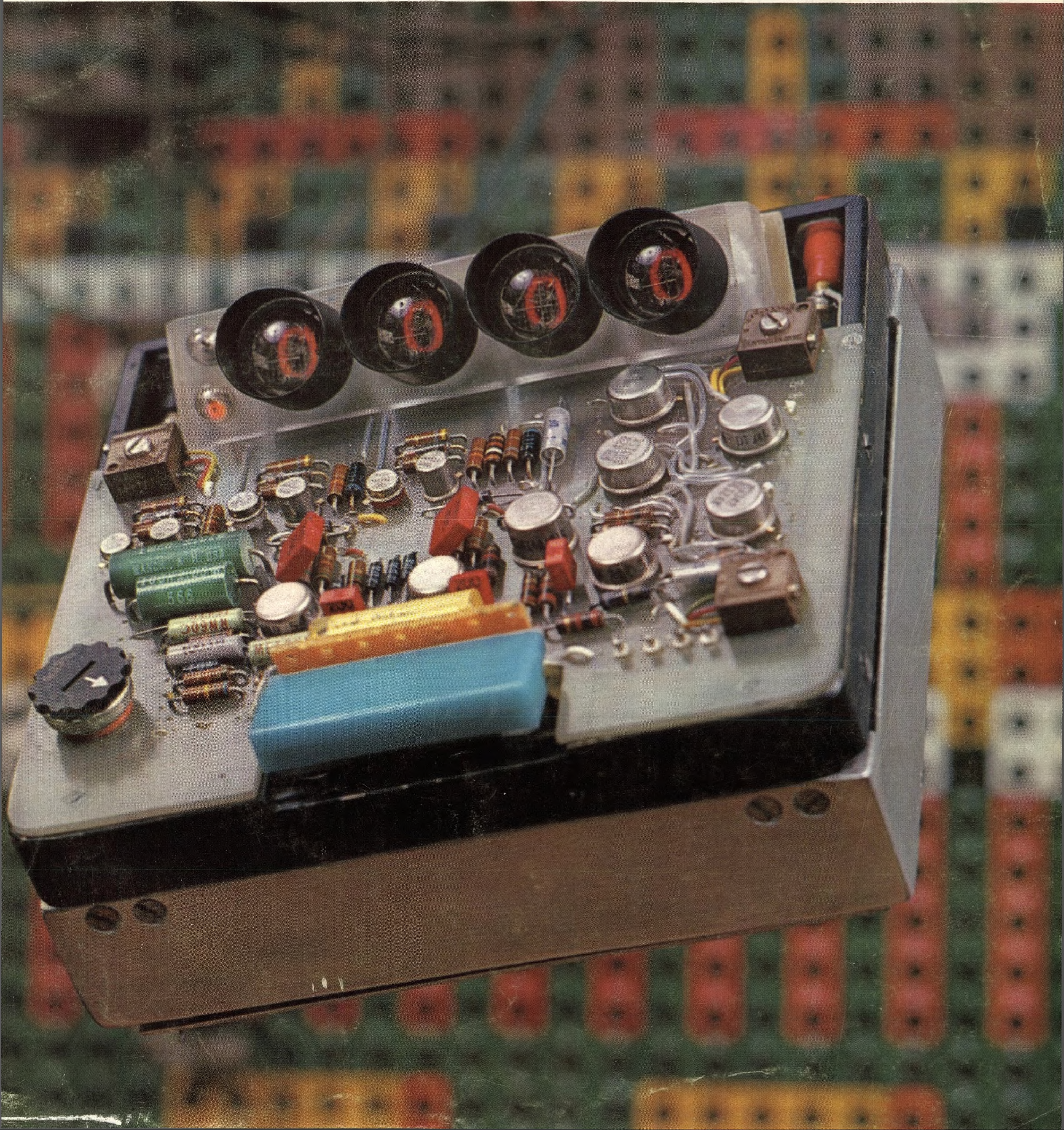
Electronics®

omputer-aided design, part 2: page 68
ew family of switching circuits: page 75
mple telemetry for complex jobs: page 98

November 28, 1966
75 cents
A McGraw-Hill Publication

Below: $100 digital voltmeter built with integrated circuits, page 88



Oscillator or Synthesizer?

If you simply need something that will put out a signal at some frequency with reasonable accuracy, buy one of our many oscillators. But if you want superior performance in a truly versatile laboratory signal source that can tackle practically any job, you want one of our synthesizers — the 70-MHz Type 1164-A, or one of our other models that cover ranges up to 100 kHz, 1 MHz, and 12 MHz.

These synthesizers give you quartz-crystal stability, a frequency settable from 3 to 9 figures or more, manual or electrical sweeping, flat output, and programmability (if you need it). In short, these signal sources will do the job for you with a minimum of complications and without need for time-consuming corrections to improve accuracy of results — yet the price is within reach.

Here are features of our 70-MHz synthesizer, the latest in our series:

- **Frequencies Up To 70 MHz**
  10-kHz to 70-MHz output with resolution as fine as 0.1 Hz. Internal crystal-controlled oscillator may be phase-locked to external standard frequency.
- **Electrical Sweeping and Manual-Search Capabilities**
  Continuously Adjustable Decade (CAD) allows a portion of the frequency range to be swept manually or electrically. The CAD will functionally replace any digit up to 1 MHz for sweep widths from a megahertz to a fraction of a hertz. This module also adds at least 2 places of resolution beyond the last decade.
- **Leveled, Monitored Output That Can Be Remotely Or Manually Controlled**
  Output is adjustable from 0.2 to 2 V behind 50 Ω and is monitored by a panel meter. Level is held constant within ±0.3 dB for all load and frequency variations and can be adjusted manually from the front panel or remotely by a potentiometer or a dc control voltage.
- **Modular Construction**
  Buy only the resolution you require; add modules as your requirements expand. Modules may be easily removed or interchanged for servicing or calibration to cut down time to practically zero.
- **Other Features**
  Remotely programmable (optional) . . . Can operate from ac line or battery for field use . . . In-line, easy-to-read numerals . . . GR-quality construction . . . All in 5¼ inches of rack space.
- **Now Look At The Price**
  Prices start at $4745 for the simplest 3-decade, 70 MHz model; the most complete model costs $7515.

Other GR synthesizers in the series:

Type 1161 — dc to 100-kHz Synthesizer	$3640 to $6590
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Type 1163 — 30-Hz to 12-MHz Synthesizer	$3895 to $6755

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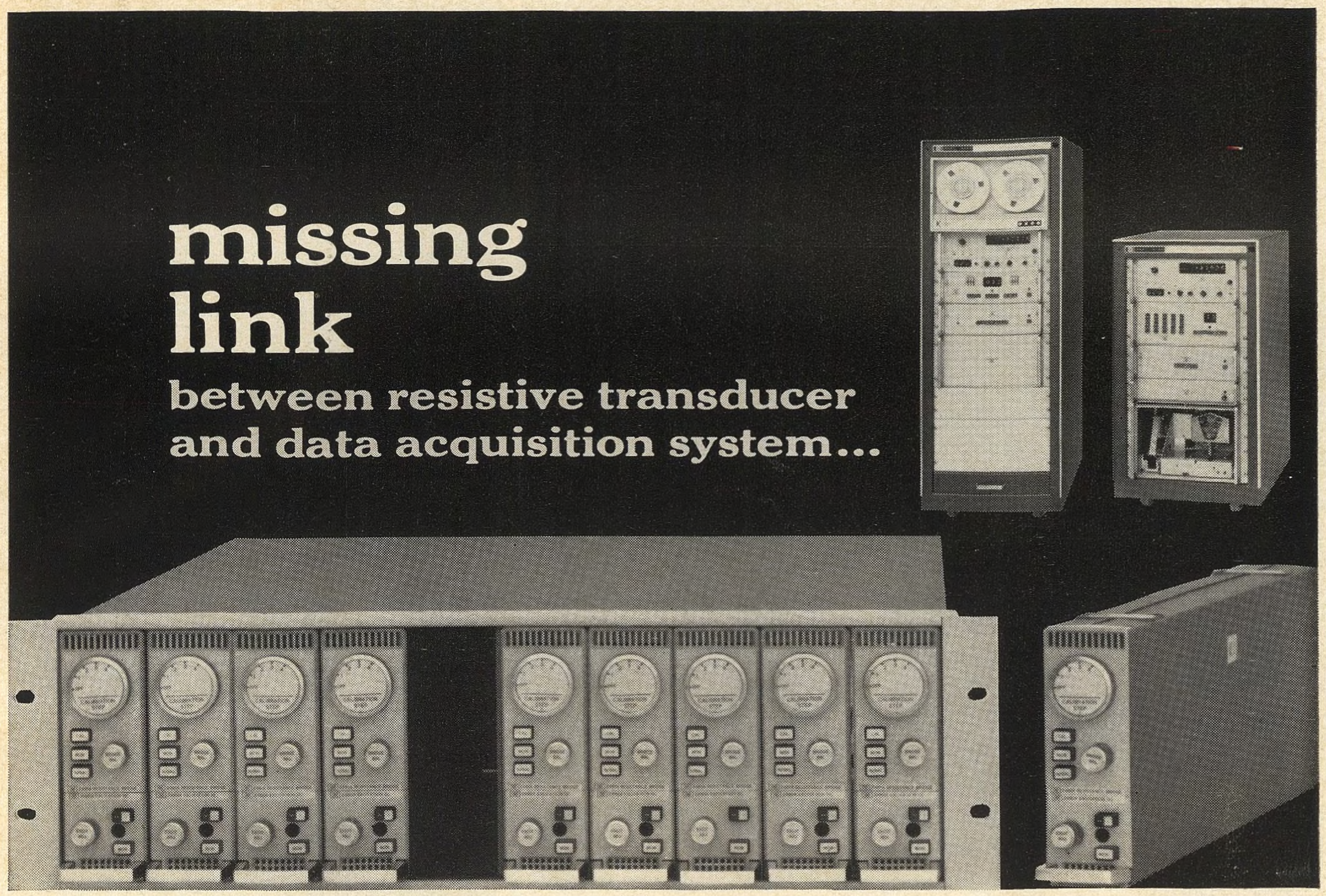
Circle 900 on reader service card



found-

in a new series of high-performance signal conditioning equipment...

