quarter of a mile from railway line, and near a farm.

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	10 44	67 49·8	67 51·4
2	11 18	67 52·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 5	1·7934	1·7930
V	9 48	1·7941	

145. TAUNTON. April 23, 1886; T. E. T. (61, 74). Lat. 51° 0′ 52″; Long. 3° 5′ 32″. In a field to the S.E. of the town; King's College, about quarter of a mile away, bearing S.W. by W. (mag.). Trinity Church a quarter of a mile away, N.N.W. (mag.).

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
−2 35	12 32	19 8·8	19 10·7
+1 30		19 8·3	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	10 34	67 32·0	67 32·7
2	11 11	67 32·5	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	13 15	1·8151 }	1·8146
		1·8156 }	
V	11 50	1·8169 }	1·8162
V	12 7	1·8170 }	

146. THETFORD. September 20, 1887; A. W. R. (60, 74). Lat. 52° 23′ 57″; Long. 0° 43′ 12″ E. In the Hundred-acre Field, on the estate of the Maharajah Duleep Singh.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 3 32	13 44	17 29·8	17 41·2
+ 3 48	..	17 28·8	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	16 5	67 58·9	68 1·4
2	16 31	67 58·7	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	14 43	1·7831	1·7791
V	13 55	1·7828	

147. THIRSK. September 20, 1886; A. W. R. (60, 74). Lat. 54° 14′ 35″; Long. 1° 20′ 38″. In the Kilvington fields, about half a mile N. of the Church. About 50 yards W.S.W. of the high road to York, and between it and the stream.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 11	11 16	19 20·6	19 21·7
+ 2 21	15 14	19 13·1	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 51	69 27·6	69 28·3
2	14 44	69 26·8	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 42	1·6930	1·6912
		1·6926	
V	11 35	1·6926	
V	12 1	1·6932	

148. TILNEY. August 1, 1888; A. W. R. Lat. 52° 42′ 10″; Long. 0° 17′ 11″ E. In a field behind a farm house on the main road from Wisbech, and about half way between Tilney Buck and the point where the road crosses the Five-Mile Drain.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 1 27	12 10	17 39·2	17 58·1

Inclination.

Needle.	G.M.T.	θ.	θ_0.
1	h. m. 13 57	° ′ 68 17·1	° ′ 68 20·7

Horizontal Force.

G.M.T.		H.	H_0.
D V	h. m. 11 20 12 1	1·7707 1·7717	1·7655

149. Tunbridge Wells. September 27, 1887; T. E. T. (61, 83). Lat. 51° 7′ 36″; Long. 0° 15′ 37″ E. On the Common, about 200 yards from the London Road; Trinity Church bearing 45° E. of N. (mag.). St. Peter's Church bearing 95° E. of N. (mag.). St. Mark's Church bearing 35° W. of S. (mag.).

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. − 1 49 + 1 39	h. m. 10 31 13 52	° ′ 17 29·1 17 29·3	° ′ 17 41·3

Inclination.

Needle.	G.M.T.	θ.	θ_0.
1 2	h. m. 12 9 12 32	° ′ 67 7·8 67 8·3	° ′ 67 10·8

Horizontal Force.

G.M.T.		H.	H_0.
D	h. m. 11 34	1·8340 1·8335	1·8299
V V	10 54 14 7	1·8333 1·8335	1·8296

150. WALLINGFORD. May 29, 1888; T. E. T. (61, 83). Lat. 51° 36′ 3″; Long. 1° 7′ 21″. Below Wallingford Bridge, 70 yards away, on the left bank, opposite the Church.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. + 0 49	h. m. 13 18	° ′ 18 3·9	° ′ 18 21·6

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	14 48	67 44·9	67 48·4
2	15 1	67 44·2	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	14 7	1·8040	1·7986
V	13 31	1·8039	

151. WEYMOUTH. April 6, 1887; T. E. T. (61, 83). Lat. 50° 36′ 16″; Long. 2° 26′ 52″. On the S. side of the Nothe, close to the shore. End of Portland Breakwater, 28° E. of S. (mag.). Bincleaves House, 60° W. of S. (mag.). Coastguard Station on Nothe, 55° W. of N. (mag.).

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 26	11 17	18 37·3	18 46·7
+ 2 4	14 3	18 38·6	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 25	67 10·3	67 11·7
2	13 46	67 8·9	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 24	1·8357	1·8329
V	11 48	1·8358	

152. WHEELOCK. February 18, 1887; T. E. T. (83). Lat. 53° 7′ 50″; Long. 2° 22′ 30″. In the field behind Wettenhall Cottage.

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 37	68 46·8	68 49·0
2	14 42	68 47·9	

153. WHITEHAVEN. August 27, 1886; A. W. R. (60, 74). Lat. 54° 32′ 37″; Long. 3° 34′ 20″. In Midgey Mount; S.E. of the Castle, and in the grounds. About 300 yards from Cukickle Gate.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 40	11 2	20 35·5	20 41·6
+ 2 22	14 21	20 36·6	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 19	69 45·8	69 47·6
2	13 52	69 47·7	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 14	1·6740	1·6727
V	11 23	1·6743	

154. WINDSOR. May 31, 1888; T. E. T. (61, 83). Lat. 51° 29′ 22″; Long. 0° 37′ 25″. To the W. of the town, near the point where the river makes a bend towards the Railway Bridge.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. + 3 47	h. m. 16 10	° ′ 18 12·2	° ′ 18 29·9

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	17 20	67 35·5	67 38·8
2	17 30	67 34·3	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	16 48	1·8132	1·8084
V	16 22	1·8142	

155. WISBECH. July 31, 1888; A. W. R. (60, 74). Lat. 52° 40′ 30″; Long. 0° 8′ 20″ E. In a field belonging to Mr. SHARP to the S. of the Leverington Road. About 50 yards E. of an octagonal pigeon house.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. − 2 26	h. m. 9 57	° ′ 17 46·7	° ′ 18 5·6

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	17 53	68 17·2	68 19·0
2	18 12	68 13·7	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	16 47	1·7707	1·7653
V	16 1	1·7713	

156. WORTHING. September 29, 1887; T. E. T. (61, 83). Lat. 50° 48′ 35″; Long. 0° 23′ 22″. In a field adjoining a new road W. of West Worthing, about 300 yards from the beach and three-quarters of a mile from the Pier; about half-way between the railway line and the beach. Tarring Church 10° E. of N. (mag.). S. Botolph's (W. Worthing) 55° E. of N. (mag.).

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
−1 10	11 6	17 46·2	17 59·0
+2 56	14 12	17 47·6	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 46	67 4·3	67 6·4
2	13 12	67 2·9	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	11 59	1·8443 }	1·8403
		1·8439 }	
V	11 20	1·8445 }	1·8401
V	14 25	1·8433 }	

Descriptions of Irish Stations.

157. Armagh Observatory. August 15, 1887; T. E. T. (61, 83). Lat. 54° 21′ 10″; Long. 6° 38′ 53″. In a field belonging to the Observatory about 100 yards S. of the house, and close to the position on which Lloyd and Ross had made observations.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+1 14	14 13	22 3·8	22 16·5
+3 15	16 1	22 2·5	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	15 9	69 55·3	69 57·6
2	15 29	69 55·2	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	16 40	1·6659	1·6625
V	14 26	1·6656	

158. Athlone. T. E. T. (61, 83).

(*a*) May 8, 1887. Lat. 53° 26′ 8″; Long. 7° 57′ 22″. On the N. bank of the Shannon and about 50 yards from the river's edge. About 1 mile from the town.

(*b*) May 9, 1887. In the middle of the kitchen garden, 150 yards behind the Prince of Wales' Hotel, and near the Protestant Church.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
May 8	+1 41	12 39	22 16·5	22 26·7
„ 9	−3 44	9 9	22 16·8	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
May 8	1	13 25	69 38·5	69 40·0
	2	13 55	69 37·6	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
May 8	D	15 18	1·6874	1·6852
	V	12 14	1·6885	

159. BAGNALSTOWN. September 8, 1887; A. W. R. (60, 74). Lat. 52° 41′ 37″; Long. 6° 57′ 36″. In a field to the W. of the Enniscorthy-road, about a quarter of a mile from the point where it crosses the railway.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 3 27	9 9	21 43·3	21 55·0

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	9 47	69 2·2	69 5·1

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
V	9 20	1·7242	1·7208

160. BALLINA. September 2, 1887; A. W. R. (60, 74). Lat. 54° 7′ 10″; Long. 9° 9′ 0″. About 400 yards S. of Belleck Castle. In a field on the west side of the road which runs north from the town; about a quarter of a mile from the river.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. −2 1	h. m. 11 6	° ′ 23 15·3	° ′ 23 26·9

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 20	70 22·8	70 25·8
2	13 42	70 23·8	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 3	1·6356	1·6323
V	11 23	1·6357	

161. BALLYWILLIAM. September 8, 1887; A. W. R. (60, 74). Lat. 52° 26′ 37″; Long. 6° 52′ 0″. In a field W. of the road, nearly S. of the station, and about one-third of a mile from it.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. −0 49	h. m. 11 56	° ′ 21 25·6	° ′ 21 37·3

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 49	69 2·7	69 5·6

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	13 7	1·7247 1·7268	1·7223
V V	12 13 12 29	1·7255 1·7258	1·7222

162. BANGOR. August 18, 1887; T. E. T. (61, 83); Lat. 54° 39′ 57″; Long. 5° 39′ 50″. Station 200 yards E. (mag.) from the Harbour.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 27 + 2 5	11 39 13 53	21 30·6 21 31·5	21 44·4

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1 2	12 48 13 15	69 59·7 69 58·1	70 1·3

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	15 7	1·6636 1·6633	1·6601
V V	11 53 14 10	1·6624 1·6632	1·6595

163. BANTRY. August 9, 1887; A. W. R. (60, 74); Lat. 51° 40′ 25″; Long. 9° 28′ 53″. In a field opposite to Ivy Cottage, about a mile and a quarter W. of the town.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 2 35	15 53	22 29·7	22 40·3
+ 5 50	18 13	22 27·8	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	17 9	68 43·1	68 46·0
2	17 41	68 42·8	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	18 59	1·7561	1·7529
V	16 10	1·7561	

164. CARRICK-ON-SHANNON. May 12, 1887; T. E. T. (61, 83). Lat. 53° 56′ 36″; Long. 8° 5′ 46″. To the N. of the Shannon Bridge, about 70 yards from the road, and close to the Quay-side; nearly opposite the door of the Royal Irish Constabulary Office.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m	h. m.	° ′	° ′
−2 49	10 29	22 52·7	23 3·1
−1 24		22 53·1	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	11 55	69 51·7	69 53·3
2	11 58	69 50·9	

Horizontal Force.

G.M.T.		H.	H_0.
V	h. m. 10 42	1·6727	1·6700

165. CASTLEREAGH. May 9, 1887; T. E. T. (61, 83). Lat. 53° 45′ 34″; Long. 8° 29′ 7″. About 150 yards W. of the Castlereagh Railway Station.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
−0 32	12 22	23 1·0	23 11·1

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 16	69 53·9	69 56·3
2	13 36	69 54·7	

Horizontal Force.

G.M.T.		H.	H_0.
V	h. m. 12 35	1·6743	1·6716

166. Cavan. September 6, 1887; A. W. R. (60, 74). Lat. 53° 59′ 4″; Long. 7° 21′ 43″. In a field about 100 yards N. of the College.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 3 29	9 13	22 26·1	
+ 1 29	14 10	22 26·7	22 37·8
	15 45	22 27·4	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 18	69 54·6	69 57·3
2	12 52	69 55·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	13 22	1·6660	1·6629
V	9 24	1·6666	

167. Charleville. August 6, 1887; A. W. R. (60, 74). Lat. 52° 20′ 54″; Long. 8° 40′ 22″. In a field about halfway between the Station and the Town.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 3 56	15 6	22 19·4	22 30·8
+ 4 37	17 52	22 19·1	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	16 43	69 4·1	69 5·3
2	17 30	69 0·8	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
V	15 36	1·7261	1·7226
V	15 20	1·7255	

168. CLIFDEN. August 30, 1887; A.W.R. (60, 74). Lat. 53° 29′ 35″; Long. 10° 4′ 10″. In a field on the S. side of the road which runs from Clifden to Ballymaconry. Three-quarters of a mile from the upper gate to the grounds of Clifden Castle.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
−1 35	11 30	24 8·2	24 20·7
+1 49	14 44	24 9·2	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 24	70 2·3	70 4·8
2	13 48	70 1·9	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 20	1·6660	1·6631
V	11 40	1·6668	

169. COLERAINE. August 21, 1887; T.E.T. (61, 83). Lat. 55° 7′ 31″; Long. 6° 40′ 24″. On the West Side of the River and 200 yards S. of the Bridge.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 0 39	13 32	22 24·3	22 36·9
	15 23	22 22·5	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	15 50	70 45·2	70 47·7

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	14 35	1·6123 } 1·6125 }	1·6091
V	14 2	1·6111 }	1·6080
V	15 8	1·6115 }	

170. COOKSTOWN JUNCTION. August 19, 1887; T. E. T. (61, 83). Lat. 54° 44′ 56″; Long. 6° 16′ 1″. About 300 yards W. of Cookstown Junction Station, on the road to Randalstown.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 0 28		21 19·6	21 32·8
+ 1 38	13 26	21 19·3	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	14 38	69 31·8	69 34·5
2	15 4	69 32·0	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	15 43	1·6862	1·6830
V	13 52	1·6865	

171. CORK. August 8, 1887; A. W. R. (60, 74). Lat. 51° 53′ 30″; Long. 8° 29′ 30″. In the quarry behind Queen's College. The second Declination was taken in a field about 250 yards to the E. of the first station. The difference between the two results is larger than was anticipated.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 3 44	10 40	22 3·8 }	22 14·3
	14 36	22 1·7 }	
+ 2 49	15 49	22 10·3	22 21·9

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 52	68 44·2	68 46·4
2	13 25	68 43·2	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 6	1·7537	1·7506
V	11 26	1·7540	

172. DONEGAL. August 23, 1887; T. E. T. (61, 83). Lat. 54° 39′ 5″; Long. 8° 6′ 57″. On the N. bank of the Port, nearly opposite the ruins of the Abbey, which bore S.S.W. Village bore due E.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 0 11	11 42	23 6·9	23 20·1
+ 1 53	15 31	23 6·4	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 46	70 12·5	70 15·3
2	14 32	70 13·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	15 7	1·6482	1·6449
V	12 2	1·6483	

173. DROGHEDA. May 15, 1887; T. E. T. (61, 83). Lat. 53° 42′ 48″; Long. 6° 22′ 4″. In a field S.S.W. of Rathmullan House, about 1 mile west of Drogheda Cathedral, and on the S. side of the River Boyne.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 0 38	11 29	21 43·8	21 54·7
+ 1 0	13 4	21 42·3	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 59	69 34·5	69 36·3
2	14 14	69 33·8	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 19	1·6921	1·6894
V	11 11	1·6921	
D	..	1·6924	1·6897
V	12 50	1·6924	

174. DUBLIN (Trinity College). May 5 and 6, 1887; T. E. T. (61, 83). Lat. 53° 20′ 35″; Long. 6° 15′ 24″. 1st Station. On the path before the Magnetic House, between it and the University Buildings. About 20 yards from the former. 2nd Station. On the middle walk and almost due E. of the Provost's House; to the N.E. of the entrance of the Magnetic Observatory.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
May 5	+1 30	13 28	21 29·5	21 40·8
„ 6	−1 6	11 46	21 29·4	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
May 5	1	15 30	69 13·9	69 15·7
	2	15 57	69 13·3	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
May 5	D	12 5	1·7108	1·7079
	V	13 11	1·7105	
„ 6	V	12 5	1·7125	1·7095
			1·7120	

175. Enniskillen.

May 14, 1887; T. E. T. (61, 83). Lat. 54° 21′ 18″; Long. 7° 39′ 50″. At Silverhill, at the S. end of lower Lough Erne. Portora Old Castle, bearing due E. (mag.); Devenish Round Tower, 38° E. of N. (mag.); Royal Schools, Portora, 35° E. of S. (mag.).

September 3, 1887; A. W. R. (60, 74). Lat. 54° 21′ 7″; Long. 7° 39′ 8″. In a field close to the river, and about 150 yards east of the Royal Schools.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
Sept. 3 (R.)	+2 39	15 44	22 53·1	23 5·3
	+2 49			
	+5 44	18 41	22 51·0	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
May 14 (T.)	1	13 5	70 12·8	
	2	13 22	70 12·0	
Sept. 3 (R.)	1	17 9	70 12·3	70 14·2
	2	17 29	70 11·5	
	2	18 24	70 10·8	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
May 14 (T.)	D	11 8	1·6526	1·6489
	V	11 42	1·6507	
Sept. 3 (R.)	V	16 17	1·6496	1·6465
	V	15 58	1·6501	

176. GALWAY. A. W. R. (60, 74).

(*a*) August 25, 1887; Lat. 53° 16′ 37″; Long. 9° 3′ 42″. On the Lawn in front of Queen's College.

(*b*) August 26, 1887; Lat. 53° 17′ 30″; Long. 9° 3′ 21″. At the lower end of Loch Cool, on the S. side, near the entrance of the river. The first station was chosen as being near to the College, but as it is on the granite, and was found to be highly disturbed, the second position was selected on the limestone.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
Aug. 25	+ 2 15	15 18	23 55·3	24 6·3
	+ 4 28	17 49	23 53·6	
„ 26	+ 2 14	15 26	23 18·0	23 29·8
	+ 2 31	..	23 18·5	
	+ 5 14	..	23 17·3	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
Aug. 25	1	16 51	69 53·5	69 55·5
	2	17 23	69 52·6	
„ 26	1	17 1	69 40·2	69 44·1
	1	17 31	69 42·3	
	2	17 16	69 42·3	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
Aug. 25 (1)	D	16 12	1·6602	1·6568
	V	15 33	1·6600	
„ 26 (1)	V	12 55	1·6631 1·6631	1·6598
(2)	D	16 22	1·6898	1·6867
	V	16 46	1·6903	

177. GORT. August 24 and 25, 1887; A. W. R. (60, 74). Lat. 53° 4′ 20″; Long. 8° 49″ 15″. In a field to the E. of the road which runs N. from the town, due N. of the Church, and about 500 yards from it.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
Aug. 24	+ 4 28	15 41	22 38·2	22 50·5
,, 25	− 4 17	8 46	22 39·1	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
Aug. 24	1	16 47	69 29·5	69 31·7
	2	17 17	69 28·7	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
Aug. 24	V	16 6	1·7046	1·7013

178. GREENORE. August 14, 1887; T. E. T. (61, 83). Lat. 54° 1′ 35″; Long. 6° 7′ 47″. On the shore near the Coast Guard Station.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 0 10	12 43	22 1·3	22 14·5
+ 3 41	15 17	22 1·0	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	14 42	69 41·7	69 42·2
2	15 1	69 37·5	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	15 50	1·6868	1·6833
V	13 13	1·6863	

179. Kells. May 16, 1887; T. E. T. (61, 83). Lat. 53° 43′ 8″; Long. 6° 52′ 46″. In a field half a mile S. of the Kells Railway Station and about 50 yards E. of the main road.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 0 14	12 30	21 56·7	22 7·0

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 51	69 36·9	69 38·7
2	14 6	69 36·2	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	13 18	1·6949	1·6925
V	12 42	1·6955	

180. KILDARE. May 6 and 7, 1887; T. E. T. (61, 83). Lat. 53° 9′ 25″; Long. 6° 54′ 30″. In the centre of the enclosed ground attached to the ruins of the Castle—a plot of ground given by the Duke of LEINSTER to the town.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
May 6	+6 7	18 56	21 50·2	22 0·4
" 7	−2 38	11 7	21 50·4	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
May 7	1	12 8	69 15·0	69 17·2
	2	12 28	69 15·1	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
May 7	D	10 39	1·7101	1·7071
			1·7096	
" 6	V	19 16	1·7105	1·7076
" 7	V	11 20	1·7101	

181. KILKENNY. September 7, 1887; A. W. R. (60, 74). Lat. 52° 38′ 41″; Long. 7° 15′ 30″. In the centre of the grounds of the Catholic College.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+1 50	14 42	21 49·0	21 58·7
+4 11	16 20	21 45·0	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	15 38	69 1·8	69 5·0
2	15 57	69 2·4	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	13 38	1·7290	1·7258
V	14 58	1·7295	

182. KILLARNEY. August 11, 1887; A. W. R. (60, 74). Lat. 52° 3′ 50″; Long. 9° 32′ 20″. In the grounds of the Victoria Hotel. To the E. of the road leading from the Hotel to the Lake.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
−1 0	11 28	22 44·1	22 55·8
+3 25	15 23	22 44·2	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 56	68 54·2	68 56·5
2	15 49	68 53·1	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 23	1·7435	1·7405
V	12 59	1·7436	

183. KILRUSH. August 22, 1887; A. W. R. (60, 74). Lat. 52° 37′ 56″; Long. 9° 29′ 40″. In a field to the W. of the road from the village to the quay, and about half-way between them.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 4 24	16 32	23 0·1	
	17 43	22 59·1	23 11·4
+ 6 12	18 33	22 59·3	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	15 50	69 20·5	69 23·2
2	16 10	69 20·3	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	18 5	1·7124	1·7090
V	17 31	1·7123	

184. LEENANE. August 31, 1887; A. W. R. (60, 74). Lat. 53° 35′ 43″; Long. 9° 42′ 28″. On the Green, immediately in front of the Hotel.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 1 34	14 31	23 24·0	23 36·2
+ 3 10	15 3	23 24·5	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
1	h. m. 16 2	° ' 70 5·3	° ' 70 8·0

Horizontal Force.

G.M.T.		H.	H_0.
V	h. m. 15 50	1·6545	1·6512

185. LIMERICK. August 20, 1887; A. W. R. (60, 74). Lat. 52° 39′ 13″; Long. 8° 38′ 46″. In a field at Summerville, the residence of J. BANNATYNE, Esq. The same position as in the survey of 1838.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. − 1 27 + 2 48	h. m. 11 50 12 42 13 57 15 13	° ' 22 24·2 22 24·8 22 24·8 22 25·4	° ' 22 36·6

Inclination.

Needle.	G.M.T.	θ.	θ_0.
1 2	h. m. 14 32 14 53	° ' 69 5·9 69 6·1	° ' 69 8·8

Horizontal Force.

G.M.T.		H.	H_0.
D V	h. m. 13 25 12 27	1·7266 1·7271	1·7235

186. LISDOONVARNA. August 23, 1887; A. W. R. (60, 74). Lat. 53° 1′ 47″; Long. 9° 17′ 34″. In a field behind the Queen's Hotel.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. + 4 17 + 5 25	h. m. 16 17 18 26	° ′ 22 48·1 22 45·2	° ′ 22 58·5

Inclination.

Needle.	G.M.T.	θ.	θ_0.
1 2	h. m. 17 25 17 46	° ′ 69 30·3 69 28·4	° ′ 69 31·8

Horizontal Force.

G.M.T.		H.	H_0.
D V	h. m. 18 51 16 35	1·7078 1·7073	1·7042

187. LISMORE. August 1, 1887; A. W. R. (60, 74). Lat. 52° 8′ 15″; Long. 7° 55′ 12″. In a field, quarter of a mile E. by S. of the Cathedral.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. − 3 29	h. m. 10 23 13 24	° ′ 21 54·1 21 54·0	° ′ 22 5·5

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	11 52	68 46·2	68 48·6
2	12 16	68 45·6	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	12 52	1·7463	1·7427
V	10 49	1·7455	

188. LONDONDERRY. August 20, 1887; T. E. T. (61, 83). Lat. 55° 1′ 24″; Long. 7° 18′ 6″. In a field adjoining the Moville Road, about 2 miles from Derry, and between the Road and the Lough. Boom Hall Lodge Gate 70° E. of N.; distant 50 yards. Boom Hall 35° W. of S.; distant 400 yards.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 0 25	12 52	22 35·5	22 50·5
+ 1 52	14 13	22 38·7	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	15 28	70 24·6	70 26·9
2	15 56	70 24·2	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	16 21	1·6368	1·6333
		1·6365	
V	13 22	1·6376	1·6338
V	13 49	1·6367	

189. OUGHTERARD. August 27, 1887; A. W. R. (60, 74). Lat. 53° 26′ 10″; Long. 9° 19′ 1″. On the shore of Lough Corrib, to the E. of the Town; on limestone.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 3 11	17 0	23 28·0	23 40·6
+ 3 25	..	23 29·5	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	18 1	69 54·1	69 56·7
2	18 28	69 54·2	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
V.	17 15	1·6795	1·6762

190. PARSONSTOWN. August 4 and 5, 1887; A. W. R. (60, 74). Lat. 53° 5′ 47″; Long. 7° 54′ 57″. In the grounds of Birr Castle, near the meridian mark used for the telescope of the Earl of ROSSE.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
August 4	(18 20 G.M.T.)	18 49	22 14·8	22 27·0
" 5	(10 40 ")	11 7	22 16·3	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
August 5	1	h. m. 13 8	° ′ 69 27·8	° ′ 69 30·3

Horizontal Force.

Date.	G.M.T.		H.	H_0.
August 5	D V	h. m. 12 8 11 27	1·7022 1·7020	1·6989

191. SLIGO. May 13, 1887 ; T. E. T. (61, 83). Lat. 54° 16′ 34″ ; Long. 8° 28′ 36″. On a promontory in the harbour, to the W. of the town, and about a quarter of a mile distant from the bridge.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m. −1 46 +1 44	h. m. 12 24 13 53	° ′ 22 55·0 22 53·9	° ′ 23 4·6

Inclination.

Needle.	G.M.T.	θ.	θ_0.
1 2	h. m. 11 35 12 2	° ′ 70 15·4 70 16·3	° ′ 70 17·8

Horizontal Force.

G.M.T.		H.	H_0.
D V	h. m. 13 23 12 39	1·6453 1·6461	51·6430

192. STRABANE. August 22, 1887; T. E. T. (61, 83). Lat. 54° 49′ 48″; Long. 7° 28′ 20″. In a field midway between the Railway Station and the Bridge at Lifford. Railway Station bore 300 yards E.S.E. (mag.); Bridge, W.N.W. (mag.); and Church at Lifford, N.N.W. (mag.).

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 0 17	12 33	22 34·3	22 46·9
+ 1 1	16 21	22 32·6	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	14 44	70 20·4	70 23·5
2	15 20	70 21·7	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m		
D	15 55	1·6391	1·6352
V	12 46	1·6380	

193. TIPPERARY. August 3, 1887, A. W. R. (60, 74). Lat. 52° 28′ 36″; Long. 8° 9′ 12″. 1st Station. In a field on the W. side of the road to Limerick Junction, about a third of a mile from the point at which it crosses the railway. 2nd Station. In a field opposite the Hotel.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h m.	° ′	° ′
+ 5 52	19 1	22 11·1	22 22·6

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 42	69 2·2	69 4·9
2	13 13	69 2·6	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	11 59	1·7317	1·7287
V	11 11	1·7321	
D	20 15	1·7292	1·7258
V	19 41	1·7289	

194. TRALEE. August 19, 1887; A. W. R. (60, 74). Lat. 52° 16′ 15″; Long. 9° 44′ 30″. In a field about a mile to the W. of the town.

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 36	69 7·7	69 9·4
2	14 10	69 5·6	

195. VALENTIA. August 16 and 17, 1887; A. W. R. (60, 74). Lat. 51° 55′ 34″; Long. 10° 17′ 40″: Lat. 51° 55′ 22″; Long. 10° 17′ 25″. Station 1. On the cliffs to the N. of the town. Station 2. In a field to the S. of the town.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
Aug. 16 (1)	+ 5 19	18 44	23 4·1	23 16·0
	+ 5 35	. .	23 3·3	
„ 17 (2)	− 1 25	13 2	23 5·1	
	+ 1 54	13 57	23 4·2	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
Aug. 17 (2)	1	12 8	68 52·9	68 54·7
	2	15 11	68 50·4	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
Aug. 17 (2)	V	13 25	1·7485	1·7452
	V	13 48	1·7478	1·7445

196. WATERFOOT. August 25, 1887; T. E. T. (61, 83). Lat. 55° 3′ 11″; Long. 6° 2′ 32″. The Declination was taken on the shore, and before the Chapel; the Forces in the road to the N. of the Chapel.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 2 11	14 59	22 1·5	22 15·1

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	16 38	70 26·3	70 29·0
2	16 55	70 26·5	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
V	16 3	1·6326	1·6293

197. WATERFORD. August 2, 1887; A. W. R. (60, 74). Lat. 52° 16′ 54″; Long. 7° 8′ 41″. In a field on the E. of the Kilmacow Road near the junction of the Lower Limestone and Shale. About a third of a mile from the junction of the Limerick and Kilkenny Railways.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
− 1 44	12 7	21 15·1	21 27·9
+ 2 17	14 40	21 17·7	

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	11 44	68 49·6	68 53·7
2	14 12	68 52·5	

Horizontal Force.

G.M.T.		H.	H_0.
	h. m.		
D	. .	1·7362	1·7329
V	12 31	1·7361	

198. WESTPORT. May 9 and 10, 1887; T. E. T. (61, 83). Lat. 53° 48′ 8″; Long. 9° 31′ 17″. In the demesne of the Marquis of SLIGO, and about 100 yards from the main entrance from the town.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
May 9	+ 4 48	17 54	23 5·5	23 15·1
„ 10	− 1 55	11 10	23 4·2	
	+ 2 4	14 13	23 5 4	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
May 10	1	13 25	70 16·9	70 17·9
	2	13 42	70 15·5	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
May 10	D	12 21	1·6536	1·6505
			1·6529	
„ 9	V	18 10	1·6545	1·6514
„ 10	V	11 25	1·6537	

199. Wexford. September 8, 1887; A. W. R. (60, 74). Lat. 52° 21′ 27″; Long. 6° 27′ 18″. On the limestone on the opposite side of the river (Ardcavan) to the Town. In a field on the Western side of the main road, about a quarter of a mile N. of the point where the roads to the Wooden Bridge and Ferry Bank unite.

Declination.

Σ.	G.M.T.	δ.	δ_0.
h. m.	h. m.	° ′	° ′
+ 4 24	17 12	21 6·4	21 18·1

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	18 22	68 55·0	68 56·2
2	18 41	68 51·6	

Horizontal Force.

G.M.T.		H.	H_0.
V	h. m. 17 49	1·7358	1·7324

200. WICKLOW. September 9 and 10, 1887; A. W. R. (60, 74). Lat. 52° 58′ 53″; Long. 6° 3′ 30″. Half a mile W. of the town, in a field on the N. side of the road through Ballynerrin, opposite to and a little beyond the old Roman Catholic Chapel.

Declination.

Date.	Σ.	G.M.T.	δ.	δ_0.
	h. m.	h. m.	° ′	° ′
Sept. 9	+5 18	18 5	21 5·0	21 21·4
,, 10	−1 55	10 55	21 14·4	

Inclination.

Date.	Needle.	G.M.T.	θ.	θ_0.
		h. m.	° ′	° ′
Sept. 10	1	11 44	69 7·6	69 9·9
	2	12 11	69 6·9	

Horizontal Force.

Date.	G.M.T.		H.	H_0.
		h. m.		
Sept. 9	D	18 49	1·7155	1·7126
	V	18 18	1·7165	

Supplementary Stations.

(Dips only observed. T. E. T. (83).)

201. Chepstow. April 22, 1889. In the courtyard of the Castle.

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	18 9	67 51·9	67 57·5
2	18 26	67 51·9	

202. Goodrich Castle. April 19, 1889. On the Barbican. To the East of the entrance to the Castle.

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	16 47	68 3·3	68 9·0
2	16 52	68 3·5	

203. Hereford. April 17, 1889. On the slope of Aylstone Hill overlooking Lugg Meadow. About a mile from Hereford, and down a short lane which leads past Lugg Vale, the residence of Mr. Hawkins.

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	16 1	68 10·2	68 15·6
2	16 20	68 9·9	

204. Ross. April 18, 1889. In the garden of the Royal Hotel. South of the house and between the large yew and the wall of the Prospect.

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	12 29	68 2·2	68 6·9
2	13 5	68 0·5	

205. Tintern. April 22, 1889. On the Monmouth Road, above the Railway Station.

Inclination.

Needle.	G.M.T.	θ.	θ_0.
	h. m.	° ′	° ′
1	13 30	67 56·2	68 1·3
2	13 49	67 55·2	

Calculation of the Isomagnetic Lines.

(1.) *The Isogonal Lines.*

The isogonals, isoclinals, isodynamics and lines of equal Horizontal Force are drawn through points, at which the values of the magnetic elements to which they refer are equal. A general term which shall include them all would be useful, and we venture to suggest *isomagnetic* as the most obvious and convenient. In nothing do different magnetic surveys differ more widely than in the methods employed of drawing these lines. Some observers have calculated them by least squares; others give maps on which they are exhibited, but say nothing about the principles in accordance with which they have been drawn. But, inasmuch as the main object and result of a survey is the delineation of these isomagnetics, it seems to us that it is most important that they should be drawn with all the accuracy that the observations will allow. Before proceeding to discuss the method of doing this, it will be well to consider the exact meaning to be attached to the operation, and to attempt to give greater precision to the language in which the various curves, and the physical phenomena which they represent, are described.

If we suppose that a series of magnetic curves are drawn, in which all distortions due to local magnetism are neglected, except those which are on a scale comparable with the dimensions of the earth itself, they would be the *terrestrial isomagnetic lines;* on the other hand, lines which showed every disturbance, however large or small, would be the *true isomagnetic lines.*

The object of a survey is to determine as nearly as possible the forms of the true lines, and to deduce from them the directions of the terrestrial lines in the district under investigation. Between these two extremes various grades of accuracy of detail intervene, and the terrestrial lines may be regarded as affected with distortions of different orders due to disturbances of various magnitudes. It is of course impossible to frame definitions which shall accurately distinguish between them, but it is nevertheless convenient to recognise three classes, into which they may be divided with respect to any particular survey.

We may regard a disturbance as being of the third, second, or first class according as its range is less than the average distance between the stations, greater than this distance, but small compared with the dimensions of the entire area under survey, or such as to involve the whole or a considerable fraction of that area.

The term *local* may be reserved for disturbances of the third class, which affect only a single station or its immediate neighbourhood, and are represented by minor bends or small loops in the isomagnetic curves.

Those of the second class may be called *regional* disturbances. They are represented by considerable distortions of the curves, but do not seriously interfere with the determination of the general direction or average distance apart of the terrestrial lines. A disturbance of the first class is however an obstacle to any inference as to the relation between the true and the terrestrial curves. It may distort them similarly, and so lead to false conclusions as to their undisturbed directions, or it may introduce such widespread and important irregularities that any conclusion deduced from the data afforded by the survey would be manifestly uncertain.

It is to be noticed that the same cause may produce disturbances of different classes in the lines corresponding to different elements. Thus a broad band of magnetic rock at right angles to the magnetic meridian, the extremities of which lay outside the district under investigation, would produce little effect on the Declination, but might affect the Dip to a much larger extent.

If an equation can be found to a family of curves which represents, as closely as possible, the general direction of the true isomagnetics of a particular kind throughout the whole country, the curves are the nearest approach to the terrestrial lines which can be deduced from the observations. The undulations of the district lines on each side of these are evidence of regional disturbances, while the still more sinuous lines obtained by joining the points calculated as corresponding to any particular value of the element from the values in two neighbouring stations are influenced by the local disturbances also.

If the district under survey is very small, the assumption that the terrestrial lines are straight is very approximately true, but the nature of the curve indicated by a straight line on a map depends on the projection on which the map is drawn.

The English observers have generally determined the position of the station by its distance north or south of a particular line of latitude, and east or west of a particular meridian, both distances being expressed in geographical miles. That this system is open to objection is evident by considering its application to a simple ideal case in which the geographical meridians are themselves supposed to be the isogonal lines. It would evidently be better under such conditions to take the latitude and longitude as coordinates, and inasmuch as in the neighbourhood of the United Kingdom there is an approximation to such an arrangement, it is probable that the latitude and longitude are at least as convenient as any other data for the determination of the position of the stations. By this plan also, we are saved the trouble of converting the longitude east or west of Greenwich into miles east or west of the prime meridian. We have therefore taken the latitude and longitude as our coordinates.

In the next place it is, we think, important to find the general equations to the isomagnetic lines, but it would be difficult to determine their form with sufficient accuracy by a graphical process. We therefore decided to trace them by a preliminary process of calculation which was carried out as follows.

The country was divided into nine overlapping districts bounded by lines of latitude and longitude. If the stations within any district were not uniformly distributed, they were weighted, so that the weighted number of stations per unit of area should be everywhere about the same. In speaking of the mean value of any quantity in a district, it will be understood that the values appropriate to any station are throughout properly weighted. The means of the latitudes, longitudes, and declinations determined the central station of the district and the declination at that station (δ_0'). It was then assumed, if l' and λ' be the *district coordinates* of a station, *i.e.*, the differences between its latitude and longitude and those of the central station, that the declination is connected with these quantities by the linear equation—

$$\delta = \delta_0' + xl' + y\lambda'.$$

Two equations of condition were then formed by adding the equations thus obtained—(1), for all stations to the north of the central station; (2), for all stations to the east of it, and dividing by the number of stations employed, each multiplied by its proper weight.

By solving these for x and y, the rates of change of the Declination per degree of latitude and longitude respectively were obtained.*

To test this method, it was applied in the case of the Dips to the whole of Scotland. This portion of Great Britain furnished a severe test, as from the irregularity of its form it is not particularly well adapted for the application of the method of equations of condition. The calculation was also made by the method of least squares. Both calculations were repeated twice, viz., with and without the inclusion of Soa and Canna, at which the local disturbance is very consirdeable. The central station was not that given by the mean latitude and longitude, but that obtained from WELSH's Dip observations, viz., lat. 56° 48′ N.; long. 4° 19′ W. In this particular again, the conditions of the selected example were unfavourable to the method of equations of condition.

In the following Table, u is the angle made by the lines of equal Inclination with the geographical meridian, r is the change in Inclination (expressed in minutes) per geographical mile, measured at right angles to the isoclinals, and θ_0' is the Dip at the central station:—

		θ_0'.	u.	r.
		° ′	° ′	
Including Soa and Canna	Least squares	71 9·7	67 23	0·625
	Equations of condition	71 9·1	68 7	0·670
Excluding Soa and Canna	Least squares	71 8·0	72 49	0·595
	Equations of condition	71 7·8	72 42	0·609

* A plan very similar to that above described was employed by Dr. VAN RIJCKEVORSEL in working up the results of his survey of the Indian Archipelago ('Magnetische Opneming van den Indischen Archipel in de Jaren 1874–77, gedaan door Dr. VAN RIJCKEVORSEL.' Amsterdam, J. MÜLLER, 1879).

These results prove that in this case, at all events, the differences between the results of the two methods of calculation are not greater than those produced in the numbers given by the method of least squares according as stations affected with considerable disturbances (23′ and 76′ respectively), and amounting to 4 per cent. only of the total number, are included or excluded.

We do not think, therefore, that it is in general advisable to use so cumbrous a method as that of least squares, when the addition of a station or two may modify the results to an extent far exceeding the error with which numbers obtained by the equations of condition are likely to be affected. If, however, the district under investigation is of such a shape that the effects of change of latitude and longitude respectively cannot be easily separated, it may be desirable either to modify the rule for obtaining the equations, or to employ least squares.

In the case of a district so large as Scotland there is another objection to the use of least squares, viz., that the fundamental assumption on which that method is based is almost certainly not true when applied to it. We shall show hereafter, as is indeed already known for other districts, that the errors are not irregularly distributed over the entire area, but that large fractions of the whole are affected with errors of a particular kind. We cannot, therefore, regard the employment of least squares as theoretically better, while it is certainly practically more inconvenient than the method of equations of condition. The following Table contains the boundaries of the nine districts, the latitudes and the longitudes of the central stations, the values of the Declination at the central stations (δ_0'), and of the change in Declination per degree of latitude and longitude ($d\delta'/dl$ and $d\delta'/d\lambda$) both expressed in minutes of arc.

TABLE V.

District.	Boundaries.		Central Station.		δ_0'.	$x = \frac{d\delta'}{dl}$.	$y = \frac{d\delta'}{d\lambda}$.
	Lat. N.	Long.	Lat. N.	Long. W.			
	° ° ′	° °	° ′	° ′	° ′	′	′
I.	All Scotland		56 48·0	4 19·0	21 38·8	14·5	40·1
II.	54 to 57	0 to 6 W.	55 27·3	3 41·6	20 55·6	16·7	36·4
III.	52 55	0 5 W.	53 26·7	2 26·0	19 39·0	15·5	33·6
IV.	50 53	2 E. 3 W.	51 47·7	0 17·5	18 6·6	17·4	28·9
V.	53 55 30	5 W. 10 W.	54 2·9	7 36·5	22 41·3	17·2	32·5
VI.	52 55	3 W. 8 W.	53 29·0	5 43·0	21 25·6	20·9	31·6
VII.	49 52	1 W. 6 W.	50 47·0	3 1·1	19 6·2	17·8	28·9
VIII.	51 54	5 W. 11 W.	52 57·1	8 13·1	22 35·0	27·3	30·1
IX.	50 53	3 W. 8 W.	51 49·5	4 47·4	20 19·7	22·4	29·2

In District I., on account of its irregular form, the method of equations of condition is not very suitable, and the method of least squares has been used. In order to compare this with the formula obtained by BALFOUR STEWART from WELSH'S observation the same coordinates have been employed as he used (the geographical-mile system), hence the values of $d\delta'/dl$ and $d\delta'/d\lambda$ can only be considered as applying to the central stations. By means of the first the Declination at any point on the meridian through that station can be calculated, and for other points on the parallel of latitude passing through such a point, the formula $y = y_0 \cos l / \cos l_0$ must be employed where y_0 and l_0 refer to the central station. In all the other districts the values of x and y are valid for the whole district.

By means of these formulæ the Declination was calculated for all points within the United Kingdom defined by whole degrees of longitude and half degrees of latitude, *e.g.*, for lat. 50° 30′, long. 2° E., 1° E., 0, 1° W., and so on. Where the districts overlapped the means of the numbers thus obtained were taken. All these values are given in the following table. The figures in brackets at the end of a row indicate the number of the district from which it was deduced. Where two or more districts overlap, the individual declinations are given in italics and the mean in ordinary type.

Throughout the central parts of the kingdom the agreement between the numbers given by the linear formulæ proper to different districts is sufficiently close to leave little doubt that the mean cannot be more than 1′ or 2′ wrong. Where greater differences appear it is generally easy to account for them. Thus, lat. 53° 30′, long. 10° W. is in the highly disturbed region in the west of Galway. Lat. 52° 30′, long. 0°, is close to a remarkable and hitherto unsuspected disturbance in the eastern counties, of which we shall have more to say hereafter. The large differences on the border of Districts I. and II. (lat. 56° 30′) are, perhaps, in part due to the irregularities in the shapes of these districts owing to which the formulæ are not obtained under favourable conditions. Both the other elements, however, agree with the Declination in indicating violent local disturbance in this region, and there can be no doubt that the discrepancies are due to a physical cause.