Getting accurate low-level signals from a transducer into today's high-performance data acquisition systems was always a problem... until the new Hewlett-Packard 2480 Series Signal Conditioners came along.

The 2480's are flexible, operate more accurately in the presence of noise, are compact and completely self-contained, offer performance never before available for improving the usefulness of transducer signals and increase the value of even the most sophisticated data acquisition systems.

This combination of features makes the 2480 Series provide the data acquisition missing link:

- **Stable built-in transducer excitation source, constant current/constant voltage, plus a unique linear mode for single active arm bridges**
- **Plug-in signal conditioning card flexibility for a wide variety of transducer configurations**
- **Fully floating and guarded for conditioning noisy signals (can't contribute to common mode problems)**
- **All this in a single, rugged package that fits 10 to 5¼"-high rack**
- **Operates under extreme environmental conditions**

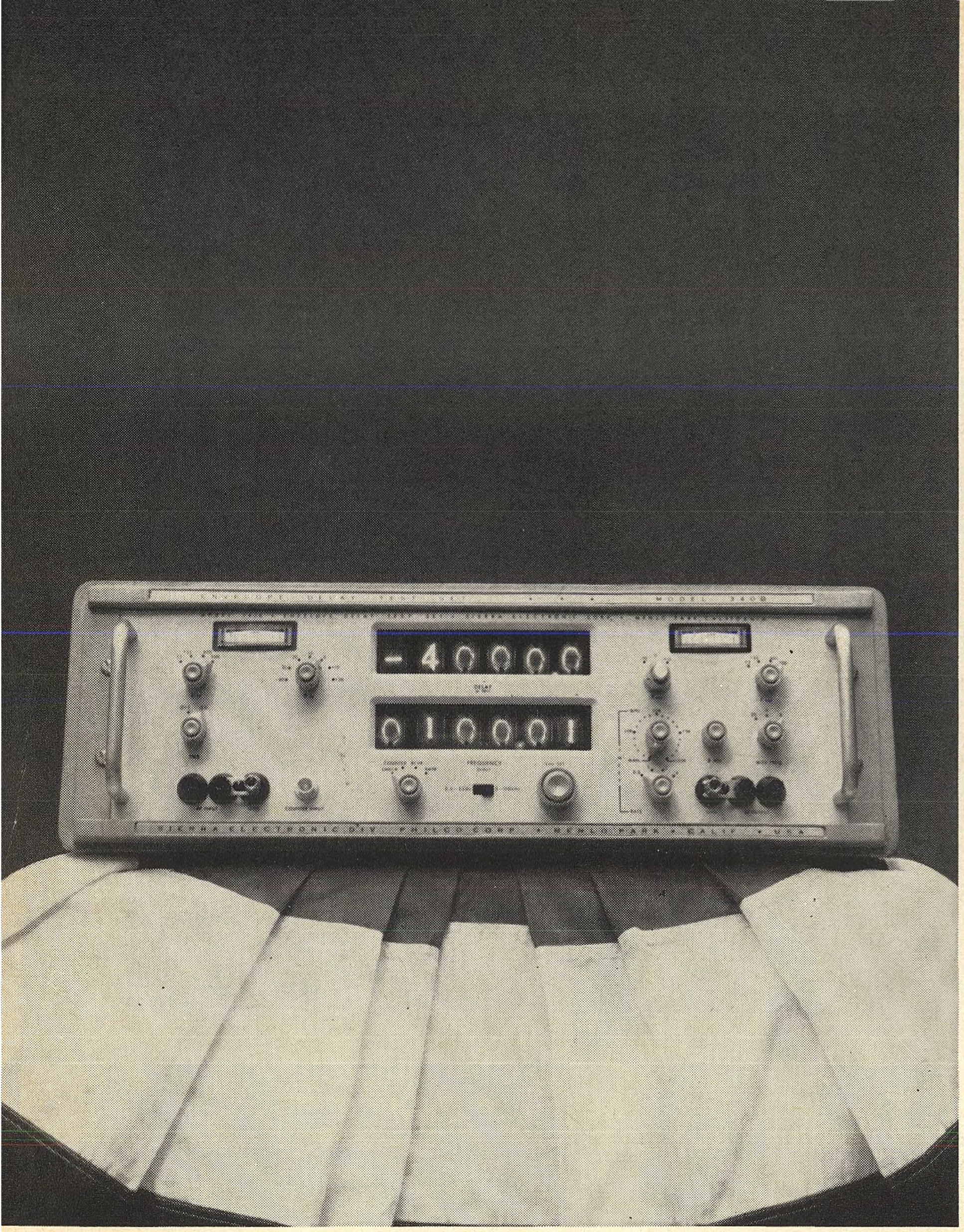
The first instruments in the series include dc excitation, resistance bridge balance and calibration, excitation coupler and monitor selector... everything you need for fast, efficient operation of data acquisition systems working in a broad network of measurement points. Excitation modules can be adjusted to drive up to five conditioning units. Additionally, the excitation coupler allows you to excite a number of transducers and condition a number of signals with a single external power supply.

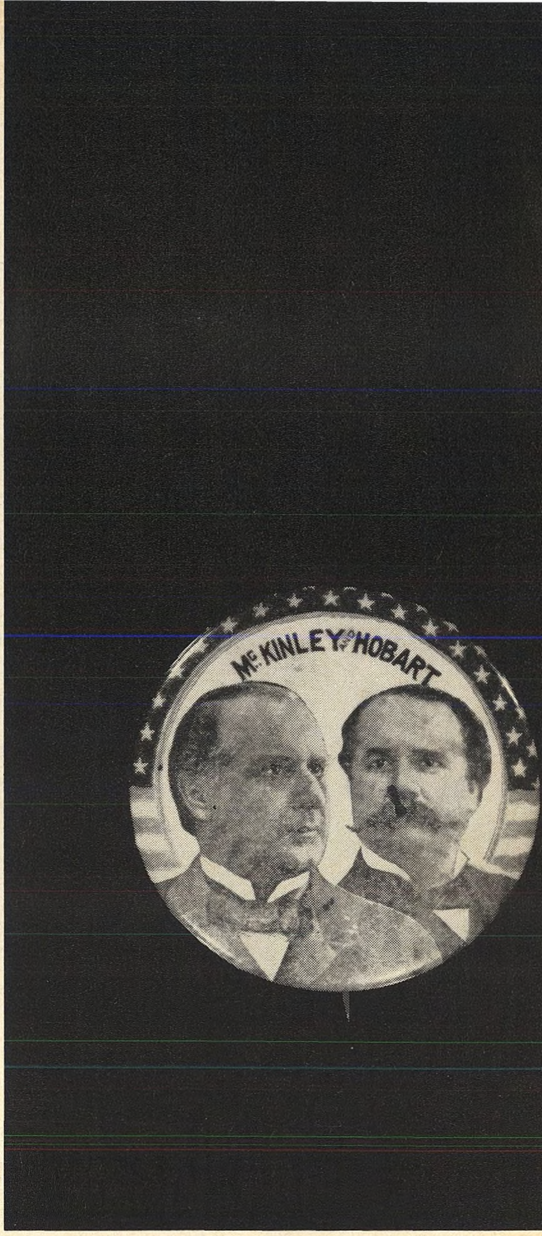
Hewlett-Packard's experience with high-quality, standard data acquisition systems led its Dymec Division to develop this new instrumentation, formerly a limitation on overall system accuracy. You owe it to yourself to check a data sheet on the flexible 2480's and accessory equipment. Excitation/conditioning units with individual built-in power supplies are available, priced from $310 per channel.

Call your Hewlett-Packard field engineer for complete information or write Hewlett-Packard, Palo Alto, California 94306, Tel. (415) 326-1755; Europe: 54 Route des Acacias, Geneva.