TABLE VI.—Declinations Calculated

Lat.	Longitude.					
	10° W.	9°	8°	7°.	6°.	5°.
° ′ 60 30	° ′	° ′	° ′	° ′	° ′	° ′
59 30						
58 30				(1) 23 46·2	23 7·9	22 29·6
57 30			(1) 24 13·7	23 34·4	22 55·1	22 15·8
56 30			(1) 24 2·8	23 22·4	*22 42·0* (2) *22 38·1* 22 40·0	*22 1·6* *22 1·7* 22 1·6
55 30			(5) 23 18·7	22 46·3	(2) *22 21·4* *22 13·8* (5) 22 17·6	21 45·0
54 30		(5) 23 34·0	23 1·5	*22 29·0* (6) *22 27·4* 22 28·2	(2) *22 4·7* *21 56·5* (5) *21 55·8* 21 59·0	*21 28·3* *21 24·2* 21 26·2
53 30	(5) *23 49·2* (8) *23 43·7* 23 46·4	*23 16·8* *23 13·6* 23 15·2	*22 43·3* *22 43·5* 22 43·4	*22 11·8* (6) *22 6·5* *22 13·4* 22 10·6	*21 39·3* (5) *21 34·9* *21 43·3* (8) 21 39·2	21 3·4
52 30	(8) 23 16·4	22 46·3	22 16·2	(6) *21 45·6* *21 46·1* (9) *21 39·4* 21 43·4	*21 14·0* *21 16·0* (8) *21 10·2* 21 13·4	*20 42·4* *20 41·0* 20 41·7
51 30	(8) 22 49·1	22 19·0	21 48·9	*21 18·8* (9) *21 17·0* 21 17·9	*20 48·7* (8) *20 47·8* 20 48·2	*20 18·6* (7) *20 16·3* 20 17·4
50 30				(9) 20 54·6	20 25·4	*19 56·2* (7) *19 58·5* 19 57·3
49 30						(7) 19 40·7

from the District Lines.

Longitude.							Lat.
4°.	3°.	2°.	1°.	0°.	1°E.	2°.	
° ′	(1) 21° 46′·6	21° 10′·0	20° 34′·0	19° 58′·0 (1)	° ′	° ′	60° 30′
(1) 22 6·2	21 29·2	20 52·0	20 14·9 (1)				59 30
21 51·4	21 13·2	20 34·9	19 56·7 (1)				58 30
21 36·5	20 57·2	20 17·9	19 38·6 (1)				57 30
21 21·2 *21 25·3* 21 23·2	*20 40·8* *20 48·9* 20 44·8	*20 0·4* *20 12·5* 20 6·4	*19 20·0* (1) *19 36·1* (2) 19 28·0				56 30
21 8·6	20 32·2	19 55·8	19 19·4 (2)				55 30
20 51·9 (3) *20 47·9* *20 52·7* (6) 20 50·8	*20 15·5* *20 14·3* 20 14·9	*19 39·1* *19 40·7* 19 39·9	*19 2·7* (2) *19 7·1* 19 4·9	18 33·5 (3)			54 30
(3) *20 32·4* *20 31·8* (6) 20 32·1	19 58·8	19 25·2	18 51·6	18 18·0 (3)			53 30
20 10·8 (6) (3) *20 16·9* *20 11·8* 20 13·2	*19 43·3* (4) *19 37·1* *19 42·6* (9) 19 41·0	*19 9·7* *19 8·2* 19 9·0	*18 36·1* *18 39·3* 18 37·7	*18 2·5* (3) *18 10·4* 18 6·4	17 41·5	17 12·6 (4)	52 30
19 49·4 *19 47·4* 19 48·4	*19 20·2* (9) (4) *19 19·7* *19 18·5* 19 19·5	*18 50·8* *18 49·6* 18 50·2	*18 21·9* *18 20·7* (7) 18 21·3	17 53·0	17 24·1	16 55·2 (4)	51 30
19 27·0 *19 29·6* 19 28·3	*18 57·8* (9) (4) *19 2·3* *19 0·7* 19 0·3	*18 33·4* *18 31·8* 18 32·6	*18 4·5* *18 2·9* (7) 18 3·7	17 35·6	17 6·7	16 37·8 (4)	50 30
19 11·8	18 42·9	18 14·0	17 45·1 (7)				49 30

Isogonal lines were next drawn by the aid of the mean values of the Declination given in this Table, the points at which they intersect any particular line of latitude or longitude being calculated on the assumption that the rate of change of the Declination with latitude or longitude may be regarded as constant over a single degree. The curves thus obtained are shown in dotted lines in Plate II. As they were deduced from the linear district formulæ they may be called the *district curves.*

By drawing a smooth curve to coincide as nearly as possible with any one of the longer of these broken district curves, a close approximation to the corresponding isogonal could be obtained, but in order that the intervals between the curves might be properly spaced out, it was thought better to obtain a general formula by which they could be expressed.

It appears from Table V., p. 236, that y increases with the latitude, but is nearly independent of the longitude. The values of x are more irregular. After several trials it was found that the mean Declinations at the central stations of the various districts could be reproduced very accurately by means of the formula,

$$\delta = 19^\circ\ 11' + 19'\cdot1\ (l - 49\cdot5) - 3'\cdot5 \cos\{45^\circ\ (l - 49\cdot5)\}$$
$$+ \{26'\cdot6 + 1'\cdot5\ (l - 49\cdot5)\}\ (\lambda - 4),$$

where l and λ are the numerical values of the latitude and longitude expressed in degrees and fractions of a degree.

It must be distinctly understood that this formula has no theoretical value except in so far as it expresses satisfactorily the equation to smooth curves drawn according to a definite rule to represent the general form of the broken district curves.

In applying it to the various stations the curves given by the periodic terms were drawn, and the values corresponding to the latitude and longitude of each read off. It is possible that errors of 0′·2 or 0′·3 may have occurred in this process. The mean values of the Declinations at the central stations of each district are in the following Table compared with the results given by the formula.

District.	Declination at central station.		Difference.
	Mean of values observed in district.	Calculated.	
	° ′	° ′	′
I.	21 38·8	21 39·4	− 0·6
II.	20 55·6	20 54·1	+ 1·5
III.	19 39·0	19 38·9	+ 0·1
IV.	18 6·6	18 4·4	+ 2·2
V.	22 41·3	22 41·5	− 0·2
VI.	21 25·6	21 26·5	− 0·9
VII.	19 6·2	19 5·6	+ 0·6
VIII.	22 35·0	22 34·4	+ 0·6
IX.	20 19·7	20 19·8	− 0·1

In District III. we included Stonyhurst; in District IV. Greenwich, Kew, and Berck-sur-Mer, and in District VII., Cherbourg. The data for the French stations were those given by M. MOUREAUX, reduced, of course, to January 1, 1886.

The values of the constants in the equation were not finally chosen until the Declination had been determined by means of a preliminary formula closely agreeing with that given above for all the points indicated in Table VI., pp. 238–9, and the values given by it and by the district curves compared. Over the greater part of the country the agreement is extremely close. It is not necessary to reproduce the numbers here, as in Plate II. we have plotted down both the broken district curves, and also the smooth curves given by the equation. The former are dotted, the latter are continuous lines. The agreement is all that can be desired, except, perhaps, on the coast of Norfolk, and on the west and north coasts of Scotland.

Taking, however, the English Channel first into consideration, we have calculated the points at which our 16° 53′, 17° 53′, etc., isogonals cut lat. 50°. When secular change is thus allowed for, these correspond to the positions of the 17°, 18° isogonals on January 1, 1885, *i.e.*, with those of M. MOUREAUX. We have also measured the corresponding points from his map. The result is shown in the following Table :—

Isogonal Jan. 1, 1885.	Longitude from Greenwich.	
	R. and T.	MOUREAUX.
°	° ′	° ′
17	1 17 E.	1 9 E.
18	0 55 W.	0 57 W.
19	3 7 W.	2 55 W.
20	5 19 W.	4 58 W.

The 20° isogonal does not pass through France, and, therefore, M. MOUREAUX's map is not of special authority on its direction, but there seems no doubt that while the 18° isogonals cut latitude 50° at the same point, there is a considerable divergence between the others.

According to the general formula, 27′·35 is the change of Declination per degree of longitude on lat. 50°. The two Channel Districts in Table V., p. 236, viz., VII. and IV. agree in giving 28′·9 for this number, and if we take this as correct and adhere to 55′ W. for the 18° isogonal, we obtain the following values :—

Isogonal.	R. and T.	MOUREAUX.
°	° ′	° ′
17	1 10 E.	1 9 E.
18	0 55 W.	0 57 W.
19	3 0 W.	2 55 W.
20	5 5 W.	4 58 W.

These are in much better accord than those obtained from the general formula, and the conclusions which may be drawn from them are that in latitude 50°,

(1.) M. MOUREAUX's lines are certainly not too far to the west;

(2.) And our 17° isogonal is not too far to the west.

Both these conclusions are important. M. MOUREAUX believes that there is what we should call a considerable regional disturbance in Brittany. The isogonals drawn by him sweep out to the west in the western part of France and do not resume their normal course until they have reached the English coast. In the English Channel, therefore, they are deflected to the west, and as both our district lines, and to a much more marked extent our terrestrial lines are still further west, it is evident that M. MOUREAUX has not in any way exaggerated the westerly tendency of the lines in the western parts of the Channel, and that, therefore, our observations tend to confirm his view. It is probable that our terrestrial curves are in this district a little too far to the west, but it must be remembered that lat. 50° is almost outside the region of our survey, and that in the Channel Isles, which with Cherbourg, are our only stations to the south of it, there are considerable disturbances.

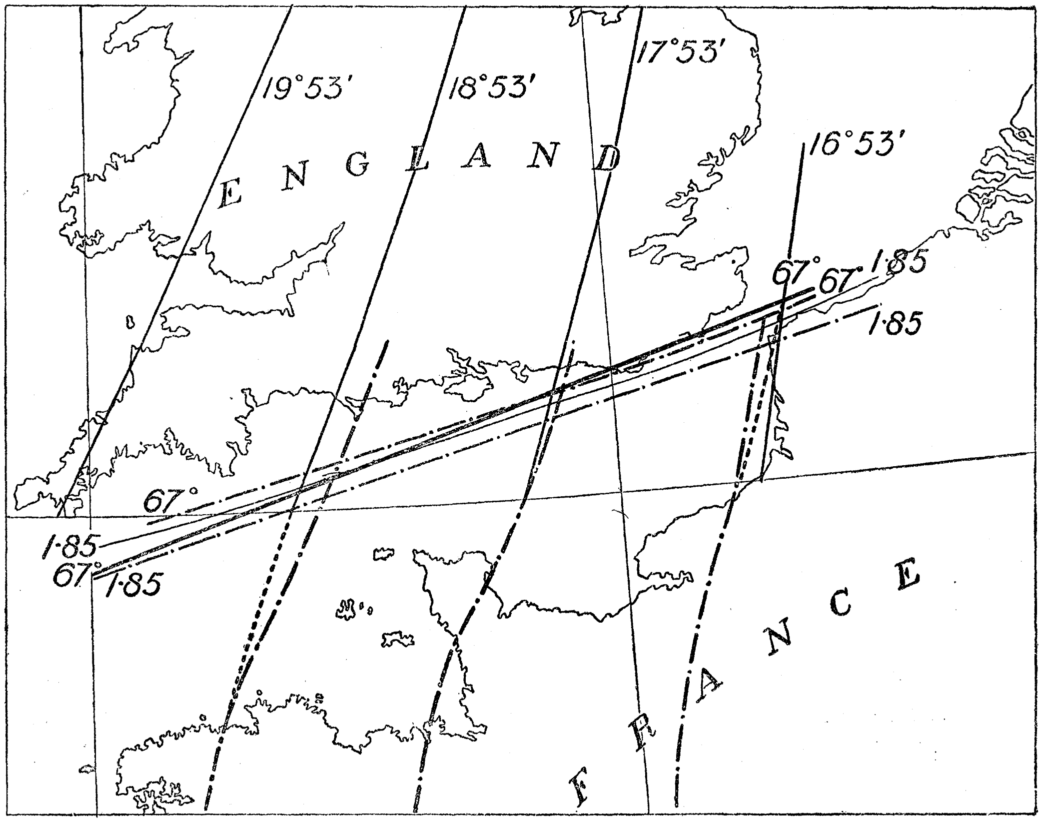
In fig. 2 the continuous lines are our terrestrial isogonals, which on January 1, 1886, corresponded to M. MOUREAUX's 17°, 18°, etc., isogonals on January 1, 1885, the secular change being about 7'. M. MOUREAUX's curves are shown with dashes and dots, and the hypothetical connections in dots. A satisfactory comparison on the borders of the areas of two surveys cannot, however, be made unless there is a closer agreement in the methods of working up the results of the observations than there is between our own and M. MOUREAUX's.

Coming next to the 17° isogonal, we find that on the coast of Norfolk the calculated Declinations are generally much lower than the observed values. This would be remedied by moving the 17° isogonal further to the east, but the fact that it is already to the east of M. MOUREAUX's line is a strong argument against such a course.

It is noticeable that Sir FRED. EVANS appears to have found some difficulty in this part of the country ('Phil. Trans.,' 1872, vol. 162, p. 330). His curves are shown in Plate II. The points at which the isogonals cut lat. 52° are given below, and it will be seen that the distance between them is a maximum in the centre of England.

Isogonal (1872).	Long.	Difference of Long.
°	°	°
25	9·54 W.	
24	7·86	1·68
23	6·16	1·70
22	4·40	1·76
21	2·40	2·00
20	0·40	2·00
19	1·47 E.	1·87

Fig. 2.



Isomagnetics in the border district of the English and French Surveys,
——— R. and T., —·—·—·— MOUREAUX, ... hypothetical connections.

We think the agreement between our calculated and observed curves is too close to leave any doubt that in this and neighbouring latitudes the law that the distance between the points of intersection with a line of latitude is constant is very approximately true. At all events, there is no trace of a change in this distance amounting to a quarter of a degree as is shown by the 1872 lines. As the observations on which Sir F. EVANS's map were based were comparatively few in number and were made exclusively at coast stations the accurate delineation of the isogonals was not easy. He makes the observed Declinations too small in the eastern counties. If the distances between the isogonals had been kept constant the 19° line would have been pushed further to the west, and a closer agreement with our observations would have been attained. Considering the circumstances under which Sir F. EVANS's map was drawn, we think the concordance between the general directions of the lines is satisfactory. We are also of opinion that our 17° isogonal is not too far to the west, and that the fact that in the eastern counties the calculated are less than the observed Declinations is due to a real physical cause. M. MOUREAUX's results confirm our own as to the 18° isogonal, and if we suppose that the easterly tendency of the lines which he assumes in the western parts of the English Channel is continued to the Straits of Dover, his 17° isogonal and our own would be in practical accord.

As regards the considerable deviation between the district and calculated terrestrial lines in the North of Scotland, we have no hesitation in adhering to the calculated lines as being probably the more correct. The masses of basalt and other igneous rocks which occur in the West of Scotland and North of Ireland produce a very marked effect on the magnetic elements. The general formula gives the Declination at the outlying station at Lerwick almost as accurately as the local district equations obtained from Scotland only. The three values are :—

		°	′
Observed Declination		20	29·7
Calculated by	Local formula	20	31·3
	General formula	20	33·7

Regarding this station as giving a fixed point it is evident that in drawing the curves to it from the South of Scotland, great weight ought to be given to the general law which is found to be obeyed with accuracy in Great Britain from the English Channel to the Tay, and in the South and East of Ireland. The only way of eliminating the effect of regional disturbances of such magnitude as these which exist in Scotland, is by studying the shape of the terrestrial lines in adjacent districts. Observations to the north of Scotland would be very valuable for this purpose, but as it would be difficult to obtain them we think that the results of the general formula must be accepted as a close approximation to the truth. We shall return to this subject in the discussion of local disturbances.

(2.) *The Isoclinal Lines.*

The isoclinals were obtained in a precisely similar manner to that above described. The districts were the same, but the positions of the central stations were in some cases slightly different, as at a few places Dips had been observed without Declinations and *vice versâ*.

In District VII. the inclusion of the Channel Isles led to rates of change with latitude and longitude so widely different from those obtained elsewhere that it was thought better to omit them. When this was done the coefficients assumed normal values. We give in the next Table the latitude and longitude of the central stations, and the corresponding values of the Dips, and the rates of change of Inclination per degree of latitude and longitude.

TABLE VII.

District.	Central Station.		$D = \theta_0'$.	$x = \frac{d\theta'}{dl}$.	$y = \frac{d\theta'}{d\lambda}$.
	Lat. N.	Long. W.			
I.	56° 48′·0	4° 19′·0	71° 8′·0	34′·1	5′·8
II.	55 27·3	3 41·6	70 19·6	31·9	8·2
III.	53 26·7	2 26·0	69 3·0	36·1	7·1
IV.	51 47·7	0 17·4	67 45·6	40·8	7·6
V.	54 1·4	7 39·3	69 59·8	38·3	9·8
VI.	53 26·7	5 42·0	69 24·8	36·2	6·3
VII.	51 8·1	3 9·6	67 41·2	38·8	6·6
VIII.	52 57·1	8 13·1	69 24·3	38·7	8·5
IX.	51 49·5	4 47·4	68 18·2	39·1	6·8

A general formula was next found to embrace the whole country. For this purpose a Table similar to Table VI., pp. 238–9, was prepared, and the district isoclinal lines were drawn from it on curve paper, on a purely artificial system, in which all degrees of latitude and longitude were regarded as of equal length. When thus drawn the mean directions of the isoclinals were nearly straight lines and practically parallel.

The equation to the 67° isoclinal was

$$l - 49^\circ{\cdot}92 + 0{\cdot}2\,(\lambda - 4) = 0,$$

where l and λ are the latitude and longitude expressed in degrees and fractions of a degree. If then s be the length of the perpendicular on this line from any point, the Dip at the station indicated by that point would (if the lines were equidistant) be given by the equation

$$\theta = 67 + \mathrm{A}s,$$

where A is a constant. This condition was not fulfilled. The distance between the lines increased approximately in the proportion of their distance from the 67° line, but a small periodic term was necessary in addition to this correction to produce the desired accuracy.

The following plan was finally adopted :—

If we write

$$p = l - 49{\cdot}92 + 0{\cdot}2\,(\lambda - 4)$$

and

$$q = p - 0{\cdot}1 \sin(20\,p)$$

we get the Dip in degrees from the equation

$$\theta = 67^\circ + \frac{1{\cdot}0083\,q}{1{\cdot}456 + 0{\cdot}03\,q}.$$

The Dips given by this formula for the central stations in each district are, in the following Table compared with those given in Table VII., p. 245.

District.	Inclination at Central Station.		Difference.
	Mean of Values observed in District.	Calculated.	
I.	71° 8'·0	71° 10'·3	−2'·3
II.	70 19·6	70 21·2	−1·6
III.	69 3·0	69 1·8	+1·2
IV.	67 45·6	67 44·5	+0·9
V.	69 59·8	69 59·3	+0·5
VI.	69 24·8	69 25·3	−0·5
VII.	67 41·2	67 41·2	0·0
VIII.	69 24·3	69 25·6	−1·3
IX.	68 18·2	68 19·7	−1·5

In Plate III. we show the broken curves obtained by the district lines and also the terrestrial isoclinals as represented by the formula.

The agreement is on the whole satisfactory, but it is possible that a closer approximation to the true terrestrial lines might have been obtained had we made the inclination to the geographical meridian increase rather more rapidly in the west. This would have diminished the discrepancy in the south of Ireland. On the other hand it would have considerably increased it in the north of Ireland and the central districts of Scotland, in which large regional disturbances undoubtedly exist. It does not, however, appear to be safe to depart from the rule that the terrestrial lines deduced from any survey should give, as nearly as possible, the mean directions of the true lines in the district under investigation. This end is better attained by our formulæ than if the agreement were closer in the south of Ireland.

Our 67° isoclinal agrees almost exactly with that of M. MOUREAUX in the more easterly parts of the English Channel (see fig. 2, p. 243). Both just cut Dungeness and Beachy Head. For the longitude of Falmouth, however, our line is 10 or 12 miles to the south of that of M. MOUREAUX.

As it is at this point much nearer to the English than the French coast, our result is probably the more trustworthy, and this opinion is confirmed by a study of the map of the French Survey. The isoclinals drawn by M. MOUREAUX upon a map on Mercator's projection are curved in the south of France, the convexity being towards the north. The curvature becomes less as the Dip increases, and the 67° line is represented as quite straight. M. MOUREAUX cannot have much to guide him in drawing this line, and a divergence such as that which exists between his line and ours could easily be introduced by an apparently trifling error in the estimation of the rate of disappearance of the curvature of the lines. Our lines would be slightly concave to the north if drawn upon a map on Mercator's projection.

(3.) *Lines of equal Horizontal Force.*

These lines were treated in the same way as the isogonals and isoclinals, and in the following Table the constants for the nine districts are tabulated as before. As Professor BALFOUR STEWART did not deduce the lines of equal Horizontal Force from Mr. WELSH's observations, there was not as much reason in this case as in the others for taking the whole of Scotland as District I. We therefore included in this district only all stations north of lat. 56°.

District.	Central Station.		H_0'.	$x = \frac{dH}{dl}$.	$y = \frac{dH}{d\lambda}$.
	Lat. N.	Long. W.			
I.	57° 26'·3	4° 30'·0	1·5580	−0·03930	−0·00575
II.	55 27·3	3 41·6	1·6363	−0·03324	−0·00882
III.	53 26·7	2 26·0	1·7164	−0·03868	−0·00661
IV.	51 47·7	0 17·4	1·7970	−0·04374	−0·00620
V.	54 2·9	7 36·5	1·6650	−0·04380	−0·01046
VI.	53 29·0	5 43·0	1·6979	−0·03771	−0·00439
VII.	50 49·3	2 57·6	1·8212	−0·04134	−0·00598
VIII.	52 57·1	8 13·1	1·7053	−0·04237	−0·00628
IX.	51 49·5	4 47·4	1·7694	−0·04212	−0·00598

By means of these data a Table like Table VI., pp. 238–9, was prepared, and lines of equal Horizontal Force were drawn on curve paper as in the case of the isoclinals (see p. 245). These at once showed that the lines above and below that corresponding to 1·7 units were differently disposed. The mean direction of each of the southern lines can be accurately represented by a linear function of the latitude and longitude, their departure from parallelism is not great, and their mean distances are nearly the same. On the other hand, though the lines in District I., *i.e.*, in the extreme north of Scotland, are parallel to the 1·7 line, which runs from the neighbourhood of Miltown Malbay to that of Scarborough, the intermediate isodynamics make smaller angles with the geographical meridian, and their average distance is greater than in the south. It is, however, difficult to decide what is the direction of the terrestrial lines. Too much weight must not be attached to the fact that the lines in the north of Scotland agree with those in the Midlands and south of England, as they are deduced from a single district of irregular form and the seat of great local and regional disturbances. There is also reason to suppose from what is known of the lines of equal Horizontal Force on the continent that the distance between them increases towards the east, and those crossing England are so represented on M. MOUREAUX's map. It may well be, therefore, that the diverging lines are those which agree most closely with the terrestrial lines of equal Horizontal Force.

On the whole then, the risk of introducing fictitious disturbances by attempting to include the whole country under one simple law would be very great.

We decided, therefore, in calculating the lines of equal Horizontal Force, to employ different formulæ for districts to the north and south of the 1·7 line.

Taking the southern district first, the lines may be regarded as straight, but, inasmuch as they run across the whole breadth of the kingdom, a very small error in the calculated slope is important. A rather complicated formula is therefore unfortunately necessary.

If c be the mean distance, expressed in degrees of latitude and measured along longitude 5° W., between any line and that which corresponds to 1·85 units, we have a relation of the form

$$1{\cdot}85 - \mathrm{H} = ac,$$

where a is a constant.

The 1·85 line cuts longitude 5° W. in latitude 49°·83, and thus the equation to the isodynamic through c is

$$l - 49{\cdot}83 = -(\lambda - 5)\,m + c,$$

where m measures the slope of the line.

Neither a nor m are quite constant, but both are functions of c, so that

$$1/a = 24{\cdot}47\left(1 + \frac{c}{1000}\right);$$

$$m = {\cdot}157 - {\cdot}0019c - {\cdot}0155 \sin(50c).$$

Thus, if we wish to find where the line corresponding to H cuts longitude λ, we find c from the equation

$$c = 24{\cdot}47\,(1{\cdot}85 - \mathrm{H}) + 0{\cdot}001\,c^2,$$

where the value of c, used in the small term in c^2, is the approximate value obtained by neglecting it. From this m is found, and l is then known.

If the latitude and longitude are given, and the Horizontal Force is required, we first find c approximately from the formula

$$c' = l - 49{\cdot}83 + 0{\cdot}157\,(\lambda - 5).$$

Subtracting from this

$$c'' = (\lambda - 5)\,\{0{\cdot}0019\,c' + 0{\cdot}0155 \sin(50\,c')\},$$

the difference is c, whence H is found.

Taking next the district north of the 1·7 line, there is no particular difficulty in finding similar equations to express the mean direction of the lines with great exactitude. If we write

$$1 \cdot 7 - \mathrm{H} = 0 \cdot 036854\, c,$$
$$l - 53 \cdot 514 = - m (\lambda - 5) + c,$$
$$m = \cdot 151 + \cdot 07 \sin (45\, c),$$

all that can be desired in this respect is attained.

These equations do not, however, give the forces at the central stations with the accuracy attained in the southern districts. Far better results are obtained if we assume that the lines are parallel to the 1·7 line and are at equal distances from each other. In this case m is constant, and, in addition to the first of the above equations, we have only

$$l - 53 \cdot 514 = - 0 \cdot 151 (\lambda - 5) + c.$$

The values obtained from the central stations by both formulæ are given in the following Table :—

District.	Horizontal Force at central stations in northern districts deduced from		
	Mean of all stations in district.	Formula with m variable.	Formula with m constant.
I.	1·5580	1·5583	1·5582
II.	1·6363	1·6390	1·6358
V.	1·6650	1·6608	1·6658
VI.	1·6979	1·6971	1·6972

We have, therefore, to choose between two formulæ. The simpler represents the lines throughout Scotland as practically parallel, both with those which in the south extend right across the kingdom without considerable curvature and with those found by the district equations for the north of Scotland, and also reproduces the values of the Horizontal Force at the central stations with great accuracy. The more complex expression represents the mean directions of the lines in the centre of Scotland and north of Ireland more satisfactorily, though these are obviously affected by some widespread disturbance, but it fails when tried by the test of the reproduction of the forces at the central stations. We think there can be no question that, under these circumstances, the simpler formula, which assigns directions to the lines in harmony with those obtained in other parts of the kingdom, must be that selected ; and we have therefore employed it.

In the following Table the values of the Horizontal Forces at the central stations are compared with the calculated values given by the formulæ—

$$1·85 - H = c\,(1 - 0·001\,c)\,/24·47$$

and

$$l - 49·83 = c - m\,(\lambda - 5)$$

and

$$m = 0·157 - 0·0019\,c - 0·0155 \sin\,(50\,c)$$

for values of $H > 1·7$, and by

$$1·7 - H = 0·036854\,c$$

and

$$l - 53·514 = c - 0·151\,(\lambda - 5)$$

for values of $H < 1·7$.

The difference between the observed and calculated results in District VIII. (South Ireland), is larger than in the other cases. It must, however, be remembered that it is absolutely very small. Thus, if the disturbed stations at Galway (which have been excluded from the calculations) were introduced, the difference would be reduced from ·0022 to ·0007. As the effect of one station is so great, it is remarkable that the discrepancies are not larger.

District.	Horizontal Force at central stations.		Difference in terms of 0·0001.
	Mean of values observed in district.	Calculated.	
I.	1·5580	1·5582	− 2
II.	1·6363	1·6358	+ 5
III.	1·7164	1·7180	−16
IV.	1·7970	1·7969	+ 1
V.	1·6650	1·6658	− 8
VI.	1·6979	1·6972	+ 7
VII.	1·8212	1·8218	− 6
VIII.	1·7053	1·7031	+22
IX.	1·7694	1·7698	− 4

We conclude this section with a Table, which gives the observed and calculated elements at every station.

In the calculations, graphic methods have been partly used, and, in some cases, this may have led to slight differences (which are, however, so small as to be quite unimportant) between the values given and those which would be deduced directly from the formulæ.

SUMMARY of Declinations, Inclinations, Horizontal and Vertical Forces, Observed and Calculated, with Differences.

Scotland.

Station.		Declination.			Inclination.			Horizontal Force.			Vertical Force.			No. of Station.
No.	Name.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	
1	Aberdeen . . .	20° 16′·3	20° 21′·0	− 4′·7	71° 12′·3	71° 7′·7	+ 4′·6	1·5734	1·5813	−·0079	4·6232	4·6260	−·0028	1
2	Arinagower (Coll)	23 40·4	22 58·2	+42·2	..	71 18·8	..	..	1·5772	..	..	..	..	2
3	L. Aylort . . .	23 16·5	22 35·4	+41·1	71 24·0	71 21·5	+ 2·5	1·5663	1·5726	−·0063	4·6542	4·6617	−·0075	3
4	Ayr	21 17·9	21 26·8	− 8·9	70 21·4	70 27·8	− 6·4	1·6345	1·6300	+·0045	4·5792	4·5937	−·0145	4
5	Ballater . . .	20 29·5	20 55·3	−25·8	71 15·4	71 10·0	+ 5·4	1·5714	1·5809	−·0095	4·6309	4·6350	−·0041	5
6	Banavie . . .	22 6·7	22 9·5	− 2·8	71 11·4	71 17·0	− 5·6	1·5940	1·5764	+·0176	4·6797	4·6529	+·0268	6
7	Banff	21 4·5	20 46·1	+18·4	71 19·0	71 26·7	− 7·7	1·5684	1·5610	+·0074	4·6381	4·6505	−·0124	7
8	Berwick . . .	19 36·4	19 57·9	−21·5	70 15·9	70 20·2	− 4·3	1·6483	1·6336	+·0147	4·5947	4·5717	+·0230	8
9	Boat of Garten .	22 7·7	21 26·1	+41·6	71 16·3	71 21·2	− 4·9	1·5786	1·5693	+·0093	4·6562	4·6506	+·0056	9
10	L. Boisdale . .	22 53·3	23 39·2	−45·9	71 39·3	71 40·9	− 1·6	1·5310	1·5530	−·0220	4·6172	4·6908	−·0736	10
11	Bunnahabhain .	23 10·3	22 29·0	+41·3	70 43·0	70 52·1	− 9·1	1·6243	1·6063	+·0180	4·6427	4·6305	+·0122	11
12	Callernish . . .	23 40·6	23 40·9	− 0·3	72 7·1	72 9·4	− 2·3	1·5236	1·5191	+·0045	4·7223	4·7192	+·0031	12
13	Campbelton . .	22 8·1	22 1·2	+ 6·9	70 34·2	70 33·4	+ 0·8	1·6244	1 6259	−·0015	4·6050	4·6059	−·0009	13
14	Canna (mean) .	23 13·0	23 6·5	+ 6·5	72 45·0	71 32·7	+72·3	1·5092	1·5607	−·0515	4·8605	4·6766	+·1839	14
15	Carstairs . . .	20 52·2	20 56·8	− 4·6	70 15·7	70 29·0	−13·3	1·6448	1·6276	+·0172	4·5841	4·5920	−·0079	15
16	Crianlarich . .	21 50·6	21 43·2	+ 7·4	70 52·5	70 58·8	− 6·3	1·5980	1·5961	+·0019	4·6083	4·6302	−·0219	16
17	Crieff	21 33·6	21 14·1	+19·5	70 53·6	70 53·2	+ 0·4	1·6079	1·6010	+·0069	4·6416	4·6199	+·0217	17
18	Cumbrae . . .	21 37·2	21 42·6	− 5·4	71 2·3	70 40·9	+21·4	1·5911	1·6159	−·0248	4·6310	4·6095	+·0215	18
19	Dalwhinnie . .	21 45·5	21 38·6	+ 6·9	71 0·1	71 14·0	−13·9	1·5909	1·5784	+·0125	4·6207	4·6454	−·0247	19
20	Dumfries . . .	20 47·4	20 43·9	+ 3·5	70 2·6	70 6·2	− 3·6	1·6542	1·6519	+·0023	4·5555	4·5642	−·0087	20
21	Dundee	20 44·5	20 42·7	+ 1·8	70 52·2	70 50·5	+ 1·7	1·6002	1·6024	−·0022	4·6132	4·6122	+·0010	21
22	Edinburgh . . .	20 47·2	20 44·4	+ 2·8	70 38·5	70 35·2	+ 3·3	1·6183	1·6195	−·0012	4·6061	4·5954	+·0107	22
23	Elgin	20 57·5	21 16·5	−19·0	71 32·0	71 31·2	+ 0·8	1·5577	1·5574	+·0003	4·6644	4·6599	+·0045	23
24	L. Eriboll . . .	22 18·1	22 26·3	− 8·2	72 9·4	72 6·2	+ 3·2	1·5198	1·5190	+·0008	4·7214	4·7039	+·0175	24
25	Fairlie	..	21 40·4	..	70 42·8	70 39·3	+ 3·5	1·6172	1·6176	−·0004	4·6222	4·6087	+·0135	25
26	Fort Augustus .	21 45 6	21 59·2	−13·6	71 27·7	71 23·8	+ 3·9	1·5641	1·5680	−·0039	4·6641	4·6584	+·0057	26
27	Gairloch . . .	22 14·4	22 59·0	−44·6	71 44·3	71 49·9	− 5·6	1·5353	1·5417	−·0064	4·6528	4·6979	−·0451	27
28	Glasgow . . .	21 11·5	21 22·4	−10·9	70 44·7	70 39·6	+ 5·1	1·6064	1·6169	−·0105	4·5988	4·6068	−·0080	28
29	Golspie	21 30·2	21 48·5	−18·3	71 46·7	71 45·8	+ 0·9	1·5382	1·5417	−·0035	4·6725	4·6790	−·0065	29
30	Hawick	20 16·0	20 22·0	− 6·0	70 7·3	70 14·4	− 7·1	1·6487	1·6416	+·0071	4·5598	4·5697	−·0099	30
31	L. Inver . . .	22 7·4	22 42·7	−35·3	72 0·2	71 59·6	+ 0·6	1·4990	1·5276	−·0286	4·6143	4·6996	−·0853	31
32	Inverness . . .	21 43·3	21 48·3	− 5·0	71 31·1	71 31·4	− 0·3	1·5642	1·5585	+·0057	4·6798	4·6642	+·0156	32

Scotland (continued)

Station.		Declination.			Inclination.			Horizontal Force.			Vertical Force.			No. of Station.
No.	Name.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	
33	Iona	° ′ 23 28·6	° ′ 22 47·7	′ + 40·9	° ′ 70 55·8	° ′ 71 8·7	′ −12·9	1·6185	1·5883	+·0302	4·6711	4·6509	+·0202	33
34	Kirkwall	21 29·3	21 27·9	+ 1·4	72 12·8	72 11·0	+ 1·8	1·5108	1·5100	+·0008	4·7093	4·6984	+·0109	34
35	Kyle Akin	23 10·4	22 42·4	+ 28·0	71 38·5	71 34·8	+ 3·7	1·5465	1·5577	−·0112	4·6603	4·6771	−·0168	35
36	Lairg	21 50·3	22 6·3	− 16·0	71 50·3	71 50·1	+ 0·2	1·5356	1·5370	−·0014	4·6811	4·6845	−·0034	36
37	Lerwick	20 29·7	20 33·7	− 4·0	72 47·1	72 35·3	+11·8	1·4710	1·4770	−·0060	4·7476	4·7098	+·0378	37
38	Lochgoilhead	21 54·2	21 49·5	+ 4·7	70 46·1	70 53·4	− 7·3	1·6021	1·6025	−·0004	4·5924	4·6252	−·0328	38
39	L. Maddy	23 18·0	23 34·3	− 16·3	71 52·1	71 54·1	− 2·0	1·5365	1·5372	−·0007	4·6921	4·7035	−·0114	39
40a	Oban	22 9·4	22 15·4	− 6·0	70 53·2	71 5·4	−12·2	1·6044	1·5904	+·0140	4·6297	4·6426	−·0129	40a
40b	„ (Kerrera)	22 11·9	22 16·4	− 4·5	70 48·8	71 5·7	−16·9	1·6103	1·5896	+·0207	4·6276	4·6416	−·0140	40b
41	Pitlochrie	21 8·3	21 15·4	− 7·1	70 57·4	71 3·2	− 5·8	1·5899	1·5895	+·0004	4·6061	4·6303	−·0242	41
42	Port Askaig	23 0·7	22 27·6	+ 33·1	70 36·2	70 50·6	−14·4	1·6340	1·6073	+·0267	4·6409	4·6268	+·0141	42
43a	Portree	25 1·1	23 3·0	+118·1	72 18·4	..	+36·5	1·5177	1·5500	−·0323	..	..	..	43a
43b	„	22 45·6	23 2·5	− 16·9	71 8·6	71 41·9	−33·3	1·5876	1·5500	+·0376	4·7517	4·6863	+·0654	43b
43c	„	20 14·3	23 2·9	−168·6	72 36·6	..	+54·7	1·5211	1·5500	−·0289	..	..	..	43c
44	Row (Gairloch)	21 47·7	21 42·5	+ 5·2	70 51·0	70 47·5	+ 3·5	1·5978	1·6096	−·0118	4·6012	4·6200	−·0188	44
45	Scarnish (Tiree)	24 27·9	23 5·7	+ 82·2	71 19·4	71 16·8	+ 2·6	1·5909	1·5798	+·0111	4·7063	4·6619	+·0444	45
46	Soa	23 14·9	22 56·5	+ 18·4	71 59·6	71 34·0	+25·6	1·5072	1·5583	−·0511	4·6368	4·6753	−·0385	46
47	Stirling	21 28·6	21 13·9	+ 14·7	70 53·3	70 45·3	+ 8·0	1·5945	1·6097	−·0152	4·6015	4·6107	−·0092	47
48a	Stornoway (Ard Point)	24 16·3	23 29·3	+ 47·0	72 10·5	72 8·2	+ 2·3	1·5196	1·5193	+·0003	4·7259	4·7141	+·0118	48a
48b	Stornoway (Castle)	24 7·6	23 29·4	+ 38·2	72 9·1	72 8·4	+ 0·7	1·5146	1·5193	−·0047	4·7038	4·7151	−·0113	48b
49	Strachur	21 48·9	21 56·1	− 7·2	70 42·9	70 54·6	−11·7	1·6095	1·6013	+·0082	4·5999	4·6268	−·0269	49
50	Stranraer	21 35·0	21 31·9	+ 3·1	70 13·5	70 11·7	+ 1·8	1·6435	1·6481	−·0046	4·5713	4·5765	−·0052	50
51	Stromness	21 27·9	21 41·1	− 13·2	72 11·7	72 12·3	− 0·6	1·5149	1·5093	+·0056	4·7169	4·7023	+·0146	51
52	E. L. Tarbert	22 4·3	22 2·4	+ 1·9	70 46·8	70 46·7	+ 0·1	1·6053	1·6107	−·0054	4·6047	4·6197	−·0150	52
53	Thurso	21 38·4	21 42·9	− 4·5	72 1·1	72 2·4	− 1·3	1·5217	1·5212	+·0005	4·6883	4·6930	−·0047	53
54	Wick	21 15·3	21 22·8	− 7·5	72 9·8	71 54·9	+14·9	1·5144	1·5290	−·0146	4·7064	4·6822	+·0242	54

England.

Station.		Declination.			Inclination.			Horizontal Force.			Vertical Force.			No. of Station.
No.	Name.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	
		° ′	° ′	′	° ′	° ′	′							
55	Aberystwith . .	19 56·5	20 11·2	−14·7	68 34·7	68 35·7	− 1·0	1·7488	1·7506	−·0018	4·4575	4·4653	−·0078	55
56	Alderney . . .	18 2·8	18 22·8	−20·0	66 38·9	66 37·2	+ 1·7	1·8691	1·8735	−·0044	4·3292	4·3335	−·0043	56
57	Alnwick . . .	19 45·0	19 43·9	+ 1·1	70 3·6	70 6·7	− 3·1	1·6511	1·6485	+·0026	4·5510	4·5560	−·0050	57
58	Alresford . . .	18 9·7	18 18·0	− 8·3	67 22·3	67 23·5	− 1·2	1·8241	1·8221	+·0020	4·3761	4·3755	+·0006	58
59	Appleby . . .	20 5·8	19 58·3	+ 7·5	69 44·9	69 42·3	+ 2·6	1·6690	1·6750	−·0060	4·5237	4·5293	−·0056	59
60	Barrow	20 9·3	20 16·1	− 6·8	69 30·6	69 31·7	− 1·1	1·6875	1·6885	−·0010	4·5157	4·5228	−·0071	60
61	Bedford . . .	18 27·4	18 14·5	+12·9	68 7·3	67 58·7	+ 8·6	1·7705	1·7818	−·0113	4·4091	4·4052	+·0039	61
62	Birkenhead . .	19 58·3	19 58·9	− 0·6	69 4·3	69 4·8	− 0·5	1·7176	1·7160	+·0016	4·4912	4·4886	+·0026	62
63	Birmingham . .	18 44·0	19 4·7	−20·7	68 21·3	68 21·8	− 0·5	1·7669	1·7605	+·0064	4·4525	4·4373	+·0152	63
64	Braintree . . .	17 55·4	17 40·3	+15·1	67 45·4	67 41·2	+ 4·2	1·7942	1·7984	−·0042	4·3871	4·3821	+·0050	64
65	Brecon	19 38·6	19 41·1	− 2·5	68 15·8	68 14·0	+ 1·8	1·7701	1·7727	−·0026	4·4399	4·4392	+·0007	65
66a	Bude Haven . .	19 56·5	19 49·8	+ 6·6	67 44·2	67 39·9	+ 4·3	1·8080	1·8120	−·0040	4·4164	4·4104	+·0060	66a
66b	,, . .		19 50·0											66b
67	Cambridge . . .	18 5·0	17 57·9	+ 7·1	68 2·4	67 56·5	+ 5·9	1·7784	1·7828	−·0044	4·4105	4·3995	+·0110	67
68	Cardiff	19 19·7	19 24·6	− 4·9	67 52·3	67 55·0	− 2·7	1·7944	1·7926	+·0018	4·4129	4·4182	−·0053	68
69	Cardigan . . .	20 25·8	20 22·3	+ 3·5	68 31·3	68 28·6	+ 2·7	1·7535	1·7600	−·0065	4·4565	4·4617	−·0052	69
70	Carlisle	20 25·8	20 18·6	+ 7·2	69 54·0	69 56·8	− 2·8	1·6625	1·6602	+·0023	4·5430	4·5482	−·0052	70
71	Chesterfield . .	19 11·9	19 2·4	+ 9·5	68 48·5	68 46·8	+ 1·7	1·7351	1·7321	+·0030	4·4752	4·4607	+·0145	71
72	Chichester . . .	18 5·5	18 2·6	+ 2·9	67 11·6	67 10·8	+ 0·8	1·8395	1·8352	+·0043	4·3745	4·3615	+·0130	72
73	Clenchwarton .	18 10·3	17 59·0	+11·3	68 17·9	68 16·0	+ 1·9	1·7662	1·7611	+·0051	4·4378	4·4171	+·0207	73
74	Clifton	19 10·7	19 7·5	+ 3·2	67 48·7	67 49·3	− 0·6	1·7996	1·7974	+·0022	4·4124	4·4091	+·0033	74
75	Clovelly . . .	19 53·8	19 49·5	+ 4·3	67 49·9	67 45·4	+ 4·5	1·8000	1·8059	−·0059	4·4177	4·4156	+·0021	75
76	Coalville . . .	18 41·4	18 52·6	−11·2	68 24·1	68 27·7	− 3·6	1·7534	1·7526	+·0008	4·4289	4·4398	−·0109	76
77	Colchester . . .	17 55·2	17 29·9	+25·3	67 35·3	67 39·0	− 3·7	1·8012	1·7998	+·0014	4·3675	4·3774	−·0099	77
78	Cromer . . .	17 35·8	17 31·1	+ 4·7	68 20·0	68 15·1	+ 4·9	1·7603	1·7597	+·0006	4·4310	4·4102	+·0208	78
79	Dover	16 57·2	17 7·0	− 9·8	67 8·0	67 5·4	+ 2·6	1·8336	1·8366	−·0030	4·3477	4·3456	+·0021	79
80	Falmouth . . .	19 53·4	19 49·7	+ 3·7	67 15·0	67 17·5	− 2·5	1·8323	1·8366	−·0043	4·3696	4·3886	−·0190	80
81	Gainsborough .	18 36·4	18 43·3	− 6·9	68 49·3	68 47·6	+ 1·7	1·7321	1·7296	+·0025	4·4705	4·4573	+·0132	81
82	Giggleswick . .	19 35·3	19 44·4	− 9·1	69 22·3	69 23·4	− 1·1	1·6962	1·6941	+·0021	4·5059	4·5047	+·0012	82
83	Gloucester . .	19 12·9	19 4·5	+ 8·4	68 4·3	68 2·3	+ 2·0	1·7811	1·7824	−·0013	4·4244	4·4198	+·0046	83
84	Grantham . . .	18 29·0	18 32·5	− 3·5	68 28·0	68 29·3	− 1·3	1·7527	1·7490	+·0037	4·4419	4·4369	+·0050	84
85	Guernsey (L'Erée)	18 32·7	18 29·9	+ 2·8	66 34·1	66 29·9	+ 4·2	1·8746	1·8815	−·0069	4·3254	4·3267	−·0013	85
86	,, (Peter Port)	18 18·4	18 27·7	− 9·3	66 32·4	66 29·4	+ 3·0	1·8796	1·8820	−·0024	4·3311	4·3262	+·0049	86
87	Harwich . . .	17 18·8	17 18·8	0·0	67 38·4	67 38·2	+ 0·2	1·8031	1·8001	+·0030	4·3833	4·3754	+·0079	87

England (continued).

Station.		Declination.			Inclination.			Horizontal Force.			Vertical Force.			No. of Station.
No.	Name.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	
		° ′	° ′	′	° ′	° ′	′							
88	Harpenden	18 16·5	18 6·3	+10·2	67 52·4	67 45·4	+ 7·0	1·7916	1·7961	−·0045	4·4063	4·3917	+·0146	88
89	Haslemere	18 7·7	18 6·0	+ 1·7	67 20·6	67 21·1	− 0·5	1·8282	1·8238	+·0044	4·3797	4·3710	+·0087	89
90	Holyhead	20 51·1	20 47·2	+ 3·9	69 23·1	69 12·5	+10·6	1·6958	1·7109	−·0151	4·5080	4·5059	+·0021	90
91	Horsham	18 3·3	17 54·6	+ 8·7	67 15·2	67 16·9	− 1·7	1·8309	1·8275	+·0034	4·3669	4·3649	+·0020	91
92	Hull	18 57·8	18 35·8	+22·0	69 3·9	68 57·8	+ 6·1	1·7125	1·7182	−·0057	4·4764	4·4670	+·0094	92
93	Ilfracombe	19 46·5	19 46·3	+ 0·2	67 53·8	67 51·5	+ 2·3	1·7952	1·7987	−·0035	4·4203	4·4205	−·0002	93
94	Jersey (Grouville)	18 36·0	18 10·1	+25·9	66 8·7	66 14·3	− 5·6	1·9053	1·8965	+·0088	4·3086	4·3077	+·0009	94
95	„ (S. Louis)	17 49·7	18 12·0	−22·3	66 13·0	66 14·8	− 1·8	1·8887	1·8961	−·0074	4·2856	4 3085	−·0229	95
96	„ (S. Owen)	18 24·7	18 15·3	+ 9·4	66 15·5	66 16·8	− 1·3	1·8904	1·8942	−·0038	4·2979	4·3110	−·0131	96
97	Kenilworth	19 1·4	18 52·6	+ 8·8	68 28·8	68 15·2	+13·6	1·7576	1·7668	−·0092	4·4574	4·4287	+·0287	97
98	Kettering	18 36·0	18 27·6	+ 8·4	68 10·7	68 10·7	0·0	1·7656	1·7695	−·0039	4·4095	4·4187	−·0092	98
99	Kew	18 16·3	17 59·5	+16·8	67 37·4	67 31·8	+ 5·6	1·8093	1·8110	−·0017	4·3950	4·3788	+·0162	99
100*a*	King's Lynn	17 57·9	17 57·7	+ 0·2	68 17·8	68 15·9	+ 1·9	1·7656	1·7610	+·0046	4·4359	4·4164	+·0195	100*a*
100*b*	„ (Gaywood)	18 1·7	17 56·6	+ 5·1	68 16·8	68 15·4	+ 1·4	1·7646	1·7615	+·0031	4·4298	4·4159	+·0139	100*b*
101	King's Sutton	18 51·8	18 37·5	+14·3	68 6·4	68 0·5	+ 5·9	1·7778	1·7819	−·0041	4·4240	4·4119	+·0121	101
102	Lampeter	18 55·3	20 4·8	− 9·5	68 25·5	68 25·0	+ 0·5	1·7559	1·7624	−·0065	4·4406	4·4543	−·0137	102
103	Leeds	19 8·9	19 17·4	− 8·5	69 10·8	69 10·3	+ 0·5	1·7082	1·7067	+·0015	4·4922	4·4863	+·0059	103
104	Leicester	18 23·6	18 43·1	−19·5	68 24·0	68 22·1	+ 1·9	1·7538	1·7581	−·0043	4·4296	4·4323	−·0027	104
105	Lincoln	18 18·9	18 33·3	−14·4	68 43·0	68 39·3	+ 3·7	1·7395	1·7385	+·0010	4·4654	4·4482	+·0172	105
106	Llandudno	20 51·5	20 22·2	+29·3	69 12·0	69 7·5	+ 4·5	1·7084	1·7149	−·0065	4·4974	4·4962	+·0012	106
107	Llangollen	20 8·4	19 54·3	+14·1	68 49·4	68 50·1	− 0·7	1·7331	1·7326	+·0005	4·4736	4·4745	−·0009	107
108	Llanidloes	19 53·8	19 55·1	− 1·3	68 33·8	68 33·5	+ 0·3	1·7501	1·7517	−·0016	4·4573	4·4595	−·0022	108
109	Loughborough	18 18·7	18 49·0	−30·3	68 27·7	68 28·5	− 0·8	1·7531	1·7513	+·0018	4·4419	4·4397	+·0022	109
110	Lowestoft	17 24·0	17 12·2	+11·8	68 0·4	67 54·6	+ 5·8	1·7797	1·7807	−·0010	4·4064	4·3872	+·0192	110
111	Mabelthorpe	18 16·5	18 9·9	+ 6·6	68 42·7	68 38·4	+ 4·3	1·7370	1·7373	−·0003	4·4578	4·4415	+·0163	111
	Malvern—													
112*a*	Colwall Green	19 3·6	19 11·7	− 8·1	..	68 10·5	..	1·7627	1·7737	−·0110	..	..	..	112*a*
112*b*	Great Malvern	19 33·0	19 10·5	+22·5	68 14·4	68 11·5	+ 2·9	1·7687	1·7722	−·0035	4·4310	4·4289	+·0021	112*b*
112*c*	Malvern Wells	19 22·4	19 10·1	+12·3	..	68 10·7	..	1·7682	1·7733	−·0051	..	..	..	112*c*
112*d*	Mathon	18 46·5	19 11·9	−25·4	..	68 11·7	..	1·7655	1·7722	−·0067	..	..	..	112*d*
	Manchester—													
113	Old Trafford	19 16·7	19 34·2	−17·5	69 3·9	69 1·4	+ 2·5	1·7125	1·7183	−·0058	4·4764	4·4814	−·0050	113
114	Manton	18 21·7	18 30·0	− 8·3	68 17·1	68 19·0	− 1·9	1·7661	1·7605	+·0056	4·4347	4·4268	+·0079	114
115	March	18 2·8	18 4·7	− 1·9	68 10·3	68 9·8	+ 0·5	1·7719	1·7684	+·0035	4·4237	4·4126	+ 0111	115

England (continued).

Station.		Declination.			Inclination.			Horizontal Force.			Vertical Force.			No. of Station.
No.	Name.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	
		° ′	° ′	′	° ′	° ′	′							
116*a*	Melton Mowbray	19 10·9	18 37·7	+33·2	68 27·8	68 25·0	+ 2·8	1·7620	1·7546	+·0074	4·4648	4·4343	+·0305	116*a*
116*b*	" "	19 4·2	18 38·2	+26·0	68 36·0	68 25·6	+10·4	1·7415	1·7539	−·0124	4·4438	4·4358	+·0080	116*b*
117	Milford Haven .	20 8·8	20 21·9	−13·1	68 9·9	68 16·6	− 6·7	1·7808	1·7738	+·0070	4·4445	4·4517	−·0072	117
118	Newark. . . .	18 46·2	18 40·7	+ 5·5	68 33·4	68 36·6	− 3·2	1·7464	1·7416	+·0048	4·4464	4·4458	+·0006	118
119	Newcastle . . .	19 30·3	19 35·6	− 5·3	69 49·5	69 51·2	− 1·7	1·6665	1·6641	+·0024	4·5356	4·5360	−·0004	119
120	Northampton . .	18 41·7	18 29·7	+12·0	68 9·4	68 5·2	+ 4·2	1·7667	1·7759	−·0092	4·4074	4·4143	−·0069	120
121	Nottingham . .	18 44·9	18 49·7	− 4·8	68 37·6	68 34·5	+ 3·1	1·7470	1·7448	+·0022	4·4639	4·4460	+·0179	121
122	Oxford	18 33·7	18 34·7	− 1·0	67 57·5	67 50·4	+ 7·1	1·7890	1·7927	−·0037	4·4187	4·4018	+·0169	122
123	Peterborough . .	18 21·9	18 15·8	+ 6·1	68 14·8	68 13·7	+ 1·1	1·7692	1·7651	+·0041	4·4338	4·4188	+·0150	123
124	Plymouth . . .	19 31·6	19 28·8	+ 2·8	67 14·7	67 18·9	− 4·2	1·8309	1·8334	−·0025	4·3651	4·3861	−·0210	124
125	Port Erin . . .	20 55·4	21 7·4	−12·0	69 48·1	69 41·3	+ 6·8	1·6678	1·6800	−·0122	4·5333	4·5388	−·0055	125
126	Preston	19 52·3	19 52·8	− 0·5	69 14·7	69 13·6	+ 1·1	1·7053	1·7051	+·0002	4·4999	4·4950	+·0049	126
127	Purfleet. . . .	17 54·5	17 43·1	+11·4	67 30·9	67 28·3	+ 2·6	1·8134	1·8136	−·0002	4·3812	4·3723	+·0089	127
128	Pwllheli . . .	20 41·9	20 31·7	+10·2	68 50·9	68 55·8	− 4·9	1·7407	1·7291	+·0116	4·4991	4·4877	+·0114	128
129	Ramsey	20 54·9	20 58·9	− 4·0	69 55·0	69 46·9	+ 8·1	1·6617	1·6737	−·0120	4·5449	4·5445	+·0004	129
130	Ranmore . . .	18 8·9	17 43·9	+25·0	67 20·0	67 23·6	− 3·6	1·8261	1·8202	+·0059	4·3725	4·3714	+·0011	130
131*a*	Reading (Caversham)	18 15·2	18 19·3	− 4·1	67 40·7	67 37·1	+ 3·6	1·8110	1·8067	+·0043	4·4109	4·3874	+·0235	131*a*
131*b*	Reading (Caversham)	18 11·6	18 19·3	− 7·7	..	..	..	1·8141	1·8067	+·0074	..	..	..	131*b*
132*a*	Redcar	19 5·6	19 7·9	− 2·6	69 31·5	69 32·5	− 1·0	1·6847	1·6828	+·0019	4·5119	4·5108	+·0011	132*a*
132*b*	"		19 8·6											132*b*
133	Ryde	18 1·6	18 12·1	−10·5	67 7·8	67 9·4	− 1·6	1·8391	1·8375	+·0016	4·3602	4·3620	−·0018	133
134	St. Cyres (Exeter)	19 28·6	19 21·6	+ 7·0	67 26·2	67 30·5	− 4·3	1·8260	1·8198	+·0062	4·3946	4·3951	−·0005	134
135	St. Leonards . .	17 24·8	17 25·5	− 0·7	66 58·9	67 0·9	− 2·0	1·8437	1·8433	+·0004	4·3396	4·3457	−·0061	135
136	Salisbury . . .	18 23·9	18 36·5	−12·6	67 25·6	67 28·6	− 3·0	1·8242	1·8179	+·0063	4·3881	4·3838	+·0043	136
137	Scarborough . .	18 48·3	18 43·0	+ 5·3	69 15·6	69 16·6	− 1·0	1·7017	1·6978	+·0039	4·4939	4·4876	+·0063	137
138	Shrewsbury . .	19 41·2	19 36·1	+ 5·1	68 36·4	68 37·2	− 0·8	1·7342	1·7457	−·0115	4·4266	4·4585	−·0319	138
139	Southend . . .	17 44·4	17 29·9	+14·5	67 30·8	67 27·0	+ 3·8	1·8112	1·8138	−·0026	4·3755	4·3681	+·0074	139
140	Spalding . . .	17 51·6	18 15·3	−23·7	68 23·1	68 20·8	+ 2·3	1·7512	1·7570	−·0058	4·4197	4·4245	−·0048	140
141	Stoke-on-Trent .	19 22·7	19 23·3	− 0·6	68 43·6	68 42·7	+ 0·9	1·7401	1·7384	+·0017	4·4693	4·4608	+·0085	141
142	Sutton Bridge .	17 54·1	18 4·1	−10·0	68 21·1	68 17·4	+ 3·7	1·7620	1·7600	+·0020	4·4395	4·4195	+·0200	142
143	Swansea . . .	19 45·6	19 51·1	− 5·5	67 59·7	68 5·7	− 6·0	1·7931	1·7830	+·0101	4·4370	4·4340	+·0030	143
144	Swindon . . .	..	18 44·9	..	67 51·4	67 47·3	+ 4·1	1·7930	1·7975	−·0045	4·4061	4·4023	+·0038	144
145	Taunton . . .	19 10·7	19 12·3	− 1·6	67 32·7	67 36·0	− 3·3	1·8154	1·8129	+·0025	4·3925	4·3984	−·0059	145

England (continued).

Station.		Declination.			Inclination.			Horizontal Force.			Vertical Force.			No. of Station.
No.	Name.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	
		° ′	° ′	′	° ′	° ′	′							
146	Thetford . . .	17 41·2	17 42·6	− 1·4	68 1·4	67 59·9	+ 1·5	1·7791	1·7776	+·0015	4·4085	4·3991	+·0094	146
147	Thirsk	19 21·7	19 15·0	+ 6·7	69 28·3	69 22·7	+ 5·6	1·6912	1·6931	−·0019	4·5165	4·4992	+·0173	147
148	Tilney	17 58·1	18 0·3	− 2·2	68 20·7	68 14·5	+ 6·2	1·7655	1·7628	+·0027	4·4468	4·4157	+·0311	148
149	Tunbridge Wells	17 41·3	17 37·2	+ 4·1	67 10·8	67 14·1	− 3·3	1·8297	1·8292	+·0005	4·3485	4·3589	−·0104	149
150	Wallingford . .	18 21·6	18 25·7	− 4·1	67 48·4	67 43·4	+ 5·0	1·7986	1·8001	−·0015	4·4087	4·3942	+·0145	150
151	Weymouth. . .	18 46·7	18 45·9	+ 0·8	67 11·7	67 14·9	− 3·2	1·8329	1·8342	−·0013	4·3593	4·3737	−·0144	151
152	Wheelock . . .	..	..	..	68 49·0	68 49·7	− 0·7	..	..	..	..	..	..	152
153	Whitehaven . .	20 41·6	20 35·2	+ 6·4	69 47·6	69 48·9	− 1·3	1·6727	1·6699	+·0028	4·5447	4·5423	+·0024	153
154	Windsor . . .	18 29·9	18 19·1	+10·8	67 38·8	67 35·4	+ 3·4	1·8084	1·8079	+·0005	4·3977	4·3841	+·0136	154
155	Wisbech . . .	18 5·6	18 4·7	+ 0·9	68 19·0	68 14·6	+ 4·4	1·7653	1·7631	+·0022	4·4398	4·4171	+·0227	155
156	Worthing . . .	17 59·0	17 51·1	+ 7·9	67 6·4	67 6·7	− 0·3	1·8402	1·8388	+·0014	4·3578	4·3554	+·0024	156
G	Greenwich. . .	17 56·3	17 50·4	+ 5·9	67 28·6	67 29·9	− 1·3	1·8141	1·8124	+·0017	4·3746	4·3751	−·0005	G
S	Stonyhurst . .	19 42·6	19 46·7	− 4·1	69 11·4	69 16·5	− 5·1	1·7002	1·7024	−·0022	4·4734	4·4957	−·0223	S

NOTE.—In the case of a few places at which several sets of observations have been made, the numbers given above differ slightly from the means of those in the Table on pp. 270–273. The reason of this is that the disturbances given above were calculated from the mean values of the elements at the various sub-stations, and are thus not quite the same as the means of the disturbances deduced for each sub-station from the elements proper to it.

Ireland.

Station.		Declination.			Inclination.			Horizontal Force.			Vertical Force.			No. of Station.
No.	Name.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	
		° ′	° ′	′	° ′	° ′	′							
157	Armagh . . .	22 16·5	22 16·2	+ 0·3	69 57·6	70 3·1	− 5·5	1·6625	1·6600	+·0025	4·5578	4·5736	−·0158	157
158	Athlone . . .	22 26·7	22 38·3	−11·6	69 40·0	69 40·8	− 0·8	1·6852	1·6865	−·0013	4·5476	4·5544	−·0068	158
159	Bagnalstown . .	21 55·0	21 47·8	+ 7·2	69 5·1	69 7·4	− 2·3	1·7208	1·7218	−·0010	4·5028	4·5141	−·0113	159
160	Ballina	23 26·9	23 34·9	− 8·0	70 25·8	70 12·9	+12·9	1·6323	1·6544	−·0221	4·5917	4·5991	−·0074	160
161	Ballywilliam . .	21 37·3	21 38·5	− 1·2	69 5·6	68 57·7	+ 7·9	1·7222	1·7326	−·0104	4·5084	4·5039	+·0045	161
162	Bangor	21 44·4	21 48·9	− 4·5	70 1·3	70 7·8	− 6·5	1·6598	1·6534	+·0064	4·5657	4·5750	−·0093	162
163	Bantry	22 40·3	22 36·6	+ 3·7	68 46·0	68 48·7	− 2·7	1·7529	1·7495	+·0034	4·5115	4·5127	−·0012	163
164	Carrick-on-Shannon	23 3·1	22 55·3	+ 7·8	69 53·3	69 59·6	− 6·3	1·6700	1·6668	+·0032	4·5607	4·5778	−·0171	164
165	Castlereagh . .	23 11·1	23 3·6	+ 7·5	69 56·3	69 55·9	+ 0·4	1·6716	1·6713	+·0003	4·5773	4·5748	+·0025	165
166	Cavan	22 37·8	22 31·9	+ 5·9	69 57·3	69 55·9	+ 1·4	1·6629	1·6691	−·0062	4·5577	4·5688	−·0111	166
167	Charleville . .	22 30·8	22 31·8	− 1·0	69 5·3	69 7·3	− 2·0	1·7226	1·7255	−·0029	4·5083	4·5235	−·0152	167
168	Clifden	24 20·7	23 48·6	+32·1	70 4·8	69 57·6	+ 7·2	1·6631	1·6726	−·0095	4·5891	4·5854	+·0037	168
169	Coleraine . . .	22 36·9	22 33·1	+ 3·8	70 47·7	70 30·3	+17·4	1·6085	1·6310	−·0225	4·6176	4·6070	+·0106	169
170	Cookstown Junction	21 32·8	22 11·4	−38·6	69 34·5	70 14·7	−40·2	1·6830	1·6474	+·0356	4·5194	4·5871	−·0677	170
171	Cork	22 18·1	22 13·3	+ 4·8	68 46·4	68 49·5	− 3·1	1·7506	1·7460	+·0046	4·5071	4·5068	+·0003	171
172	Donegal . . .	23 20·1	23 12·7	+ 7·4	70 15·3	70 24·0	− 8·7	1·6449	1·6407	+·0042	4·5827	4·6077	−·0250	172
173	Drogheda . . .	21 54·7	21 52·9	+ 1·8	69 36·3	69 39·5	− 3·2	1·6895	1·6852	+·0043	4·5441	4·5455	−·0014	173
174	Dublin	21 40·8	21 40·9	− 0·1	69 15·7	69 25·6	− 9·9	1·7087	1·6985	+·0102	4·5128	4·5254	−·0126	174
175*a*	Enniskillen . .	23 5·3	22 50·5	+15·2	70 14·2	70 10·7	+ 3·5	1·6489	1·6543	−·0054	4·5816	4·5894	−·0078	175*a*
175*b*	” . .		22 50·1					1·6465		−·0078				175*b*
176*a*	Galway	24 6·3	23 10·1	+56·2	69 53·0	69 43·1	+ 9·9	1·6583	1·6856	−·0273	4·5274	4·5612	−·0338	176*a*
176*b*	”	23 29·8	23 10·2	+19·6	69 41·6	69 43·6	− 2·0	1·6867		+·0011	4·5581	4·5632	−·0051	176*b*
177	Gort	22 50·5	22 56·8	− 6·3	69 31·7	69 34·2	− 2·5	1·7013	1·6954	+·0059	4·5571	4·5515	+·0056	177
178	Greenore . . .	22 14·5	21 51·8	+22·7	69 42·2	69 48·8	− 6·6	1·6833	1·6756	+·0077	4·5514	4·5574	−·0060	178
179	Kells	22 7·0	22 9·8	− 2·8	69 38·7	69 43·2	− 4·5	1·6925	1·6818	+·0107	4·5619	4·5513	+·0106	179
180	Kildare	22 0·4	21 57·8	+ 2·6	69 17·2	69 23·6	− 6·4	1·7073	1·7021	+·0052	4·5150	4·5268	−·0118	180
181	Kilkenny . . .	21 58·7	21 55·9	+ 2·8	69 5·0	69 7·9	− 2·9	1·7258	1·7218	+·0040	4·5154	4·5158	−·0004	181
182	Killarney . . .	22 55·8	22 50·1	+ 5·7	68 56·5	69 3·3	− 6·8	1·7405	1·7325	+·0080	4·5203	4·5257	−·0054	182
183	Kilrush . . .	23 11·4	23 5·5	+ 5·9	69 23·2	69 23·4	− 0·2	1·7090	1·7088	+·0002	4·5435	4·5439	−·0004	183
184	Leenane . . .	23 36·2	23 39·7	− 3·5	70 8·0	69 58·7	+ 9·3	1·6512	1·6707	−·0195	4·5697	4·5848	−·0151	184
185	Limerick . . .	23 36·6	22 39·7	− 3·1	69 8·8	69 18·0	− 9·2	1·7235	1·7131	+·0104	4·5244	4·5333	−·0089	185
186	Lisdoonvarna . .	22 58·5	23 10·5	−12·0	69 31·8	69 36·0	− 4·2	1·7042	1·6941	+·0101	4·5653	4·5553	+·0100	186
187	Lismore . . .	22 5·5	22 2·8	+ 2·7	68 48·6	68 54·3	− 5·7	1·7427	1·7395	+·0032	4·4952	4·5087	−·0135	187

Ireland—continued.

Station.		Declination.			Inclination.			Horizontal Force.			Vertical Force.			No. of Station.
No.	Name.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	
		° ′	° ′	′	° ′	° ′	′							
188	Londonderry . .	22 50·5	22 52·5	− 2·0	70 26·9	70 31·1	− 4·2	1·6335	1·6313	+·0022	4·5997	4·6113	−·0116	188
189	Oughterard . .	23 40·6	23 22·6	+18·0	69 56·7	69 50·5	+ 6·2	1·6762	1·6789	−·0027	4·5916	4·5733	+·0183	189
190	Parsonstown . .	22 27·0	22 27·5	− 0·5	69 30·3	69 28·6	+ 1·7	1·6989	1·6997	−·0008	4·5452	4·5404	+·0048	190
191	Sligo	23 4·6	23 16·2	−11·6	70 17·8	70 13·6	+ 4·2	1·6430	1·6522	−·0092	4·5880	4·5959	−·0079	191
192	Strabane . . .	22 46·9	22 54·7	− 7·8	70 23·5	70 25·7	− 2·2	1·6352	1·6377	−·0025	4·5901	4·6064	−·0163	192
193	Tipperary . . .	22 22·6	22 19·4	+ 3·2	69 4·9	69 8·2	− 3·3	1·7272	1·7236	+·0036	4·5188	4·5219	−·0031	193
194	Tralee	..	23 2·5	..	69 9·4	69 12·2	− 2·8	..	1·7227	..	..	..	..	194
195	Valentia . . .	23 16·0	23 8·5	+ 7·5	68 54·7	69 3·6	− 8·9	1·7448	1·7336	+·0112	4·5245	4·5298	−·0053	195
196	Waterfoot . . .	22 15·1	22 9·5	+ 5·6	70 29·0	70 23·6	+ 5·4	1·6293	1·6374	−·0081	4·5968	4·5967	+·0001	196
197	Waterford . . .	21 27·9	21 43·1	−15·2	68 53·7	68 53·9	− 0·2	1·7329	1·7374	−·0045	4·4897	4·5015	−·0118	197
198	Westport . . .	23 15·1	23 38·4	−23·3	70 17·9	70 4·4	+13·5	1·6509	1·6642	−·0133	4·6103	4·5907	+·0196	198
199	Wexford . . .	21 18·1	21 23·7	− 5·6	68 56·2	68 51·6	+ 4·6	1·7324	1·7389	−·0065	4·4982	4·4967	+·0015	199
200	Wicklow . . .	21 21·4	21 26·4	− 5·0	69 9·9	69 11·3	− 1·4	1·7126	1·7151	−·0025	4·5002	4·5119	−·0117	200

Supplementary Stations.

Station.		Declination.			Inclination.			Horizontal Force.			Vertical Force.			No. of Station.
No.	Name.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	Observed.	Calculated.	Difference.	
201	Chepstow . . .	..	..	..	67° 57′·5	67° 56′·6	+0·9	..	..	..	..	..	..	201
202	Goodrich . . .	..	..	..	68 9·0	68 5·1	+3·9	..	..	..	..	..	..	202
203	Hereford . . .	..	..	..	68 15·6	68 12·6	+3·0	..	..	..	..	..	..	203
204	Ross	..	..	..	68 6·9	68 7·1	−0·2	..	..	..	..	..	..	204
205	Tintern	..	..	..	68 1·3	67 59·1	+2·2	..	..	..	..	..	..	205

Local and Regional Disturbances.

We now come to the consideration of the local and regional disturbances which exist in many parts of the United Kingdom, and which we have investigated much more fully than has hitherto been done.

As the problem is one of difficulty, it is necessary that every step should be carefully considered. It may be attacked in three ways, which are not independent, but each of which is attended with special advantages and disadvantages, and which, when combined, afford in many cases the means of arriving at definite conclusions.

(1.) If the true isomagnetic curves are drawn as accurately as possible, without any attempt to smooth the irregularities, they present in disturbed districts distorted forms which enable us to judge of the nature and magnitude of the disturbance. The great advantage of this method is, that it is independent of calculation. It is not affected by errors possibly introduced by the method of determining the terrestrial curves. The conclusions arrived at are based directly upon the observations.

The objections that may be raised to it are, that it can only be used with effect in the case of considerable disturbances, and that it may tend to exaggerate the importance of those which, though of great local intensity, are of small range. A curve may be carried many miles from its true position, in order to pass through a station, the disturbance at which dies out within a very short distance.

When the stations are as numerous as ours, and when the curves are drawn with a due regard to the possibility of isolated maxima and minima, we do not think that the risk of error on this account is as great as it might at first sight appear, but in so far as it exists, it may be checked by the second method.

(2.) If the disturbances of the elements, *i.e.*, the differences between the observed values and those calculated from the general equations given above, are plotted down on a map, it is found that they are not scattered haphazard, but that certain districts exhibit definite peculiarities, such as that the observed value is always too large or too small. From a study of such maps deductions can be made as to the nature of the disturbing forces.

This method is open to the objection that the peculiarities in question may not correspond to physical realities, but may be due to the inadequacy of the formulæ. The calculated rate of increase of the declination with longitude, for instance, may be made a little too rapid in one part of the country, and a little too slow elsewhere. The observed declinations may, therefore, appear too large in the one district and too small in another, and thus a mere mathematical error may create a fictitious attractive or repulsive force.

To this objection, it may be answered that the observed disturbances are too large and too irregular to be thus explained. Taking, for instance, the English and Welsh stations which lie between long. 3 W. and long. 5 W., the mean disturbances of the Declinations for the groups indicated, are as follows :—

Four most northerly stations	14′·4 W.
Intermediate group of eight stations . .	6·0 E.
Six most southerly stations	3·0 W.

A glance at the isogonals (Plate II.) in this part of the kingdom, is sufficient to show that it is impossible to believe that the real terrestrial curve not only crosses and recrosses that which we have drawn between Plymouth and Holyhead (which is quite possible), but that the amplitude of the oscillation amounts to more than 20′ of Declination, or to about 45′ of longitude. If this were so, the terrestrial would be nearly as sinuous as the true curves (*cf.* Plate V.).

It is also to be observed, that even if there is a slight tendency of the kind supposed, it will be partly corrected by the first method. The objection to that is, that too much stress may be laid on the peculiarities of individual stations—to this, that too great weight may be given to the characteristics of districts.

If the two methods point to the same conclusion the two criticisms are mutually destructive.

A more serious objection is, that the indications are, at times, somewhat ambiguous. An increase in the Declination may be due to a small force acting at right angles to the magnetic meridian, or to a large one acting nearly parallel to it. The value of the disturbance of the Horizontal Force will often decide to which of these the effect is due, but nevertheless, it is not easy to deduce definite conclusions from a mere inspection of the maps. This consideration has, therefore, led us to supplement this method by another.

(3.) In this third method, we calculate the magnitude and direction of the disturbing force at each station. If δ be the observed, and δ_c the calculated value of the Declination, if a similar notation be used for the other elements, and if N, W, and Z be the northerly, westerly, and vertical components of the disturbing force, we have

$$N = H_c \cos \delta_c - H \cos \delta,$$
$$W = H_c \sin \delta_c - H \sin \delta,$$
$$Z = H_c \tan \theta_c - H \tan \theta,$$

whence the magnitude and direction of the disturbing force are known. Obviously the danger to be feared, in this case, is that the differences with which we deal are too small to give trustworthy results. The calculation must, however, lead to conclusions compatible with those to which the study of the disturbances points, and even if the results are only approximate, they are valuable as indicating, in a way which is more easily interpreted, the direction and magnitude of the forces under investigation.

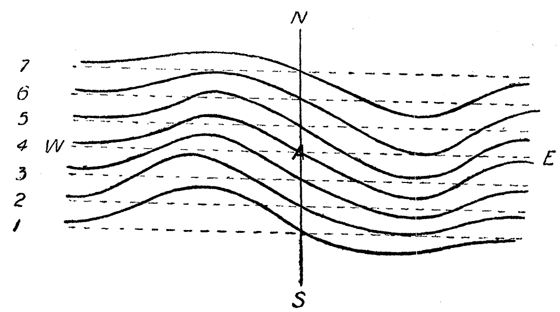
Having thus described the general course which we propose to adopt, we shall now consider the methods more in detail. After that we shall apply them to certain districts, of which we have made a special study, and then to the whole area of the survey.

In attempting to discover the order which underlies the apparent irregularity of the disturbances, it is necessary to proceed on a working hypothesis, and we shall postulate only the possibility of the existence of points or surfaces which exert magnetic forces. They will be called attractive or repulsive according as they attract or repel a north-seeking pole. If the existence or apparent existence of such centres is established the cause of the phenomenon will be a proper subject for enquiry.

The distortion produced by a symmetrical mass of magnetic matter on the isogonals depends upon the angle which these curves make with the magnetic meridian.

If we are dealing with a sufficiently small area, both the isogonals and the magnetic meridians may be represented by straight lines. If these lines are mutually perpendicular, and if the declination is westerly and increases with the latitude, the forms of the true isogonals in the neighbourhood of a symmetrical attracting mass, the centre of which is below the surface at A, will be of the type shown in Fig. 3, in which NS is the magnetic meridian through A.

Fig. 3.



---- Terrestrial Isogonals running approximately east and west.

——— True Isogonals produced by centre of attraction at A.

In Japan the distribution of the isogonals and meridians approximates to this simple arrangement, and in the neighbourhood of the Fossa Magna according to Dr. NAUMANN ('Die Erscheinungen des Erdmagnetismus,' Stuttgart, 1887), a very remarkable disturbance of this kind is produced.

If the isogonals and meridians are very nearly coincident, and if the Declination increases with the longitude, the effect on the isogonals of a weak attractive centre will be of the type shown in Fig. 4. If, however, the disturbing force is sufficiently powerful to make the Declination, at some point to the east of the centre, greater than its undisturbed value at the centre, the form of the lines must approximate to that shown in Fig. 5. The Declination will increase rapidly with the longitude, attain a maximum value, fall to its normal value at points on the magnetic meridian which pass through the centre—on each side of which the attracting matter is supposed to be symmetrically situated—then fall to a minimum, and finally resume its normal rate of increase.

If, retaining all the other assumptions, we suppose that the isogonals and meridians are inclined at an angle of less than 90°, the distorted curves will assume forms similar to those in Fig. 6. It will be noticed that if the undisturbed isogonals be rotated about A in the limiting cases when they coincide with AE or AN, the distorted curves will assume the forms shown in Figures 3, and 4, or 5.

Fig. 4.

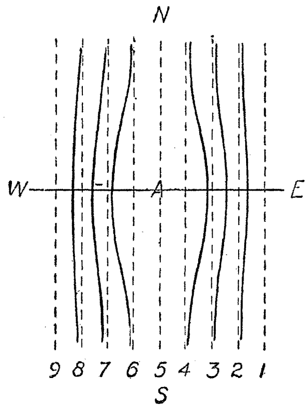
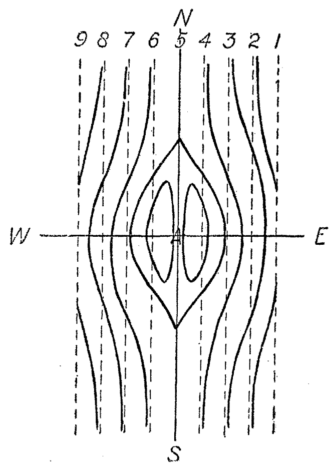


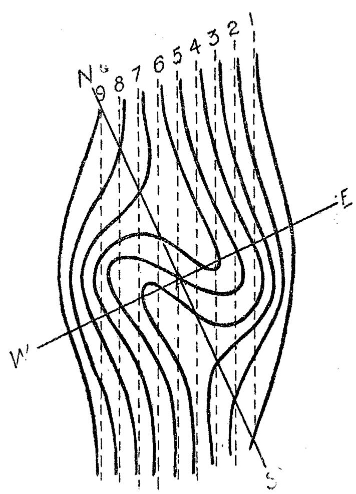
Fig. 5.



- - - - Terrestrial Isogonals running approximately north and south.

——— True Isogonals produced by (Fig. 4) a weak, and (Fig. 5) a strong centre of attraction at A.

Fig. 6.



- - - - Terrestrial Isogonals approximately parallel.

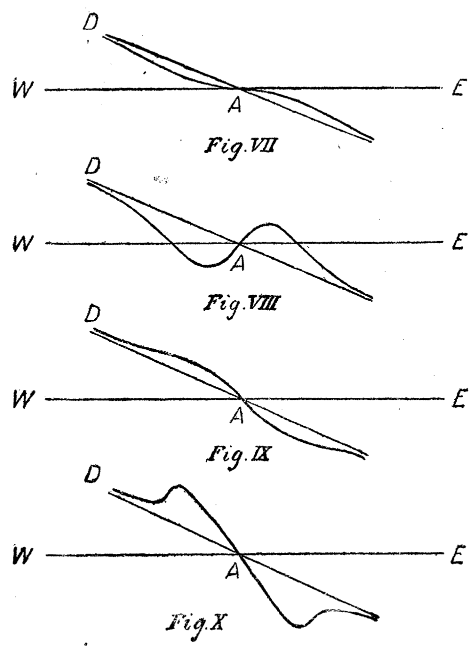
——— True Isogonals produced by a centre of attraction at A.

It is, of course, quite possible that a single closed curve may sometimes be formed. An underground attracting surface, rising up steeply on the eastern side and falling away very gently to the west, might cause a maximum declination on the east without any corresponding minimum on the west; but in general the normal complement of a closed isogonal is another of the same type.

The curves shown in figs. 3 to 6 will not be realised in practice, but their main characteristics may be reproduced, and a knowledge of their forms is very useful in interpreting maps on which the true isomagnetic curves are drawn.

These facts may also be illustrated by means of diagrams of another kind. Thus if, in figs. 7 and 8, the slope of the line AD represents the normal rate of increase of the Declination with longitude, the effect of an attractive centre below A will be represented by the curves shown, which correspond to the two cases of a weak and strong attraction respectively. If, however, the force is repulsive, the curves assume the forms shown in figs. 9 and 10. In this case there may be two maxima and minima, following each other in order on opposite sides of the centre of repulsion. The isogonals will be drawn together in its neighbourhood, and there may be two systems of loops, one on each side of the centre.

Figs. 7 to 10.



A centre of attraction will also be indicated by a convergence of the lines of equal Horizontal Force and Dip in its neighbourhood.

The observed will be greater than the calculated Force to the south, and smaller to north, of the centre. The Dip, on the other hand, will be less and greater than its calculated values at stations to the south and north respectively of a point at which the directions of the normal and disturbing Forces coincide.

The phenomena are more complicated if the effect of the disturbance is to increase the value of the element on that side of the centre of attraction on which it would be normally the greater, instead of increasing it (as in the case of the Declinations) on that side (the east) on which it is normally the less.

Thus, if we represent a northward movement by progress along the line WE (fig. 10) from W to E, the effect of a strong centre of attraction would be to check the ordinary decrease of the Horizontal Force with latitude. If the centre were sufficiently powerful, the decrease might be converted into an increase; and since immediately over the centre the value must be normal, a minimum and maximum must follow in order. Another minimum and maximum may occur on the further side. The effect of a centre of attraction on the lines of equal Horizontal Force is thus the same as that of a centre of repulsion on the isogonals. In the case of the Dip, as in that of the Declination, there can only be two critical points on opposite sides of the point defined above.

The Vertical Force will increase with latitude at more than the normal rate to the south of a centre of attraction, and at less than the normal rate to the north of it. The lines of equal Vertical Force will thus be drawn southwards in the neighbourhood of such a centre.

If the Vertical Force attains a maximum value it will be at a point above the centre, and it must be followed by a minimum—at which, however, the Vertical Force will be greater than its calculated value.

It is evident from this discussion that there are a number of signs of a centre of attraction which may not all coexist, and which will be complicated in actual practice by irregularities in the distribution of the attracting masses, but which may nevertheless be of considerable practical help in a survey of local magnetic disturbances. (*Cf.* LAMONT: 'Erdmagnetismus in Nord-Deutschland,' 1859, p. 21.)

We have dwelt on them, not because they present any difficulty, or even because they are altogether novel. Mr. BENNETT BROUGH, A.R.S.M., has given a full account of the methods employed by the Swedish mining engineers in exploring for iron ore. ("Use of the Magnetic Needle," &c. 'Journal of the Iron and Steel Institute,' No. 1, 1887, pp. 289–303.) They are accustomed to map out the neighbourhood of a mass of ironstone with a magnet, in order to determine its exact position. We believe, however, that the systematic use of the forms of the isomagnetic curves has been largely overlooked in the case of surveys comparable with that described in this paper.

In Plates V. to VIII., the values of the Declinations, Horizontal Forces, Dips, and Vertical Forces determined at the various stations are entered and true magnetic curves are drawn. These curves have not been chosen for equal differences of the values of the element to which they refer, but those have been selected which exhibit the most marked peculiarities. In this way attention is best drawn to disturbed stations and districts which can then be studied in accordance with the plan above suggested.

Turning next to the investigation of the disturbances or differences between the observed and calculated values of the elements, we note that apart from the assurance they afford that the peculiarities studied are common to a district and do not depend only on a single station, they often supply additional information to that which can be gained from the true isomagnetics.

Thus, in the case of the Horizontal Force, a maximum followed by a minimum may be either to the north or the south of the centre of attraction. In the former case, however, both the maximum and minimum values are less, while in the latter case they are greater than the normal values at the stations at which they occur, and if one maximum and minimum only are formed, the disturbances at once decide whether they are to the north or south of a centre of attraction.

The lines which separate regions of positive disturbance in which the observed is greater than the calculated value from those in which it is negative are also of importance. Thus, in the case of the Horizontal Force, if such a line is approximately perpendicular to the magnetic meridian, and if in passing over it from south to north we leave a region in which the disturbance is positive and enter one in which it is negative, we either pass over a centre or line of attraction or pass from the range of the influence of one centre of repulsion into that of another.

If the centre is not at a great depth below the surface, and if the magnetic matter is not widespread at its minimum depth, it will cause a sudden reversal in the sign of the disturbances which will, however, be large near the centre on both sides. On the other hand, passage from the region of influence of one centre to that of another will, if the distance between them is considerable, be marked by a transition from small positive to small negative disturbances, or *vice versâ*.

Similar remarks may be made with respect to the disturbances of the Declination, but they are most easy to interpret when the line which separates a positive from a negative region runs approximately north and south. If such a line meets another which separates a southern region of positive from a northern region of negative Horizontal Force disturbance, all the disturbing forces in the neighbourhood tend towards the point of intersection. It will be convenient to speak of such a point as a *peak*, and to call a line which divides regions of positive from those of negative disturbance of the Declination or Horizontal Force, so as to indicate attraction towards it, a *ridge line*. In like manner, a line which separates the regions of influence of two attractive centres may be called a *valley line*.

In the choice of these terms we are, no doubt, influenced by our views of the facts to be hereafter set forth, but they are convenient, quite apart from any theory of the cause of local magnetic forces. It will be proved beyond doubt that in some cases these forces emanate from matter below the surface of the earth. If this is so, an increment in their intensity must be due either to a closer approximation to the matter or to an increase in its magnetisation. We have no magnetic test to discrimate between the two, and therefore, without prejudice, adopt a nomenclature which is perhaps most consistent with the first hypothesis. If we wished to keep absolutely free from all expression of an opinion as to the causes of the phenomena, we might have called a peak (to which the lines of magnetic disturbing force converge), a magnetic sink, and so on, and for the present the terms we suggest may be taken as indicating merely points and lines from and to which such lines of force run.

The disturbances of the Declination and Horizontal Force, together with the ridge and valley lines are shown in Plates IX. and X.

The absolute value of the disturbance of the Vertical Force is especially uncertain. In the cases of the Declination and Horizontal Force a centre of attraction affects stations on opposite sides with disturbances of opposite signs, to that the true mean value for the district can be found, and the true disturbance at each station deduced. It is, however, possible that the disturbance of the Vertical Force may always be of the same sign. Thus, if the centres of force are rocks magnetised by induction, the north-seeking pole of a magnet would most frequently be attracted downwards in the northern hemisphere as the north-seeking poles of the rock magnets would be deeply buried in the earth. This hypothesis is that which experience has justified in Sweden. If this is so, the mean value of the Dip or Vertical Force in a district will be greater than its undisturbed value, and negative values do not necessarily indicate an upward force. It is therefore safer only to use the disturbances of the Vertical Force as a means of indicating relative maxima and minima.

If, however, centres of repulsion exist, they might be detected by the observation that a large negative (upward) disturbance of the Vertical Force was accompanied with a sudden reversal of the disturbing Horizontal Force in neighbouring stations. If the Horizontal Forces are small, the negative disturbing Vertical Force is more probably to be interpreted as indicating a downward attraction of less than average magnitude.