Data subject to change without notice. Prices f.o.b. factory.

HEWLETT PACKARD hp DYMEC DIVISION





The day Sierra announced this . . .

Delay distortion became a new issue in the maintenance campaign when data crossed paths with your carrier system. To insure clear, coherent communications, you need all the inside information you can get about each individual transmission circuit. Unknown envelope delay, in particular, can easily garble those well-ordered bit formations into a meaningless shower of babble.

Sierra's new Model 340B helps keep your system tuned to peak performance. It measures delay from 300 Hz to 110 kHz, permitting measurements both on 4-kHz voice circuits and on circuits utilizing group frequencies (60–108 kHz). You have a built-in choice of three measuring modes: end-to-end, loop-back, or end-to-end with return reference path.

Model 340B opens a new frontier of speed and simplicity with such features as:

—Single delay range covering —20,000 to +20,000 μsec

—Direct digital readout with resolution of 0.1 μsec or 1.0 μsec

A second digital readout indicates carrier frequency to the nearest 10 Hz. Electronic sweeping and a built-in 1-MHz frequency counter (±1 digit, ±1 Hz accuracy) round out a solid list of performance features. Price, with one modulation frequency: $4,750.

For the campaign literature, write Sierra/Philco, 3885 Bohannon Drive, Menlo Park, California 94025.

other ways of measurin envelope delay on carri circuits became as date as this

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Electronics

November 28, 1966
Volume 39, Number 24

News Features

Probing the News

Electronics Review

Electronics Abroad

Departments

Technical Articles

I. Design

II. Application

Electronics

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Readers Comment

Great pretenders

To the Editor:

The article [Oct. 31, p. 100] by Alex Martens describes what must be some of the unavoidable conclusions of any qualified, reasonable person experienced in screening and interviewing engineering job applicants.

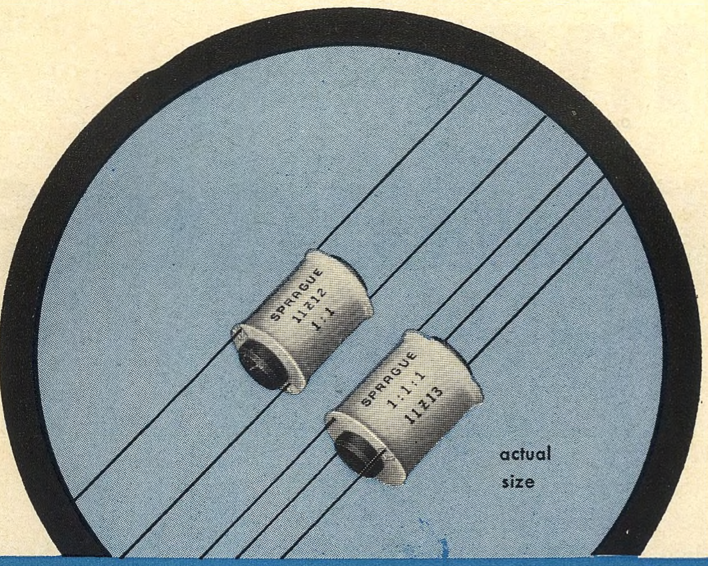
Applicants' resumés simply cannot be trusted. At first it was incredible to me than an "experienced" graduate engineer could not solve a simple RC circuit problem. Now, case-hardened by innumerable interviews, I know better. The many really competent engineers who may read this letter will, like myself at first, find it difficult to accept, but they have not had the unnerving experience of weeding out the "great pretenders."

We interview about one person of every 15 who submit resumés to us; we hire about one person of every 15 interviewed. Why do we have to go through so much screening of resumés and interviewing? We can substantiate by our experience the obvious, time-wasting shortcomings of resumés which Martens cites, including the lack of salary-requirement data. Such data is essential; the applicant only loses time by not supplying it at once.

Some of our help-wanted ads are very specific in terms of required qualifications and the basic nature of the job. Yet most resumés we receive in response to these ads display completely unrelated experience, marginal or no qualifications for the work the ad described, and frequently state a desire for work completely unrelated to the specific job described in the ad.

Some applicant-versus-employer problems evaporate completely if viewed from an experienced interviewer's vantage. One finds, for example, that "design experience" truly means different things to different engineers; some engineers simply can't or don't mentally distinguish between the experience, hard knocks and proficiency gained in conceiving circuits tailored to exacting requirements and the experience gained in adapting or copying a tried-and-proven com-

New from Sprague!



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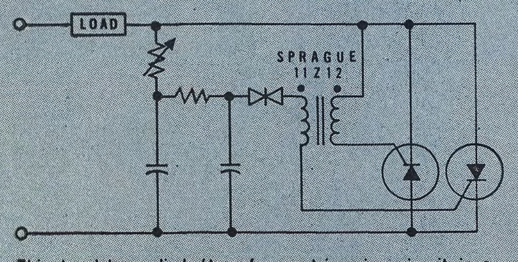
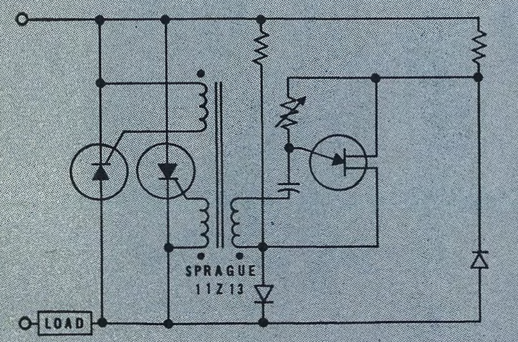


This breakdown-diode/transformer triggering circuit is a typical application for Type 11Z12 Trigate Pulse Transformers.



This unijunction-transistor/transformer triggering circuit is a typical application for Type 11Z13 Trigate Pulse Transformers.

*trademark

Dependable enough for industrial equipment, yet priced for high-volume commercial applications

Here's good news for designers of appliances; lighting controls; air-conditioning and heating controls; industrial controls. You can actually cut costs while upgrading your present method of SCR triggering!

Type 11Z Trigate* Pulse Transformers offer these unique features:

1. Balanced pulse characteristics and energy transfer from primary to secondary and tertiary windings.
2. Minimum saturation effect to allow operation where increased pulse widths are required.
3. Fast pulse rise time and increased current capability to prevent SCR *di/dt* failure.
4. Increased energy transfer efficiency.

Designed for operation over the temperature range of —10 C to +70 C, Trigate Pulse Transformers are available in 2-winding and 3-winding configurations for half-wave and full-wave applications. Both designs are rated for use with line voltages up to 240 VAC.

For complete information, write to Sprague World Trade Corporation, P.O. Box 73, North Adams, Massachusetts, U.S.A., or the nearest affiliated organization listed below.

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Electromag Division, 2 Rue de Merode, Renaix, Belgium
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pany-standard circuit.

In my mind, involvement in some aspect of design does not necessarily constitute cogent design or development experience. People can't really be blamed for being technically naive or for apparent gross exaggeration in their resumés when they simply haven't had the benefit of experience which would amend their misconceptions.

Viewed in this manner, much of the pros and cons of employment policies, employer "inconsideration" versus engineer's "subterfuge," simply don't merit heated arguments, nor finger pointing by either side. Applicants do, and probably should, describe themselves as favorably as possible in a resumé. Employers do, and probably should, be skeptical of that description and spend no more time and effort than necessary to detect the applicant who can earn his money and who perhaps, just perhaps, can learn to do more and to progress professionally in behalf of himself and his employer.

Name withheld

▪ The author of this letter has interviewed hundreds of applicants and screened thousands of resumés in his job with one of the largest firms in the East.

Undeserved bad name

To the Editor:

The Volder algorithm on which Lear Siegler's Divic computer is based [Sept. 5, p. 105], is an ingenious and interesting concept. However, it is not suitable for tracking a real-time input, because it is not incremental—it carries out each computation with the full value of the argument. On the other hand, an incremental device can change a function value corresponding to an increment in the argument without using the total argument.

The digital differential analyzer, which is a general-purpose incremental computer, is very fast; it has a bad name because it is naively thought to be inaccurate. But the elementary trigonometric, hyperbolic and exponential functions can be calculated incrementally with no approximations at all using an algorithm based on equations for the circular and hyperbolic sines and cosines of $(\theta + h)$ [See: "Calculus of Finite Differences" by Charles Jordan, Chelsea Publishing Co., p. 88]. The only inherent errors are due to finite register length, which is limited only by the economic size of the machine.

A family of very compact computing modules is being studied at Univac for computing these functions, one member of which applies to loran navigational systems.

It consists basically of eight shift registers that initially contain value of θ, corresponding to a starting point, and h, the desired increment. Small values of h give precise results, but the algorithm's accuracy in no way depends on whether h is large or small. By shifting data back and forth among these registers, through hardware that implements the operations in the equations, the position of an airplane or ship is determined in terms of the intersection of a hyperbola and an ellipse.

Thomas M. McSherry
Aerospace Analysis Dept.
Univac
St. Paul, Minn.

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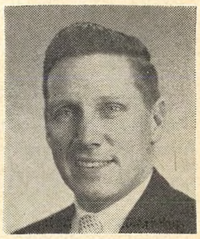
People

Long a leader in bipolar integrated circuits, the Semiconductor division of the Fairchild Camera & Instrument Corp. may be drawing a bead on metal oxide semiconductors. It has hired **Charles H. Sutcliffe**, 41, from the General Instrument Corp., which with Philco-Ford Corp. dominates the MOS field, to fill the new position of manager of MOS integrated circuits. Fairchild group vice president Robert N. Noyce tends to play down the significance of the move, saying that it will serve mainly to give central control to the company's somewhat scattered MOS effort. But Noyce adds that Fairchild now considers MOS technology at the reliability levels necessary for device production; and with the company's biggest competitor, Texas Instruments Incorporated, also showing interest in MOS, the battle of the giants may be on.



Charles H. Sutcliffe

Sutcliffe's first order of business will be to take a six-week trip around the country, mainly to discuss with potential users what sort of MOS devices are needed, and what the applications of MOS are. "Fairchild will have some products coming out soon, some 'me-too' and some totally new," he says. "For the future, I think that MOS will definitely predominate in large-scale arrays because of the great circuit density possible and, because fewer process steps are required."

Price advantage. He also believes that the lower costs of MOS will make custom circuits profitable, and that parallel data processing methods may even make MOS circuits suitable for computers, where their relatively slow speed is considered an insuperable handicap.

Sutcliffe holds a doctorate in solid state physics (University of Pennsylvania, 1953) and was an assistant group vice president at General Instrument. He spent 11 years in Philco's Semiconductor division at Lansdale, Pa., and was general manager of semiconductor operations when he left in August,

People

1964, to become vice president of General Instrument in charge of rectifier operations.

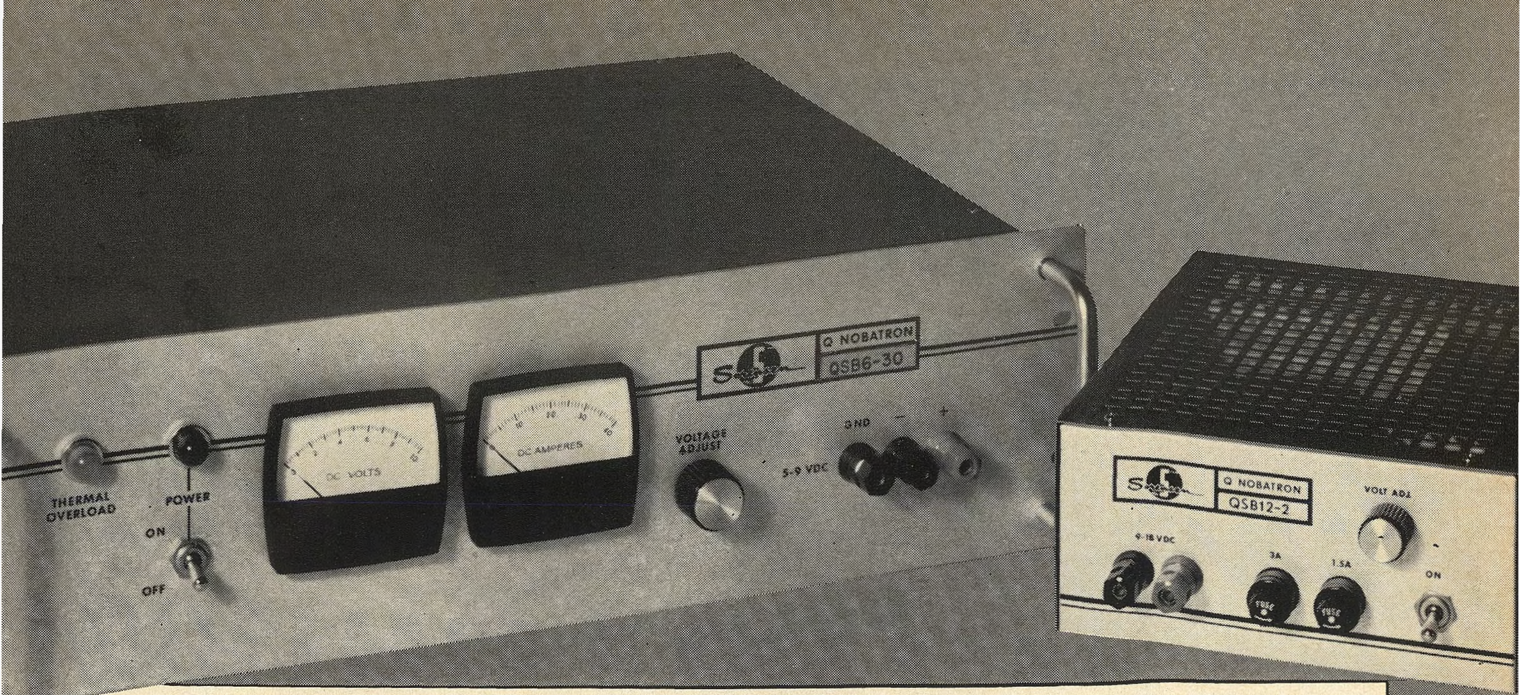
When the Philco Corp. purchased General Micro-electronics, Inc., last January some observers saw the move as an attempt by Philco to provide itself with an in-house metal-oxide-semiconductor (MOS) capability. However, the new director of engineering and research for what is now the Philco-Ford Corp.'s electronics group, **Louis A. deRosa,** puts the question quietly to rest. "Philco-Ford is spending so much money for research and development in MOS," says deRosa, "that it would not be justified without an outside market." deRosa's authority encompasses all six divisions in the electronics group. The Philco-Ford Corp. is a subsidiary of the Ford Motor Co.

Louis A. deRosa

The 56-year-old electrical engineer just completed what he called a reconnaissance trip to the West Coast to acquaint himself with the activities of the group's western divisions, meet the personnel and assess the strengths and weaknesses of the operation.

Design. Although deRosa believes MOS offers many potential advantages, he says Philco-Ford will by no means ignore the standard forms of circuit fabrication. "MOS gives us a chance to use new attacks in design," he adds.

Philco-Ford has invested a great deal of time and money in developing high-speed devices. At last month's Northeast Electronics Research and Engineering Meeting in Boston the company unveiled a high-speed 9-gigahertz silicon transistor. deRosa asserts that in speeding up devices a company opens up a wider market for itself, and compares this development to the supersonic transport which flies so fast that it does the work of several planes and more than offsets the cost involved in building it.



MODEL SELECTION CHART

Voltage	Amps.	Model	Price	Amps.	Model	Price	Amps.	Model	Price	Amps.	Model	Price
5-9	4	QSB 6- 4	$115	8	QSB 6- 8	$170	15	QSB 6-15	$225*	6	QSB 6-30	$295*
9-18	2	QSB 12- 2	115	4	QSB 12- 4	170	8	QSB 12- 8	225*	15	QSB 12-15	295*
13-26	1.5	QSB 18-1.5	115	3	QSB 18- 3	170	6	QSB 18- 6	225*	12	QSB 18-12	295*
18-36	1	QSB-28- 1	115	2	QSB 28- 2	170	4	QSB 28- 4	225*	8	QSB 28- 8	295*

*For optional voltmeter and ammeter add $30.

Sorensen OEM/Lab. Power Supply

New Sorensen QSB's give you OEM prices with laboratory performance.

The Sorensen QSB Series, medium range power supplies available in 25, 50, 100 watt models (6, 12, 18 and 28 Vdc nominal) provide laboratory performance in compact bench or rack packages that are ideally suited for budget-type OEM computer, communications and test instrumentation applications. Features such as: precise regulation ($\pm$.005% line and load for most models), low ripple (250 μV rms, 1 mV peak to peak), response time (30 μs), all combined with prices starting at $115. Other features include: inputs 105-125/200-240/210-250 Vac, 47-420Hz; current regulation $\pm$.01%; temp. range 0-71°C; temp. coefficient .015%/°C; stability .025%/8 hrs.; remote programming and sensing; series/parallel operation. For additional QSB details, or for data on other standard/custom power supplies, AC line regulators or frequency changers, contact your local Sorensen representative, or Raytheon Company, Sorensen Operation, Richards Ave., Norwalk, Connecticut 06856. Telephone: 203-838-6571. TWX 710-468-2940.