On turning to Plate XI., in which the disturbances of the Vertical Force are plotted down, it will be observed that there is, on the whole, an excess of positive values in the south-east, and that large negative values are more common in the north and west. It is obvious that in Scotland the disturbances are much greater than in England, and very large positive values of vertical disturbance occur in the western isles. Indeed, if we include the enormous value obtained at Canna, the average for the whole of Scotland is positive. Leaving out, however, this very abnormal station, it can hardly be doubted that negative values are more common in the north-west. If this result could be trusted as corresponding to physical fact, it might indicate that the country as a whole is magnetised in the direction of the magnetic meridian. We cannot, however, draw such a conclusion, more especially as it can be shown that the observed effect may probably be a result of our ignorance of the datum lines from which the disturbances of the Dips and Vertical Forces ought to be measured.

We have taken the Dip, as given by direct observation, as one of our fundamental elements, and in drawing the terrestrial curves which satisfy the conditions that the mean value of the Dip for each district when attributed to the central station is accurately reproduced by the formula, we have been compelled to ignore the possibility of an unbalanced downward Vertical Force acting at every station. If we suppose that in consequence of this the calculated Dips ought, all over the country, to be diminished by a positive quantity, we get for the corresponding decrement in Vertical Force

$$dV = H \sec^2 \theta \, d\theta.$$

If we take the values of H and θ at Wick and St. Leonards, and write for $d\theta$ the circular measure of 1′ multiplied by x, the unknown number of minutes by which the calculated Dip has been taken too large, we get at

Wick . . . . $dV = 0\cdot0048x$,
St. Leonards . . . . . . $dV = 0\cdot0036x$.

Hence in the north the error will be greater than in the south, that is, the excess of the calculated over the true undisturbed Vertical Force is greatest in the north. Consequently the difference between the observed and calculated Vertical Force will be more frequently negative in the north, the excess of the error amounting to 0·0012 metric unit for every minute by which the calculated Dip is too large.

If, then, apart from local attractions the country, as a whole, attracts the needle so that the Dip is everywhere 10′ greater than it would be if the British Isles were replaced by sea, the error in the calculated Vertical Forces deduced from calculated Dips, obtained on the assumption that no such defect exists, would be 0·0120 greater in the north of Scotland than in the Channel, so that negative disturbances would largely predominate in the north.

As from the geological character of Scotland it is probable that the error in the calculated Dip would not be constant, but would be greater than in England, the validity of this explanation is even more probable than this calculation indicates.

It is not, therefore, safe to draw conclusions based on the relation between the Vertical disturbing Forces at distant stations.

In the calculation of the disturbing forces we are not aiming at, and could not attain to, results which would give more than a general idea of their direction and magnitude. It may be possible to conclude with certainty that an attractive mass exists near certain stations, even if the directions of the forces are wrong by 10° or 15° and their magnitudes are inaccurate by 50 per cent.

To show that a degree of accuracy of this kind is attained we collect here the results at stations where we have taken a full set of observations at two or more places, or on different occasions. There are of course localities where it would be hopeless to get a good result from a single observation. Such places are Canna and Portree. At these we should never have observed except for the sake of investigating the disturbances which we knew were very great, and we therefore do not now take them into account. It is sufficient if the agreement between different observations is satisfactory at stations which we regarded at the time of observation as normal.

At Stornoway we made four sets of measurements, the first in 1884 in the Castle Grounds, the other three in 1885 and 1888 on Ard Point, about a mile distant from the former station. The ground was not good, as when we observed simultaneously about 50 yards apart on Ard Point the declinations differed by 18′.

At Loch Aylort we observed in 1884 and 1888 as nearly as possible on the same station. At Oban we observed on the mainland in 1888, and on the island of Kerrera which is about a mile distant, in 1884 and 1885. In the Sound of Islay we had two stations about four miles apart, viz., Port Askaig in 1884 and Bunnahabhain in 1888. All these places, though typical Scotch stations, were on ground which elsewhere would be considered but indifferently good for our purpose. At three other places more favourably situated we also observed twice, viz., at Stranraer in 1884 and 1888, at Reading in 1886 and 1888, and at Bude Haven in 1886. At the two former the stations were as nearly as possible the same on the two occasions, at Bude Haven they were less than half a mile apart.

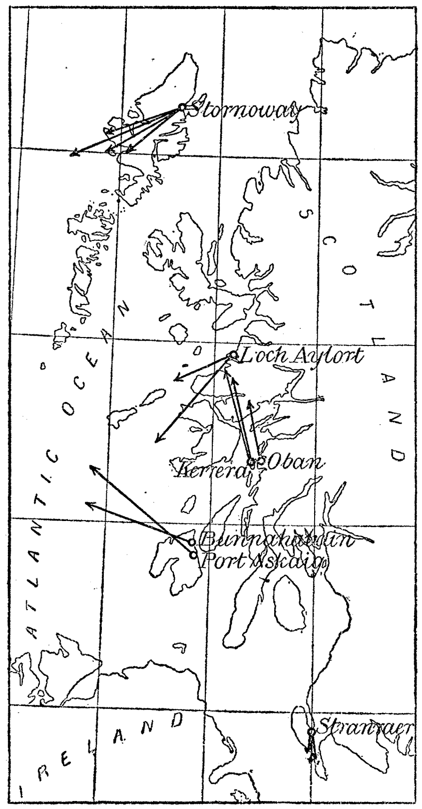
The results are summed up in the following Table. The resultant Horizontal disturbing Force is indicated by F, and the angle which its direction makes with the geographical meridian by ϕ. The latter is taken as positive on the western side, due north being represented by 0°.

Station.	Rock.	Date.	F.	ϕ.	Z.
Stornoway—				°	
(1) Castle Grounds	Gneiss	1884	·0175	129·6	−·0113
(2) Ard Point . .		1885	·0179	109·2	Dip not observed
		1888 (T)	·0198	119·7	+·0046
		1888 (R)	·0278	113·5	+·0120
Loch Aylort . . .	Gneiss	1884	·0267	141·1	−·0326
		1888	·0139	112·3	+·0178
Oban—					
(1) Mainland . .	Trap	1888	·0143	10·9	−·0129
(2) Kerrera . . .		1884	·0196	16·9	−·0132
		1885	·0219	16·2	−·0124
Sound of Islay—					
(1) Port Askaig .	Primary	1884	·0309	53·1	+·0141
(2) Bunnahabhain.	Limestone	1888	·0265	69·9	+·0122
Stranraer	Clay, Slate	1884	·0038	178·5	−·0072
		1888 (R)	·0065	181·8 }	−·0034
		„ (T)	·0062	175·4 }	
Reading	Clay	1886	·0049	− 8·3	+·0235
		1888	·0084	−10·2	Dip not observed
Bude Haven . . .	Shale	1886	·0065	143·1	+·0091
			·0048	180·0	+·0030

The annexed small map (fig. 11) illustrates these numbers by showing the direction and magnitudes of the disturbing forces as determined on two occasions at stations in Scotland.

An inspection of this map and of the table justifies the statement that the magnitude and direction of the disturbing forces can be determined with an accuracy sufficient to enable us to draw conclusions from groups of stations even if it would not always be safe to argue from one.

Fig. 11.



If the station is on good ground we may place more confidence in the results. Stranraer is interesting as being the only place where we both took complete sets of observations simultaneously on good ground. The results are in very close accord. But those obtained elsewhere leave no doubt as to the order of the magnitude of the disturbing force nor as to its direction to within (in unfavourable cases) 15° or 20°.

The difference in the signs of the Vertical Forces obtained at Loch Aylort and Stornoway in different years may in part be due to the uncertainty of the secular correction for the Dip, which appears to be very abnormal, especially at Loch Aylort (see p. 86). In this case we should be driven to the conclusion that a real change in the local Force had taken place. It is noticeable that the Vertical Force disturbance was apparently (algebraically) greater at Stornoway, Loch Aylort, Kerrera, and Stranraer on our second visits to these places.

The following Table contains the particulars as to the disturbing force at every station in accordance with the notation described above. On Plate XIII., the directions and magnitudes of the Horizontal disturbing Forces are shown, and regions of positive and negative Vertical Force disturbance are indicated, the former being shaded.

TABLE of Disturbing Forces.

No. of Station.	Name of Station.	F.	ϕ.	Z.
1	Aberdeen	82	−144°	− 28
2	Arinagower	..	..	..
3	Loch Aylort	267	+141	− 326
		139	+112	+ 178
4	Ayr	61	− 22	− 145
5	Ballater	151	−108	− 41
6	Banavie	176	+ 18	+ 268
7	Banff	112	+ 70	− 124
8	Berwick	179	− 15	+ 230
9	Boat of Garten	212	+ 86	+ 56
10	L. Boisdale	301	−114	− 736
11	Bunnahabhain	265	+ 70	+ 122
12	Callernish	45	+ 21	+ 31
13	Campbelton	36	+136	− 9
14	Canna	737	−112	+1839
15	Carstairs	173	+ 14	− 79
16	Crianlarich	39	+ 83	− 219
17	Crieff	114	+ 74	+ 217
18	Cumbrae	222	+174	+ 215
19	Dalwhinnie	127	+ 36	− 247
20	Dumfries	29	+ 56	− 87
21	Dundee	23	+180	+ 10
22	Edinburgh	17	+152	+ 107
23	Elgin	86	− 67	+ 45
24	L. Eriboll	37	− 56	+ 175
25	Fairlie	..	..	+ 135
26	Fort Augustus	74	−101	+ 57
27	Gairloch	210	− 85	− 451
28	Glasgow	117	−133	− 80
29	Golspie	89	− 92	− 65
30	Hawick	76	− 1	− 99
31	L. Inver	326	−129	− 853
32	Inverness	61	0	+ 156
33	Iona	326	+ 59	+ 202
34	Kirkwall	27	− 39	+ 109
35	Kyle Akin	140	+154	− 168
36	Lairg	73	− 79	− 34
37	Lerwick	62	−144	+ 378
38	Lochgoilhead	23	+122	− 328
39	Loch Maddy	73	− 72	− 114
40*a*	Oban	143	+ 11	− 129
40*b*	Oban (Kerrera)	196	+ 17	− 132
		219	+ 16	− 124
41	Pitlochrie	33	− 63	− 242
42	Port Askaig	309	+ 53	+ 141
43	Portree	619	+145	+ 712
		384	+ 11	− 378
		806	− 89	+1705
44	Row (Gairloch)	121	−170	− 188
45	Scarnish	394	+ 98	+ 444
46	Soa	518	−166	− 385
47	Stirling	166	+177	− 92
48*a*	Stornoway (Ard Point)	179	+109	..
		198	+120	+ 46
		278	+114	+ 120
48*b*	Stornoway (Castle)	175	+130	− 113
49	Strachur	88	− 1	− 269

TABLE of Disturbing Forces—*continued.*

No. of Station.	Name of Station.	F.	φ.	Z.
50	Stranraer	{ 38 65 62	° +178 −178 +175	− 72 } − 34
51	Stromness	80	− 25	+146
52	E. Loch Tarbert	54	−167	−150
53	Thurso	20	− 53	− 47
54	Wick	150	−146	+242
55	Aberystwith	77	− 83	− 78
56	Alderney	117	− 94	− 43
57	Alnwick	29	+ 28	− 50
58	Alresford	48	− 47	+ 6
59	Appleby	69	+168	− 56
60	Barrow	35	− 85	− 71
61	Bedford	132	+168	+ 39
62	Birkenhead	15	+ 8	+ 26
63	Birmingham	124	− 40	+152
64	Braintree	91	+136	+ 50
65	Brecon	28	−135	+ 7
66	Bude Haven	{ 65 48	+143 +180	+ 91 + 30
67	Cambridge	57	+158	+110
68	Cardiff	32	− 35	− 53
69	Cardigan	67	−175	− 52
70	Carlisle	41	+ 77	− 52
71	Chesterfield	56	+ 78	+145
72	Chichester	46	+ 37	+130
73	Clenchwarton	77	+ 67	+207
74	Clifton	27	+ 57	+ 33
75	Clovelly	63	+179	+ 21
76	Coalville	57	− 63	−109
77	Colchester	133	+102	− 99
78	Cromer	25	+ 92	+208
79	Dover	60	−102	+ 21
80	Falmouth	47	+175	−190
81	Gainsborough	42	− 36	+132
82	Giggleswick	49	− 45	+ 12
83	Gloucester	46	+126	+ 46
84	Grantham	41	− 7	+ 50
85	Guernsey, L'Erée	101	−134	− 13
86	„ Peter Port	56	− 96	+ 49
87	Harwich	30	+ 17	+ 79
88	Harpenden	70	+148	+146
89	Haslemere	44	+ 30	+ 87
90	Holyhead	153	−166	+ 21
91	Horsham	57	+ 73	+ 20
92	Hull	124	+136	+ 94
93	Ilfracombe	36	−162	− 2
94	Jersey, Grouville	168	+ 77	+ 9
95	„ S. Louis	144	−103	−229
96	„ S. Owen	65	+144	−131
97	Kenilworth	103	+173	+287
98	Kettering	59	+150	− 92
99	Kew	90	+119	+162
100*a*	King's Lynn	46	+ 19	+195
100*b*	„ „ (Gaywood)	40	+ 60	+139
101	King's Sutton	85	+138	+121
102	Lampeter	81	−123	−137

TABLE of Disturbing Forces—*continued.*

No. of Station.	Name of Station.	F.	φ.	Z.
			°	
103	Leeds	45	− 51	+ 59
104	Leicester	108	− 95	− 27
105	Lincoln	89	− 48	+172
106	Llandudno	159	+134	+ 12
107	Llangollen	71	+107	− 9
108	Llanidloes	20	−140	− 22
109	Loughborough	155	− 65	+ 22
110	Lowestoft	61	+116	+192
111	Mablethorpe	34	+113	+163
112*a*	Malvern, Colwall	119	−140	..
112*b*	„ Great Malvern	121	+127	+ 21
112*c*	„ Wells	81	+149	..
112*d*	„ Mathon	147	− 98	..
113	Manchester	105	−104	− 50
114	Manton	70	− 18	+ 79
115	March	36	+ 2	+111
116*a*	Melton Mowbray	185	+ 85	+305
116*b*	„ „	182	+152	+ 80
117	Milford Haven	98	− 23	− 72
118	Newark	56	+ 49	+ 6
119	Newcastle	35	− 27	− 4
120	Northampton	111	+165	− 69
121	Nottingham	33	− 27	+179
122	Oxford	38	−153	+169
123	Peterborough	52	+ 56	+150
124	Plymouth	30	+168	−210
125	Port Erin	135	−134	− 55
126	Preston	4	− 34	+ 49
127	Purfleet	60	+111	+ 89
128	Pwllheli	125	+ 45	+114
129	Ramsey	121	−150	+ 4
130	Ranmore	85	+ 65	+ 11
131*a*	Reading	49	− 8	+235
131*b*	„ (Caversham)	84	− 10	..
132	Redcar	23	− 15	+ 11
133	Ryde	59	− 56	− 18
134	St. Cyres (Exeter)	72	+ 50	− 5
135	St. Leonards	6	− 31	− 61
136	Salisbury	91	− 29	+ 43
137	Scarborough	47	+ 52	+ 63
138	Shrewsbury	118	−173	−319
139	Southend	81	+126	+ 74
140	Spalding	134	− 98	− 48
141	Stoke-on-Trent	17	+ 10	+ 85
142	Sutton Bridge	55	− 51	+200
143	Swansea	105	+ 4	+ 30
144	Swindon	..	..	+ 38
145	Taunton	26	0	− 59
146	Thetford	17	− 7	+ 94
147	Thirsk	38	+138	+173
148	Tilney	29	− 4	+311
149	Tunbridge Wells	22	+ 95	−104
150	Wallingford	26	−108	+145
151	Weymouth	13	180	−144
152	Wheelock	..	..	..
153	Whitehaven	42	+ 69	+ 24
154	Windsor	58	+104	+136

TABLE of Disturbing Forces—*continued.*

No. of Station.	Name of Station.	F.	φ.	Z.
155	Wisbech	22	+ 30°	+227
156	Worthing	44	+ 90	+ 24
G	Greenwich	36	+ 79	− 5
S	Stonyhurst	22	− 93	−223
157	Armagh	25	+ 27	−158
158	Athlone	59	− 81	− 68
159	Bagnalstown	38	+131	−113
160	Ballina	224	−146	− 74
161	Ballywilliam	104	−154	+ 45
162	Bangor	68	+ 3	− 93
163	Bantry	39	+ 52	− 12
164	Carrick-on-Shannon	49	+ 72	−171
165	Castlereagh	37	+107	+ 25
166	Cavan	68	+177	−111
167	Charleville	31	−147	−152
168	Clifden	183	+145	+ 37
169	Coleraine	226	−162	+106
170	Cookstown Junction	402	− 6	−677
171	Cork	52	+ 49	+ 3
172	Donegal	56	+ 63	−250
173	Drogheda	44	+ 33	− 14
174	Dublin	103	+ 21	−126
175	Enniskillen	107	+160	− 78
176*a*	Galway	386	+159	−338
176*b*	,,	97	+106	− 51
177	Gort	67	− 5	+ 56
178	Greenore	134	+ 78	− 60
179	Kells	108	+ 14	+106
180	Kildare	53	+ 36	−118
181	Kilkenny	43	+ 41	− 4
182	Killarney	85	+ 42	− 54
183	Kilrush	29	+110	− 4
184	Leenane	195	−151	−151
185	Limerick	105	+ 14	− 89
186	Lisdoonvarna	117	− 7	+100
187	Lismore	36	+ 46	−135
188	Londonderry	24	0	−116
189	Oughterard	92	+130	+183
190	Parsonstown	8	−140	+ 48
191	Sligo	107	−126	− 79
192	Strabane	45	−102	−163
193	Tipperary	38	+ 47	− 31
194	Tralee	..	..	..
195	Valentia	118	+ 42	− 53
196	Waterfoot	85	−176	+ 1
197	Waterford	18	− 98	−118
198	Westport	174	−116	+196
199	Wexford	70	−134	+ 15
200	Wicklow	36	−114	−117

Surveys of Selected Districts.

Having described and, as we hope, justified the methods by which we propose to investigate local and regional disturbances, we now proceed to discuss their application to districts of which we have made a special study. The results we shall arrive at will help us in the further elucidation of the magnetic state of the whole country.

The Malvern Hills.

The general nature and direction of the magnetization of igneous rocks is a problem on which comparatively few observations have been made. It is, indeed, known that when examined in detail they present great irregularities, and Commander Creak, F.R.S., has shown ('Roy. Soc. Proc.,' vol. 40, 1886, p. 83) that when islands disturb the magnetic needle in the northern hemisphere they attract, and in the southern repel the north-seeking pole of a magnet. This is what would be expected if they were the upper extremities of magnetic masses magnetized by the Earth's induction.

In like manner in Sweden, where (as has already been stated) the method of searching for iron ore by means of the magnet has been carried to considerable perfection, the assumption made, and justified by experience, is that the upper parts of the beds of ironstone attract the north-seeking pole.

Observations somewhat similar to those of Commander Creak can be carried out on land in cases where igneous rocks rise in the midst of sedimentary deposits, and such observations are specially interesting in cases, such as that of the Malvern Hills, in which the axis of the magnetic mass runs north and south.

If its depth is considerable with respect to its length, and if it is magnetized by induction, we should expect the upper visible parts to attract (in the northern hemisphere) the north-seeking pole. If, on the other hand, it is possible to conceive of a shallow mass of magnetic rock surrounded by non-magnetic matter, the northern end might repel the north-seeking pole. Finally, if the mass was itself magnetized independently of the present inductive action of the Earth, as is certainly the case with small masses of highly magnetized lodestone, its effect on a compass needle could only be determined by experiment.

With the view, then, of making a beginning towards the study of these questions in the United Kingdom, we determined the polarity of the northern end of the Malvern Hills.

This range consists of syenite and granite. The mass of igneous rocks runs due north and south for about eight miles, and is at the broadest part but little more than half a mile wide. On its eastern side is a great fault which extends many miles north and south of the range itself. Two stations, Great Malvern (112*b*) and Malvern Wells (112*c*), were taken on the eastern side of the hills. They were both on the Red Marl, and distant about a mile and a quarter from the centre of the range. Two corresponding stations were also taken on the western side at about the same distance, and both on the Old Red Sandstone. Of these Mathon (112*d*) was 0·3 mile to the north of the latitude of Great Malvern, and the line joining them cuts the range at about a mile from its northern end, passing close to its highest point. Colwall (112*a*) is about three-quarters of a mile to the south of the latitude of Malvern Wells, and the line joining them cuts the range about 2½ miles south of the northern termination of the igneous rocks.

The Declination and Force were determined at all these stations. Time did not allow of the Dip being taken elsewhere than at Great Malvern.

The results are given in the following Table :—

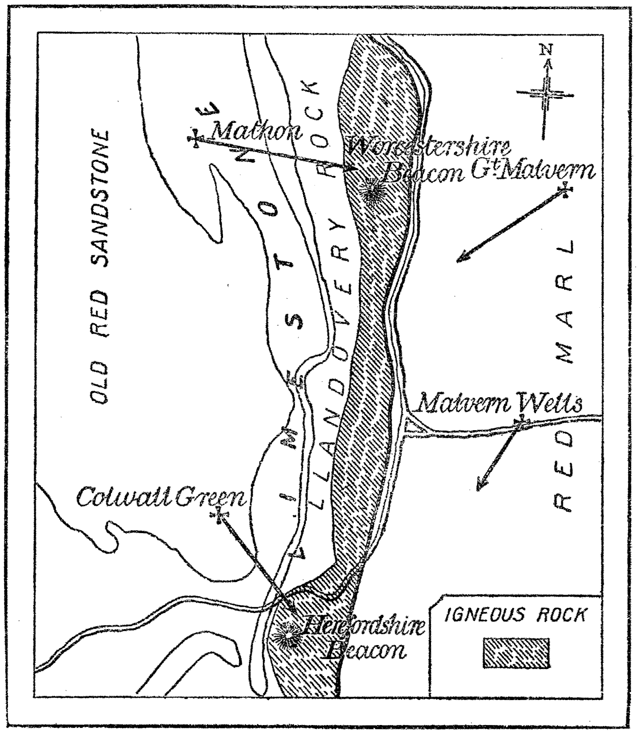
		Declination.	Force.
Eastern Stations	Great Malvern	19° 33'·0	1·7687
	Malvern Wells	19 22·4	1·7682
Western Stations	Mathon	18 46·5	1·7655
	Colwall Green	19 3·6	1·7627

From these the disturbing forces were deduced, the notation being the same as that used on p. 268.

	F.	ϕ.
Great Malvern	·0121	126·6
Malvern Wells	·0081	148·7
Mathon	·0147	− 97·8
Colwall Green	·0119	−140·4

The accompanying Map shows the direction of these forces and their relative magnitudes. The Worcestershire Beacon (1440 ft.) is the highest point on the range; to the south of this the height diminishes, and then increases again to the Herefordshire Beacon. The directions of the disturbing forces tend towards these hills, and the results are, we think, only compatible with the view that the Malverns attract the north-seeking pole of the magnet.

Fig. 12.



Disturbing Forces near the Malvern Hills.

The Island of Canna.

The attraction exerted by the Malverns having been demonstrated, it is convenient to discuss in the next place a locality where the disturbances are enormously greater.

Popular tradition has long attributed to the basaltic rocks of the Island of Canna the power of deviating the needle through very large angles. The compasses of passing ships are supposed to be affected by the eastern extremity of the island, on which stands Compass Hill.

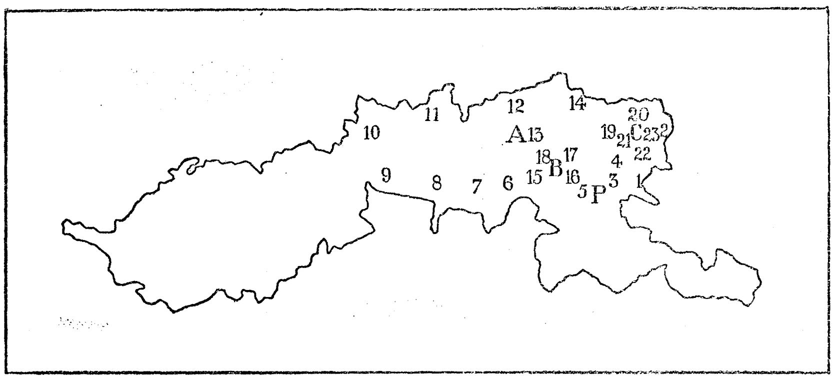
Magnetic observations were made on the Island by Sir FREDERICK EVANS ('Phil. Trans.,' 1872, vol. 162, p. 325), but, we have, we believe, been able to add considerably to what was already known of its magnetic properties.

The island, which is about fifteen miles south-west of Skye, is about five miles long, its greatest length lying nearly due east and west. It is divided into two approximately equal portions by a neck of comparatively low elevation. The highest ground is in the eastern part where it rises to a height of 724 feet, and our observations have been confined to this portion. The cliffs on the north side are here some hundreds of feet in height and fall sheer into the sea. On the south side several small valleys lead to the shore, but the hills rise very steeply about a quarter of a mile inland, and the tops of several consist of irregular masses of basaltic columns. On Compass Hill, which is the most easterly point on the island, the longer axis of the mass runs north and south. Its height on the inland side is from 20 to 40 feet, while it falls steeply towards the sea. On another hill which rises behind Kaill, the residence of R. THOM, Esq., the columnar mass is small and more clearly defined. The north or landward side is 15 or 20 feet high, the south side is a steep cliff. We roughly estimate the length at about 50 yards. In fig. 13 the position of this hill is indicated by B, that of the highest point on the island by A, and that of Compass Hill by C.

In 1884 we determined the magnetic elements by means of the Kew Magnetometer No. 60, and the Dip Circle No. 74, at the position marked P. The differences between the observed and calculated values are given in the following table :—

Date 1884.			
	Observed.	Calculated.	Difference.
Declination.	21° 8′·4	23° 6′·5	−1° 58′·1
Dip	72 45·0	71 32·7	1 12·3
Horizontal Force . .	1·5092	1·5607	− ·0515

Fig. 13.



Stations on Canna.

Although these observations show that the station was highly disturbed, the effect on the Declination is not so great as to be detected, except by a careful observation. In 1888 we observed by means of a small azimuth compass at 23 stations which are indicated on the map, and determined at each the bearings of a number of distant points. The observations were made on August 16 and 17, bright sunny days with a northerly wind, on which the atmosphere was very transparent. We were therefore able to take the bearings, not only of prominent headlands on Skye and Rum, but also of some distant objects, such as the Ushinish Lighthouse on N. Uist in the Hebrides.

The azimuth compass was a small instrument which did not admit of great accuracy, but, as will be seen in the sequel, it was sufficient for the purpose we had in view.

We carried a chart with us, and marked the position of each station while on the spot. On the average, about four bearings were taken at each station, and at no station was the number less than two.

The bearings of the objects selected were afterwards taken from the chart, and, by comparing these with the observations, the Declination was determined. The agreement between the individual observations at each station was in general only moderately good, but, even in cases where only two observations were taken, we think the means are accurate to about half a degree.

Throwing out thirteen stations which were evidently highly disturbed, we took the mean of the Declinations at the other ten as giving the mean Declination for the easterly half of the island, which is 22°·8.

By subtracting this from the Declinations found at the stations, we obtained the disturbance of the Declination at each. The results are given in the following Table :—

Station.	Disturbance.	Station.	Disturbance.
I.	0°·4 W.	XIII.	0°·4 E.
II.	1·6 E.	XIV.	6·0 W.
III.	0·9 W.	XV. (W.)	1·9 W.
IV.	3·3 W.	XVI. (S.)	10·4 E.
V.	1·1 W.	XVII. (E.)	3·6 E.
VI.	1·6 E.	XVIII. (N.)	11·5 W.
VII.	1·5 W.	XIX.	5·8 E.
VIII.	1·3 W.	XX. (N.)	9·9 W.
IX.	8·1 W.	XXI. (W.)	25·8 E.
X.	0·6 E.	XXII. (S.)	10·3 E.
XI.	5·8 E.	XXIII. (E.)	23·8 E.
XII.	0·3 E.		

Stations XV. to XVIII. inclusive were taken round the basaltic mass on the summit of the hill behind Kaill, and on the sides indicated by the letters which follow the numbers.

Stations XX. to XXIII. were in like manner taken round the summit of Compass Hill. In both these cases the compass was generally within a foot or two of the basaltic columns. The observations, therefore, show that these are powerfully magnetic. The disturbing force at Station XXI. was nearly half that due to the horizontal intensity of the earth's magnetic field. On the other hand, it is evident that their influence diminishes very rapidly with the distance. Station VI. was only a few hundred yards from the hill behind Kaill, yet the compass was not affected by more than 1°·6.

Stations I., II., III., and IV. are grouped round the southern half of Compass Hill, at distances between 200 and 500 yards from the summit ; but the largest disturbance of the Declination is 3°·3 W.

Stations XXIII. and II. are situated one above the other on the eastern side of Compass Hill, the horizontal distance between the two being not more than 80 yards ;

yet the disturbance diminishes from 23°·8 E. at Station XXIII., near the top of the hill, to 1°·6 E. at Station II., near its base.

These conclusions are completely borne out by observations made on the "Coventina," in which we visited the island in 1884 and 1888.

On leaving Canna for Loch Boisdale in 1884 we sailed as close as possible to the northern face of the island, and took frequently the compass bearings of points on Skye. We were unable to detect the smallest deviation of the needle.

In 1888 observations were made under still more favourable circumstances. We approached the island from the north, and, when about three miles distant, the yacht was directed towards a mark on Rum, by which its course could be kept without reference to the compass. We were then sailing magnetic S. $\frac{1}{4}$ E., in the most favourable direction for the effect of Compass Hill (if any) to be detected. We passed it within 200 yards of the shore, but observed no deviation of the compass; and we are quite certain that, if there was any, it was less than one-eighth of a point, *i.e.*, less than 1°·5.

The net result of our observations is that the basaltic cliffs of Canna are powerfully magnetic, and may deviate the needle of a compass placed near them by about two points, *i.e.*, about 23°, but that the effect diminishes very rapidly with the distance, and is inappreciable on a ship's compass 200 yards from the base of the hill, to which tradition ascribes, and in which we have ourselves detected, the most powerful magnetic properties.

We have adopted 22°·8 as the mean value of the Declination at the less disturbed stations in Canna in August, 1888; this leads to 23° 13′ for January 1, 1886, which is only 6′ in excess of the calculated value. This is interesting, inasmuch as Plate IX. shows that neighbouring stations have Declination disturbances of opposite signs, and indicates that a line of no regional disturbance runs near to Canna.

Thus the four stations, Kyle Akin (No. 35), Soa (No. 46), Canna (No. 14), and Loch Boisdale (No. 10), lie very nearly in a straight line, and the disturbances of the Declinations vary continuously, being 28′·0, 18′·4, 6′·0, and − 45′·9, which proves that Canna lies near an attractive centre or ridge. This is in harmony with the fact that the disturbance of the Vertical Force is positive, and is enormously great, amounting to 0·1839, or about 0·04 of the whole Vertical Force.

A comparison of the results obtained at Malvern and Canna points very clearly to the otherwise probable conclusion that far-reaching effects are to be expected quite as much from the great mass and uniform magnetization of rocks as from their being highly magnetized. The basalt of Canna is far more susceptible and more magnetic than the Malvern syenite, but we doubt if a mile and a quarter from Compass Hill it would produce an effect on the Declination needle at all equal to that which we have shown is due at that distance to the Malverns.

The Eastern and South-Eastern Counties.

A problem of considerable interest has to be considered in connection with the Eastern and South-eastern counties. In the greater part of this district, the surface soil is such that it certainly can produce no marked effect upon the magnet, yet in this apparently "good ground," we have found magnetic disturbances of very wide range.

It is well known that the Declinations obtained at the Kew and Greenwich Observatories differ more widely than the difference of longitude will explain. The difference is not so great as appears at first sight, as the Kew results as published are not corrected for diurnal variation.

The published mean Declinations at these two stations in 1886 are, Greenwich 17° 54′·5, and Kew 18° 16′·9, of which the Kew result must be diminished by about 6′. This gives a difference of 16′, which exceeds that corresponding to the difference of longitude by 10′. We are not aware that any attempt has hitherto been made to connect this discrepancy between the Declinations at these two important observatories with any regional disturbance in their neighbourhood.

The fact which first led us to believe that they lie within the area of such a disturbance was that there is not only a small decrease in the Declination between Kew and Reading (instead of an increase as the difference of longitude requires), but that there is also a very small difference between Worthing and Ryde.

The Declination at Reading should be about 20′ greater than that at Kew, but the observation made there in 1886 proved that it is 1′ less.

The Declination was again determined in 1888 at the same spot near Reading, with the result that the Declination, when reduced to epoch, came out 3′·6 lower than before, thus increasing the discrepancy between the actual and calculated differences between the two stations.

In like manner, the difference of longitude between Ryde and Worthing is equivalent to a change of 22′ in the Declination, whereas the observed value at Ryde was only 2′·6 higher than that at the more easterly station.

In order to investigate these differences more fully, we determined to run a chain of stations along the valley of the Thames, to observe at another series half-way between the Thames and the Channel, and to interpolate a station between Worthing and Ryde.

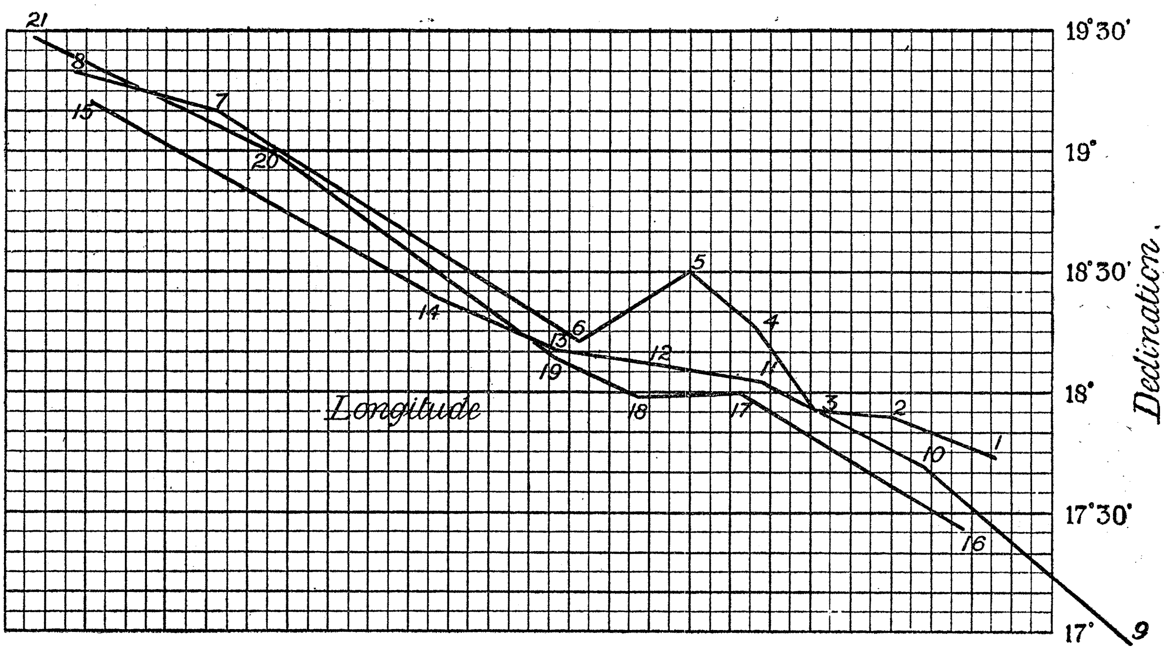
The result is shown in the annexed diagram (fig. 14). Horizontal lengths indicate the longitudes of stations and vertical lines the Declination.

Three groups of stations, such that all places included in each are of nearly the same latitude are taken, thus forming three lines crossing the whole of the south of England. In the cases of Weymouth and Ryde, which lie considerably to the south of the line which nearly passes through the other stations corrections of 14′ and 7′ respectively have been added. Chichester is to the north of the line and its Declination has also been corrected by 7′.

It will be noticed that all three exhibit an anomaly on or immediately to the south of a line joining Greenwich and Reading. In the valley of the Thames the Declination attains a maximum value near Windsor and a well marked minimum near Reading. To the south of this district there is a remarkable slackening in the rate of increase of the Declination.

An inspection of this figure is sufficient to prove that the anomaly in the Declination difference of Greenwich and Kew is not due to any accidental peculiarity of the position of either observatory, but is the result of a regional disturbance extending at least from that part of the valley of the Thames which lies between Greenwich and Reading to the south coast.

Fig. 14.



Declinations at—

1. Southend
2. Purfleet
3. Greenwich
4. Kew
5. Windsor
6. Reading
7. Clifton
8. Cardiff
9. Dover
10. Tunbridge Wells
11. Horsham
12. Haslemere
13. Alresford
14. Salisbury
15. Taunton
16. St. Leonards
17. Worthing
18. Chichester
19. Ryde
20. Weymouth
21. Exeter.

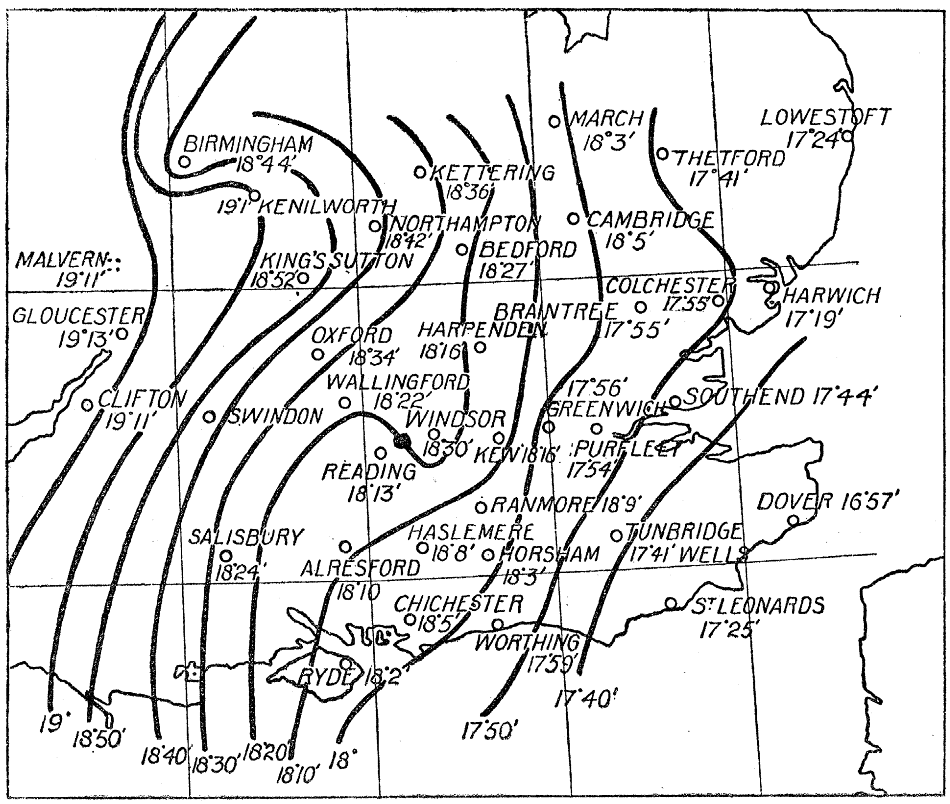
The curves in the diagram when compared with figs. 7 and 8 (p. 263) are seen to be such as would be produced if a centre of force attracting the north-seeking pole of a magnet were situated near Windsor. Immediately over such a centre the value of the Declination would be normal, while it would be too great and too small at stations to the east and west respectively. If the centre were relatively weak the increase in the Declination with longitude instead of being represented by the slope of a straight line would be given by a curve of the same type as that in fig. 7, if it were strong we should have a curve like that in fig. 8.

Fig. 15 shows the true isogonals in this part of the country and proves that the form they assume corresponds to the last case.

The existence of a widespread disturbance is proved not only by the remarkable bend in the 18° 10′ isogonal between Kew and Reading, but also by several other stations. Thus the Declination at Harpenden is the same as that of Kew (18° 16′), though it is about thirty miles to the north of it and should therefore be 9′ greater. Again, Ranmore, Haslemere and Alresford, with Declinations of 18° 9′, 18° 8′ and 18° 10′ prove that the 18° 10′ line has really the great inclination to the meridian which the outer curves in fig. 6, p. 262, show. They are further supported by Horsham, Chichester, and Ryde, with Declinations of 18° 3′, 18° 5′ and 18° 2′ respectively.

The isoclinals and lines of equal Horizontal Force do not show any equally striking peculiarities in this part of the country. The latter, however, run a little too far north to the south of the Thames (see Plate VII.). This is as it should be, for to the south of an attracting centre the Horizontal Force will be abnormally great.

Fig. 15.

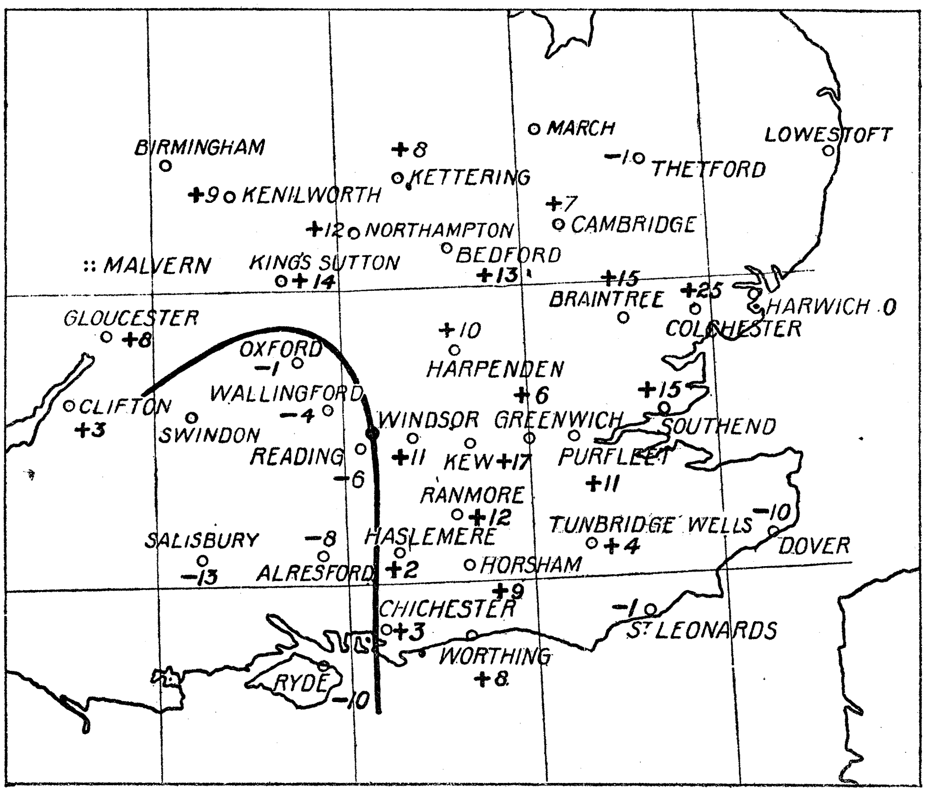


Isogonals in South-Eastern England.

The point at which the terrestrial and true isogonals would intersect if the district were not otherwise disturbed is marked by a dot, which will hereafter be called the *focus* of the Reading disturbance.

Let us now turn to the calculated disturbances of the elements. In the accompanying map (fig. 16) the figures represent the differences between the observed and calculated values of the Declination expressed in minutes of arc, and taken as positive when the needle is turned to the west. There is a sharply marked boundary between the regions of positive and negative disturbance which passes through the focus. To the west of it the needle is deflected to the east and *vice versâ*.

Fig. 16.



Declination disturbances in minutes of arc.

\+ Indicates that the observed westerly Declination is greater than the calculated value.

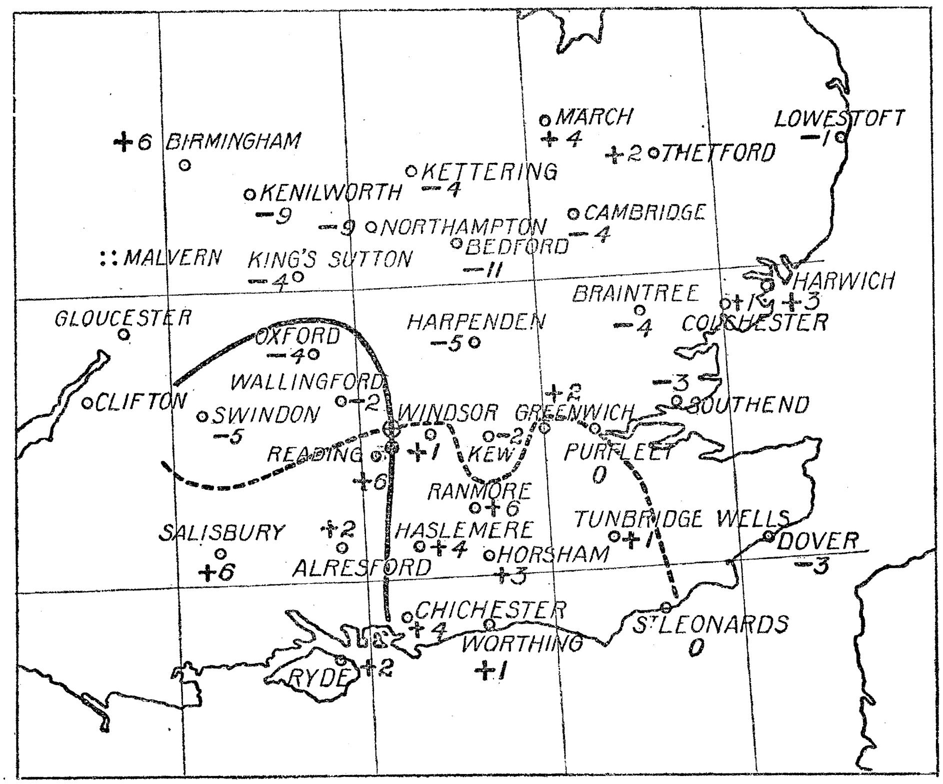
——— Curve of no disturbance.

To the south of the focus the needle is oppositely deflected on each side of a line which runs nearly due north and south. To the north the effect on the Declination needle dies out.

If the cause of the disturbance were a mass of "magnetic matter" below the surface of the Earth symmetrical with respect to the isogonals, the line which divided easterly from westerly disturbances of the Declination would intersect that which divided positive from negative disturbances of the Horizontal Force over the focus or centre. The next map (fig. 17) shows that this condition is very nearly fulfilled, the two points being only 7 or 8 miles apart. Lastly, the maximum disturbance of the

Vertical Force should occur at the same point, and fig. 18 shows that we find it to be at Reading, which is our nearest station to the two points found as above described. All three elements then combine to indicate that the centre of the Thames Valley disturbance lies between Reading and Windsor, and is a few miles to the north and east of Reading.

Fig. 17.



Horizontal Force disturbances in terms of 0·001 metric unit.

+ Indicates that the observed is greater than the calculated value of H.

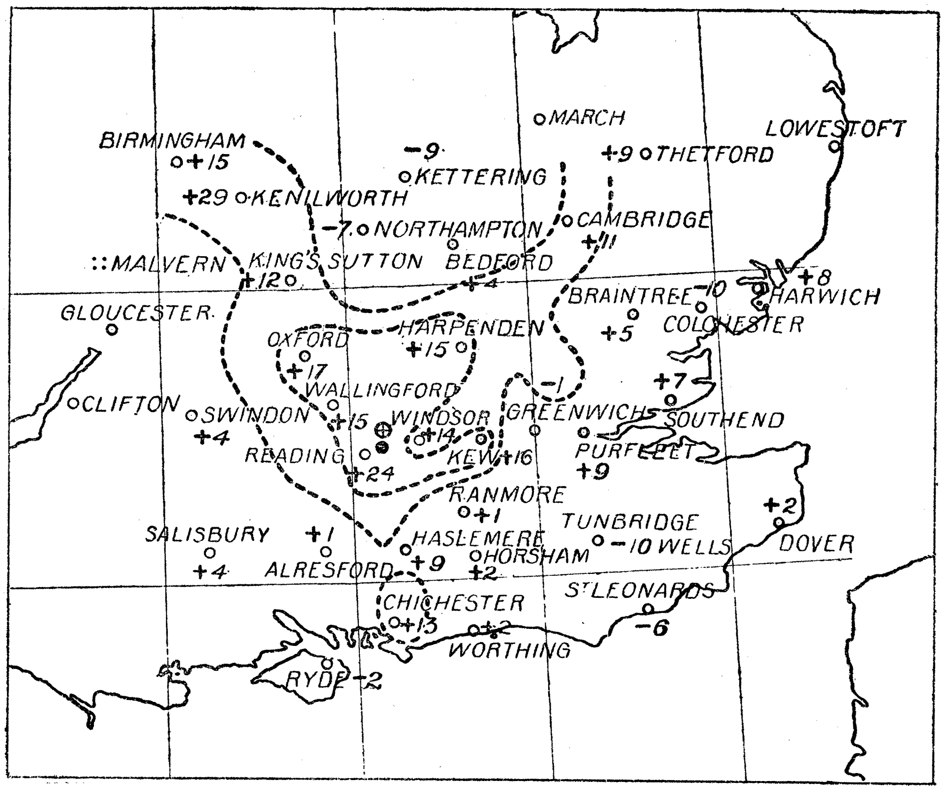
——— Locus of no declination disturbance.

– – – – Locus of no horizontal force disturbance.

The Map of Vertical Force disturbances, however, teaches us a good deal more. If we draw contour lines to enclose all stations at which the Vertical disturbing Force is greater than 0·010 and 0·015 metric unit respectively, the first comprises two independent curves, the one embracing a large area around the focus, and the other surrounding Chichester.

If the cause of the phenomenon were an underground mass of igneous rock we might picture it as a sub-terrestrial mountain of which the peak is near the focus. The slope would be most rapid towards the south-east. Two ridges would run north-east and north-west towards Oxford and Cambridge, a third, less lofty, to Chichester, and a fourth, nearly due east, terminating very abruptly at Kew. If all this were so, the disturbing forces at stations in the neighbourhood ought to be directed towards the lofty central mass. Close to the peak it would itself form the centre of attraction. At stations near to, but not over, outlying ridges, the needle might be deflected towards them. Immediately over a ridge the direction of the disturbance would change rapidly, and thus give an idea of instability. The Horizontal Forces would be least over the peak, would increase up to a certain distance, and would finally die out.

Fig. 18.



Vertical Force disturbances in terms of 0·001 metric unit.

+ Indicates that the observed is larger than the calculated value.

– – – – Contour lines of equal Vertical Force disturbance.

In fig. 19 we have depicted the disturbing Horizontal Forces. They are drawn in the proper directions, and to a scale on which 0·9 mm. corresponds to 0·001 metric units. They fulfil the above conditions exactly, and we think leave no doubt that in the south-east of England over an area of 10,000 square miles the lines of magnetic disturbing force tend to a centre which lies near to and probably between Twyford and Henley-on-Thames. We have treated this district in great detail, because we rely upon these results to prove that the methods of calculation and deduction adopted are satisfactory, at all events in districts where the surface rock or soil is non-magnetic. If the results attained elsewhere present greater difficulties it must be due to the greater complications introduced by the interference of local with regional disturbances.

Fig. 19.

Disturbing Horizontal Magnetic Forces in South-Eastern England.

The maps which have been used to illustrate our discussion of the Reading disturbance give indications of other minor centres, and in particular the isogonals are considerably distorted in the north. It appears that if we draw a line through King's Lynn (No. 100), Spalding (No. 140), Melton Mowbray (No. 116), Loughborough (No. 109), Birmingham (No. 63), and Malvern (No. 112), the district through which it passes is the seat of local disturbances, which, though individually less widespread than that already discussed, are nevertheless of considerable intensity.

We will now investigate several points in this neighbourhood. It will not be necessary to do this in the same detail as before. The places to be considered lie so near to the borders of the district already studied, that methods which are so consistent in the one cannot be subject to any important error in the other.

The Wash.

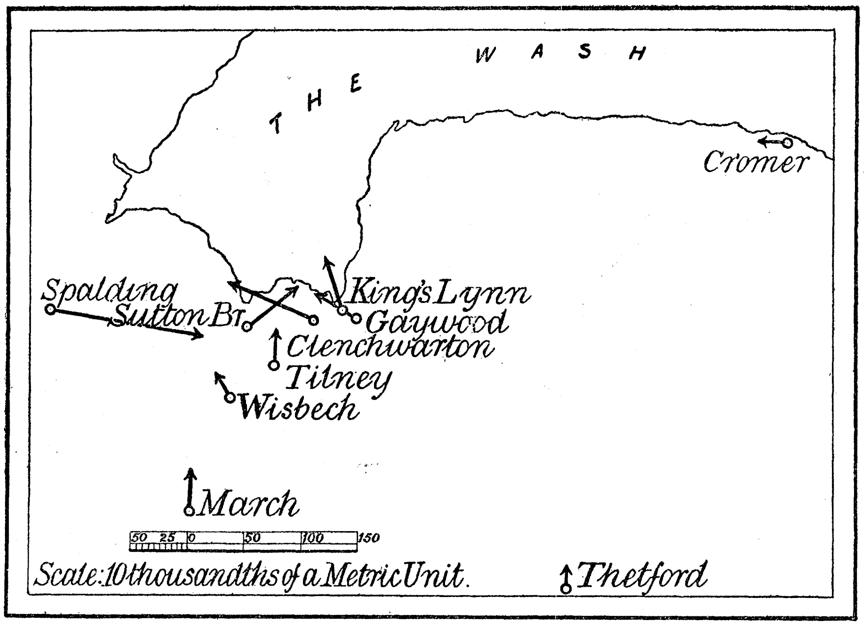
We have discovered a remarkable disturbance in the neighbourhood of the Wash. No more unlikely region could *primâ facie* have been suggested, but the evidence for its existence is conclusive.

Our attention was first called to it by the fact that the Declination found in 1888 at Spalding is less than that observed at King's Lynn in 1886. Allowing for the difference of longitude, the Declination at Spalding ought to be about 16′ greater than at King's Lynn. The two values found and reduced to epoch were

King's Lynn, 1886	17°	57′·9,
Spalding, 1888	17	51·6.

Thus, if the King's Lynn value is normal, that at Spalding is 22′ too small.

Fig. 20.



Disturbing Horizontal Magnetic Forces near the Wash.

A special survey was therefore made of the district with the following results.

A chain of stations was run along the edge of the Wash. The measurements at King's Lynn were repeated near to, but not on the same site, and observations were made at Clenchwarton and Sutton Bridge between King's Lynn and Spalding. The latitudes of these stations did not differ by more than 2′; the longitudes and Declinations were as follows:—

Stations.	Longitude.	Declination. Jan. 1, 1886.
King's Lynn (Gaywood 1888)	0° 26′·0 E.	18° 1′·7
King's Lynn (1886) . . .	0 24·3 E.	17 57·9
Clenchwarton (1888) . . .	0 21·3 E.	18 10·3
Sutton Bridge (1888) . . .	0 11·8 E.	17 54·1
Spalding (1888)	0 8·6 W.	17 51·6

These results make it certain that near the south of the Wash the Declination diminishes instead of increasing (as at normal stations) with the longitude.

The accompanying map shows the directions and magnitudes of the disturbing forces in this district. They indicate a centre of attraction to the north of the line which joins Spalding and King's Lynn.

The Leicestershire District.

Another series of local disturbances exists to the west of that which has just been described. The facts which first attracted our attention to it were that at two pairs of stations, viz., Birmingham and Northampton, Leicester and Peterborough, the observed Declination at the more westerly was only about 2′ greater than that at the more easterly station, though the calculated differences were as much as 35′ in the first case, and 27′ in the second case.

The observations indicated that in this district the isogonal lines run nearly east and west instead of nearly north and south, and we proceeded to investigate their forms more closely. We thought that the anomaly was probably connected with the fact that in Charnwood Forest, which is not very distant from Leicester, igneous rocks appear upon the surface, and observations were made round this district, though we were always careful that our station should be on what was apparently good observing ground.

We have thus confirmed the existence of a great easterly trend in the isogonal lines, and though the magnetic state of the district appears to be complicated, and to require further investigation, we have also established several facts which will probably prove to be of fundamental importance in the solution of the problems connected with it.

Three of the most interesting stations are Coalville (No. 76), Loughborough (No. 109), and Melton Mowbray (No. 116). Loughborough and Coalville are both on the Red Marl, with alluvium near to the streams. Between them lies Charnwood Forest, in which are masses of porphyry, greenstone, and syenite.

We should, perhaps, expect from the analogy of the Malverns that at these two stations the needle would be attracted towards the crystalline rocks. This does not appear to be the case, or, as is more probable, the stations are too far distant to be affected. At Loughborough, which is the more easterly station, the disturbance of the Declination is 30′·3 *towards the east,* while at Coalville it is in the same direction, but only to the extent of 11′·2.

About 12 or 13 miles further to the east is Melton Mowbray, situated on Lower Lias clay with argillaceous limestone at its base, yet a series of observations made here on April 22, 1888, gave a Declination disturbance of + 32′, *i.e.,* towards the west. Unfortunately, the observation for the geographical meridian could only be made near noon, as the sun was invisible during the rest of the day; but so remarkable did the result appear that the place was revisited on April 30. Another station on the other side of the town, about a mile and a half distant from the first, was chosen, and the new observation was made under favourable conditions at about 5.45 P.M. The result indicated a Declination disturbance of + 26′, which was in close accord with that previously obtained. At first sight, then, it appears that the peculiarities of the district might be explained by the hypothesis that a centre of force, powerful relatively to Charnwood Forest, exists somewhere between Melton Mowbray and Loughborough. The disturbances of the Declination at these two stations are in opposite directions and of nearly equal amounts. This view does not, however, correspond with the directions of the disturbing forces obtained at Melton Mowbray. If it were correct they should both have acted in nearly parallel directions towards the west. As a matter of fact, at the first station the disturbing force acts nearly due west, while at the second it is only 11° from south.

This indicates that the disturbance at Melton Mowbray is of a more local character, and cannot, in the manner suggested, be brought into relation with the oppositely directed disturbances at Coalville and Loughborough.

If, however, we turn from the Horizontal to the Vertical disturbing Forces we find that the peculiarities of these various stations may be connected, and that a magnetic map of the district can be drawn which may furnish the first rough outlines to which details may hereafter be added without rendering them substantially incorrect.

This explanation is based upon the fact that whereas in this part of England the disturbances of the Vertical Forces are for the most part positive, at four consecutive stations in this neighbourhood they are negative.

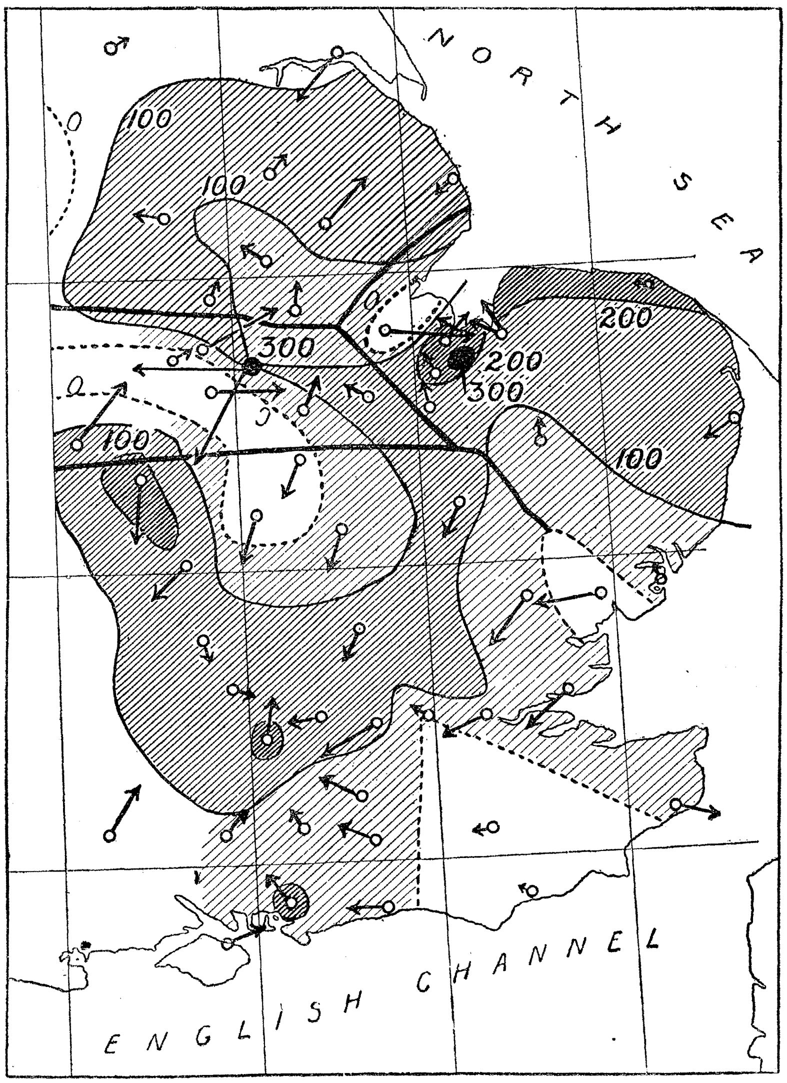
These stations are Coalville, Leicester, Kettering, and Northampton. Whether the low Vertical Forces are due to the presence of a repulsive centre, or to a deep cleft or valley in the attracting mass, we cannot tell. Indeed, the latter hypothesis might account for a repulsion if the mass of attracting matter which we have supposed to culminate in the Reading peak terminated abruptly on its northern edge. For, if it were magnetised by induction it is possible that some of the lines of force might escape upwards to the surface, diminish the Vertical Force, and urge the north pole northwards.

Contour lines drawn as in the accompanying map (fig. 21), indicate the possibility of a very sudden rise in the magnetic matter from a line drawn through Coalville, Leicester, and Kettering, to another which passes through Chesterfield, Nottingham, Melton Mowbray, and Peterborough. This view is supported by the fact that a ridge line, on passage across which the disturbance of the Declination changes sign, runs from near Chesterfield to near Melton Mowbray.

If this view were correct, Melton Mowbray would have to be regarded as near the summit of an extremely steep peak, as the Vertical Force changed from 0·0305 to 0·0080 in the small distance between the two stations. The direction of the Horizontal Forces would indicate a point a little to the west of both stations as the actual peak.

Fig. 21 is an attempt to realise the magnetic constitution of this part of England from this point of view. In studying it we must remember that the direction of the Horizontal Force at a station where the Vertical Force is a maximum or minimum must be indeterminate in the sense that it cannot be deduced from the Vertical Forces

Fig. 21.



Contour lines of Vertical Disturbing Force and Horizontal Disturbing Forces in South-Eastern England. Each darker tint corresponds to an increment of 0·0100 metric unit in the Vertical Disturbing Force.

at neighbouring stations. All that we know when the Vertical Force is a maximum is, that a peak is probably in the neighbourhood, but on which side of the station we do not know, unless, as in the case of the Reading disturbance, other stations indicate it.

The whole district may apparently be divided into four parts, of which the boundaries are indicated on the map by heavy lines.

The southernmost is the region of the Reading disturbance. The tendency of the Horizontal Forces to act towards regions of high Vertical Force is unmistakeable. At King's Sutton the direction of the resultant appears to be affected by the region of high Vertical Force to the north, near Kenilworth. At Worthing and Ryde the Horizontal Forces point direct to the Chichester peak. At Purfleet and Southend the directions of the Forces are more southerly than the distribution of the Vertical Forces would have led us to suspect.

The most easterly district is that of the Wash disturbance. Near King's Lynn the Vertical Force is great. It is greatest at Tilney, which is the central station. The Forces at neighbouring stations converge to a point to the north of this, and the Horizontal Force at Tilney itself is directed northward. It is therefore likely that here, as in the case of Reading, the true peak, though near, is not at the spot at which we found the greatest Vertical Force. It probably lies to the north of it.

The central district is that of the Leicestershire disturbance. Here the phenomena are more complicated, and we wish it to be distinctly understood that we think it probable that Melton Mowbray does not occupy the position of unique importance which our observations allot to it. Nevertheless, we must point out that the hypothesis that a narrow ridge of attracting matter runs somewhat in the position we have assigned to it, is remarkably supported by the direction of the Horizontal Forces at Coalville, Loughborough, Leicester, and Manton, which would all be explained on this hypothesis. At Melton Mowbray the directions are, of course, indeterminate by means of the Vertical Force, and it is quite possible that the phenomena observed there may be due to some relatively small dyke, and not to an uprising of a part of a widespread mass of igneous rock. Until this district is more fully surveyed we are justified in adopting the view represented on the map, which is consistent with all the known facts.

There is, however, one station in the district, viz., Birmingham, which is not in harmony with the rest, as the direction of the Horizontal disturbing Force is toward the region of minimum Vertical Force. Perhaps this indicates that this region is not connected, as we have supposed, with the larger region of low Vertical Force to the west, but that the two are severed by a district of high Vertical Force running from Birmingham northward. Future investigation can alone decide this question.

The most northerly of the four districts is almost outside the region of our special surveys. We only introduce it to show that there is a large region of high Vertical Force to the north of Melton Mowbray, and that, therefore, there is nothing anomalous in the northerly directions of the Horizontal Forces at Nottingham and Grantham. If it be true that in the Leicestershire disturbance the attracting matter lies within narrow limits, it is quite possible that at these stations the predominant influence may be that of the larger northern mass.

On the whole, then, if we take the region bounded by the sea, by lat. 53° and long. 2° W., which includes about 50 stations, we think the Horizontal Forces unmistakeably tend to act toward the region of great Vertical Force. There is one striking exception at Birmingham, and one or two more doubtful ones on the lower reaches of the Thames, and the rule must be construed subject to the obvious condition that a true maximum of Vertical Force, though probably near to, is not necessarily at the station at which we happen to have found the largest among the Vertical Forces we have measured.

Subject to these exceptions and to this proviso the rule holds good.

General Results of the Investigation of the Local and Regional Disturbances.

Having described the results obtained in districts to which we have devoted special attention we now proceed to apply the same methods to the whole area of the survey. In adopting this course we are fully aware that the number of our stations is not sufficient to enable us to speak with any certainty as to the details of the magnetic peculiarities of the districts we are about to discuss, and it is quite possible that we may have arrived at some conclusions which must hereafter be modified. It appears to us that even under these conditions our work is much more likely to be useful if we give what only professes to be a first rough sketch map of the magnetic forces in play in the country than if we leave our successors to get what hints they can from observations which we ourselves have made no attempt to collate. Even, therefore, if our conclusions were much less certain than we believe them to be we think it would be better to state them.

Fortunately, however, we are able to take up a much stronger position than this. Our conclusions may be tested, (1) by the agreement of the results of the various methods of attacking the problem, (2) by the agreement of our results in Scotland with those which can be deduced from Mr. WELSH's survey, (3) by the establishment of relations between the magnetic phenomena at stations scattered over wide areas, and (4) by the establishment of a connexion between the magnetic and geological characteristics of various districts. In all these particulars we venture to assert that they will bear investigation, and we cannot but believe that we have detected the main directions of the lines of disturbing magnetic force.

The method we adopt is as follows :—

We draw the ridge and valley lines (see p. 265) which mark the centres and the boundaries of districts which are under the influence of a dominant locus of attraction. We take each district bounded by two valley lines, and study it by means of the true isomagnetics of the disturbances and disturbing forces, and lastly, we discuss the relations between its magnetic and geological characteristics.

The following are *a priori* probable consequences of the hypothesis that each district, bounded by two valley lines, is subject to an attraction tending towards the centre :—

(1.) Since the regional forces are weak near a valley line it is in such a position that we should expect the effects of such local forces as might exist to predominate, and discrepancies to occur more frequently than elsewhere.

(2.) The centre of a district, in the neighbourhood of the ridge line, should be a region of relatively high Vertical Force. It will be remembered that the ridge line is drawn by means of the disturbances of the Declination and Horizontal Force only, and, therefore, an agreement between its position and that of a region of high Vertical Force is an independent confirmation of the accuracy of the theory that the forces in play in the district form a connected system, that is, they are regional and not merely local.

(3.) The directions of the Horizontal Forces at points of maximum or minimum Vertical Force may be indeterminate in the sense that they cannot be deduced from the distribution of the Vertical Forces. This point has already been insisted on.

(4.) In crossing a valley line both sets of attractions in the region which it separates tend to produce a maximum and minimum of the Horizontal Force (see fig. 10, p. 263). If the southerly attraction were alone in play both of these would have values less than the normal. If the northerly acted alone both values would be greater than the normal. Hence, since the maximum will be to the north of the minimum it is probable that in producing it the effect of the northern attraction will predominate and the values will be greater than the normal, while in the case of the minimum they will probably be less.

Comparison with Mr. WELSH'S *Survey of Scotland.*

No more severe test of the physical reality of the disturbing forces deduced by us from our observations can be applied than by the enquiry whether similar methods applied to Mr. WELSH'S survey lead to similar results. In part, the severity of the test lies in the fact that the methods cannot be precisely similar. As England was so imperfectly surveyed in 1857, we are compelled to assume a linear function to express the isomagnetics in Scotland at that date. The isogonals and isoclinals were calculated by BALFOUR STEWART, who used the geographical mile system of co-ordinates. Unfortunately the third element selected by him for calculation was the Total Force, which throws but little light upon problems such as those we are now investigating. We have, therefore, calculated the lines of equal Horizontal Force, using, as in our other calculations, the differences between the latitudes and longitudes and those of the central station as co-ordinates, and by combining these with BALFOUR STEWART'S calculated values we have found the disturbing forces at the various stations.

Again, Mr. WELSH omitted the determination of one or more of the elements at many stations. He apparently had chiefly the terrestrial isomagnetics in view, and did not consider that for the discovery of the local peculiarities of a station, it is essential that all three elements should be determined at it. In part this omission was due to misadventure. A number of Declination observations had to be rejected as the mirror was found to have been out of adjustment. If, therefore, the calculated magnitudes and directions of the disturbing forces depend to any great extent on the distribution of the stations or on the method of reduction, conclusions drawn from WELSH's survey and our own could not be in harmony.

In the case of the Declination comparison is possible, not only with the survey of 1857, but with the observations collected by Sir F. EVANS in 1872. We have measured the distances of the stations from the isogonals given by him ('Phil. Trans.,' 1872, vol. 162, p. 319), and have deduced the disturbances. In the accompanying map (fig. 22) we have combined the results of all three surveys.

The direction of a short line drawn through the stations, shows whether the north pole of the needle was deflected to the east or west. Observations made by Mr. WELSH are indicated by a dotted line, those due to the naval officers by two short lines with a dot between them, and our own by a continuous line.

A discrepancy between any two of the surveys is thus indicated by a cross.

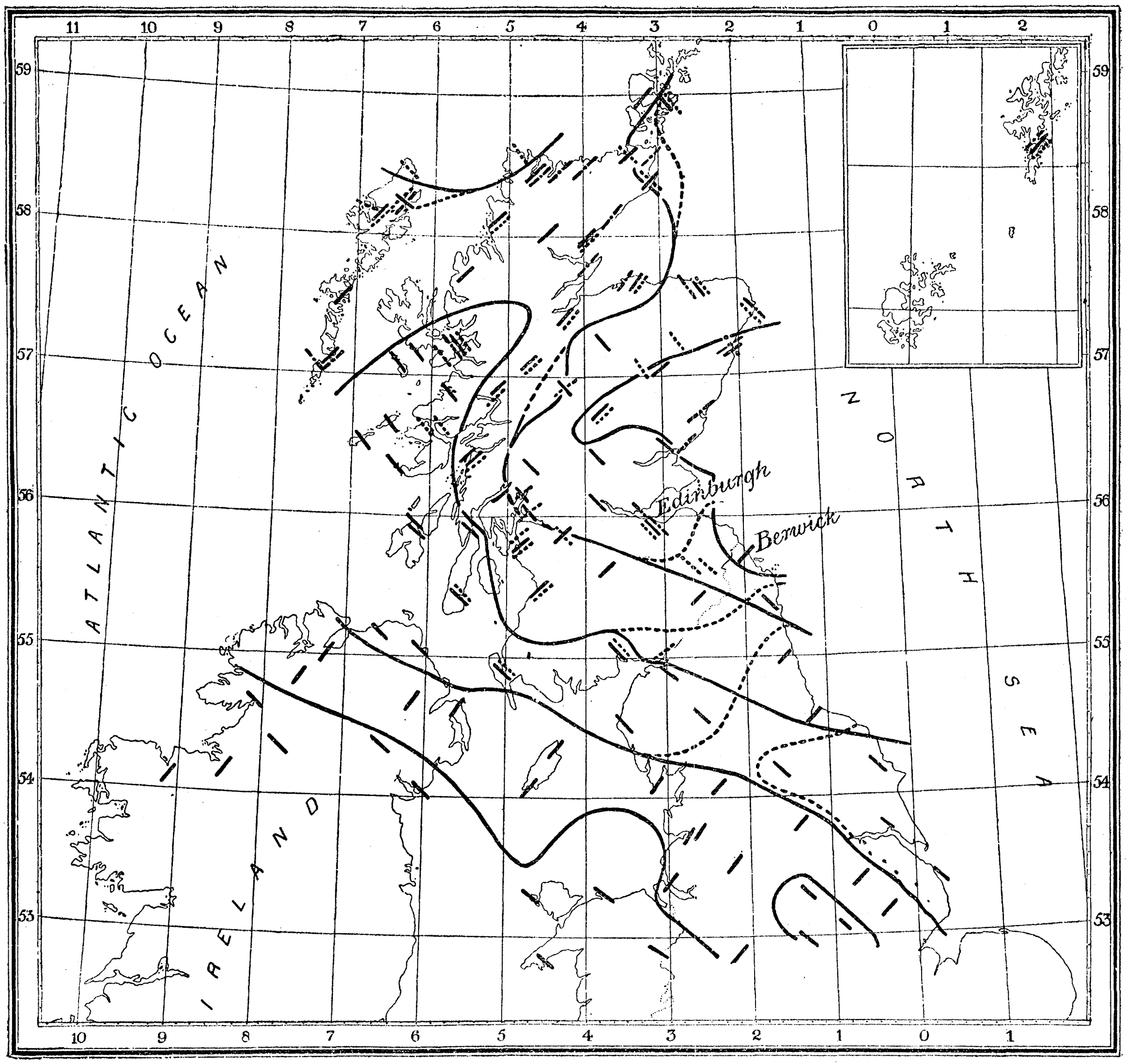
Lines of no disturbance are drawn, separating districts in which the regional disturbance is of opposite signs, and passing, when possible, through stations at which different results have been obtained in different surveys.

Without insisting on the accuracy of the details of these curves, we think that a study of the map can only lead to the conclusion that the districts which they bound are affected by some common cause which produces a similar effect upon the needle. It can hardly be doubted for instance that the magnet is deviated in opposite directions in the neighbourhood of Elgin and Banff. All three surveys agree as to this fact. Again, the evidence is very strong that on the mainland to the north of the Caledonian Canal, except, perhaps, near Cape Wrath and the Pentland Firth, the needle is deflected by regional forces to the east, while in the Islands on the West Coast and the Mull of Cantyre it is deflected to the west. Of course it would be possible to find in these districts places, such as Canna or the Cuchullin Hills in Skye, where large deviations in both directions could be obtained within a few yards, but the great majority of survey stations are chosen too carefully for the local error to become so overwhelmingly predominant. We have omitted Portree because the ground there is known to be unfavourable to our purpose. The differences between the three results obtained are too great to make a mean value trustworthy. At Canna on the other hand, where it will be remembered we observed at twenty-three places, the mean value cleared of the larger disturbances agrees with the results obtained at neighbouring stations.

The following facts are also important.

Seven stations were common to the surveys of 1857, 1872, and 1886. One of these, Lerwick, we disregard, as it lies so far from the rest of the district. In five out of the remaining six the disturbance of the middle epoch as deduced from the isogonals given by Sir F. EVANS is intermediate to those which were obtained in 1857 and 1886. At Oban there is an enormous discrepancy, which is not supported by

Fig. 22.



Directions of Declination Disturbances.

the observations made in 1872 and by ourselves on the neighbouring island of Kerrera. There can be little doubt that the 1872 observation was subject to a powerful local disturbance. The coincidence of the results in the other cases can hardly be accidental. The figures are given in the following Table, Kerrera being added for the sake of comparison with Oban :—

DECLINATION Disturbances.

	1857.	1872.	1886.
	′	′	′
Aberdeen	+ 5·1	− 4·0	− 6·7
Edinburgh	+ 19·8	+ 10·0	+ 4·2
Kyle Akin	+ 38·2	+ 27·0	+ 24·9
Oban	− 11·1	+ 55·0	− 8·3
Kerrera	..	− 5·0	− 6·8
Thurso	+ 13·8	+ 7·0	− 5·2
Wick	+ 11·6	+ 7·0	− 8·5

It is difficult to offer any satisfactory suggestion as to the causes of the apparently regular change. It may be due only to the fact that the three methods of deducing the disturbances by calculations are different, or it may be due to real changes in the local forces. Such alterations are not impossible since if the rocks were magnetised by induction on the earth's field the direction and intensity of the induced magetisation would be subject to secular change, but the differences are too great to be explained thus.

But whether local changes have taken place or not, there can be no doubt that the general distribution of the Declination disturbances in Scotland is the same now as it was in 1857.

In Map 22 the dotted lines are the curves of no disturbance which would have been drawn from our own observations alone. The differences introduced by the addition of WELSH's and EVANS's surveys are quite unimportant in the North. In the South they simplify the lines instead of introducing complications. As the disturbances at Edinburgh and Berwick are of opposite signs, we had to carry a line of no disturbance between them. Mr. WELSH, however, had two stations a little to the West of Berwick, viz., Makerstoun and Melrose, and at these the disturbance is of the same sign as at Edinburgh.

The introduction of these justifies us in treating Berwick as an isolated station, and the simple system represented by the continuous lines results. We have adopted these as the true lines of no Declination disturbance in this part of the Kingdom.

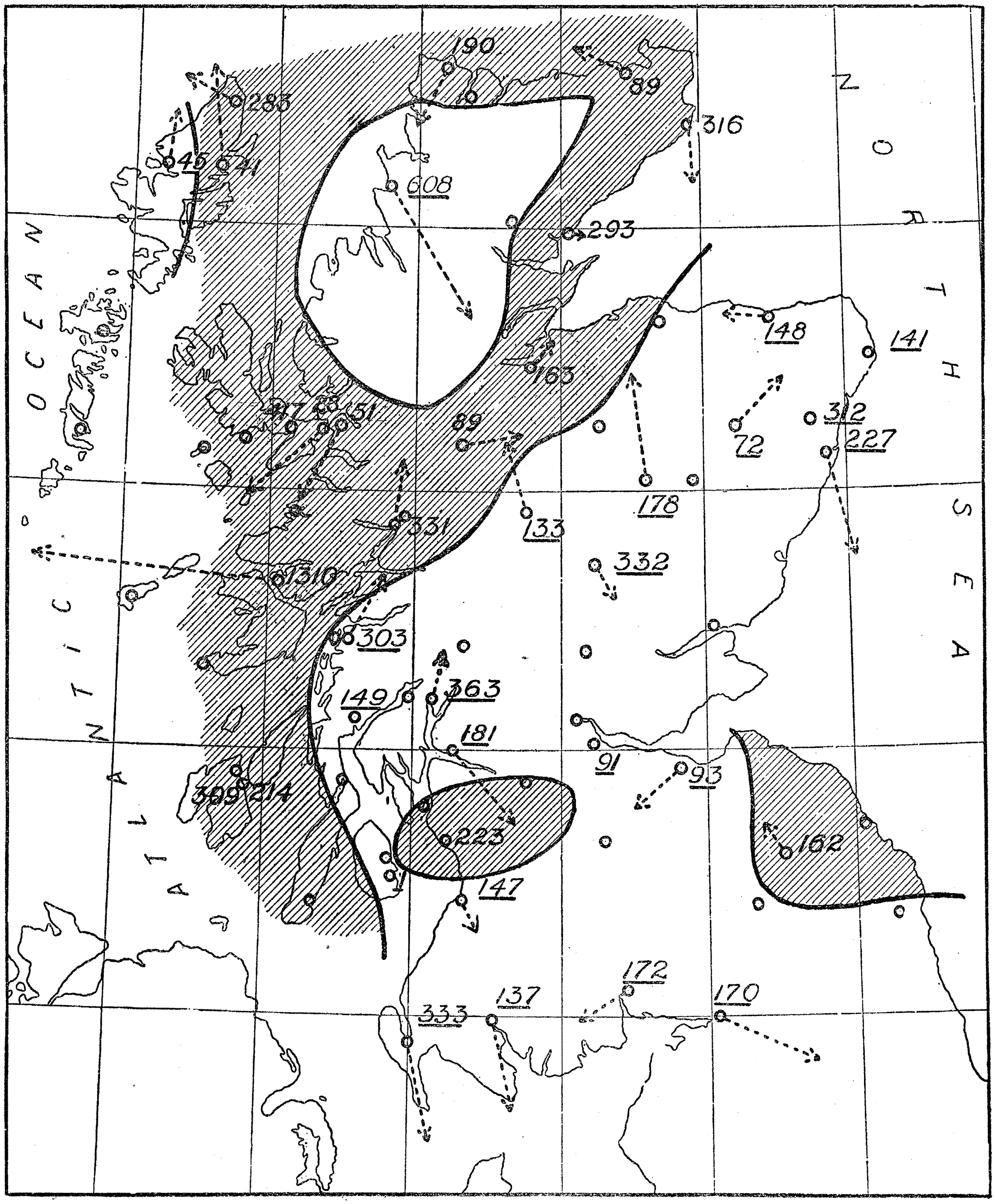
As Sir FREDERICK EVANS did not add any Dips or Horizontal Forces to the list of those already known, we proceed at once to the direct comparison of the disturbing forces deduced from our own and Mr. WELSH's surveys. The magnitudes and directions of these calculated by us as above described are as follows :—

DISTURBING Forces in Scotland from Mr. WELSH'S Survey in 1857.

Station.	Latitude.		Longitude.		F.	φ.	Z.
	°	′	°	′			
Aberdeen	57	9	2	05	163	−164°	− 227
Alford	57	14	2	45	109	− 43	− 72
Ardrishaig	56	1	5	27	43	+151	− 149
Ardrossan	55	39	4	47	..	..	+ 223
Ayr	55	28	4	38	59	−150	− 147
Balmacarra	57	17	5	39	127	+152	+ 51
Banff	57	39	2	31	77	+ 87	− 148
Braemar	57	1	3	25	184	+ 9	− 178
Bridgend	55	48	6	16	..	..	+ 309
Broadford	57	15	5	51	..	..	+ 417
Callernish	58	10	6	44	99	− 6	− 45
Corpach	56	51	5	8	100	− 3	+ 331
Cross	58	29	6	17	90	+ 67	+ 283
Dalwhinnie	56	56	4	17	107	+ 19	− 133
Dumfries	55	5	3	36	96	+123	− 172
Durness	58	34	4	44	112	+152	+ 190
Edinburgh	55	58	3	11	94	+131	− 93
Fort Augustus	57	9	4	40	80	− 87	+ 89
Glenmorven	56	38	5	58	410	+ 86	+1310
Golspie	57	58	3	58	7	− 90	+ 293
Gretna	55	1	3	3	172	−113	− 170
Helensburgh	56	2	4	43	149	−139	− 181
L. Inver	58	10	5	12	248	−148	− 608
Inverness	57	28	4	11	49	− 39	+ 163
Kintore	57	15	2	23	..	..	− 312
Kirkwall	58	59	2	58	153	+ 45	+ 250
Kyle Akin	57	16	5	44	174	+134	+ 28
Lamlash	55	31	5	5	..	..	− 1
Larbert	56	2	3	49	..	..	− 91
Lerwick	60	9	1	8	100	− 6	+ 238
Lochgoilhead	56	10	4	54	66	− 10	− 363
Makerstoun	55	35	2	31	65	+ 37	+ 162
Newton Stewart	54	56	4	28	155	−168	− 137
Oban	56	27	5	26	120	− 31	− 303
Peterhead	57	31	1	46	71	+174	− 141
Pitlochrie	56	42	3	43	58	−150	− 332
Port Askaig	55	52	6	8	..	..	+ 214
Stornoway	58	15	6	23	152	+ 7	+ 41
Stranraer	54	54	5	2	175	−166	− 333
Thurso	58	35	3	32	94	+ 65	+ 89
Wick	58	25	3	5	90	+172	+ 316

These values are shown in fig. 23. The arrows represent the Horizontal Forces in magnitude and direction. The numbers are the Vertical disturbing Forces in terms of 0·0001 metric unit. When negative they are underlined. Lines of no Vertical Force disturbance are also drawn. The shaded parts are regions of positive Vertical Force disturbance. A comparison of this with figs. 25 and 26 will suffice to show that there is a close agreement between the two. Thus, in the case of the Vertical Forces, we both find regions of high Vertical Force along the lines of the Caledonian Canal and the Western Isles, and on the East and West Coasts of South Scotland.

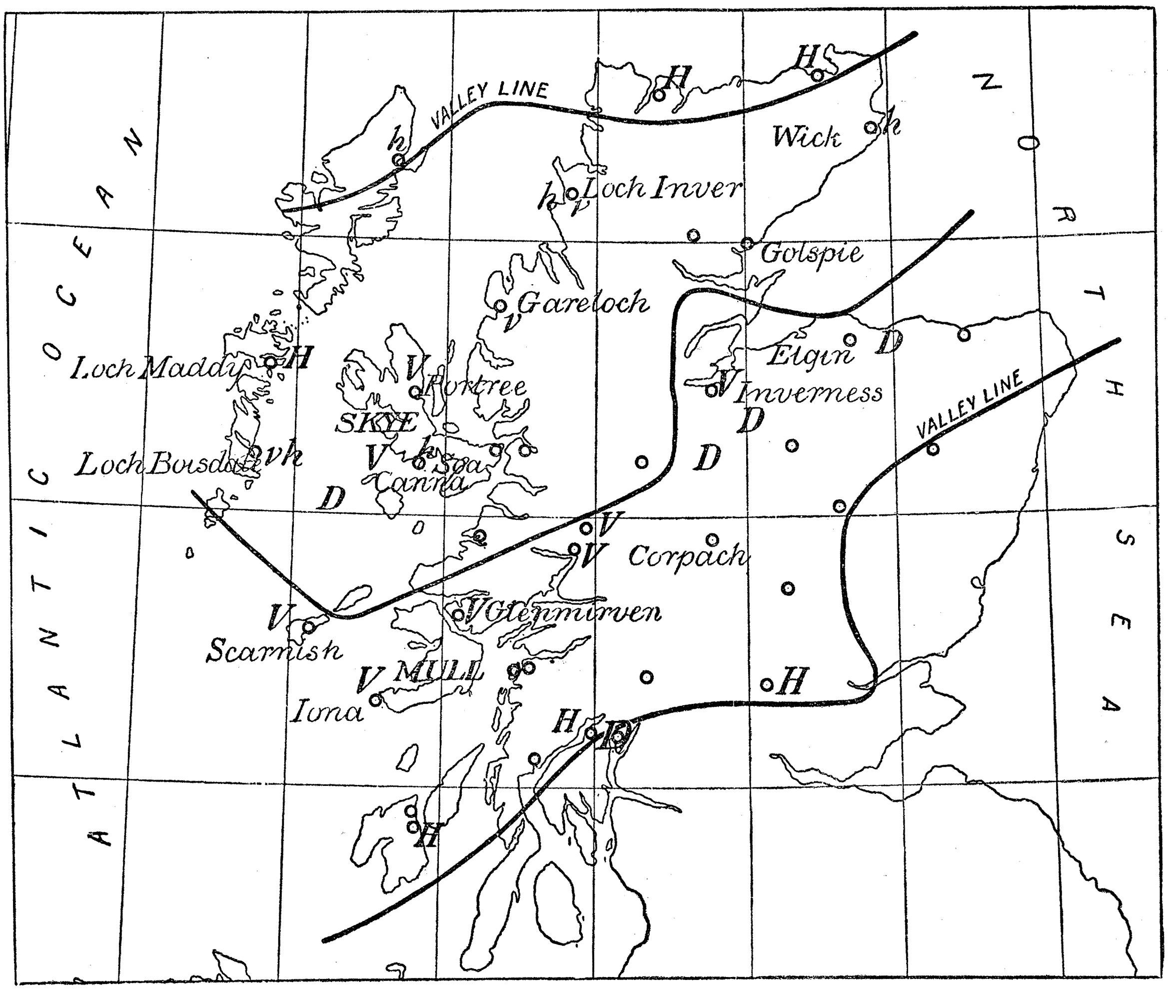
Fig. 23.