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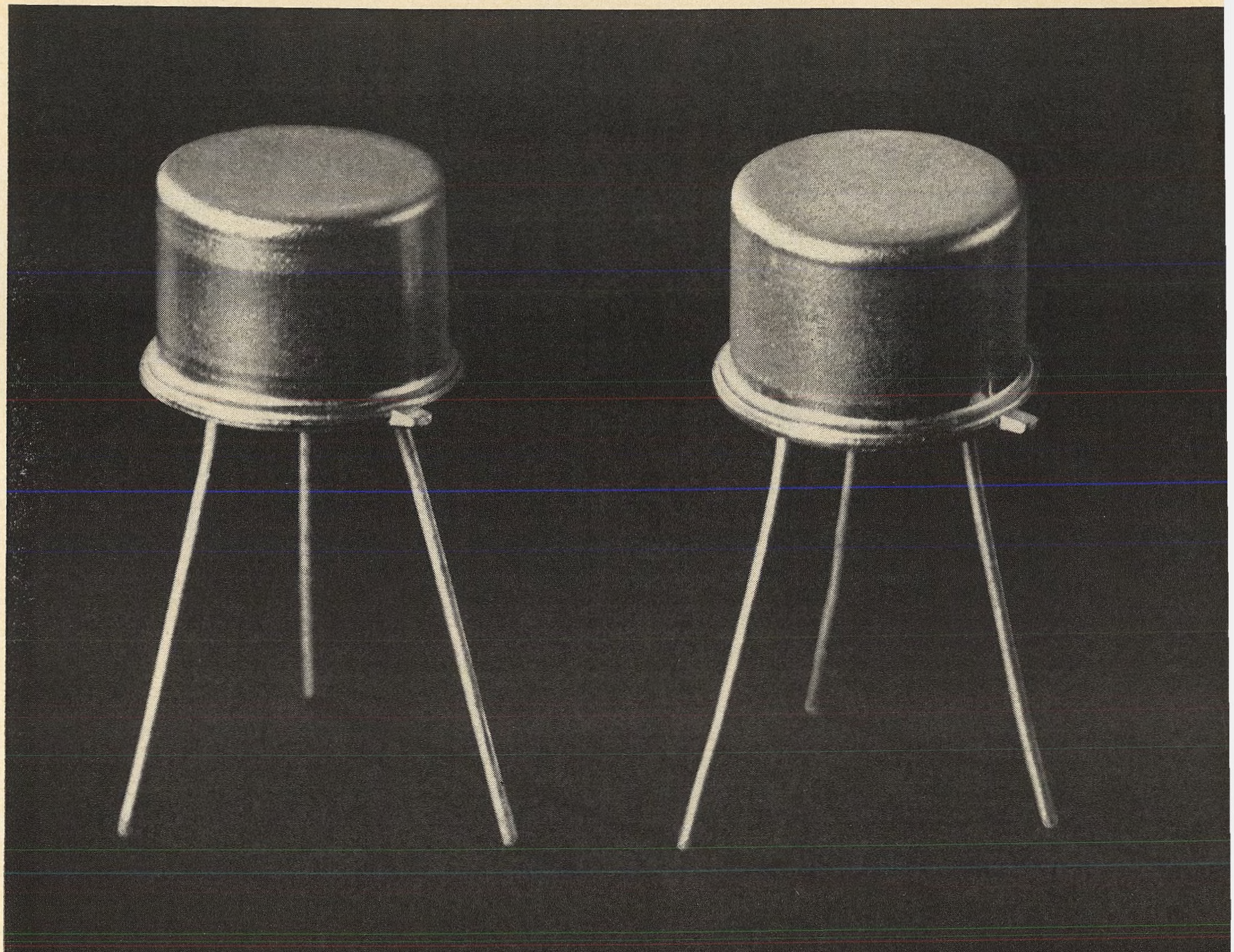
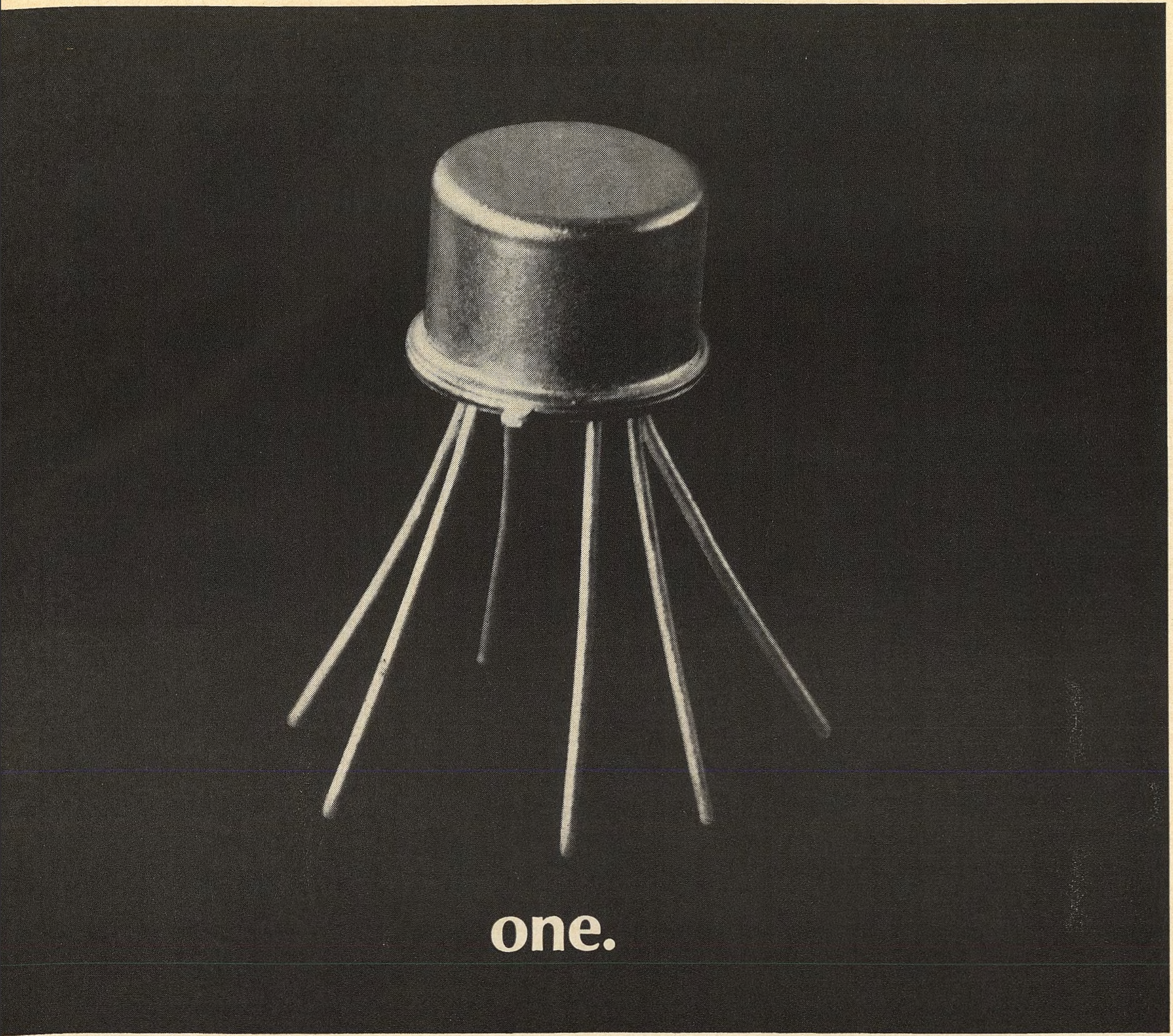
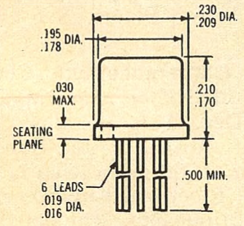


Two for the space of

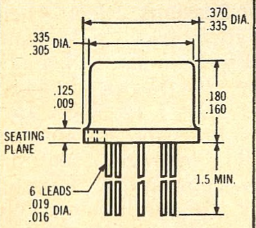
Fairchild dual transistors and differential amplifiers save space, give you greater design flexibility and provide uniform performance. You can get two discrete transistors into the space normally occupied by one. Pick virtually any of Fairchild's catalog PNP or NPN transistors for dual encapsulation. See table for several of Fairchild's PNP dual transistors and differential amplifiers. For differential amplifiers we select adjacent chips off the same wafer to give you the closest possible match of electrical characteristics. For price, delivery, and complete specifications, check with any Fairchild Distributor, or write for our new brochure.



Selected PNP High-Gain, Low-Noise Dual Transistors and Differential Amplifiers: (Write for full line PNP and NPN Brochure)



FT PACKAGE CONFIGURATION



2N PACKAGE CONFIGURATION

Differential Amplifiers:	2N4020 FT4020	2N4021 FT4021	2N4022 FT4022	2N4023 FT4023	2N4024 FT4024	2N4025 FT4025
LV_{CEO}	−45V	−60V	−60V	−45V	−60V	−60V
$\frac{h_{FE1}}{h_{FE2}}$ @ $I_C = 100\mu A$ to 1.0mA; $V_{CE} = -5.0V$	0.8 min. 1.0 max.	0.8 min. 1.0 max.	0.8 min. 1.0 max.	0.9 min. 1.0 max.	0.9 min. 1.0 max.	0.9 min. 1.0 max.
h_{FE} @ $V_{CE} = -5.0V$;						
$I_C = 1.0\mu A$	180 min.	60 min.	180 min.	180 min.	60 min.	180 min.
$I_C = 10\mu A$	250 min.	100 min.	250 min.	250 min.	100 min.	250 min.
$I_C = 100\mu A$	250 min.	100 min.	250 min.	250 min.	100 min.	250 min.
$I_C = 1.0mA$	250 min.	100 min.	250 min.	250 min.	100 min.	250 min.
NF @ $I_C = 20\mu A$; $V_{CE} = -5.0V$; $f = 100Hz$; $BW = 15Hz$; $R_S = 10k\mu$	4.0db max.	10db max.	4.0db max.	4.0db max.	10db max.	4.0db max.
$\lvert V_{BE1} - V_{BE2} \rvert$ @ $I_C = 100\mu A$	5.0mV max.	5.0mV max.	5.0mV max.	3.0mV max.	3.0mV max.	3.0mV max.