Disturbance map of Scotland, from Mr. Welsh's survey, 1857–58.

There are a few discrepancies in the direction of the Horizontal Forces, but the general agreement and occasional differences will be better discussed when we deal, as we are now about to do, with separate districts. We propose to treat of the results of the two surveys simultaneously, and we think we shall succeed in showing that, although it would have been impossible to draw our conclusions from Mr. WELSH's less numerous stations, they are strongly confirmed by the deductions which we have made from his survey.

Fig. 24.



Highland District.

The Highland District.

In fig. 24 we have collected all the information which the isomagnetics in Plates V. to VIII. afford of this district. Those places only are named to which we actually refer. Where the more westerly of two stations has the smaller Declination, the isogonals are distorted (Plate V.), and indicate a centre of attraction between the two. All such points are marked *D*.

Loops in the Vertical Force isomagnetics indicate maxima and minima of Vertical Force, which are marked *V* and *v* respectively. As no observations could be made to the west of the islands in the south-west of Scotland, it is impossible to prove formally that the Vertical Forces in this district are maxima. The values at Scarnish and Iona are, however, the same as those at Wick and Golspie respectively, which are nearly two degrees farther north. We have, therefore, felt justified in marking them as maxima, thereby indicating that they are very large. Canna and Portree are so disturbed that but little reliance can be placed upon observations taken there, but they both give maximum values of the Vertical Force (Plate VIII). At Corpach and Glenmorven we find that Mr. WELSH's observation gave maximum values of the Vertical Force. At two of the most northern stations the Horizontal Force is a minimum; at three of the most southern it is a maximum (Plate VIII.). They are marked with *h* and *H* respectively.

From this map we can form an opinion as to the magnetic constitution of the district. Points of high Vertical Force, and centres to which the needle is attracted, cluster thickly along a line which passes from Elgin to Inverness, thence along the line of the Caledonian Canal to Corpach, and so to Mull.

Another similar line runs north through Skye, and indications of a region of low Vertical Force, which separates the two, are given in the minimum values found at Gairloch and Loch Inver. There is a subsidiary centre of attraction near Strachur.

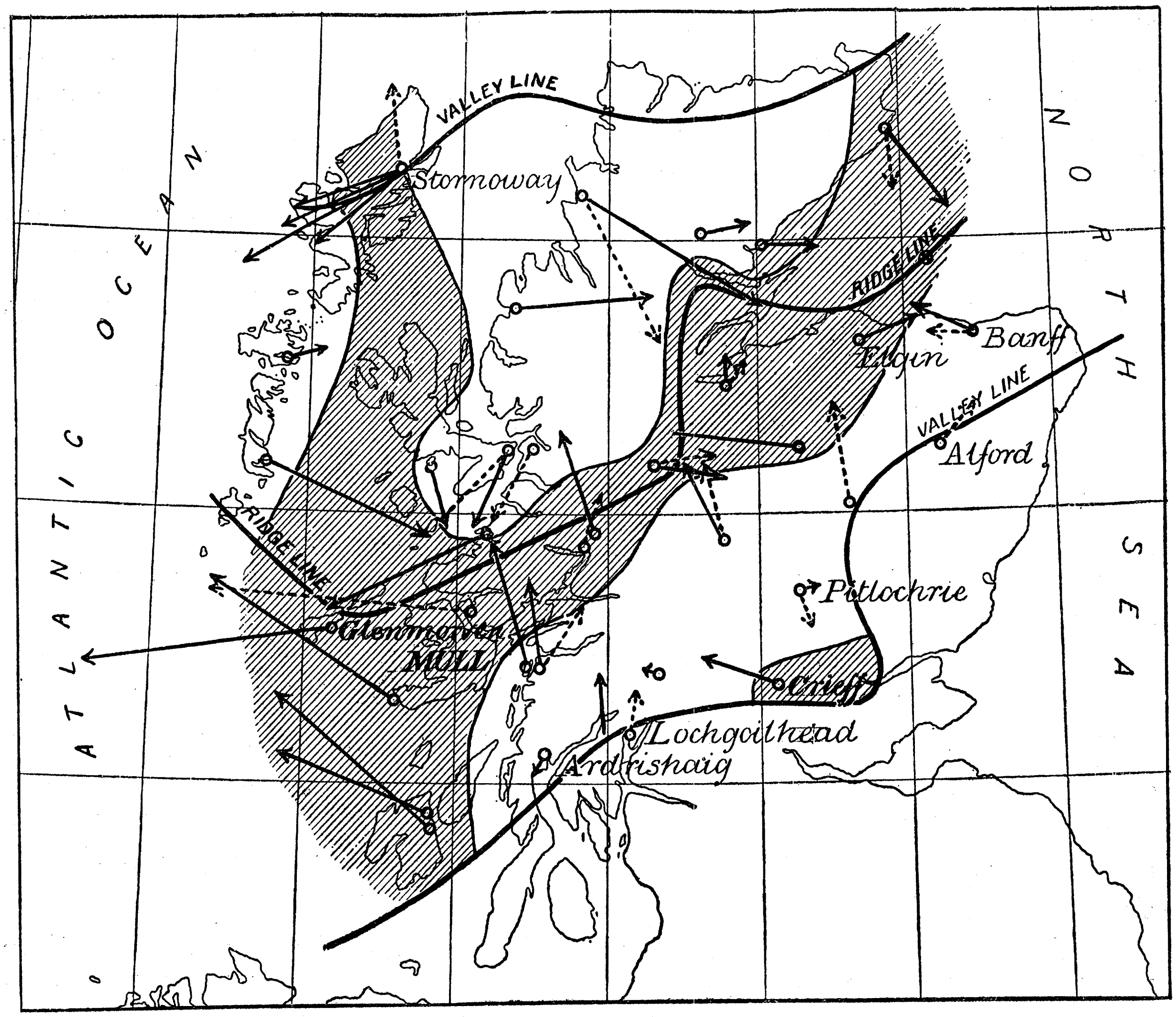
The view that a general attraction is exerted toward the centre of the district is supported by the occurrence of maximum and minimum values of the Horizontal Force in the south and north respectively. The minima at Loch Boisdale and Soa and the maximum at Loch Maddy (which necessarily follows) indicate a strong subsidiary centre of attraction to the south of these places. BALFOUR STEWART, arguing from WELSH's results, placed such a centre to the south of Mull, but as we shall show, it is probably to the west of that island ('Brit. Assoc. Report,' 1859, p. 190).

It must be remembered that all these conclusions follow from the mere inspection of the results of the observation with no more calculation than is necessary to reduce them to the same epoch. In the next map (fig. 25) we show the results of the calculations carried as far as possible, *i.e.*, to the point of deducing the disturbing forces.

The shaded parts are the regions of positive (*i.e.*, of great) Vertical Force. The boundaries are fixed by the very rough method of assuming that between neighbouring stations the rate of change of the disturbing force is uniform. The arrows represent the Horizontal disturbing Forces in magnitude and direction. The dotted arrows represent the disturbing forces calculated from Mr. WELSH's survey.

There are only two or three discrepancies, and they all occur, as we anticipated, near valley lines. The most remarkable is Stornoway. There can be no doubt as to the accuracy of our results obtained on three different occasions and at two stations, and we can only suppose either that there has been a real change or that Mr. WELSH's station was subject to some very great local disturbance. Lochgoilhead, which our observations place just over the valley line in the next district is, according to WELSH, just within this. At Pitlochrie there is a large angle between the two forces. It is doubtful whether the valley line is here correctly drawn. The region of high Vertical

Fig. 25.



Highland District.

Force near Crieff seems to belong to the next district. At Crieff itself the disturbance of the Vertical Force is a maximum, and there is probably a peak in the neighbourhood. The direction of the Horizontal Force cannot therefore be deduced from the Vertical Forces, and the fact that it happens to act northwards has perhaps led to its being wrongly included in this district. If the valley line runs direct from Alford to Lochgoilhead it would pass close to Pitlochrie. Our result would thus make its relations uncertain, as the direction of the Horizontal Force would lie nearly along the valley line. The direction deduced from WELSH's observation would place it in the next district. The same remark applies, though more doubtfully, to Ardrishaig.

If, however, these three or four border stations be put aside, the map leads to a consistent view of the magnetic state of the district, which is in exact accord with that previously arrived at. The ridge line lies in the region of greatest Vertical Force disturbance. The Horizontal Forces tend towards that region, and at points within it are, on the whole, directed to the ridge line. The discrepancies between our results and those of Mr. WELSH are hardly, if at all, greater than those between our own, when repeated. It is remarkable that the south-western stations indicate a centre of attraction out at sea, but our results are completely confirmed by WELSH's at Glenmorven. We should certainly have expected *a priori* that Mull, which is highly basaltic, would be a centre of attraction.

Between Elgin and Banff there is a strong local centre. WELSH observed the Horizontal Force at Banff only, but the Declination obtained by him at Elgin is less than that at Banff, the difference being about 10′, as against 7′ given by our survey. The two sets of observations are thus in agreement.

The Scotch Coal-field District.

This district is bounded on the north by the valley line which forms the southern boundary of that which has just been discussed.

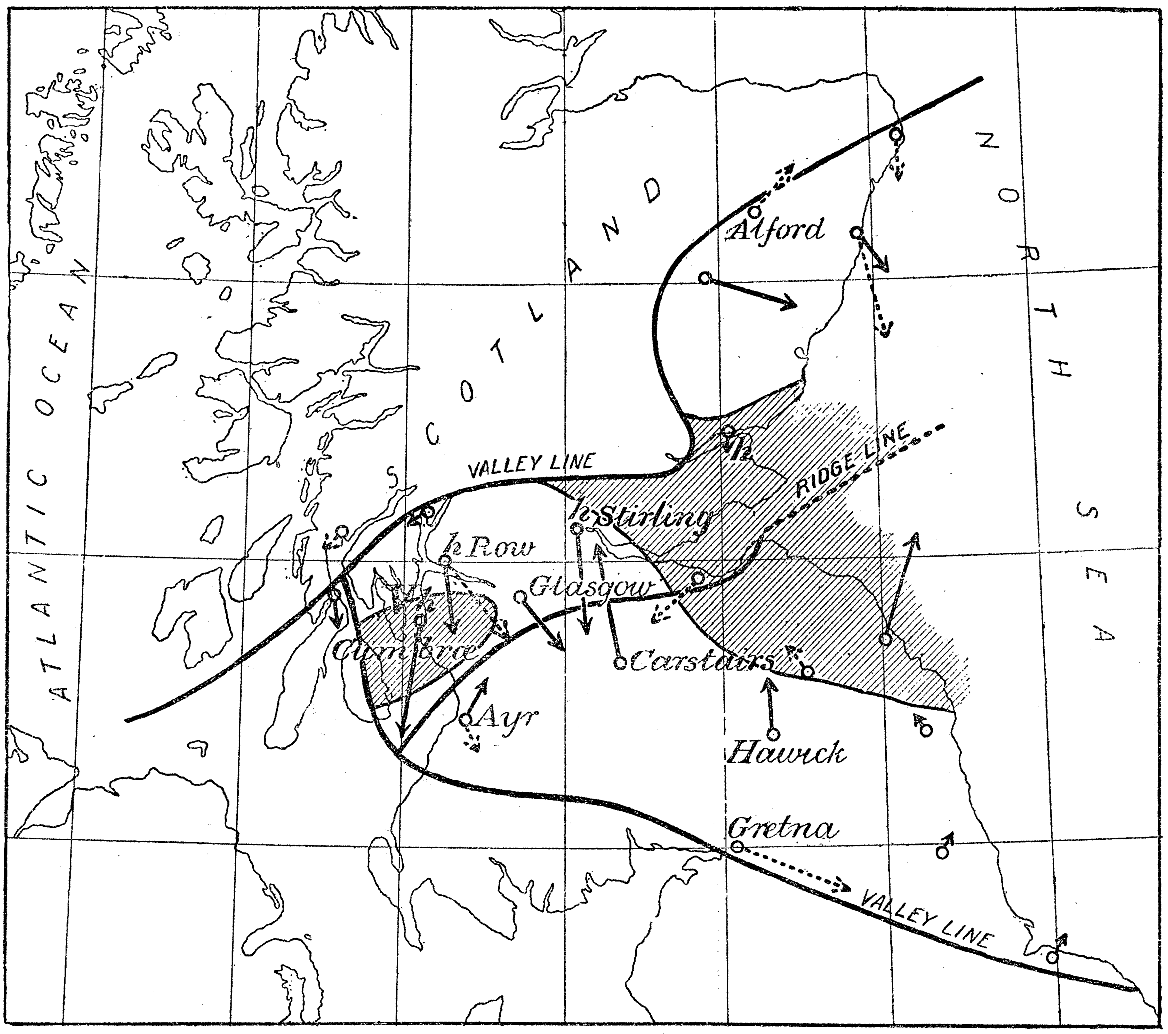
The southern boundary is inclined to the magnetic meridian at an angle which does not give any special advantage to either the Horizontal Force or the Declination as a means of determining its position. We have therefore taken the Declination line corrected (as described on p. 296) by WELSH's observations at Makerstoun and Melrose.

There is not a single abnormal station in this district, and the results of WELSH's observations fit in very well with ours. At Ayr, indeed, there is a very considerable discrepancy, and the forces at Alford and Gretna are larger than we should have expected if they are regarded as the resultants of the attractions of the two regions, close to the boundaries of which these stations are situated.

All the four stations at which the Horizontal Force is a minimum, viz. (taking them in order from the west), Cumbrae, Row, Stirling and Dundee, are situated close to the northern boundary of the Scotch Coal-field, in which there are large masses of basalt.

The ridge line runs through the middle of this basaltic district and passes through or near two regions in which the disturbance of the Vertical Force is positive (*i.e.*, in which the force is great) to the east and west respectively. At Cumbrae the Vertical Force is a maximum, and the existence of a region of high Vertical Force in this neighbourhood is remarkably confirmed by the fact that WELSH's observations give a positive disturbance at Ardrossan a few miles further south, though at the neighbouring stations both to the south and north it is negative (fig. 23). On the whole then there can be no doubt that in this district the ridge line passes through the region of greatest Vertical Force disturbance. It obviously does so in the east. In the west the region of positive disturbance is defined by a single station only, and its boundaries are uncertain. If we included WELSH's observations at Ardrossan they would be pushed further south. In the central region there are clear indications of a maximum disturbance, though the largest values are negative. Thus at Row and Stirling the

Fig. 26.



Scotch Coal-field District.

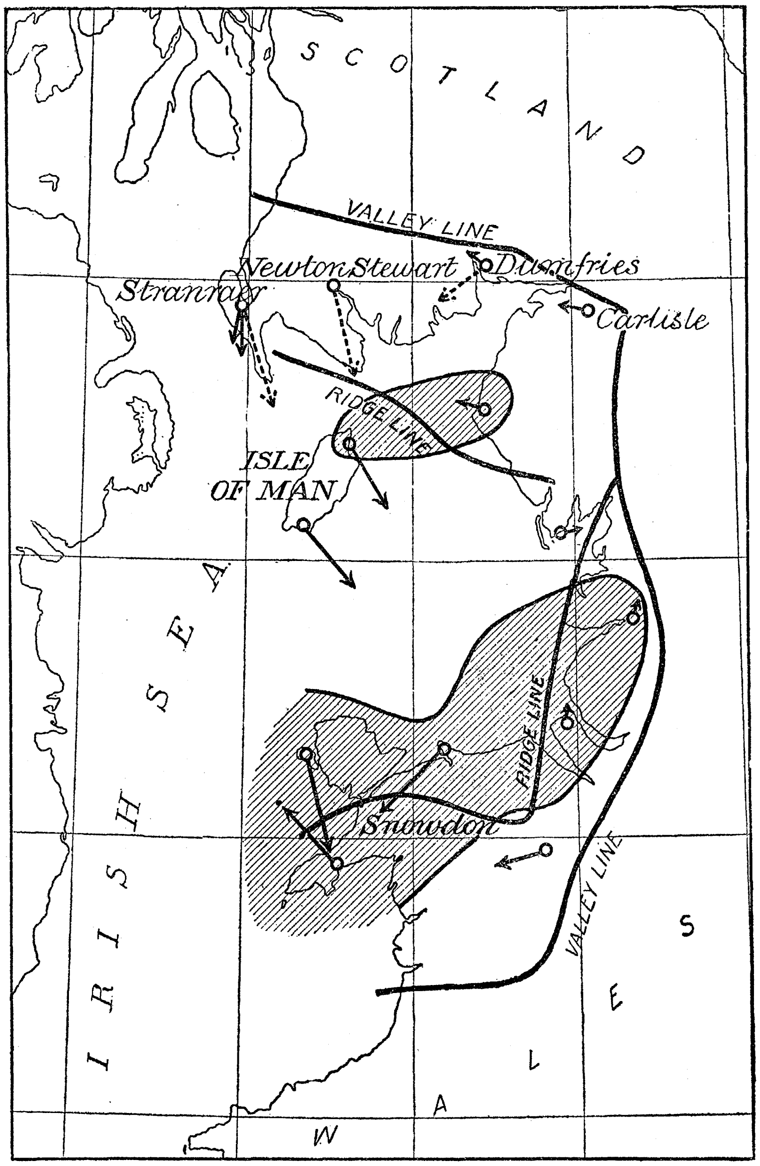
Vertical Force disturbances are −·0188 and −·0092; at Glasgow and Carstairs −·0080 and −·0079; and at Ayr and Hawick −·0145 and −·0099. The two central stations which are nearest to the ridge line have algebraically the largest values.

The convergence of the Horizontal disturbing Forces towards the ridge line is unmistakeable. The isogonals (Plate V.) give evidence of a subsidiary centre of attraction near Lochgoilhead.

North-Western England, North Wales, and Galloway.

The stations in this group are bounded on the west by the northern part of the Irish Sea. They are few in number, and so large a portion of the intervening spaces is covered with water that we cannot hope to unravel the intricacies of the district.

Fig. 27.

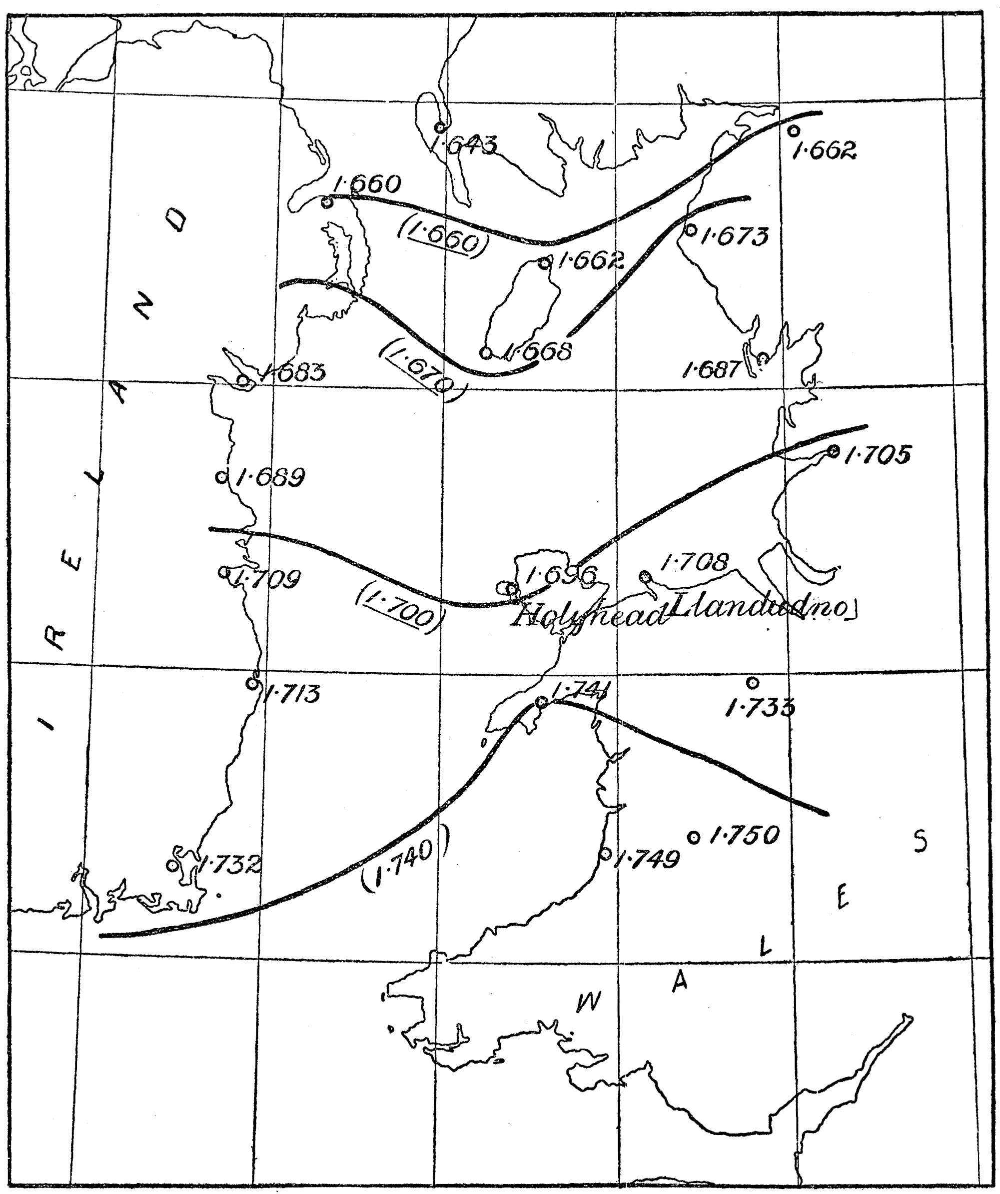


North-West England, North Wales, and Galloway.

The valley line which bounds it on the east has been drawn through the centre of the region of low Vertical Force which exists there (see Plate XI.). The southern part is obtained from the Horizontal Force disturbances (see Plate X.).

At Dumfries and Carlisle the disturbing forces are small, and coincide in direction with the valley line, *i.e.*, they fairly represent the resultants of two attractions exerted on each side of it. At Stranraer, and in the Isle of Man, our disturbing Horizontal Forces act towards the south, and this result is confirmed by those

Fig. 28.



North-West England, North Wales, and Galloway.

deduced from WELSH's observations at Stranraer and Newton Stewart. They are much larger than ours, and at Dumfries the southward tendency is more marked. It must be remembered, however, that the calculations by which these results have been deduced from the 1857 survey have been conducted on the assumption that the

Scotch isomagnetics are linear functions of the coordinates which determine the geographical position, and that the errors involved in the assumption would chiefly affect stations such as these, which are on the border of the district.

If it is necessary to prove that these results are independent of the method of calculation, Fig. 28 is sufficient for the purpose.

The lines of equal Horizontal Force converge in a most remarkable way towards North Wales, which is one of the most certain indications of a centre of attraction. Again the Declinations at Holyhead and Llandudno differ only by 0'·4, while the difference of longitude corresponds to 25'. This again is strong evidence of the existence of a centre of attraction between them.

If, as appears probable, there are two regions of high Vertical Force in the district, it is possible that the northern one may be connected rather with the Cumberland Lakes than with North Wales. However this may be, and while fully admitting that it requires further study, we think that this district appears to obey the rules which hold good elsewhere.

The North-Eastern District.

This district is bounded on the north and west by valley lines which have been already described. On the south we have drawn a line which passes through the centres of two regions of negative Vertical Force disturbance.

The southern portion lies within the limits of our special surveys and has been so fully discussed that nothing need be added here. The northern part presents a feature of peculiar interest.

The results as directly observed do not furnish such clear indications as in a district where the presence of crystalline rocks is more obvious. The isogonals are, however, bent in the peculiar manner which indicates centres of attraction. Thus the 19° 6' line (Fig. 29) points to such a centre to the south of Thirsk, the 18° 48' isogonal points to another between Hull and Gainsborough. As both these lines depend in part upon the same stations, it is satisfactory to find that they are completely confirmed by the quite independent 18° 16' line which runs nearly due east and west between Lincoln and Mablethorpe.

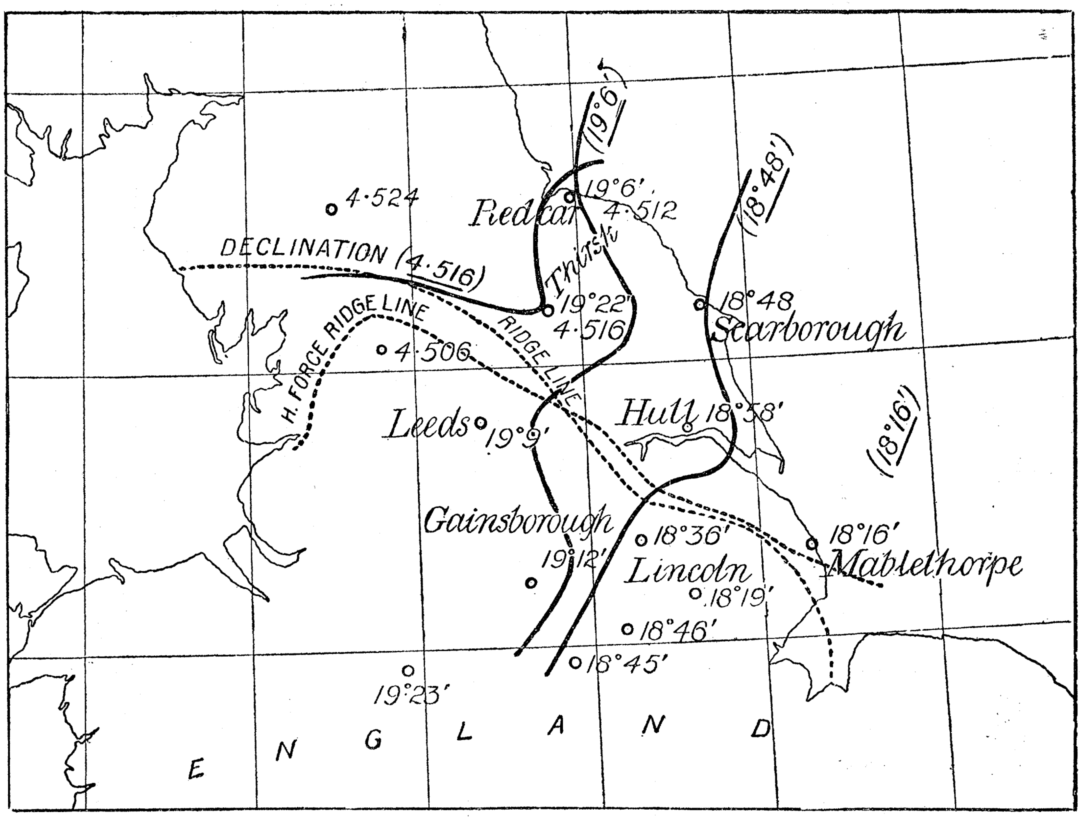
The Vertical Force isomagnetic which corresponds to 4·516 metric units bends southward to Thirsk in a way that is again an indication of a centre of attraction. There are thus signs of an attractive region lying between the following pairs of stations, viz., Mablethorpe and Lincoln, Hull and Gainsborough, Thirsk and Leeds.

On turning to the disturbances (Plates IX. and X.), we find that both the Declination and the Horizontal Force give nearly coincident ridge lines running along the line just indicated. The declination line passes northward to the Cumberland Lakes and southward to the Wash. The Horizonal Force line turns south amid the Yorkshire Hills and runs toward North Wales.

As we should expect from the close agreement of the Declination and Horizontal Force ridge lines the disturbing forces in this district are very easy to interpret. In no place in the kingdom is a locus of attraction more clearly indicated. At Appleby, Thirsk, Hull, and Mablethorpe the disturbing forces act in a south or south-easterly direction; at Giggleswick, Leeds, Gainsborough, and Lincoln they point north-east.

A well-marked ridge line thus runs from the Lincolnshire Wolds through Yorkshire and the limestone district of Westmoreland to the Cumberland Lakes.

Fig. 29.

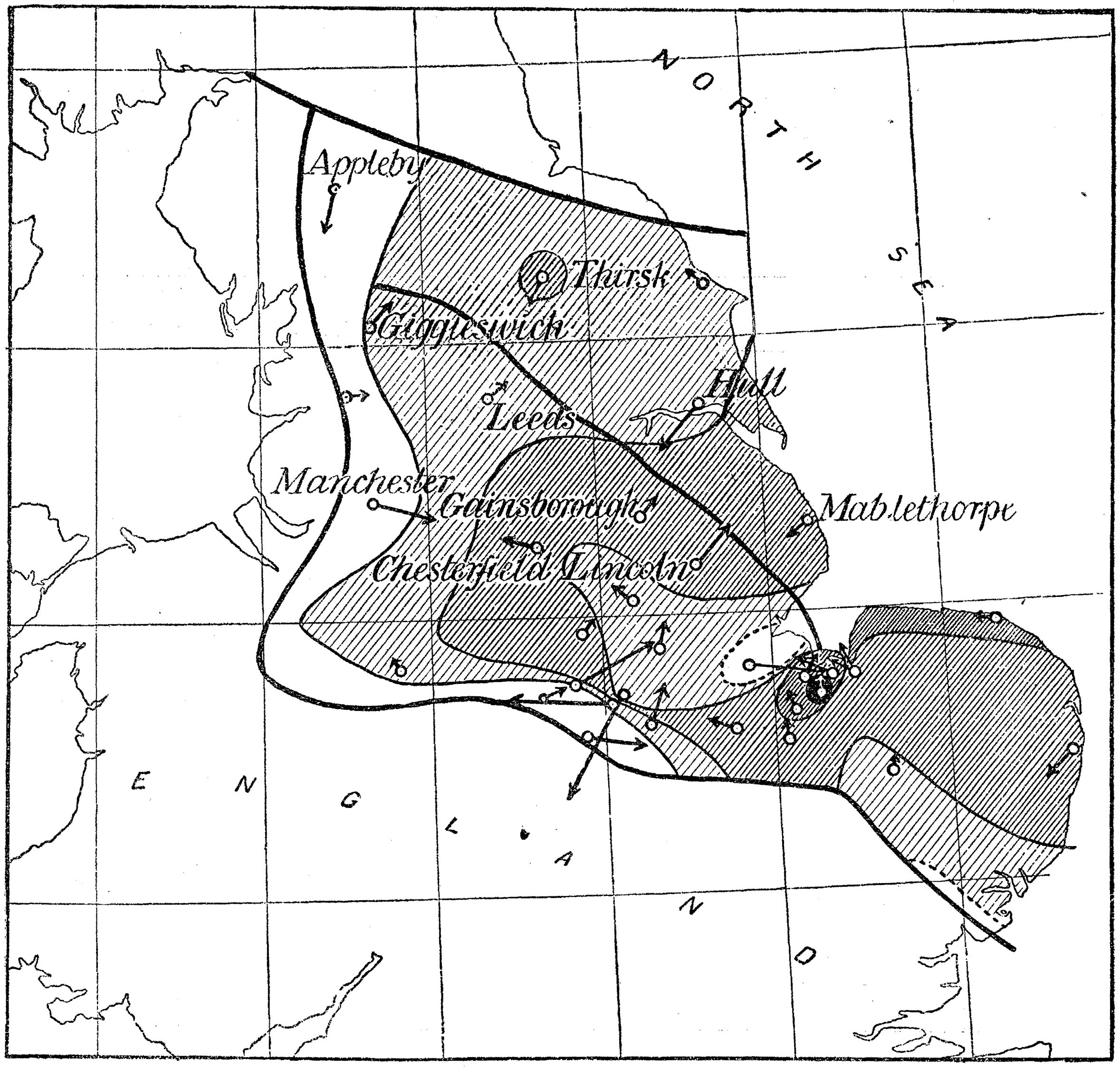


North-Eastern England.

In the southern part of its course it traverses a region of high Vertical Force, and passes near the station at which the positive disturbance is a maximum, terminating in the Wash peak.

The observations at Manchester and Chesterfield appear to indicate another centre of attraction in the limestone district of Derbyshire, but two stations are hardly sufficient to decide such a point. It is, however, very significant that the limestones of Derbyshire are intercalated with the basaltic rocks known locally as "toadstones," and although these do not cover a great area at the surface it is by no means improbable, as Professor JUDD informs us, that large masses of similar rocks occur at no great depth.

Fig. 30.



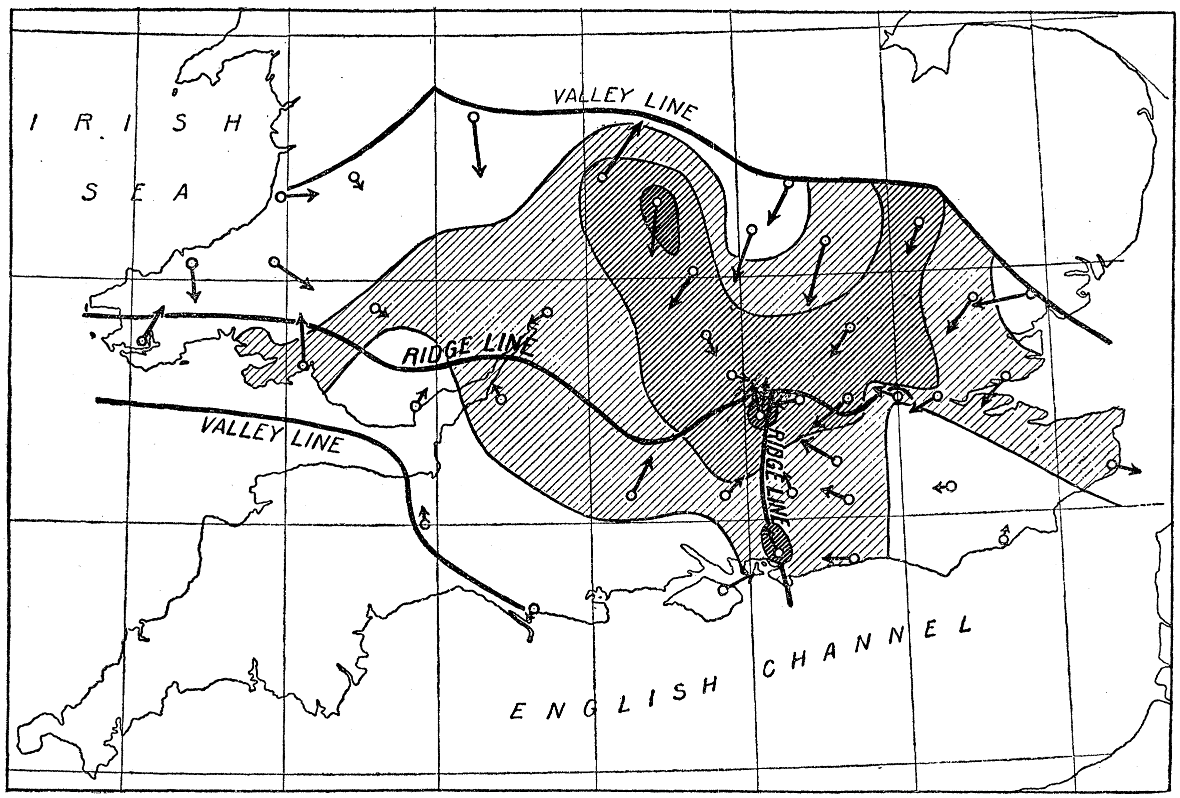
North-Eastern England.

The Southern District.

The Southern District contains those parts of England and Wales to the south of the regions which have already been discussed with the exception of Devonshire and Cornwall. In the latter outlying district the disturbing forces indicate on the whole an attraction to the south of the peninsula.

The Home Counties have been already discussed, and we only refer to the district again to point out that the ridge line which runs westward through the Reading peak is continued into the Welsh coal-fields. This fact is very important, and will be hereafter discussed when we consider the relations between the magnetic and geological peculiarities of this district.

Fig. 31.



Southern England and Wales.

Ireland.

In Ireland, as elsewhere, the Horizontal Forces tend towards the regions of greatest Vertical Force.

At Coleraine and Waterfoot, stations to the north of the great mass of basaltic crystalline rocks in Antrim, the disturbing forces tend southward. At Cookstown Junction and Bangor, on its southern borders, they are directed to the north.

Kells is a point of maximum Vertical Force, and the forces at neighbouring stations are all directed towards it.

A clearly marked ridge line runs through a region of positive Vertical Force disturbance in Connemara, and extends to the north beyond it.

Another series of stations of high Vertical Force extend eastwards from Clare, and they apparently dominate all the region to the south of them. The direction of the disturbing force at Kilrush is anomalous. At Charleville there is a minimum of

Vertical Force, and therefore the direction of the Horizontal Force cannot be determined from the rule.

The Wicklow and Arklow mountains, which are composed of granite, do not appear to exert any important effect on neighbouring stations, but there is a region of high Vertical Force in Wexford.

Magnetic Map of the United Kingdom.

In Plate XIII. we have attempted to represent the magnetic state of the whole country by bringing together the results of our studies of the magnetic districts into which it may be divided.

The valley and ridge lines are shown. The unshaded parts are regions of negative Vertical Force disturbance, and the three shades employed indicate that the disturbance is greater than 0 but less than ·01, greater than ·01 but less than ·02, and greater than ·02 metric unit respectively.

The lines representing the Horizontal Forces are drawn to a scale on which 1 mm. = 0·001 metric unit, except at Canna and Soa, where the disturbances are so large that the arrows would be inordinately long.

Considerations which have been adduced in the foregoing discussion have led us to depart, in a few minor points, from the strict rules by which the valley and ridge lines have been drawn. Thus, the line which separates the Highland and Scotch Coal-field Districts has been drawn so as to include Crieff in the latter.

The rather uncertain valley line in Mid-Wales, which was taken from the Horizontal Force disturbances (Plate X.), is replaced by the closely neighbouring ridge line, taken from the Declination disturbances (Plate X.). This would necessitate valley lines on each side of it, the position of which is uncertain.

In Ireland too, the ridge line which runs from Antrim to the neighbourhood of Kells, is not very definite, and it is best to consider the clearly marked portion of it in Antrim as only doubtfully connected with the centre of attraction near Kells. These points must be left for future investigation, but the unquestionable existence of widespread regional disturbance in the districts we have specially studied in England, together with the general agreement between the two maps of Scotland, deduced from the surveys of 1857 and 1886, leads us to hope that Plate XIII. gives the first approximation to a map of the disturbing magnetic forces in play over the whole kingdom.

On the Relation between the Magnetic and Geological Constitution of the Magnetic Districts.

Up to the present, we have discussed the various districts into which we have divided the country from the point of view of their magnetic peculiarities only.

It now remains to investigate the question whether any connection can be established between these and their geological characteristics.

It is well known that certain varieties of crystalline rocks are often more or less magnetic, and that when they are permanently magnetised the poles are sometimes very irregularly distributed.

We have, however, thought it worth while to investigate the magnetic state of some pieces of diorite and basalt, brought from Malvern and Canna respectively.

The fragments were cut into small rectangular blocks, delicately suspended and tested. We have to thank Dr. HOFFERT, Demonstrator in the Physical Laboratory of the Science Schools at South Kensington, for undertaking this part of the work. The observations were very tedious, and were, for the most part, made by Messrs. GRAY, ANDERSON, and WILKINSON, students in the laboratory.

Of several blocks from Malvern only one showed any polarity in its natural state, but when placed between the poles of an electromagnet it became magnetised by induction, so that the time of oscillation was reduced from 72^s to 56^s. The stone brought from Canna was part of a basaltic column and its upper, lower, east and west ends were marked. It showed polarity, but the upper end was a north-seeking pole, so that it was magnetised in a direction opposed to that which would be induced by the magnetic field of the earth. The moment due to the permanent magnetism was calculated by three different methods, viz.: (1) by the difference of time of oscillation when the direction of the field (about twelve times as strong as that of the earth) was reversed, (2) by the deflection when the stone was placed E. and W., and (3) by the difference of times when the position of the stone was reversed. The results obtained were

·0023 ·0027 and ·0019 C.G.S. unit.

The periods of oscillation were 93^s and 86^s in the earth's field and the artificial field above described. The general conclusion arrived at was that, as the volume was about 1 c.c., the permanent intensity of magnetisation was about 0·002 C.G.S. unit, and that in a field of strength F the induced intensity was about 0·0015 F.

We have examined the relations between the magnetic disturbing forces and the geology of the area of the survey by means of a geological map which has been specially prepared for us under the kind superintendence of Professor JUDD (Plate XIV.). Details are disregarded, but the principal masses of basaltic and non-basaltic crystalline rocks and the main groups of the sedimentary formations are clearly distinguished from each other. This may be compared with Plate XIII., in which the magnetic disturbing forces and the ridge and valley lines are shown.

As the ridge lines are drawn according to an arbitrary rule, they are only intended to draw attention to the districts in which loci of attraction probably exist. We have no real knowledge of their distances from the stations between which they run. In the geological map, therefore, the stations on each of the principal ridge lines have been connected by lines, the spaces enclosed have been shaded, and thus the districts within which the main loci of attraction probably lie are clearly indicated.

It must be remembered that the outlines of these districts depend largely on the accidental positions of stations which were selected without reference to them, and that we must rather expect such rough indications of relations between magnetic and geological facts as may serve to guide future investigations than complete and unmistakeable harmony.

When regarded from this point of view, however, we think the results are very suggestive.

In the Highlands one region of attraction encloses the Caledonian Canal, another is evidently in close relation with the basaltic masses in Skye, Glenmorven, and Mull, though, as has been pointed out, the main centre of attraction appears to be to the west of these islands.

A third region in Scotland encloses the basaltic rocks of Arran and of the Scotch Coal-fields. The fact that the Fifeshire basalt lies outside it is probably due only to the accidental circumstance that we have no stations between Stirling (47) and Dundee (21).

A fourth region evidently consists of the Antrim basalt. There is a fifth in Connemara, where the rocks are granite.

With regard to North Wales, if we consider it as forming one district with Shropshire, we see that a line drawn through the centre of the basaltic rocks would first run from east to west, then nearly north, and finally turn to the west between Anglesea and Carnarvonshire. The district is thus very irregular and the ridge lines do not give much information, but we must point out that the Horizontal Forces at the stations which border it all tend inwards towards the axis above suggested. This is true of Holyhead (90), Llandudno (106), Llangollen (107), Shrewsbury (138), Aberystwith (55), and Pwllheli (128).

If this suggested relation is hereafter verified, every considerable mass of basaltic rock in the kingdom will be closely connected with a region of magnetic attraction. Of smaller masses it is to be noted that at Falmouth (80) the disturbing force acts southward toward the serpentine of the Lizard, and that the relatively small masses in Pembrokeshire and Wexford are within another region of attraction. Our measurements do not assign any particular importance to the outcrop of basaltic rock near Limerick (185) nor to the dykes in the north of England. It is, however, curious that a line drawn through Melton Mowbray and the Wash peak (indicated by circles) passes towards Wales through the only basalt in the Midlands.

Taking the evidence as a whole, we think we are justified in saying that large masses of basaltic rock indicate regions of magnetic attraction.

The other crystalline rocks appear to be much less important magnetically. Thus the Malverns, though a strong local centre, do not disturb a district of any considerable magnitude. If the effects of the two classes of rocks when they appear on the surface are in such marked contrast, it may be open to question whether strong magnetic attraction in a district in which no crystalline rocks appear on the surface does not indicate not only crystalline but basic crystalline rocks beneath it.

However this may be, there are two regions of attraction which are not connected with basaltic rocks on the surface, at all events as the main cause of their peculiarities.

One of these runs westward from London to the South Wales Coal-field, and the directions of the disturbing forces in Wexford are such as would be caused if it crossed the Irish Channel. This extension is doubtful, but the line is most clearly marked right across England, and its general direction is such as to make it almost impossible to avoid the conclusion that it is connected with the palæozoic ridge, the existence of which, long ago predicted by Mr. GODWIN AUSTEN, has been proved by deep borings near London, and which is supposed to connect the Welsh and Belgian Coal-fields.

If the palæozoic rocks are nearer the surface here than elsewhere, the crystalline rocks may approach it also within a moderate distance, and if they are susceptible to magnetisation the observed results would follow. The palæozoic rocks are supposed to form basins, and if those beneath them have a similar outline, it would be possible to explain a centre of attraction such as the Reading peak.

The last region of attraction runs from the Wash through south-east Yorkshire toward the Cumberland Lakes, and, as Professor JUDD first pointed out to us, it includes the line to the north of the Humber, along which the oolitic and liassic strata thin out rapidly, and where, therefore, the crystalline rocks are probably suddenly brought much nearer to the surface. It is continued northward toward the igneous masses in Cumberland.

The centre of attraction which apparently exists at Kells, in Ireland, is not sufficiently accounted for by the surface geology of the district in which it is placed, and we have not felt ourselves justified in representing it as connected with the Antrim basalt, as the fact that this connection requires further confirmation has been already pointed out.

On the whole, then, we think we may assert that every region of magnetic attraction, with the possible exception of that near Kells, is marked either by the presence of basalt, or by some geological peculiarity which makes it possible or even probable that within it crystalline rocks, capable of affecting the magnet, are nearer the surface than elsewhere. This is possible as regards the line of fault marked by the Caledonian Canal, and probable as regards south-east Yorkshire and the south of England.

The former district is remarkable from the fact that it was far more strongly affected by the earthquake of Lisbon than the rest of the British Isles, and this may, perhaps, indicate that it has special relations to the primary rocks, which would account for its magnetic importance.

On comparing the geological map with Plate XIII., on which the disturbing forces are shown for the whole country, a difficulty arises from the fact that the Vertical disturbing Forces appear, on the whole, to be greater over the districts in the east and south of England, where the later sedimentary rocks occur, than over Wales and Ireland, where, from their absence, it would *primâ facie* appear probable that the downward attraction would be greater.

Of course many hypothetical explanations could be offered of the fact, such as that the primary rocks in England might possibly contain larger quantities of ferruginous matter, &c., but we must be content with observing that if a fairly uniform increase in the disturbing Vertical Force were to take place from east to west, it is very doubtful whether we should have detected it. Probably it would cause a disturbance of the first order, the terrestrial lines would be deflected, and the disturbances at distant points would not be comparable.

If the true Vertical Force isomagnetics could be prolonged beyond Wales into another district in which the tertiary strata re-appeared, a southward trend in Wales would indicate an increase in the force. On looking at Plate VIII. we think it will be admitted that the slope of the lines of equal Vertical Force is greater in Wales than in England, which is in harmony with the existence of a southward bend, but the fact that they are extremely irregular and terminate on the west in the sea makes any certain deduction impossible. We must, therefore, regard the distribution of the Vertical Force disturbances as presenting some difficulty, and must emphasise the necessity of using them only to compare neighbouring stations.

The Causes of Local and Regional Magnetic Forces.

It has long been known that distortions of the isomagnetics occur chiefly in the neighbourhood of crystalline rocks, and it has been generally assumed that this is due to so-called rock magnetism, the rocks being magnetised either permanently or by the inductive action of the earth's field.

Dr. NAUMANN, in the work already quoted ('Die Erscheinungen des Erdmagnetismus,' Stuttgart, 1887), has recently opposed this view.

The arguments which may be brought against it are: (1) That rocks brought from considerable depths do not exhibit magnetic qualities until they have been for some time upon the surface; (2) That the effects which rocks or mountains produce on the magnet, even if very great when the distance is small, diminish so rapidly as the distance increases that they are quite insufficient to account for the widespread effects which are attributed to them; (3) That extensive local magnetic disturbance is associated rather with geological faults than with the presence of igneous rocks; (4) That the cause of the phenomena is to be looked for in the effects produced on earth-currents by dislocations of the strata rather than in rock magnetism. We will consider these arguments in the inverse order to that in which we have stated them.

Mr. PREECE, F.R.S., Chief Electrician to the General Post Office, has been good enough to have measurements of the earth-currents made in several of the districts in which we have found large disturbances of the Declination. The currents flowing between various post-offices have been observed, and the directions and intensities of the currents noted.

The following Table gives the data obtained on telegraph lines between Melton Mowbray and stations in its neighbourhood. The letters P.D. signify Potential Difference.

Station.	Bearing from Melton.	Distance from Melton in miles.	Earth currents in milliampères.	Direction of current.	Resistance of circuit in ohms.	P.D. per mile in volts.
Long Clawson	N. 17° W.	6·0	0·062	From	912	0·009
Oakham	S. 50° E.	9·0	0·045	Melton	477	0·002
Asfordby	W.	2·5	0·070	in all	317	0·009
„ (Private Line)	W. 15° N.	1·9	0·067	cases	317	0·011

These potential differences per mile are much smaller than those which occur during magnetic storms, and which on the earth-current theory must, we suppose, be regarded as the causes of the deflections of the Declination needle which then take place. During a very violent storm in 1881 Mr. PREECE found a P.D. of 1·9 volt per mile. We will take for comparison a less extreme case. Yearly records of the movements of the Declination needle, and of the registers of the earth-currents apparatus, are published by the Greenwich Observatory, and the Astronomer-Royal informs us that half an inch on the earth-current registers corresponds approximately to a P.D. of one volt in circuit.

On September 10, 1886, an increase of 16′ took place in the Declination between 22^h and $22^h{\cdot}5$, and between $21^h{\cdot}8$ and $21^h{\cdot}2$ a change in the intensity of the current in one of the circuits occurred which corresponded to a change of P.D. of about 0·9 volt. The direction of the current was such as to produce the observed movement of the needle, and if we regard the current as its cause, since the distance between the earth plates is 3 miles, we find that a deflection of 16′ was produced by a potential difference of 0·3 volt per mile.

There are two earth-current circuits mutually at right angles, both of which are inclined at about 45° to the magnetic meridian. The second was but slightly affected, and, therefore, the effective difference of the potential was about $0{\cdot}3 \cos 45° = 0{\cdot}2$ volt per mile nearly.

At Melton Mowbray we find the disturbance of the Declination to be 33′ W. at one of the two stations. It changes very rapidly, falling to 26′ W. within a mile and a quarter, and to nearly 30′ E. at Loughborough, which is thirteen miles distant. If currents produce it they must therefore be very local. On the other hand we know that the disturbances produced during magnetic storms are simultaneous over areas such as that of the United Kingdom, and if the currents produce the deflections, they also must be widespread, so that if we assume that the same earth-current is required at Melton to produce a permanent deflection as is observed at Greenwich when an equal temporary deflection takes place, we are not overstating the case.

Now, during the whole of the year 1886, there were only a few occasions on which the earth-currents were stronger than on that which we have selected as an example, and we may therefore say that on the earth-current theory there should be permanently at Melton a potential difference of 0·3 volt per mile (for the smaller deflection of 26′ is 1·6 times that observed at Greenwich on the selected occasion) an amount which is only registered at Greenwich during violent storms, and is nearly thirty times greater than that observed in a circuit only two miles in length in the neighbourhood of Melton itself.

So far we have dealt only with the magnitudes of the currents. The case becomes much stronger when we consider their directions. On all the circuits out of Melton Mowbray referred to in the table on p. 315, the earth-currents flowed from that station. Hence, on all the currents except that to Oakham, the direction of the current was such as to produce a deflection of the North Pole to the east, *i.e.*, in the opposite direction to that which was actually observed, while the P.D. between Oakham and Melton was the smallest of those measured, being only 0·002 volt per mile. We do not lay stress on this, as the distance was perhaps rather too great, the main fact being that the earth-currents between Asfordby and Melton, on the same side of the latter town as that on which our second station was placed, were not only much too small (if we may judge from what is observed at Greenwich) to produce the observed deflection, but that they were actually in the wrong direction.

To make certain that nothing in this argument depends upon the particular deflection obtained at Greenwich on the selected occasion, we have taken twenty other examples in which Declination disturbances of from 3′ to 22′ were accompanied by changes in the earth-currents. To avoid the necessity for correcting for diurnal variation they were chosen from the nocturnal hours when the magnet is normally steady, and occasions were selected on which one circuit only was appreciably affected. Except in these particulars they were chosen haphazard.

If we divide the E.M.F. per mile in volts (V) by the Declination disturbance (Δ) we get a number which expresses a relation between the two, and which, if they were cause and effect, ought to be constant. The following table shows that the selected example was not particularly favourable to our views. As the first station at Melton was on the south side of the town we assume that the potential difference was the same as that between Melton and Oakham. At the second station we take it to be that between Melton and Asfordby. In both cases the whole is supposed to be effective, *i.e.*, it is not resolved along the magnetic meridian. A negative sign means that the current flowed in the direction opposite to that which would be required to produce the observed deflection.

Station.		
Greenwich	Largest value of V/Δ	0·028
	Smallest ,, ,,	0·008
	Mean ,, ,,	0·016
	Value on selected occasion	0·013
Melton Mowbray	Station 1	0·00006
	,, 2	0·00040

We are quite aware that an argument of this sort is open to criticism. The exact relation between earth-currents and magnetic storms is uncertain; in short circuits the earth-currents may be masked by those due to the earth-plate, and we have been compelled to assume that the conditions at Greenwich and Melton are the same. We should not, therefore, have put the argument forward had the conclusion depended on any nice balance of figures. As it is, we think it supports the view that the permanent earth-currents at Melton Mowbray are very much less, and less extended, than the temporary currents observed at Greenwich during ordinary but considerable storms, though the permanent Declination disturbance which they are supposed to produce is of the same order as the temporary deflections which are observed simultaneously with the currents at Greenwich.

Similar results were obtained near to the Reading and to the Wash disturbances. If these are produced by earth-currents they must circulate round the peaks, and thus the potentials at points on opposite sides of them should be different. Near the Wash the direction of the telegraph wires is not very favourable for a test, but we owe to the kindness of Mr. PREECE, to whom we must again express our obligation, a series of measurements made at Reading and Windsor. Of these it is only necessary to say that, though Reading and Windsor are on opposite sides of the focus of disturbance, and though the needle is deflected 11′ to the west at Windsor and 6′ to the east at Reading, so that the assumed current circulating round the peak ought to run in opposite directions through them, the observed earth-currents were so small that no measure of their magnitude could be taken.

It might be urged, in answer to these arguments, that the earth-currents by which local disturbances are produced are not mere surface currents, but that they flow through the mass of the earth, possibly where the strata are (as recently suggested by Professors LAMB and SCHUSTER) of higher conductivity.

To this it may be replied that the greater the depth at which the currents are supposed to be situated, the more difficult is it to account for the fact that their effects are so local.

A more conclusive answer is the fact that our observations show clearly that the needle is attracted to certain lines or points round which currents would have to circulate in the same direction (*i.e.*, with the hands of a watch) in order to account for the facts. If the magnetic field of the earth is due to currents flowing from east to west, it is easy to imagine that they might be deflected by layers of more or less than average conductivity; but why should they form local eddies, in which the flow is always in the same direction? They must circulate similarly round the Reading and Wash peaks, round Kells, probably also round the Antrim basalt and the Toad-stones of Derbyshire. In accordance with Commander CREAK's investigation, they must flow round magnetic islands in opposite directions in the two hemispheres. They must flow in different directions on the two sides of the palæozoic ridge in the southern counties, of the Malverns, of the Yorkshire ridge, of the Scotch coal-field, and of the Caledonian Canal. It may be possible to imagine physical causes which would account for such a state of things, but it does not appear easy to frame an hypothesis which shall be more probable than that involved in the theory of magnetic rocks.

As regards Dr. NAUMANN's view, that geological faults determine local magnetic action, it is disputed in its application to Japan by Dr. KNOTT, who has superintended the recent magnetic survey of that country. We find at Malvern a mass of crystalline rock bounded by a fault. Either the rock or the fault may be supposed to be the cause of the attraction toward the ridge which is undoubtedly exerted on the needle; but whereas the rock is susceptible of magnetisation, and its effect on the magnet is precisely such as would be produced if it were magnetised by induction in the earth's field, there is no shred of direct evidence to prove that the fault is capable of causing or deflecting earth-currents, so as to make them flow in opposite directions on its opposite sides. It is more probable that the action of faults is due to the displacement of crystalline rocks in their neighbourhood; and that a fault is, at all events, not a necessary cause of regional attractions is proved by our observations in Scotland. Two great fault lines traverse that country, one coinciding with the Caledonian Canal and the other running from Stonehaven to the mouth of the Clyde. The first of these is, and the second is not, associated with a locus of attraction.

Taking the next argument in order, we agree that mountains which exercise considerable influence on the magnet when close to them produce no effect at distances which are small relatively to the range of regional disturbances. It must, however, be remembered that the depth from the surface to magnetic rocks concealed by overlying strata may not exceed the horizontal distances at which the Malverns and the Wash affect the Declination, and that their influence on the Vertical Forces might extend over vast areas. If, as would often be the case, they were not horizontal, but approached the surface by a gentle slope, the magnet would certainly tend to turn towards or away from the nearer and more elevated portions, according to the nature of their magnetisation.

If the slope were less than the angle of Dip, the sides of the sub-terrestrial hill would be magnetised, so as to attract the north-seeking pole, and the empirical rule that the Horizontal Forces tend toward places of greatest Vertical Force would be amply and completely explained.

Dr. NAUMANN's argument loses a great part of its force if we regard a widespread disturbance of the isogonals around a mountain range as due not to the direct action of the mountains but to a far reaching mass of rocks of which they are the culminating point.

Lastly, as to the statement that rocks containing iron only become magnetic when brought to the surface—without impugning the actual observations, we can only say that so important a generalisation requires a much more extended basis of fact than any that is provided for it. If the Malvern granites produce in their immediate neighbourhood a magnetic effect, it is evident that rocks, the susceptibility of which can only be detected by refined methods, may in large masses deflect the lines of force in the earth's magnetic field to an appreciable extent.

On the whole then, while fully admitting that there is room for much further investigation on this head, and that any view is more or less hypothetical, we do not think that any theory has hitherto been proposed which offers fewer difficulties than that of rock magnetism.

If the cause of the magnetic disturbance is induced magnetism, it would vary with the direction and intensity of the earth's magnetic field, but the change could hardly be great relatively to the secular variations of the elements. It is therefore important to note that in the 'Phil. Trans.' for 1870 (vol. 160, p. 274), Sir E. SABINE gives the Declination at Greenwich and Kew as having been practically identical in 1842·5.

His values are :—

Greenwich	23° 13′,
Kew	23° 11′.

As according to his isogonals the Declination at Kew should, at that epoch have been 9′ greater than that at Greenwich, whereas, according to his table, it was 2′ less, the difference due to disturbance was − 11′ (*i.e.*, the Kew value was too small), whereas in 1860 it was + 11′, in 1865 + 10′, and is now 10′ (p. 270). If then we accept Sir E. SABINE's table as correct, we must assume that a disturbance difference amounting in all to 22′ was established between 1842·5 and 1860, which has remained constant during the twenty-nine years which have elapsed since the latter epoch.

We, therefore, wrote to Mr. WHIPPLE asking him for information as to the observations given by SABINE, as having been made at Kew in 1842·5. It should be noted that the authority quoted by SABINE is "Ob^{y}," which indicates an official origin for the value given.

Mr. WHIPPLE writes, "I have now looked over all the MSS. papers I can find, referring to this Observatory in 1842, and I am quite unable to find any reference to the observation quoted in the 'Phil. Trans.' for 1870, p. 274. There was no Staff here at the date, nor any official publication, hence I do not see how "Observatory," or, as printed, "Ob^y," could be any authority. Again, in SABINE's contribution, 'Phil. Trans.,' 1849, p. 208, Greenwich and Bushey are both given with the names of the observers, and I think there can be no doubt that if SABINE had observed here in 1842, he would have certainly quoted the observations in that table. . . . I fear we must consider it somewhat too hypothetical to trust to."

On the whole then, it appears to us most likely that the number given by SABINE was not deduced from an observation made in 1842, but was reduced to that epoch from the Kew Observatory records, which did not begin till some years afterwards, and that in the deduction some numerical blunder was made.

SUMMARY.

We may now attempt to sum up the result of our studies of local and regional magnetic forces in the United Kingdom.

We have proved beyond possibility of doubt that two centres of attraction exist near Reading and the Wash respectively, and in the former case it is evident that the Horizontal disturbing Forces tend towards regions of maximum Vertical disturbing Force.

We have then gone through the United Kingdom district by district, and have shown that the same rule holds good everywhere. Putting aside stations of maximum or minimum Vertical Force and stations on valley lines (which do not furnish real exceptions) there are not half a dozen which are clearly anomalous in the whole 200 ; nor has this result been obtained by splitting the whole area of the survey up into a large number of small districts which have been carved cut so as to secure an appearance of uniformity of behaviour. Omitting the border stations on the south of Scotland, in Devonshire and Cornwall, the Channel Isles and Dover, the magnetic constitution of the rest of Great Britain is accounted for by five principal ridge lines only.

The first is coincident for a great part of its length with the direction of the great fault of the Caledonian Canal. The second and third are connected with the masses of basalt in the Western Isles and the Scotch Coal-field respectively.

The fourth runs for 100 miles parallel to, if not coincident with, a line in Yorkshire and Cumberland along which geologists believe that crystalline rocks may occur near the surface, and sends out a branch toward the igneous rocks which occur in North Wales.

The fifth runs for nearly 200 miles from London to Milford Haven along another similar geological line, and sends out a branch to the south coast from near Reading.

It is probable that to these a sixth in North Wales and Shropshire should be added.

There are indications of other minor centres at Malvern, in Derbyshire, and in the neighbourhood of Charnwood Forest, but the number of stations involved is small. The vast majority are included in the few and simple systems above described.

These results are not the outcome of the calculations only, for all the principal conclusions can be drawn from the observations alone. Mr. WELSH's survey, though including fewer stations at which all the elements were determined than ours, though omitting almost altogether stations in the Western Isles, though worked up (as regards the Dip and Declination) by means of a different system of geographical coordinates, and in the case of all three elements by means of an assumption as to the linearity of the isomagnetics which we have abandoned, confirms our conclusions. In four only of the 28 of his stations which fall within our districts, viz., Stornoway, Pitlochrie, Ayr, and Dumfries is there an important difference between us as to the direction of the disturbing forces.

In the most highly disturbed districts, at Loch Inver, Kyle Akin, Broadford, Glenmorven we agree as to the order of the magnitude and as to the direction of the forces. At Cumbrae and Fairlie we find closely neighbouring stations of positive surrounded by others of negative Vertical Force disturbance, and WELSH confirms us by a similar result at Ardrossan, not ten miles off.

These coincidences between the results of the two surveys, and between the magnetic peculiarities and the geological constitution of districts cannot be accidental, and we venture to assert that, throughout the kingdom, the lines of Horizontal magnetic disturbing Force tend towards regions of maximum Vertical disturbing Force, which are themselves defined by the presence of crystalline rocks, and especially of basalt, either visible on the surface or concealed by superimposed masses of sedimentary strata.

Beyond this general conclusion we do not wish at present to go. The detailed constitution of our principal magnetic districts (except in the case of the Reading and Wash disturbances) has yet to be investigated. We have not discriminated between various possible causes of a decrease in the Vertical Force, such as the removal of the attracting mass to a greater depth, or the formation of repulsive poles, either by induction or permanent magnetism. We do not think the last word has been said on the cause or causes of local and regional forces. All these require and will, in the future, no doubt, receive attention. We trust, however, that by following out to their logical conclusion the premises of a not improbable working hypothesis, we have succeeded in showing that local and regional forces obey certain simple laws, and that by means of these the kingdom can be divided into magnetic districts in which the relations between the direction of the disturbing forces and the main geological characteristics are so suggestive as to be worthy of careful statement and further investigation.

Tables for the Calculation of the Magnetic Elements in the Future.

We conclude this paper with Tables, by means of which the values of the magnetic elements may be determined during the next few years for any place in the United Kingdom. For this purpose we should know as accurately as possible—(1) the values of each element at the station at the epoch of the survey; (2) the secular change; (3) the local disturbance. To determine the first of these, we give the next three Tables (VIII., IX., X.), in which the values of the elements deduced from the general formulæ are given for all intersections within the kingdom of lines of latitude and longitude which correspond to whole degrees, together with the variation per degree of latitude and longitude. The method of using them requires no explanation.

The values in the Table of Horizontal Forces display some irregularities. This is partly due to the fact, that a discontinuity is introduced along the line $H = 1 \cdot 7$, on opposite sides of which we have used different formulæ. The formula also, which is applied to the southern district, does not represent parallel lines, but lines of which the slope is a periodic function of the latitude. We have slightly smoothed the irregularities, a process which will introduce some discrepancies between the numbers given by the Table and by the formulæ, but we have thought it better not to attempt to do away with all traces of the discontinuity.

Table VIII.—Declinations at Intersections of Deg

Latitude N.	Longitude. 10° W.		9° W.		8° W.		7° W.		6° W.		5° W.		4° W.
° 60											23° 15′·2	*42′·3*	22° 32′·9
											23′·2		*21′·8*
59											22° 52′·0	*40′·9*	22° 11′·1
											22′·5		*21′·0*
58					24° 27′·5	*39′·3*	23° 48′·2	*39′·4*	23° 8′·8	*39′·3*	22° 29′·5	*39′·4*	21° 50′·1
					25′·1		*23′·6*		*22′·1*		*20′·6*		*19′·1*
57					24° 2′·4	*37′·8*	23° 24′·6	*37′·9*	22° 46′·7	*37′·8*	22° 8′·9	*37′·9*	21° 31′·0
					23′·2		*21′·7*		*20′·2*		*18′·7*		*17′·2*
56			24° 15′·6	*36′·4*	23° 39′·2	*36′·3*	23° 2′·9	*36′·4*	22° 26′·5	*36′·3*	21° 50′·2	*36′·4*	21° 13′·8
			24′·0		*22′·4*		*21′·0*		*19′·4*		*18′·0*		*16′·4*
55	24° 26′·5	*34′·9*	23° 51′·6	*34′·8*	23° 16′·8	*34′·9*	22° 41′·9	*34′·8*	22° 7′·1	*34′·9*	21° 32′·2	*34′·8*	20° 57′·4
	26′·2		*24′·7*		*23′·2*		*21′·7*		*20′·2*		*18′·7*		*17′·2*
54	24° 0′·3	*33′·4*	23° 26′·9	*33′·3*	22° 53′·6	*33′·4*	22° 20′·2	*33′·3*	21° 46′·9	*33′·4*	21° 13′·5	*33′·3*	20° 40′·2
	28′·1		*26′·6*		*25′·1*		*23′·6*		*22′·1*		*20′·6*		*19′·1*
53	23° 32′·2	*31′·9*	23° 0′·3	*31′·8*	22° 28′·5	*31′·9*	21° 56′·6	*31′·8*	21° 24′·8	*31′·9*	20° 52′·9	*31′·8*	20° 21′·1
	30′·0		*28′·5*		*27′·0*		*25′·5*		*24′·0*		*22′·5*		*21′·0*
52	23° 2′·2	*30′·4*	22° 31′·8	*30′·3*	22° 1′·5	*30′·4*	21° 31′·1	*30′·3*	21° 0′·8	*30′·4*	20° 30′·4	*30′·3*	20° 0′·1
							26′·2		*24′·8*		*23′·2*		*21′·8*
51							21° 4′·9	*28′·9*	20° 36′·0	*28′·8*	20° 7′·2	*28′·9*	19° 38′·3
											22′·5		*21′·0*
50											19° 44′·7	*27′·4*	19° 17′·3

of Degrees of Latitude and Longitude.

ongitude.												
4° W.		3° W.		2° W.		1° W.		0°.		1° E.		2° E.
22° 32′·9	*42′·4*	21° 50′·5	*42′·3*	21° 8′·2	*42′·4*	20° 15′·8						
21′·8		*20′·2*		*18′·8*								
22° 11′·1	*40′·8*	21° 30′·3	*40′·9*	20° 49′·4								
21′·0		*19′·5*		*18′·0*								
21° 50′·1	*39′·3*	21° 10′·8	*39′·4*	20° 31′·4								
19′·1		*17′·6*		*16′·1*								
21° 31′·0	*37′·8*	20° 53′·2	*37′·9*	20° 15′·3								
17′·2		*15′·7*		*14′·2*								
21° 13′·8	*36′·3*	20° 37′·5	*36′·4*	20° 1′·1	*36′·3*	19° 24′·8						
16′·4		*15′·0*		*13′·4*		*12′·0*						
20° 57′·4	*34′·9*	20° 22′·5	*34′·8*	19° 47′·7	*34′·9*	19° 12′·8	*34′·8*	18° 38′·0				
17′·2		*15′·7*		*14′·2*		*12′·7*		*11′·2*				
20° 40′·2	*33′·4*	20° 6′·8	*33′·3*	19° 33′·5	*33′·4*	19° 0′·1	*33′·3*	18° 26′·8				
19′·1		*17′·6*		*16′·1*		*14′·6*		*13′·1*				
20° 21′·1	*31′·9*	19° 49′·2	*31′·8*	19° 17′·4	*31′·9*	18° 45′·5	*31′·8*	18° 13′·7	*31′·9*	17° 41′·8	*31′·8*	17° 10′·0
21′·0		*19′·5*		*18′·0*		*16′·5*		*15′·0*		*13′·5*		*12′·0*
20° 0′·1	*30′·4*	19° 29′·7	*30′·3*	18° 59′·4	*30′·4*	18° 29′·0	*30′·3*	17° 58′·7	*30′·4*	17° 28′·3	*30′·3*	16° 58′·0
21′·8		*20′·2*		*18′·8*		*17′·2*		*15′·8*		*14′·2*		*12′·8*
19° 38′·3	*28′·8*	19° 9′·5	*28′·9*	18° 40′·6	*28′·8*	18° 11′·8	*28′·9*	17° 42′·9	*28′·8*	17° 14′·1	*28′·9*	16° 45′·2
21′·0		*19′·5*		*18′·0*								
19° 17′·3	*27′·3*	18° 50′·0	*27′·4*	18° 22′·6								

Table IX.—Horizontal Forces at Intersections of

Latitude N.	Longitud												
	10° W.		9° W.		8° W.		7° W.		6° W.		5° W.		4° W
60°										*56*	1·4610	*55*	1·466
											368		*369*
59									1·4923	*55*	1·4978	*56*	1·503
									368		*369*		*368*
58					1·5180	*56*	1·5236	*55*	1·5291	*56*	1·5347	*55*	1·540
					369		*368*		*369*		*368*		*369*
57					1·5549	*55*	1·5604	*56*	1·5660	*55*	1·5715	*56*	1·577
					368		*369*		*368*		*369*		*368*
56			1·5862	*55*	1·5917	*56*	1·5973	*55*	1·6028	*56*	1·6084	*55*	1·613
			368		*369*		*368*		*369*		*368*		*369*
55	1·6175	*55*	1·6230	*56*	1·6286	*55*	1·6341	*56*	1·6397	*55*	1·6452	*56*	1·650
	368		*369*		*368*		*369*		*368*		*369*		*368*
54	1·6543	*56*	1·6599	*55*	1·6654	*56*	1·6710	*55*	1·6765	*56*	1·6821	*55*	1·687
	367		*368*		*373*		*378*		*384*		*388*		*391*
53	1·6910	*57*	1·6967	*60*	1·7027	*61*	1·7088	*61*	1·7149	*60*	1·7209	*58*	1·726
	414		*417*		*417*		*414*		*410*		*406*		*404*
52	1·7324	*60*	1·7384	*60*	1·7444	*58*	1·7502	*57*	1·7559	*56*	1·7615	*56*	1·767
							407		*406*		*407*		*410*
51							1·7909	*56*	1·7965	*57*	1·8022	*59*	1·808
											409		*414*
50											1·8431	*64*	1·849

ions of Degrees of Latitude and Longitude.

Longitude.													
	4° W.		3° W.		2° W.		1° W.		0°.		1° E.		2° E.
5	1·4665	*56*	1·4721	*55*	1·4776	*56*	1·4832						
	369		*368*		*369*								
5	1·5034	*55*	1·5089	*56*	1·5145								
	368		*369*		*368*								
5	1·5402	*56*	1·5458	*55*	1·5513								
	369		*368*		*369*								
6	1·5771	*55*	1·5826	*56*	1·5882								
	368		*369*		*368*								
5	1·6139	*56*	1·6195	*55*	1·6250	*56*	1·6306						
	369		*368*		*369*		*368*						
5	1·6508	*55*	1·6563	*56*	1·6619	*55*	1 6674	*56*	1·6730				
	368		*369*		*368*		*369*		*370*				
5	1·6876	*56*	1·6932	*55*	1·6987	*56*	1·7043	*57*	1·7100				
	391		*392*		*393*		*393*		*391*				
8	1·7267	*57*	1·7324	*56*	1·7380	*56*	1·7436	*55*	1·7491				
	404		*403*		*404*		*405*		*409*				
6	1·7671	*56*	1·7727	*57*	1·7784	*57*	1·7841	*59*	1·7900	*60*	1·7960	*61*	1·8021
	410		*414*		*418*		*424*		*431*		*439*		*447*
9	1·8081	*60*	1·8141	*61*	1·8202	*63*	1·8265	*66*	1·8331	*68*	1·8399	*69*	1·8468
	414		*420*										
4	1·8495	*66*	1·8561										

TABLE X.—Dips at the Intersections of Degrees

Latitude N.	Longitude.													
	10° W.		9° W.		8° W.		7° W.		6° W.		5° W.		4° W.	
60°														
59					72° 42′·0	6′·0	72° 36′·0	6′·0	72° 30′·0	6′·0	72° 24′·0	6′·1	72° 17′·9	6′
					30′·2		30′·4		30′·6		30′·8		31′·1	
58					72° 11′·8	6′·2	72° 5′·6	6′·2	71° 59′·4	6′·2	71° 53′·2	6′·4	71° 46′·8	6′
					31′·3		31′·5		31′·7		31′·9		32′·0	
57					71° 40′·5	6′·4	71° 34′·1	6′·4	71° 27′·7	6′·4	71° 21′·3	6′·5	71° 14′·8	6′
					32′·3		32′·4		32′·6		32′·9		33′·1	
56					71° 8′·2	6′·5	71° 1′·7	6′·6	70° 55′·1	6′·7	70° 48′·4	6′·7	70° 41′·7	6′
					33′·2		33′·5		33′·7		33′·8		34′·0	
55	70° 48′·4	6′·7	70° 41′·7	6′·7	70° 35′·0	6′·8	70° 28′·2	6′·8	70° 21′·4	6′·8	70° 14′·6	6′·9	70° 7′·7	6′
	33′·8		34′·0		34′·2		34′·3		34′·5		34′·7		34′·8	
54	70° 14′·6	6′·9	70° 7′·7	6′·9	70° 0′·8	6′·9	69° 53′·9	7′·0	69° 46′·9	7′·0	69° 39′·9	7′·0	69° 32′·9	7′
	34′·7		34′·8		35′·0		35′·2		35′·4		35′·6		35′·8	
53	69° 39′·9	7′·0	69° 32′·9	7′·1	69° 25′·8	7′·1	69° 18′·7	7′·2	69° 11′·5	7′·2	69° 4′·3	7′·2	68° 57′·1	7′
	35·6		35′·8		36′·0		36′·2		36′·3		36′·5		36′·8	
52	69° 4′·3	7′·2	68° 57′·1	7′·3	68° 49′·8	7′·3	68° 42′·5	7′·3	68° 35′·2	7′·4	68° 27′·8	7′·5	68° 20′·3	7′
									37′·5		37′·7		37′·9	
51									67° 57′·7	7′·6	67° 50′·1	7′·7	67° 42′·4	7′
									38′·6		38′·9		39′·2	
50									67° 19′·1	7′·9	67° 11′·2	8′·0	67° 3′·2	8′

egrees of Latitude and Longitude.

igitude.												
° W.		3° W.		2° W.		1° W.		0°.		1° E.		2° E.
		72°·42′·0	6′·0	72° 30′·0	6′·0	70° 30′·0						
		30′·2		*30′·4*		*30′·6*						
°17′·9	*6′·1*	72° 11′·8	*6′·2*	72° 5′·6	*6′·2*	71° 59′·4						
1′·1		*31′·3*		*31′·5*		*31′·7*						
°46′·8	*6′·3*	71° 40′·5	*6′·4*	71° 34′·1	*6′·4*	71° 27′·7						
2′·0		*32′·3*		*32′·4*		*32′·6*						
°14′·8	*6′·6*	71° 8′·2	*6′·5*	71° 1′·7	*6′·6*	70° 55′·1						
3′·1		*33′·2*		*33′·5*		*33′·7*						
°41′·7	*6′·7*	70° 35′·0	*6′·8*	70° 28′·2	*6′·8*	70° 21′·4						
4′·0		*34′·2*		*34′·3*		*34′·5*						
)° 7′·7	*6′·9*	70° 0′·8	*6′·9*	69° 53′·9	*7′·0*	69° 46′·9	*7′·0*	69° 39′·9				
4′·8		*35′·0*		*35′·2*		*35′·4*		*35′·6*				
°32′·9	*7′·1*	69° 25′·8	*7′·1*	69° 18′·7	*7′·2*	69° 11′·5	*7′·2*	69° 4′·3	*7′·2*	68° 57′·1		
5′·8		*36′·0*		*36′·2*		*36′·3*		*36′·5*		*36′·8*		
°57′·1	*7′·3*	68° 49′·8	*7′·3*	68° 42′·5	*7′·3*	68° 35′·2	*7′·4*	68° 27′·8	*7′·5*	68° 20′·3	*7′·5*	68° 12′·8
6′·8		*37′·0*		*37′·2*		*37′·5*		*37′·7*		*37′·9*		*38′·1*
°20′·3	*7′·5*	68° 12′·8	*7′·5*	68° 5′·3	*7′·6*	67° 57′·7	*7′·6*	67° 50′·1	*7′·7*	67° 42′·4	*7′·7*	67° 34′·7
7′·9		*38′·1*		*38′·4*		*38′·6*		*38′·9*		*39′·2*		*39′·5*
°42′·4	*7′·7*	67° 34′·7	*7′·8*	67° 26′·9	*7′·8*	67° 19′·1	*7′·9*	67° 11′·2	*8′·0*	67° 3′·2	*8′·0*	66° 55′·2
9′·2		*39′·5*		*39′·8*		*40′·2*		*40′·5*		*40′·8*		*41′·2*
° 3′·2	*8′·0*	66° 55′·2	*8′·1*	66° 47′·1	*8′·2*	66° 38′·9	*8′·2*	66° 30′·7	*8′·3*	66° 22′·4	*8′·4*	66° 14′·0

The determination of the rate of secular change is a more difficult matter, but at the completion of our work we have more data at our disposal than in the earlier stages, when coefficients had to be chosen for the reduction of observations. The plans adopted in the case of each element are as follows :—

1. *Declination.*

We have deduced from Sir F. EVANS's Map for 1872 (*loc. cit.*) the Declinations at 24 points distributed uniformly all over the kingdom, and have compared them with the values given by our Table VIII., on page 238. The secular corrections thus calculated show an increase from east to west amounting to about 0′·11 and 0′·14 per degree of longitude in latitudes 58° and 52° respectively.

There is also an increase with latitude above the latitude 52°.

The results are exhibited in the following Table :—

TABLE XI.—Mean Secular Change of Declination per annum between 1872 and 1886.

Latitude.	Longitude.					
	10° W.	8° W.	6° W.	4° W.	2° W.	0°.
°	′	′	′	′	′	′
60	..	..	..	9·1	9·0	..
58	..	9·6	9·2	8·8	8·9	..
56	..	9·1	8·6	8·3	8·2	..
54	9·3	8·5	8·1	7·8	7·8	7·9
52	9·4	8·9	8·1	7·8	7·8	7·7
50	..	..	..	8·3	8·0	..

This is in fair accord with the observations at individual stations given on p. 88, but as Sir FREDERICK's isomagnetics were not deduced by any definite system of calculation, but little importance must be attached to minor variations and discrepancies.

We do not, for instance, feel justified in assuming that there is a real increase of the secular coefficient to the south of lat. 52°, especially as M. MOUREAUX's values in France for corresponding intervals are less than ours.

It is also in accord with the results of the comparison of our observations with those of WELSH, which show that between 1857–1886 the secular change in Scotland increases with the latitude and with west longitude. We think, therefore, that the most that can be said at present is that the secular change at the time of our survey, as given by the mean of the Greenwich and Kew values (p. 91), was in the neighbourhood of London about 6′·5 per annum, and that a comparison with Sir F. EVANS's results shows that it is about 1′·5 greater in the south-west of Ireland, and about 2′ larger in the north-east of Scotland.

Hence by smoothing the irregularities in Table XI. above, and reducing all the numbers so as to give the present rate at London we get the figures in Table XII., p. 325.

These may be checked in future by means of the observations at Kew, Greenwich, Falmouth, Stonyhurst, and Valentia, but we do not think a comparison of two observatories only leads to trustworthy laws of rate of change of secular variation with geographical position. There can be no question that Declination change on the whole increases with the latitude, yet the secular coefficient is less at present at Stonyhurst than at Greenwich and Kew. It is therefore very much to be regretted that the observations so sedulously carried on by the late Provost LLOYD, at Trinity College, Dublin, have of late years been interrupted.

We may point out that the best position for a magnetic observatory would be in the centre of a widespread region of low Vertical Force. The disturbing rocks would probably produce less effect in such a situation, and all the phenomena might be expected to be more normal. Unfortunately Kew and Greenwich are within the range of the Reading disturbance, and Stonyhurst is in a region where the Vertical Force changes very rapidly both to the east and west of that place.

2. *Inclination.*

We have also in the case of the Dip found the secular change between 1842·5 and 1886 by comparing Table X. with Sir E. SABINE'S map for the earlier epoch. The result confirms the conclusions previously arrived at, viz., that the secular change diminishes with latitude and increases with west longitude. As, however, the north-westerly stations are on the line of minimum change they probably do not form real exceptions to the general rule. Partly by this method and partly by the map of assumed values (p. 85) we have selected those given in Table XII.

3. *Horizontal Force.*

This element when treated in the same way gives since 1842·5 a greater rate of secular change in the south than in the north, and in the west than in the east. The latter conclusion is in accord with that of M. MOUREAUX.

We are now inclined to think that the high value of the secular change between the years 1883–85 at Greenwich (·0028) led us to assume rather too high a value (·0022) for the south of England.

The mean annual change for Greenwich between the years 1883–87 is ·0020 and for Kew ·0017. The values for Greenwich in 1857 and 1887 are 1·769 and 1·818, but in 1861 a new instrument was introduced, and to make the two values comparable we must subtract 0·016 from the first. This leads to a difference of 0·065 or a secular change of 0·0022.

Though this is a little greater than the present rate, we do not think the evidence is sufficient to justify us in altering the rates obtained for Scotland by a comparison for the interval 1857–87, and we assume that they are valid at the present time. For the neighbourhood of London we take 0·0019, and by the aid of SABINE'S and WELSH'S papers we have arrived at the values given in the following Table :—

TABLE XII.—Rates of Secular Change per Annum in the Declination, Inclination, and Horizontal Force, in terms of Minutes of Arc for the Declination and Dip, and of Metric Units for the Horizontal Force.
(N.B.—The two former elements are diminishing, the Horizontal Force is increasing.)

Latitude.	Longitude.												
	10° W.	9° W.	8° W.	7° W.	6° W.	5° W.	4° W.	3° W.	2° W.	1° W.	0°	1° E.	2° E.
60°							8·6 1·0 ·0015	8·4 0·9 ·0015	8·3 0·9 ·0015	8·1 0·9 ·0014			
59°			9·0 1·2 ·0018	8·9 1·1 ·0017	8·7 1·1 ·0017	8·6 1·1 ·0017	8·4 1·0 ·0016	8·3 1·0 ·0016	8·1 1·0 ·0016				
58°			8·8 1·3 ·0019	8·6 1·2 ·0018	8·5 1·2 ·0018	8·3 1·2 ·0018	8·2 1·1 ·0017	8·0 1·1 ·0017	7·9 1·1 ·0017				
57°			8·6 1·4 ·0020	8·5 1·3 ·0019	8·3 1·3 ·0019	8·2 1·3 ·0019	8·0 1·2 ·0018	7·9 1·2 ·0018	7·7 1·2 ·0018				
56°			8·4 1·4 ·0020	8·2 1·4 ·0019	8·1 1·4 ·0019	7·9 1·3 ·0019	7·8 1·3 ·0018	7·6 1·3 ·0018	7·5 1·2 ·0018				
55°		8·4 1·6 ·0021	8·2 1·5 ·0021	8·1 1·5 ·0020	7·9 1·5 ·0020	7·7 1·4 ·0020	7·6 1·4 ·0019	7·5 1·4 ·0019	7·3 1·3 ·0019				
54°	8·3 1·7 ·0021	8·1 1·6 ·0021	8·0 1·6 ·0021	7·8 1·6 ·0020	7·7 1·5 ·0020	7·5 1·5 ·0020	7·4 1·5 ·0019	7·2 1·4 ·0019	7·1 1·4 ·0019	6·9 1·4 ·0018	6·8 1·3 ·0018		
53°	8·1 1·8 ·0022	8·0 1·7 ·0022	7·8 1·7 ·0022	7·7 1·7 ·0021	7·5 1·6 ·0021	7·4 1·6 ·0021	7·2 1·6 ·0020	7·1 1·5 ·0020	6·9 1·5 ·0020	6·8 1·5 ·0020	6·6 1·4 ·0019	6·5 1·4 ·0019	6·4 1·4 ·0018
52°	7·9 1·9 ·0022	7·7 1·8 ·0022	7·6 1·8 ·0022	7·4 1·8 ·0021	7·3 1·7 ·0021	7·1 1·7 ·0021	7·0 1·7 ·0020	6·8 1·6 ·0020	6·7 1·6 ·0020	6·5 1·6 ·0019	6·4 1·5 ·0019	6·2 1·5 ·0019	6·1 1·5 ·0018
51°					7·1 1·8	7·0 1·8 ·0021	6·8 1·8 ·0020	6·7 1·7 ·0020	6·5 1·7 ·0020	6·4 1·7 ·0019	6·2 1·6 ·0019	6·1 1·6 ·0019	5·9 1·6 ·0018
50°						6·7 1·9 ·0022	6·6 1·9 ·0021	6·4 1·8 ·0021	6·3 1·8 ·0021				

The local disturbance at any place may be estimated from the disturbances at neighbouring stations as given in Plates IX., X., and XII. It is evident that this correction must be somewhat uncertain, but the maps will at all events give information as to whether the disturbance is likely to be large or small. As an example of the use of the tables and maps, we calculate the Declination for lat. 52° 30′ N. and long. 1° 30′ W. on July 1, 1889.

From Table VIII. it was

$$18^\circ\ 29'\cdot 0 + 8'\cdot 2 + 15'\cdot 2 = 18^\circ\ 53'\cdot 4 \text{ on January 1, 1886.}$$

From Table XII. the secular change is

$$-(6\cdot 5 + \cdot 1 + \cdot 15) \times 3\cdot 5 = -23'\cdot 6$$

which reduces the value to 18° 29′·8.