Dual Transistors:	2N4017 FT4017	2N4018 FT4018	2N4019 FT4019
h_{FE} @ $V_{CE} = -5.0V$;			
$I_C = 1.0\mu A$	60 min.	60 min.	180 min.
$I_C = 10\mu A$	100 min.	100 min.	250 min.
$I_C = 100\mu A$	100 min.	100 min.	250 min.
$I_C = 1.0mA$	100 min.	100 min.	250 min.
LV_{CEO}	−80V	−60V	−45V
NF @ $I_C = 20\mu A$; $V_{CE} = -5.0V$; $f = 100Hz$; $BW = 15Hz$; $R_S = 10k\mu$	10db max.	10db max.	4.0db max.

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Meetings

Meeting and Technical Display of American Institute of Aeronautics and Astronautics; War Memorial Auditorium, Prudential Center, Boston **Nov. 29-Dec. 2.**

Vehicular Communications Conference, IEEE; Montreal, Quebec, **Dec. 1-2.**

Meeting of the National Committee of the International Scientific Radio Union; Cabana Motor Hotel, Palo Alto, Calif., **Dec. 7-9.**

Electronics Industry Plating Symposium, American Electroplaters' Society; Robert Treat Hotel, Newark, N. J., **Dec. 8-9.**

Magnetic Core Design Seminar, Magnetic Powder Core Association, a division of the Metal Powder Industries Federation; Holiday Inn, Newton, Mass., **Dec. 8.**

Electrical and Electronic Measurement and Test Instrument Conference, IEEE; Talisman Motor Inn, Ottawa, Canada, **Jan. 9-11.**

Symposium on Reliability, American Society for Quality Control, IEEE; Sheraton-Park Hotel, Washington, **Jan. 10-12.**

Symposium on Computers and Communications, IEEE; Miramar Hotel, Santa Monica, Calif., **Jan. 19.**

American Society for Quality Control Meeting, American Society for Quality Control; California State Polytechnic College, Kellogg Campus, Pomona, Calif., **Jan. 21.**

Midwest Welding Conference, Illinois Institute of Technology Research Institute; Illinois Institute of Technology, Chicago, **Jan. 24-25.**

Ultrasonic Manufacturers Association Technical Symposium and Meeting, Ultrasonic Manufacturers Association; New York, **Jan. 25.**

Symposium on Nondestructive Testing of Welds, Illinois Institute of Technology Research Institute; Illinois Institute of Technology, Chicago, **Jan. 30-Feb. 2.**

American Society for Testing and Materials Symposium on Adhesion (Cold Welding) of Materials in Space Environments, American Society for Testing and Materials; Royal York Hotel, Toronto, Canada, **Feb. 5-6.**

American Society for Testing and Materials Meeting, American Society for Testing and Materials; Statler Hilton Hotel, Detroit, Mich., **Feb. 5-10.**

Electronic Packaging Conference, Society of Automated Engineers; Roosevelt Hotel, New York, **Feb. 14-16.**

International Solid State Circuits Conference, IEEE; University of Pennsylvania, Sheraton Hotel, Philadelphia, **Feb. 15-17.***

Airborne Photo-Optical Instrumentation Seminar, Society of Photo-Optical Instrumentation Engineers; Ramada Inn, Cocoa Beach, Fla., **Feb. 20-21.**

National Air Meeting on Collision Avoidance, Institute of Navigation; Dayton, Ohio, **Feb. 23-24.**

Technical Meeting and Equipment Exposition, Institute of Environmental Sciences; Washington, **April 10-12.**

International Conference on Electronics and Space, Electronic Industries Association of France; Paris, **April 10-15.**

Call for papers

Joint Automatic Control Conference, sponsored by the Instrument Society of America, IEEE, American Institute of Aeronautics and Astronautics, American Society of Mechanical Engineers and American Institute of Chemical Engineers, at the University of Pennsylvania, June 28-30. **Dec. 1** is deadline for submitting papers to G.K.L. Chin, IBM Corp., 1000 Westchester Ave., White Plains, N.Y.

International Conference on Communications, IEEE; Minneapolis, June 12-14. **Dec. 1** is deadline for submission of abstracts to Robert Collins, technical program chairman, Department of Electrical Engineering, University of Minnesota, Minneapolis, Minn., 55455.

Semiconductor Sessions, Electrochemical Society, dielectrics and insulation, the electrothermics and metallurgy and the electronics divisions; Dallas, Texas, May 7-12. **Dec. 15** is deadline for submission of abstracts to Harry Sello, manager, materials and processes department, Fairchild Semiconductor, Research and Development Laboratories, 4001 Junipero Serra Boule, Palo Alto, Calif. 94304.

*** Meeting preview on page 16**

Infinite resistance at null to 1100 volts is one feature of our new solid state differential voltmeter. Accuracy to ±0.0025% of dial setting is another. Price of $1095 doesn't hurt our cause either. Ratio measurement lets you compare two external sources with a resolution of 0.0001%. In the TVM mode, input resistance is 100 megohms. Reference regulation is 0.0002%. Stability is 13 ppm peak-to-peak per 60 days.

Of course, that's not the whole story. Other features include 6 digit inline readout with a dial resolution of 1 ppm. The recorder output is well isolated and linear to within 0.5% of end scale. Ten percent overranging minimizes range changing and offers increased resolution on the lower end of each range. A continuously adjustable last digit allows exact null and eliminates meter interpolation for resolution. The half-rack Model 895A weighs 16 pounds.

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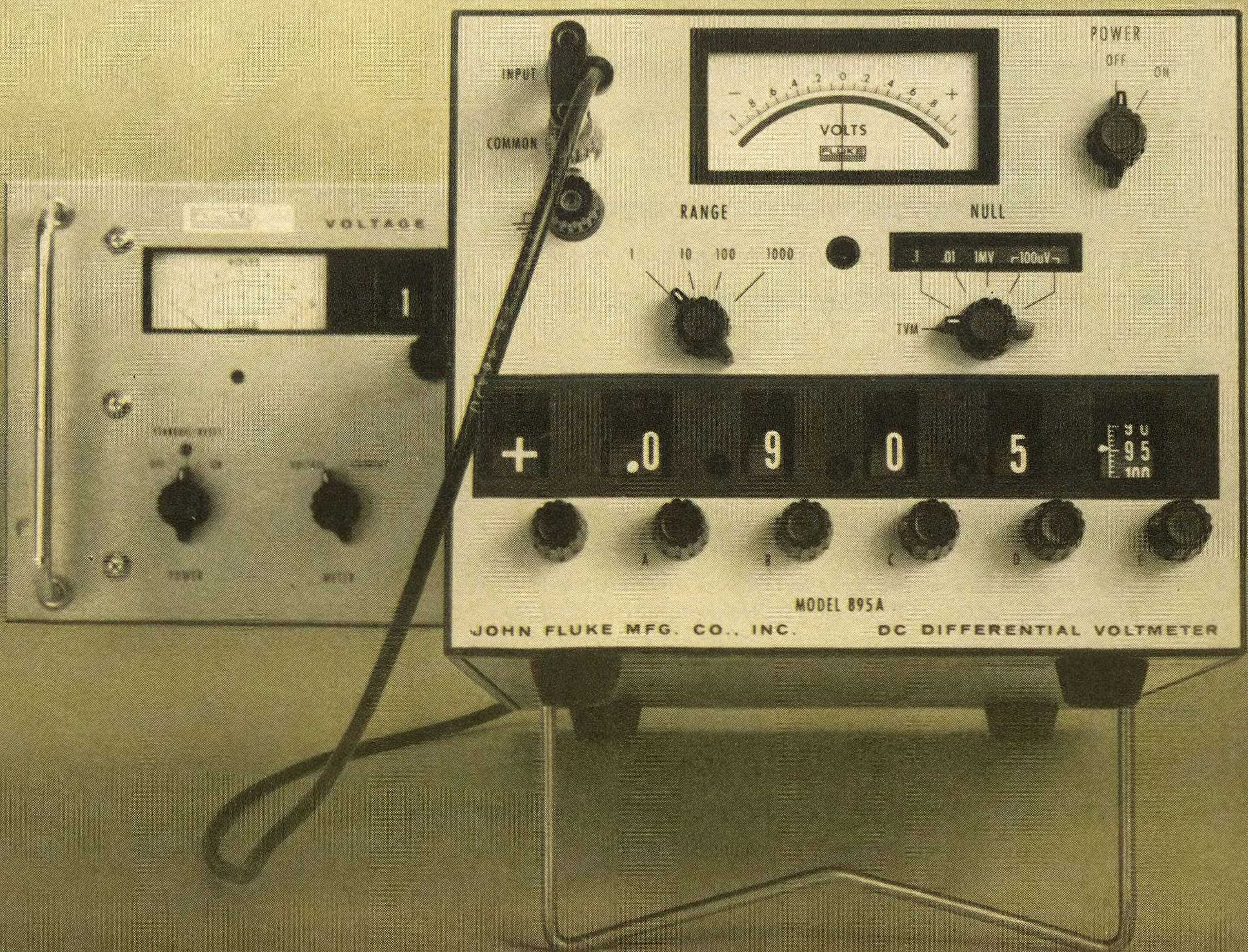


Meeting preview

What's next

Two of the latest technologies in the electronics industry—computer-aided design and large-scale integration—will dominate the International State Circuits Conference in Philadelphia on Feb. 15.

The conference will start with a session on the present status and the future of LSI [see story on p. 133]. This will be followed by an evening panel discussion that will assess the condition and problems of logic partitions from the standpoint of the natural partitions in traditional computer systems.

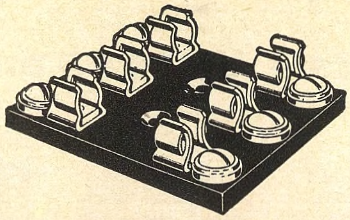
The panel members from the Radio Corp. of America, International Business Machines Corp., Univac division of the Sperry Rand Corp. and Bell Telephone Laboratories will also discuss what types of system redesigns can improve partitions, algorithms for computer-aided partitions and test sequence simplification.

The problem. The case for computer-aided design will be presented by an expert in the field, William Happ of the National Aeronautics and Space Administration. Happ will describe the scope and availability of programs for computer-aided design and the efforts under way toward standardization. In addition, he'll criticize the compatibility, availability and idiosyncracies of existing programs.

Speakers from IBM's East Fishkill facility will explain the use of computer-aided design in fabricating picosecond silicon monolithic current-mode integrated circuits. Engineers from Bell Labs will describe a low-cost computer console used for graphical display during computer-aided design.

One paper will examine a distributed model for the saturation characteristics and internal currents of an integrated circuit. Another will analyze an experiment with an on-line graphics-aided circuit analysis program.

An evening session on computer-aided design will investigate several areas: computer aids to modeling analysis, design of discrete component circuits, non-ideal models and sensitivity analysis.



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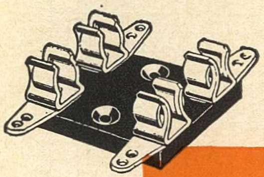
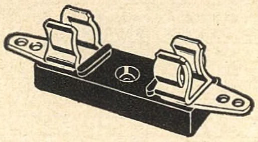
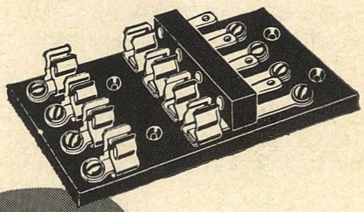
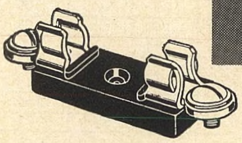






BUSS FUSES



Single pole, multiple pole, small base, full base, molded base, laminated base, porcelain base – signal activating fuse blocks and special blocks of all types for BUSS Small Dimension fuses.

Fuse blocks to meet JAN and Military specifications.

Get full data for your files, write for BUSS bulletin, Form SFB – it gives a comprehensive picture of the complete line of Small Dimension fuses and fuse mountings.

For fuses and fuseholders of unquestioned high quality for every protection need, *insist on . . .*

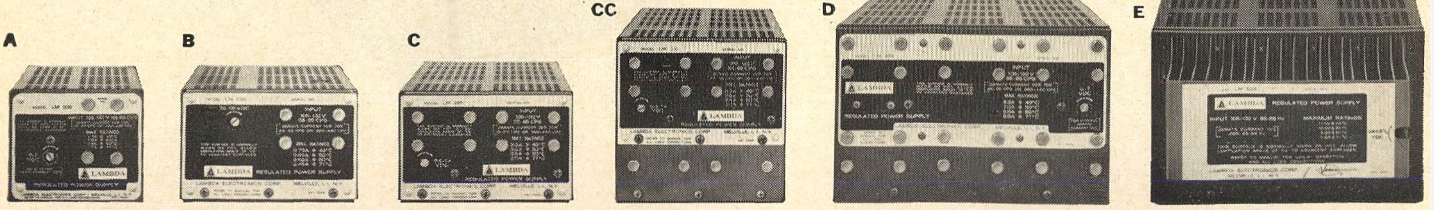
BUSS QUALITY

BUSSMANN MFG. DIVISION, McGraw-Edison Co., St. Louis, Mo. 63107

Meet any programable or fixed voltage need

Up to 150 volts • Up to 95 amps

A B C CC D E



FEATURES and DATA

Full line of accessories and options to meet your system needs. Meet Mil. Environment Specs. **RFI**—MIL-I-16910: **Vibration:** MIL-T-4807A: **Shock:** MIL-E-4970A • Proc. 1 & 2: **Humidity:** MIL-STD-810 • Meth. 507: **Temp. Shock:** MIL-E-5272C • (ASG) Proc. 1: **Altitude:** MIL-E-4970A • (ASG) Proc. 1: **Marking:** MIL-STD-130: **Quality:** MIL-Q-9858: **Fungus Proofing** (optional) all models available with MIL-V-173 varnish for all nutrient components.

Convection cooled—no heat sinking or forced air required

Wide input voltage and frequency range—105-132 VAC, (200-250 VAC, optional at no extra charge) 45-440 cps

Regulation (line) 0.05% plus 4MV **(load)** 0.03% plus 3MV:

Ripple and Noise—1 MV rms, 3MV p to p

Overvoltage protection available for all models up to 70 VDC

High Performance Option—All models available with these specifications for $25.00 extra: **Line regulation**—.01% + 1MV; **Load regulation**—.02% + 2MV: **Ripple and Noise**—½MV rms; 1½MV p to p: **Temp. Coef.**—.01%°C

ACCESSORIES and OPTIONS

System Rack Adapters

LRA-5 • 3½″ height by 2⁷⁄₁₆″ depth. Price $35.00

LRA-4 • 3½″ height by 14″ depth. (For use with chassis slides) Price $55.00

LRA-5 and **LRA-4** mount the following combinations of LM models: up to 4 A package sizes • 3 B or 3 C package sizes • 2 A and 1 B or 1 C package sizes

LRA-3 • 5¼″ height by 2⁷⁄₁₆″ depth. Price $35.00

LRA-6 • 5¼″ height by 14″ depth. (For use with chassis slides) Price $60.00

LRA-3 and **LRA-6** mount the following combinations of LM models: up to 4 A, B or C package sizes • 3 CC package sizes • 2 D or 2 E package sizes • 2 A, B or C and 1 CC or 1 D or 1 E package sizes • 1 CC and 1 D or 1 E package sizes • 1 D and 1 E package sizes

Metered Panels • 3½″ Metered panel MP-3 is used with rack adapters LRA-4, LRA-5 and packages A, B and C. Price $40.00

5¼″ Metered panel MP-5 is used with rack adapters LRA-6, LRA-3 and packages A, B, C, CC, D and E. Price $40.00

To order these accessory metered panels, specify panel number which MUST BE FOLLOWED BY the MODEL NUMBER of the power supply with which it will be used.

F and G LM Packages are full rack power supplies available metered or non-metered. For metered models, add suffix M to the Model No. and $30 to the non-metered price.

Other Options • Also available are Overvoltage Protectors, Fungus Proofing, and High Performance Options at moderate surcharges.