From Plate IX. we see that the station is in a region of negative disturbance, and that the true Declination is probably less than the calculated amount by 15′ or 20′.

It is obvious that for this purpose much rougher methods of calculation would suffice, but the main reason for making the process as accurate as possible is that the values of disturbing forces can only be determined if the rates of secular change are carefully discussed and accurately known. As we hope that these will be further investigated, we give the fullest data at our disposal for the calculation of the undisturbed values of the elements.

INDEX.

Page.

AUSTEN, Mr. GODWIN, Palæozoic Rocks beneath London 313
Basalts and Magnetic Attraction 312
Base-station, Kew as 57
BROUGH, Mr. B., A.R.S.M., on Use of the Magnetic Needle 264
Bunnahabhain, Comparison of Instruments at 60
,, Disturbances at 268
Canna, Special Survey of 276
Causes of Local and Regional Magnetic Forces 314
Central Stations 236
,, ,, Declinations at 240
,, ,, Horizontal Forces . . . 247
,, ,, Inclinations 244
Centre of Attraction, Effect on Isomagnetics 262
Chronometers 61
,, Rate of, Method of Obtaining 61
Comparison of Kew and Survey Instruments 58
Compass Hill, Canna 276
"Contour Lines" of Vertical Force . . . 285
CREAK, Commander, F.R.S., on Disturbances produced by Islands 274
,, On Local Disturbances 318
Crystalline Rocks, Magnetic Condition of . 311
Declination, Diurnal Changes in 65
,, Specimen Form 71
,, Secular Change, British Islands 88
,, ,, ,, France . . . 90
,, Observations, Errors of . . . 78
,, Equation for Calculating . . 240
Declinations calculated from District Lines . 238
Defects of Earlier Surveys 55
Descriptions of Stations 95–232
District Curves 240
Districts, Division of Country into . . . 234
Disturbance, Diurnal 64
Disturbances, Three Classes of 233
,, Local and Regional, Discussion of 259
Disturbing Forces, Table of 270–273
Diurnal Variation and Disturbance . . . 64
Earth-currents 315
Eastern and South-Eastern Counties, Special Survey 280
England and Wales, Results at Stations 133–200

Page.

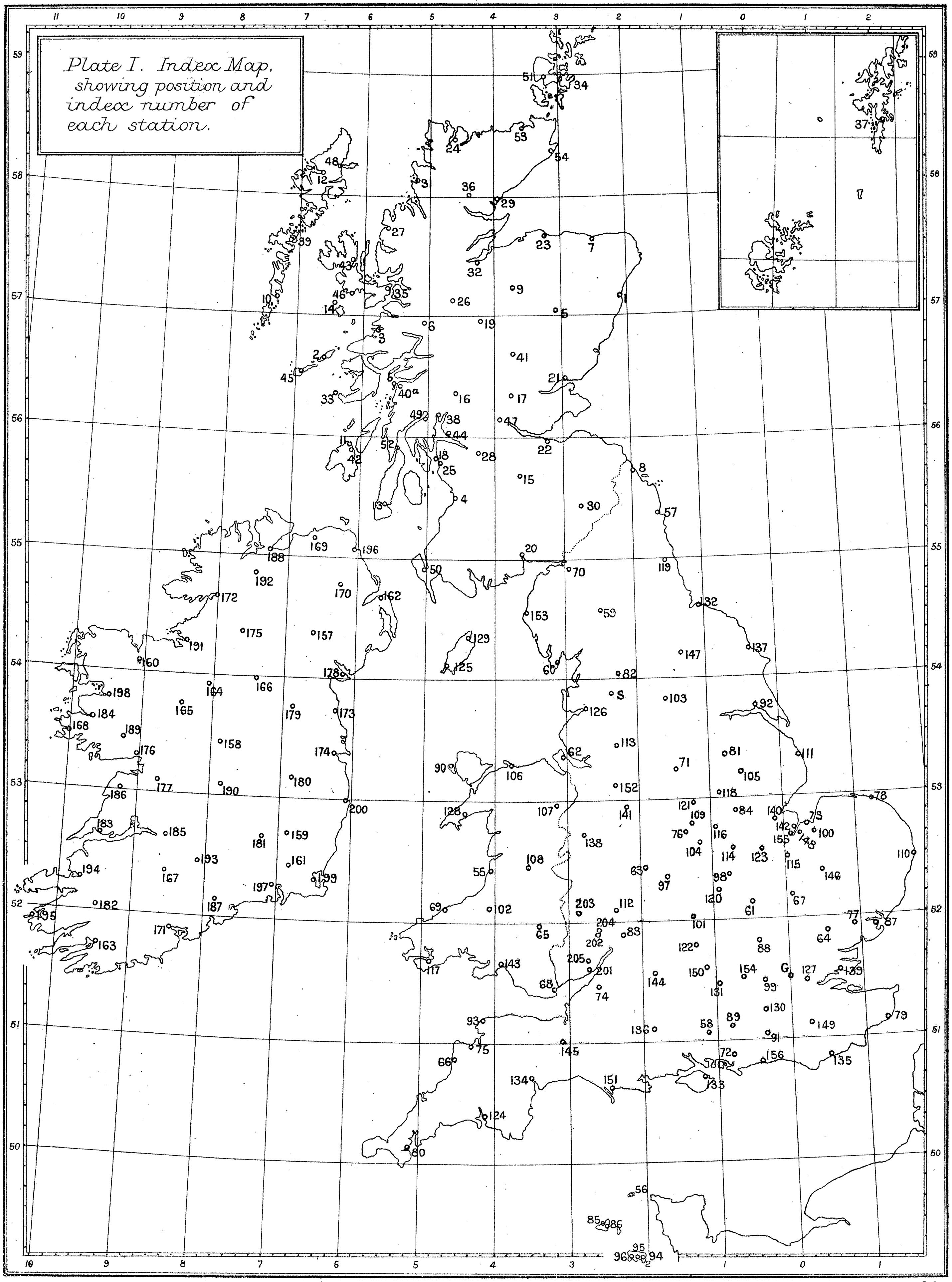
Epoch of Survey 56
Equation to Isogonals 240
,, Isoclinals 245
,, Isodynamics 249
Equations of Condition, Results obtained by 235
Errors of Experiment 76
EVANS, Sir F., Isogonals 243
,, ,, Island of Canna 276
,, ,, Deduction of Disturbances . 294
Focus near Reading 282
,, ,, the Wash 288
,, ,, Kells 309
France, Secular Change in Dip 87
Geological and Magnetic Constitution of Districts 310
Greenwich, Annual Variation 81
,, and Kew, Anomalous Difference of Declinations at 281
Herefordshire Beacon as an Attracting Centre 276
Highland District, Disturbance Map of . . 301
Horizontal Force, Diurnal Changes . . . 66
,, ,, Independent Determinations of 73
,, Specimen Form 74
,, Errors of Observation 78
,, Secular Change 92
,, Equation for Calculating . . . 249
Inclination, Diurnal Changes 68
,, Specimen Form 76
,, Errors of Observation 79
,, Secular Change 82
,, ,, ,, Map of . . . 85
,, Equation for Calculating . . . 245
Independent Results for H. 73
Instruments 57
Ireland, Results at Stations 201–232
,, Disturbing Forces in 309
Isoclinals, Equation to 245
Isodynamics ,, ,, ... 249
Isogonals ,, ,, ... 230
,, Effect of Attracting Centre on . 261
Isomagnetic Lines, Calculation of 233
,, ,, Terrestrial and True . . 233
JUDD, Professor, F.R.S., on Crystalline Rocks in Yorkshire 313

Page.

Kew as Base-station 57
,, Annual Variation at 81
,, Observations at 160
King's Lynn, Centre of Attraction near . . 287
KNOTT, Dr., Survey of Japan 318
Least Squares, Results obtained by . . . 235
Leicestershire District, Special Survey of . 288
Local Disturbances Defined 233
,, Magnetic Forces, Causes of 314
Loch Aylort, Disturbances at 268
Magnetic and Geological Constitution of Districts, Relation between 311
Magnetometer, Alterations in 56
Malvern Hills, Special Survey of 274
Map, Magnetic, of United Kingdom . . . 310
Melton Mowbray, Disturbances at . . . 288
Mirror, Adjustments of 64
MOUREAUX, M., Survey of France 62
,, Isogonals for English Channel 241
,, Isoclinals ,, ,, 246
NAUMANN, Dr., on the Causes of Local and Regional Magnetic Forces 314
,, on Isogonals near the Fossa Magna 261
N.W. England, N. Wales, and Galloway . 304
Oban, Disturbances at 268
Observations, Number of 63
,, Method of Taking 63
P., Value of 71
"Peaks" 265
Port Askaig, Disturbances at 268
Reading, Focus near 282
Regional Disturbances Defined 233
,, Magnetic Forces, Causes of . . . 314
Results of Observations, Method of Tabulating 93
"Ridge" Lines 265
RIJCKEVORSEL, Dr. VAN, Survey of Indian Archipelago 235

Page.

RÜCKER and THORPE "On Magnetic Irregularities," &c. 55
SABINE, Sir E., Magnetic Survey, &c. . . . 55
,, Secular Change in Declination 89
Scotch Coal-field District, Disturbances in . 302
Scotland, Results at Stations 95-133
,, Disturbance Map of, from WELSH'S Survey 298
Secular Corrections 81
,, Change, Declination 89
,, ,, Horizontal Force 92
,, ,, Inclination 82
Southern District, Disturbances in . . . 308
Spalding, Centre of Attraction near . . . 287
Stations, Selection of 62
STEWART, BALFOUR, on WELSH'S Results . . 300
Stornoway, Disturbances at 268
Stranraer, Comparison of Instruments at . 61
,, Disturbances at 269
Summary of Results at Stations . . 251–258
Supplementary Stations for Secular Change in Dip 84
,, ,, Results at . . . 258
Surveys, Earlier, referred to 55
Tabulation of Observations 69
Terrestrial and True Isomagnetics . . . 233
"Valley" Line 265
Variation, Diurnal 64
Vertical Forces, Disturbances in 266
Wash, The, Special Survey of Neighbourhood of 286
WELSH, Mr., Magnetic Survey by 55
,, Results used for Secular Change 84
WELSH'S, Mr., Survey, Comparison with, of Disturbances in Declination 293
,, Survey, Disturbing Forces . 297
WHIPPLE, Mr., on SABINE'S Observations . . 320
Worcestershire Beacon as an Attracting Centre 275



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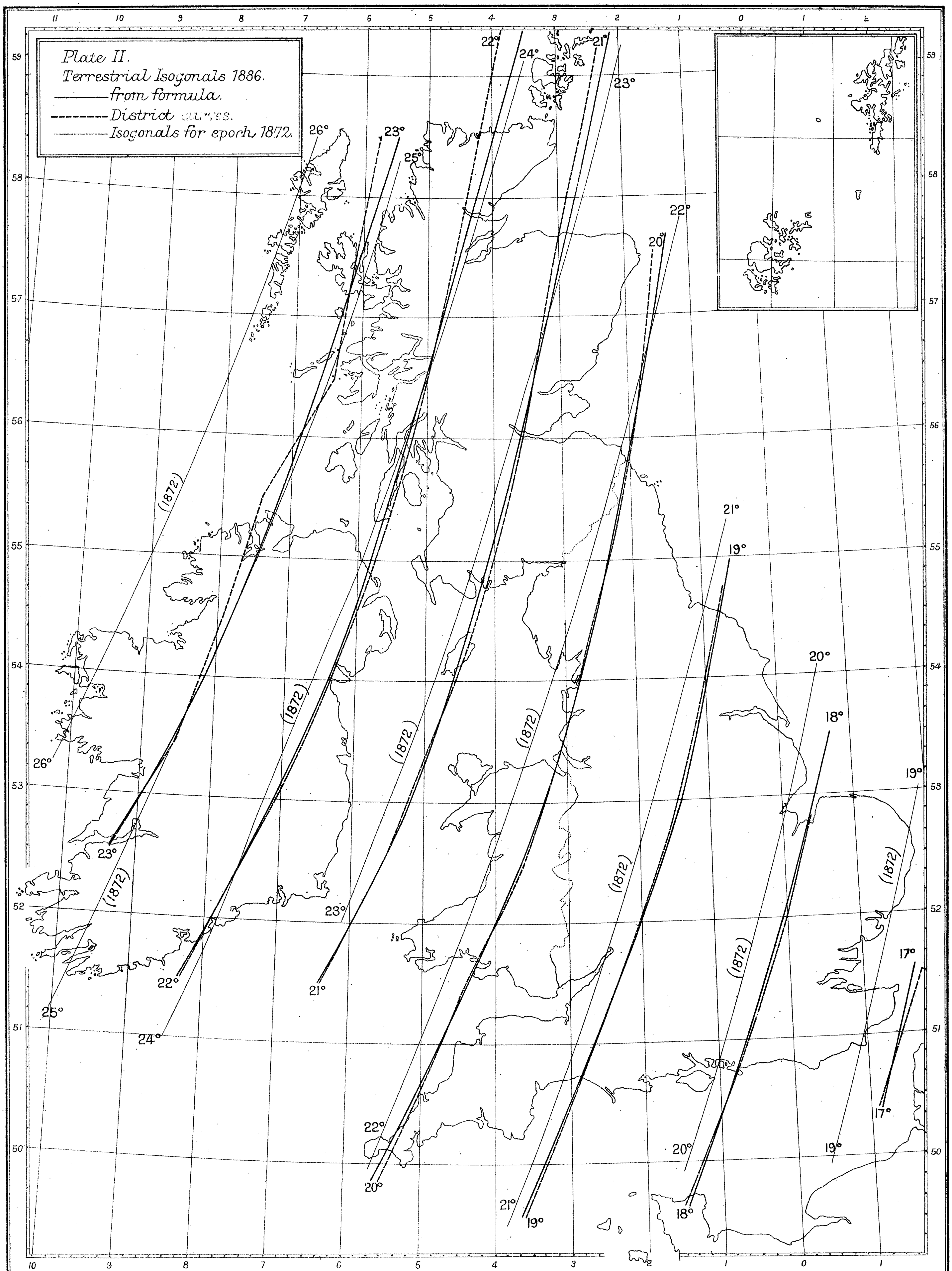

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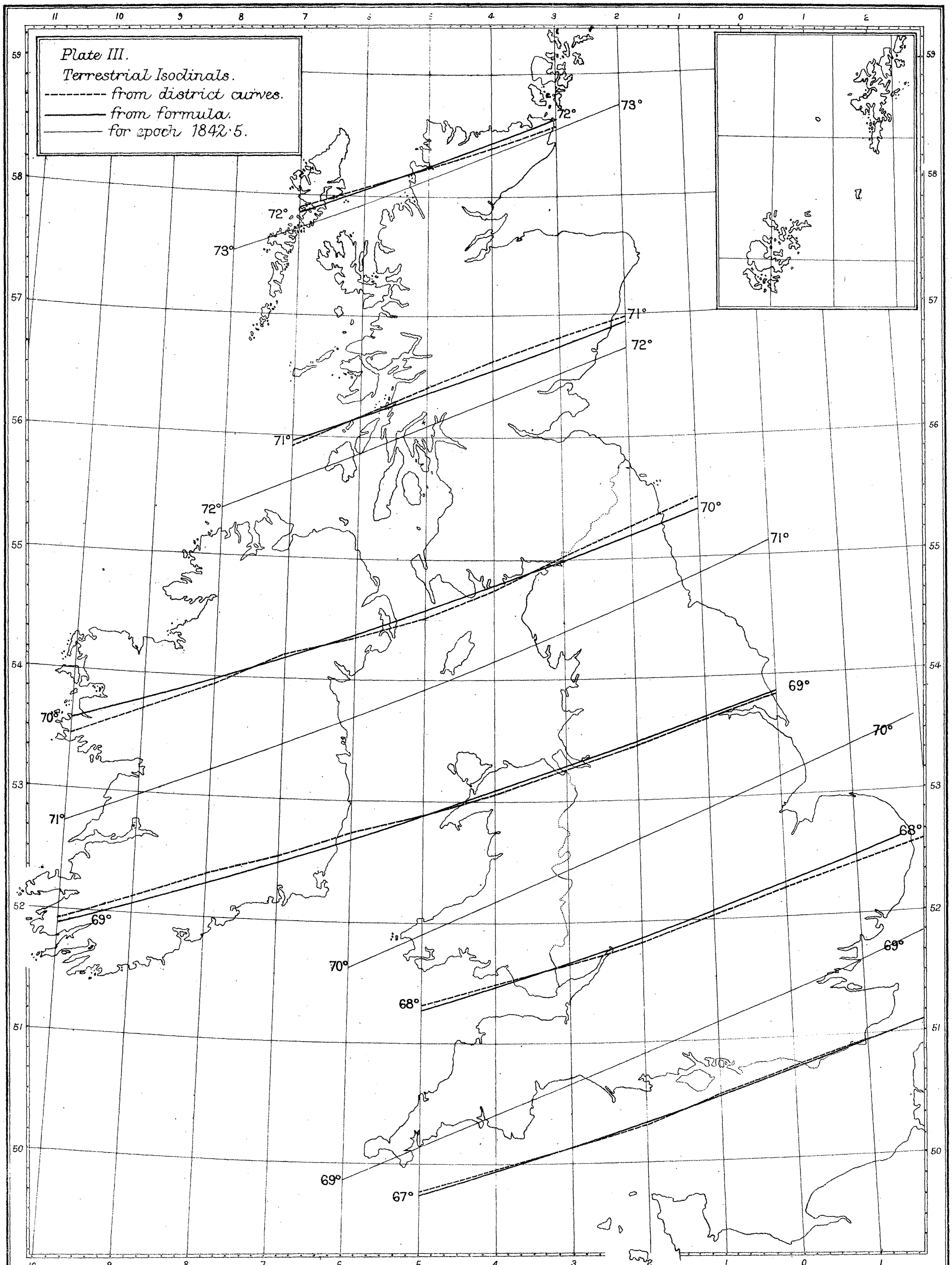

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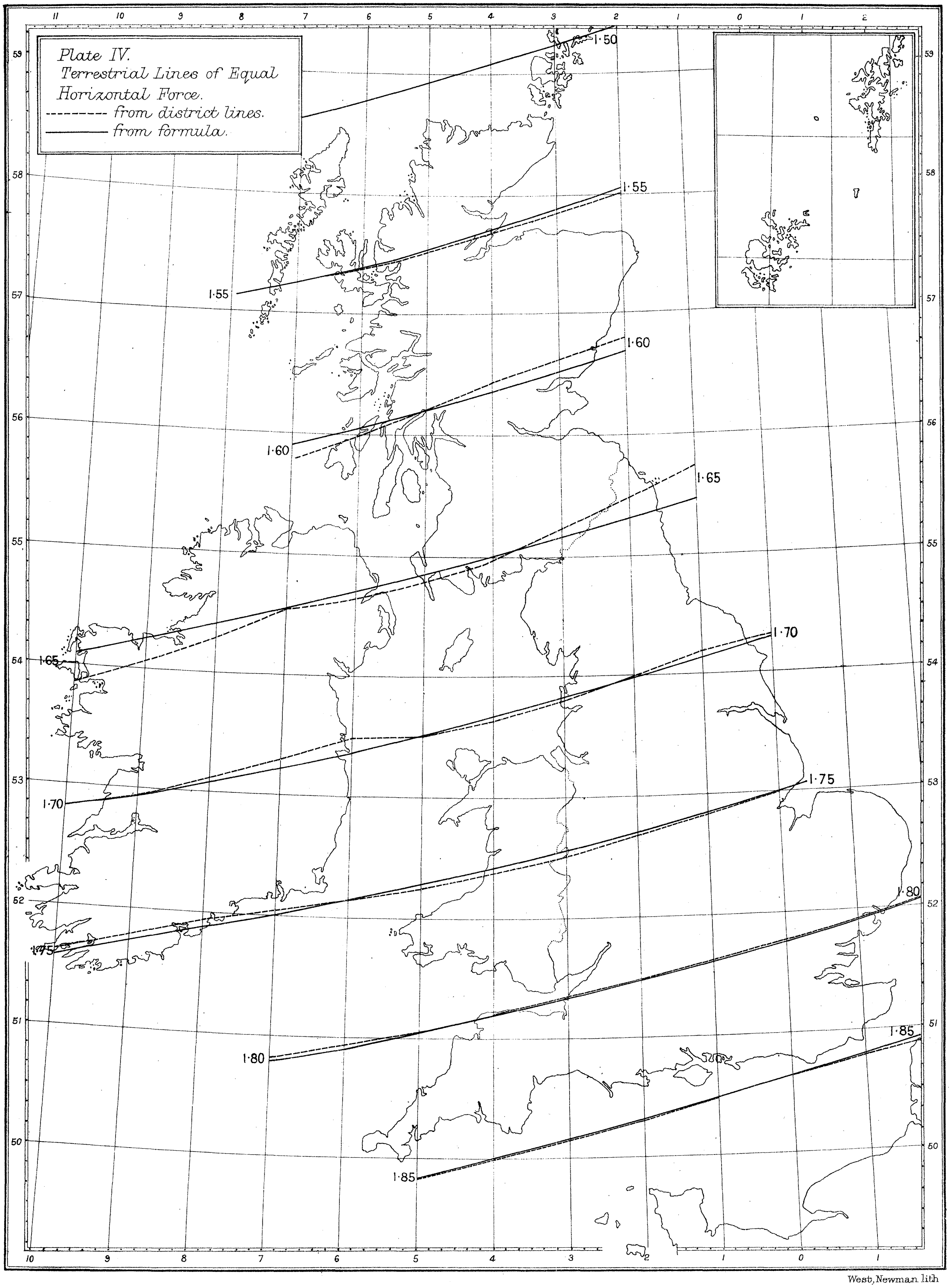

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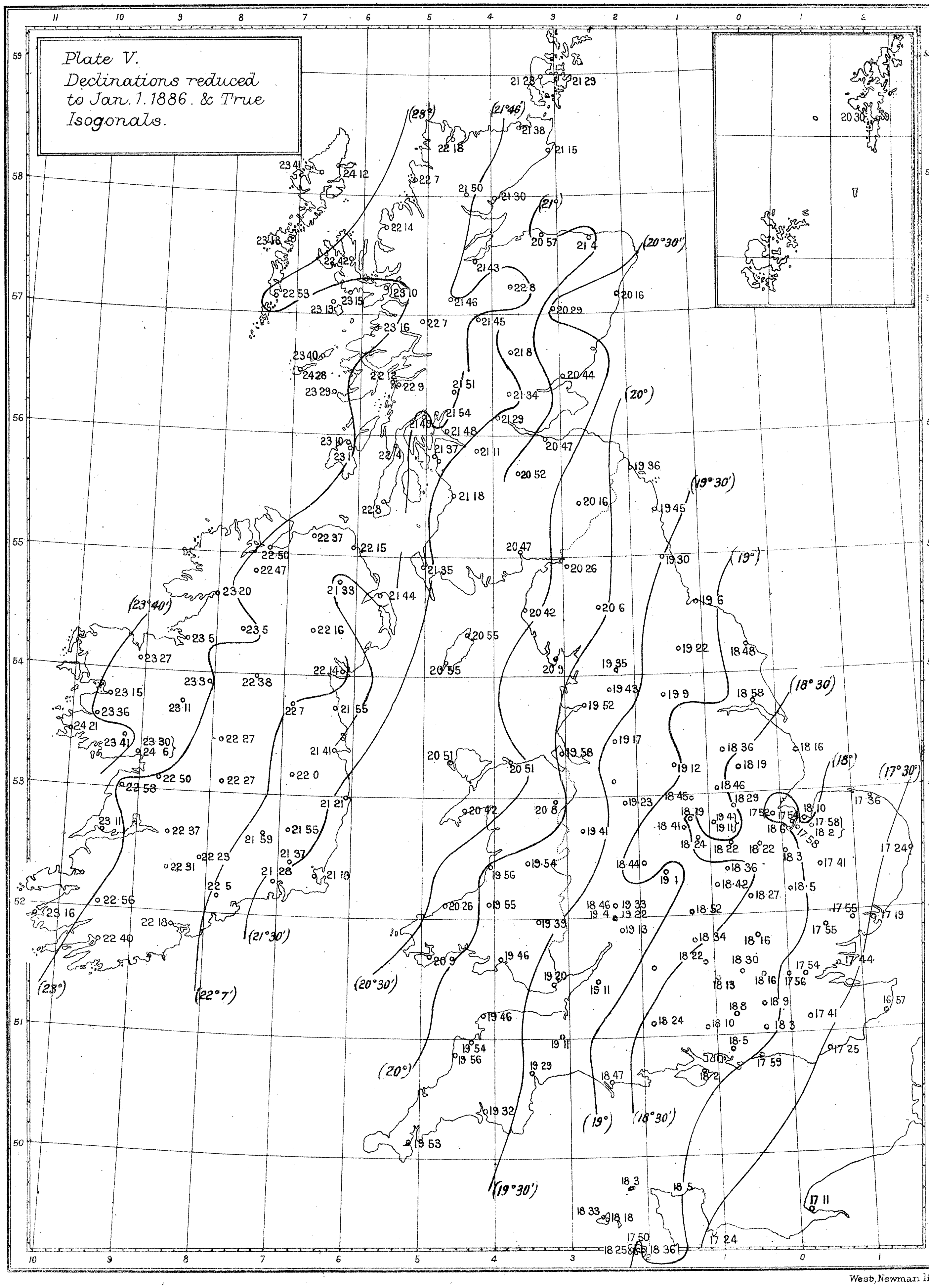

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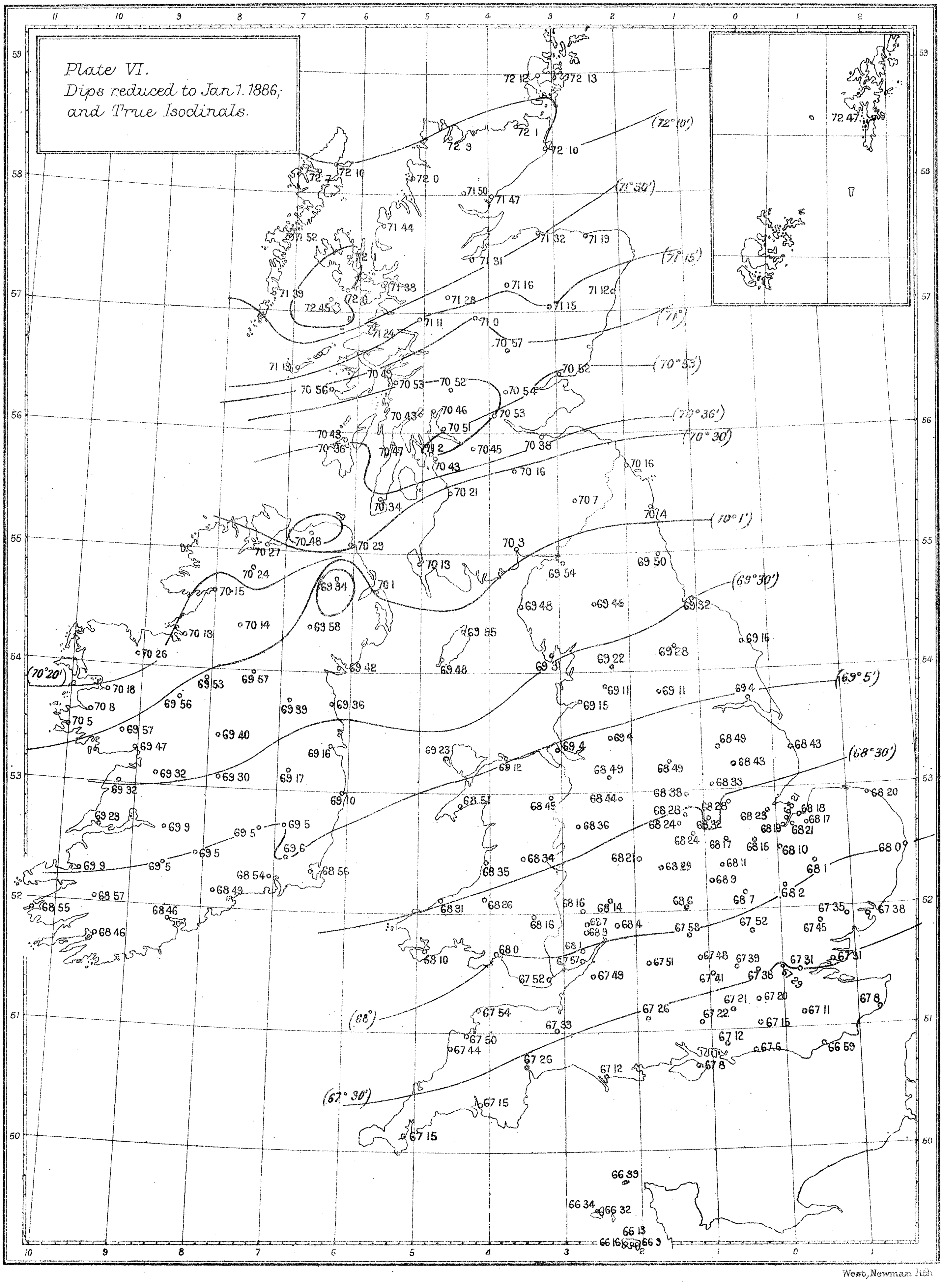

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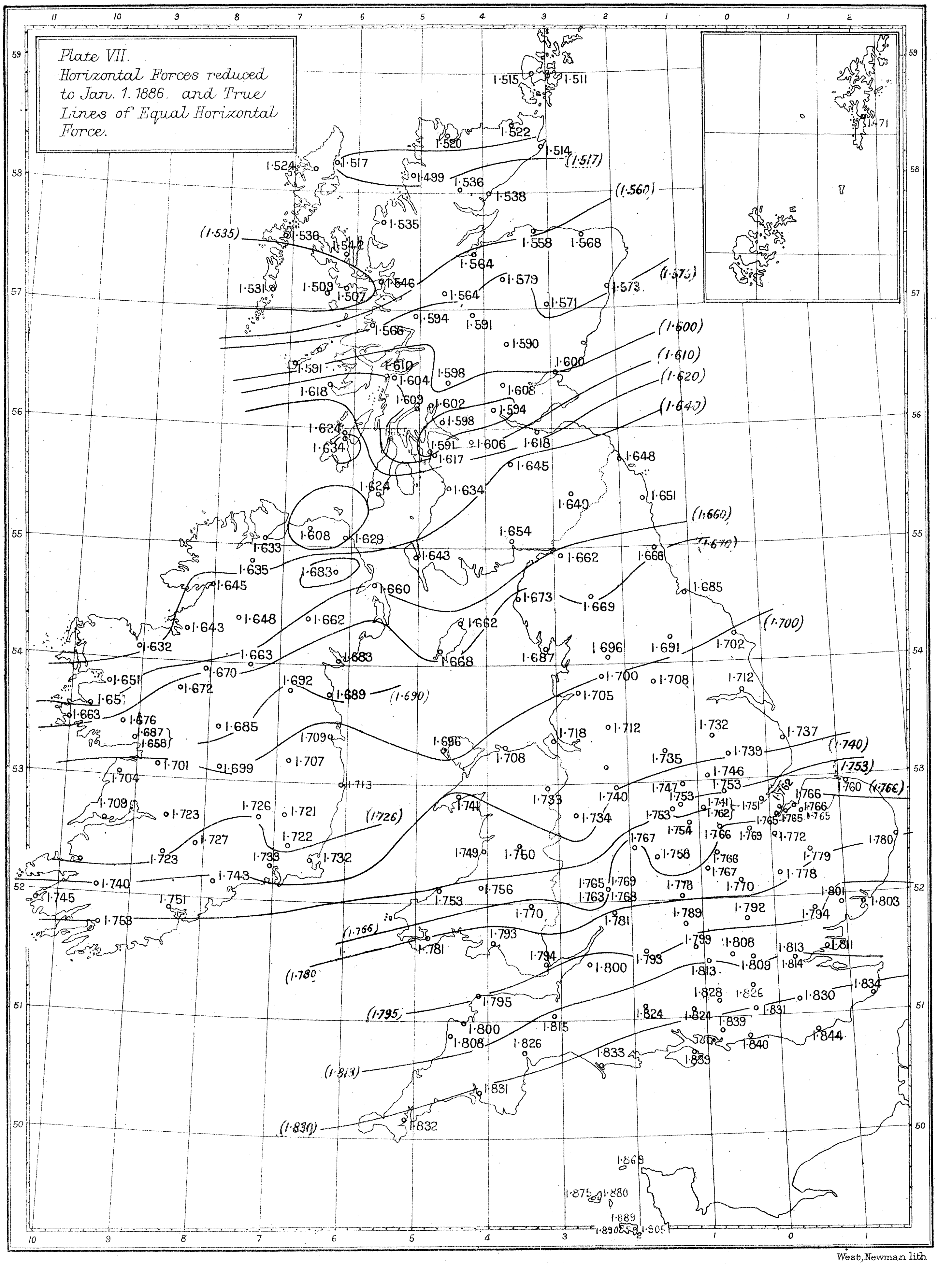

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Table VIII.—Declinations at Intersections of Degrees of Latitude and Longitude.

Latitude N.	10° W.		9° W.		8° W.		7° W.		6° W.		5° W.		4° W.		3° W.		2° W.		1° W.		0°.		1° E.		2° E.
60											23° 15'·8	44'·8	22° 32'·0	42'·4	21° 50'·5	38'·0	21° 8'·9	53'·4	20° 15'·9						
											23'·3		21'·0		20'·2		19'·5								
59											22° 53'·0	37'·9	22° 11'·1	40'·8	21° 30'·3	40'·9	20° 49'·4								
											22'·5		21'·6		19'·7		18'·5								
58					24° 27'·6	39'·3	23° 48'·3	50'·4	22° 57'·9	37'·6	22° 20'·5	27'·4	21° 53'·1	42'·5	21° 10'·6	19'·2	20° 51'·4								
					23'·4		23'·6		23'·1		20'·6		19'·4		17'·6		15'·4								
57					24° 2'·4	37'·8	23° 24'·6	37'·9	22° 46'·7	37'·8	22° 8'·9	37'·9	21° 31'·0	37'·8	20° 53'·2	37'·4	20° 16'·8								
					20'·2		21'·7		20'·3		18'·7		17'·8		15'·7		14'·2								
56			24° 15'·0	33'·4	23° 42'·2	39'·3	23° 3'·0	39'·4	22° 26'·5	35'·3	21° 50'·2	37'·4	21° 12'·8	35'·0	20° 37'·8	36'·4	20° 1'·1	36'·3	19° 24'·8						
			23'·9		23'·5		24'·0		19'·3		17'·5		15'·4		15'·2		13'·4		12'·0						
55	24° 26'·5	34'·9	23° 51'·6	33'·8	23° 17'·8	35'·9	22° 41'·9	34'·5	22° 7'·1	35'·6	21° 32'·2	34'·8	20° 57'·4	34'·9	20° 22'·6	34'·8	19° 47'·7	34'·9	19° 12'·8	34'·8	18° 38'·0				
	20'·8		23'·7		22'·3		19'·7		20'·2		15'·7		17'·3		16'·1		13'·9		12'·7		11'·2				
54	24° 6'·3	33'·4	23° 27'·9	33'·4	22° 56'·0	33'·7	22° 22'·2	32'·7	21° 40'·9	33'·4	21° 16'·5	35'·3	20° 40'·2	32'·4	20° 6'·8	30'·7	19° 33'·5	33'·5	19° 0'·1	33'·7	18° 26'·6				
	24'·1		25'·6		25'·1		23'·6		23'·1		20'·6		19'·1		17'·0		16'·1		14'·6		13'·4				
53	23° 42'·2	31'·9	23° 0'·8	34'·7	22° 28'·0	31'·0	21° 58'·0	33'·2	21° 24'·8	31'·9	20° 52'·9	31'·8	20° 21'·1	40'·9	19° 40'·2	32'·8	19° 17'·4	31'·9	18° 45'·5	32'·9	18° 12'·7	31'·9	17° 42'·9	32'·9	17° 10'·0
	20'·5		25'·5		27'·0		27'·5		24'·5		22'·5		21'·0		19'·5		18'·0		16'·5		15'·6		15'·2		13'·8
52	23° 9'·3	30'·4	22° 31'·6	30'·3	22° 1'·5	29'·4	21° 31'·1	30'·3	21° 0'·8	30'·4	20° 30'·4	30'·3	20° 0'·1	30'·5	19° 29'·7	30'·3	18° 59'·4	28'·4	18° 29'·0	30'·9	17° 55'·7	30'·4	17° 25'·8	30'·3	16° 55'·0
							24'·2		24'·5		23'·2		22'·5		20'·3		18'·5		17'·2		13'·8		12'·2		13'·8
51							21° 1'·8	25'·9	20° 36'·0	28'·5	20° 7'·2	28'·9	19° 35'·3	28'·9	19° 10'·6	28'·9	18° 40'·6	28'·8	18° 11'·8	28'·9	17° 42'·9	28'·8	17° 14'·1	28'·9	16° 45'·2
											22'·5		18'·0		19'·5		18'·5								
50											19° 44'·7	27'·4	18° 17'·3	27'·5	18° 50'·0	27'·4	18° 22'·6								

Table IX.—Horizontal Forces at Intersections of Degrees of Latitude and Longitude.

Latitude N.	10° W.		9° W.		8° W.		7° W.		6° W.		5° W.		4° W.		3° W.		2° W.		1° W.		0°.		1° E.		2° E.
60										56	1·4616	55	1·4625	56	1·4721	55	1·4776	56	1·4843						
											·562		·566		·568		·569								
59									1·4998	57	1·5028	56	1·5004	55	1·5050	56	1·5145								
									·568		·559		·569		·562		·565								
58					1·6180	56	1·6236	55	1·5221	55	1·5847	55	1·5602	56	1·5128	55	1·5618								
					·562		·559		·559		·568		·562		·558		·560								
57					1·6349	55	1·6604	56	1·5880	56	1·5715	56	1·5771	55	1·5625	55	1·5882								
					·568		·560		·568		·563		·258		·560		·568								
56			1·5962	55	1·7017	56	1·6478	55	1·5920	56	1·6054	55	1·6189	55	1·6125	56	1·6230	57	1·6800						
			·565		·562		·564		·569		·558		·569		·564		·566		·563						
55	1·6155	55	1·6090	56	1·6830	57	1·6841	56	1·6897	55	1·6152	57	1·6508	54	1·6530	56	1·6810	5	1·6674	5	1·6780				
	·568		·569		·566		·569		·568		·569		·565		·569		·567		·569		·570				
54	1·6543	56	1·6589	57	1·6863	56	1·6720	55	1·6763	58	1·6821	57	1·6878	57	1·6882	55	1·6987	5	1·7015	5	1·7150				
	·567		·568		·570		·575		·564		·569		·567		·592		·570		·578		·577				
53	1·6910	57	1·6987	60	1·7027	58	1·7038	57	1·7142	60	1·7209	58	1·7237	5	1·7324	58	1·7086	54	1·7453	5	1·7151				
	·474		·577		·477		·574		·560		·565		·574		·567		·454		·590		·592				
52	1·7381	60	1·7381	65	1·7444	59	1·7632	57	1·7565	56	1·7675	55	1·7871	59	1·7722	57	1·7794	57	1·7841	5	1·7900	61	1·7960	62	1·5081
							·207		·596		·597		·579		·574		·468		·434		·571		·495		·117
51							1·7960	56	1·7936	57	1·8032	59	1·8091	60	1·8141	61	1·8203	63	1·8263	6	1·8301	64	1·8395	66	1·5106
											·499		·354		·480										
50											1·8101	62	1·8185	66	1·8551										

TABLE X.—Dips at the Intersections of Degrees of Latitude and Longitude.

Latitude N.	10° W.		9° W.		8° W.		7° W.		6° W.		5° W.		4° W.		3° W.		2° W.		1° W.		0°.		1° E.		2° E.
70															72°43'.0	6'.0	72°36'.0	6'.0	72°30'.0						
															31'.2		31'.3		30'.6						
69					72°42'.0	6'.0	72°36'.0	6'.0	72°30'.0	6'.0	72°24'.0	6'.2	72°17'.8	6'.5	72°11'.3	6'.3	72°5'.0	6'.2	71°59'.4						
					30'.2		30'.3		30'.6		30'.8		31'.0		30'.8		30'.9		31'.7						
68					72°11'.8	6'.3	72°5'.6	6'.2	71°59'.4	6'.2	71°53'.2	6'.4	71°46'.8	6'.2	71°40'.6	6'.4	71°34'.1	6'.4	71°27'.7						
					31'.3		31'.5		31'.7		31'.9		32'.0		32'.8		32'.4		32'.6						
67					71°40'.5	6'.4	71°34'.1	6'.4	71°27'.7	6'.4	71°21'.3	6'.5	71°14'.8	6'.6	71°8'.2	6'.5	71°1'.7	6'.6	70°55'.1						
					32'.0		32'.4		32'.6		32'.9		33'.1		33'.3		33'.7		33'.7						
66					71°8'.5	6'.5	71°1'.7	6'.6	70°55'.1	6'.7	70°48'.4	6'.7	70°41'.7	6'.7	70°35'.0	6'.8	70°28'.2	6'.8	70°21'.4						
					33'.2		33'.5		33'.7		33'.8		34'.0		34'.2		34'.3		34'.5						
65	70°45'.4	6'.7	70°41'.7	6'.7	70°32'.0	6'.8	70°28'.2	6'.8	70°21'.4	6'.8	70°14'.6	6'.9	70°7'.7	6'.9	70°0'.8	6'.9	69°53'.9	7'.0	69°46'.9	7'.0	69°39'.9				
	33'.7		34'.0		34'.2		34'.3		34'.5		34'.7		34'.9		35'.0		35'.2		35'.4		35'.6				
64	70°11'.6	6'.9	70°7'.7	6'.9	70°0'.8	6'.9	69°53'.9	7'.0	69°46'.9	7'.0	69°39'.9	7'.0	69°32'.9	7'.1	69°25'.8	7'.1	69°18'.7	7'.2	69°11'.5	7'.2	69°4'.3	7'.2	68°57'.1		
	34'.7		34'.8		35'.1		35'.2		35'.4		35'.6		35'.8		36'.0		36'.2		36'.4		36'.6		36'.8		
63	69°36'.9	7'.0	69°32'.9	7'.1	69°25'.8	7'.1	69°18'.7	7'.2	69°11'.5	7'.2	69°4'.3	7'.2	68°57'.1	7'.3	68°49'.8	7'.3	68°42'.5	7'.3	68°35'.2	7'.3	68°27'.9	7'.5	68°20'.3	7'.5	68°12'.8
	35'.6		35'.9		36'.0		36'.2		36'.3		36'.5		36'.8		37'.0		37'.2		37'.5		37'.7		37'.9		38'.1
62	69°1'.3	7'.2	68°57'.1	7'.3	68°49'.8	7'.3	68°42'.6	7'.3	68°35'.2	7'.4	68°27'.5	7'.5	68°20'.3	7'.5	68°12'.8	7'.5	68°5'.3	7'.5	67°57'.7	7'.6	67°50'.1	7'.7	67°42'.4	7'.7	67°34'.7
									37'.5		37'.7		37'.9		38'.1		38'.4		38'.6		38'.9		39'.2		39'.5
61									67°57'.7	7'.6	67°50'.1	7'.7	67°42'.4	7'.7	67°34'.7	7'.8	67°26'.9	7'.8	67°19'.1	7'.9	67°11'.2	8'.0	67°3'.2	8'.0	66°55'.2
									38'.6		39'.0		39'.2		39'.5		39'.8		40'.3		40'.5		40'.8		41'.2
60									67°19'.1	7'.9	67°11'.2	8'.0	67°3'.2	8'.0	66°55'.2	8'.1	66°47'.1	8'.2	66°38'.9	8'.3	66°30'.7	8'.3	66°22'.4	8'.4	66°14'.0