WIDE VOLTAGE RANGE

PROGRAMABLE LM SERIES MODELS

PACKAGE A 3³⁄₁₆″x3¾″x6½″	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40°C	50°C	60°C	71°C	
LM 251	0-7	0.35	0.31	0.29	0.27	$ 69
LM 201	0-7	0.85	0.75	0.70	0.55	79
LM 202	0-7	1.7	1.5	1.4	1.1	89
LM 252	0-7	2.0	1.8	1.4	1.1	99
LM 257	0-14	0.27	0.24	0.23	0.22	69
LM 203	0-14	0.45	0.40	0.38	0.28	79
LM 204	0-14	0.90	0.80	0.75	0.55	89
LM 258	0-14	1.2	1.1	1.0	0.80	99
LM 259	0-24	0.18	0.16	0.15	0.14	69
LM 260	0-24	0.35	0.30	0.25	0.20	79
LM 261	0-24	0.70	0.65	0.60	0.45	89
LM 262	0-24	0.80	0.75	0.70	0.60	99
LM 263	0-32	0.14	0.12	0.11	0.10	69
LM 205	0-32	0.25	0.23	0.20	0.15	79
LM 206	0-32	0.50	0.45	0.40	0.30	89
LM 264	0-32	0.66	0.60	0.50	0.32	99
LM 265	0-60	0.08	0.07	0.07	0.06	79
LM 207	0-60	0.13	0.12	0.11	0.08	89
LM 208	0-60	0.25	0.23	0.21	0.16	99
LM 266	0-60	0.35	0.31	0.28	0.25	109
LM 267	0-120	0.10	0.09	0.08	0.07	109
LM 268	0-120	0.13	0.12	0.10	0.09	119

PACKAGE B 3³⁄₁₆″x4¹⁵⁄₁₆″x6½″	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40°C	50°C	60°C	71°C	
LMB-0-7	0—7	2.8	2.6	2.3	1.5	$109
LMB-0-14	0—14	1.6	1.5	1.3	1.2	109
LMB-0-32	0—32	0.80	0.70	0.60	0.5	109
LMB-0-60	0—60	0.45	0.40	0.35	0.3	109
LM-217	8.5—14	2.1	1.9	1.7	1.3	119
LM-218	13—23	1.5	1.3	1.2	1.0	119
LM-219	22—32	1.2	1.1	1.0	0.80	119
LM-220	30—60	0.70	0.65	0.60	0.45	129

PACKAGE C 3³⁄₁₆″x4¹⁵⁄₁₆″x9⅜″	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40°C	50°C	60°C	71°C	
LM-225	0—7	4.0	3.6	3.0	2.4	$139
LMC-0-14	0—14	2.2	2.0	1.8	1.5	139
LMC-0-32	0—32	1.1	1.0	0.90	0.80	139
LMC-0-60	0—60	0.60	0.55	0.50	0.45	139
LM-226	8.5—14	3.3	3.0	2.5	2.0	139
LM-227	13—23	2.3	2.1	1.7	1.4	139
LM-228	22—32	2.0	1.8	1.5	1.2	139
LM-229	30—60	1.1	1.0	0.80	0.60	149

PACKAGE D 4¹⁵⁄₁₆″x7½″x9⅜″	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40°C	50°C	60°C	71°C	
LM-234	0—7	8.3	7.3	6.5	5.5	$199
LMD-0-14	0—14	4.9	4.2	3.4	2.7	199
LMD-0-32	0—32	2.5	2.1	1.7	1.3	180
LMD-0-60	0—60	1.3	1.1	0.95	0.75	239
LM-235	8.5—14	7.7	6.8	6.0	4.8	199
LM-236	13—23	5.8	5.1	4.5	3.6	209
LM-237	22—32	5.0	4.4	3.9	3.1	219
LM-238	30—60	2.6	2.3	2.0	1.6	239

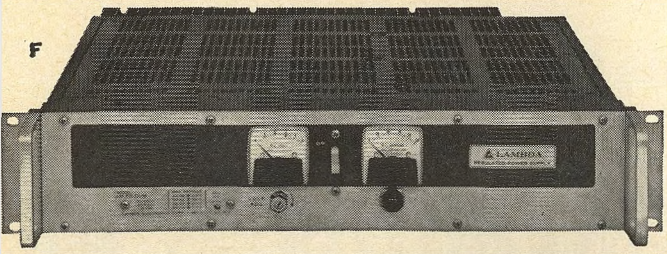
PACKAGE E 4¹⁵⁄₁₆″x7½″x11⅞″	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40°C	50°C	60°C	71°C	
LME-0-7	0—7	12.0	10.5	8.5	6.8	$249
LME-0-14	0—14	7.4	6.4	5.2	4.1	249
LME-0-32	0—32	3.7	3.2	2.6	2.1	249
LME-0-60	0—60	2.1	1.7	1.4	1.1	249

PACKAGE F 3½″x19″x16½″	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40°C	50°C	60°C	71°C	
LMF-0-7	0—7	25.0	21.0	17.0	14.0	$425

PACKAGE G 5¼″x19″x16½″	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF:				Price**
		40°C	50°C	60°C	71°C	
LMG-0-7	0—7	35.0	29.0	24.0	20.0	$575

with Lambda Modular Power Supply Systems

F



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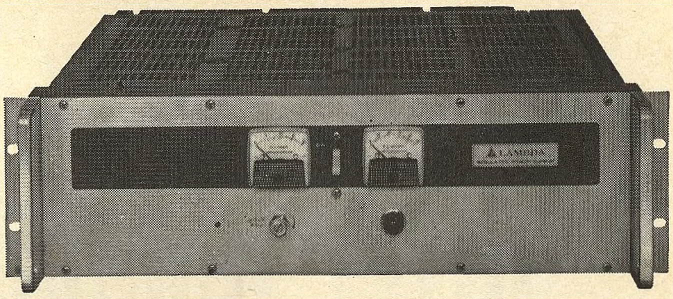


FIXED VOLTAGE RANGE

LM SERIES MODELS

PACKAGE B 3³⁄₁₆"x4¹⁵⁄₁₆"x6½"	ADJ. VOLT. RANGE VDC	*MAX. AMPS AT AMBIENT OF: 40°C	50°C	60°C	71°C	Price**
LM B3	3 ±5%	3.8	3.3	2.6	1.6	$119
LM B3P3	3.3±5%	3.8	3.3	2.6	1.6	119
LM B3P6	3.6±5%	3.8	3.3	2.6	1.6	119
LM B4	4 ±5%	3.8	3.3	2.6	1.6	119
LM B4P5	4.5±5%	3.7	3.2	2.5	1.5	119
LM B5	5 ±5%	3.7	3.2	2.5	1.5	119
LM B6	6 ±5%	3.2	2.9	2.4	1.4	119
LM B8	8 ±5%	3.2	2.9	2.4	1.4	119
LM B10	10 ±5%	2.7	2.5	2.2	1.4	119
LM B12	12 ±5%	2.5	2.3	2.1	1.3	119
LM B15	15 ±5%	2.2	2.0	1.8	1.3	119
LM B18	18 ±5%	2.0	1.8	1.7	1.3	119
LM B20	20 ±5%	1.8	1.6	1.5	1.2	119
LM B24	24 ±5%	1.4	1.3	1.2	1.1	119
LM B28	28 ±5%	1.3	1.2	1.1	1.0	119
LM B36	36 ±5%	1.1	1.0	0.90	0.85	129
LM B48	48 ±5%	0.9	0.85	0.80	0.75	129
LM B60	60 ±5%	0.7	0.65	0.60	0.54	129
LM B100	100 ±5%	0.37	0.34	0.30	0.28	139
LM B120	120 ±5%	0.30	0.28	0.25	0.23	139
LM B150	150 ±5%	0.25	0.23	0.20	0.19	149

PACKAGE C 3³⁄₁₆"x4¹⁵⁄₁₆"x9⅜"	ADJ. VOLT. RANGE VDC	*MAX. AMPS 40°C	60°C	Price**
LM C3	3 ±5%	5.3	3.7	$139
LM C4	4 ±5%	5.2	3.6	139
LM C4P5	4.5±5%	5.1	3.5	139
LM C5	5 ±5%	5.1	3.4	139
LM C6	6 ±5%	4.8	3.3	139
LM C12	12 ±5%	4.0	2.9	139
LM C15	15 ±5%	3.5	2.8	139
LM C20	20 ±5%	3.1	2.6	139
LM C24	24 ±5%	2.5	2.2	139
LM C28	28 ±5%	2.3	2.0	139
LM C48	48 ±5%	1.6	1.3	149
LM C150	150 ±5%	0.39	0.33	169

NEW PACKAGE CC 4¹⁵⁄₁₆"x4¹⁵⁄₁₆"x9⅜"	ADJ. VOLT. RANGE VDC	*MAX. AMPS 40°C	60°C	Price**
LM CC3	3 ±5%	11.0	8.2	$179
LM CC4	4 ±5%	11.0	8.2	179
LM CC4P5	4.5±5%	10.5	8.0	179
LM CC5	5 ±5%	10.5	8.0	179
LM CC6	6 ±5%	9.0	7.7	179
LM CC12	12 ±5%	7.3	5.9	169
LM CC15	15 ±5%	6.0	5.1	169
LM CC20	20 ±5%	5.0	4.2	169
LM CC24	24 ±5%	4.0	3.4	169
LM CC28	28 ±5%	3.5	3.1	169
LM CC48	48 ±5%	2.5	2.2	189
LM CC150	150 ±5%	0.7	0.62	199

PACKAGE D 4¹⁵⁄₁₆"x7½"x9⅜"	ADJ. VOLT. RANGE VDC	*MAX. AMPS 40°C	60°C	Price**
LM D3	3 ±5%	13.1	9.2	$199
LM D4	4 ±5%	13.1	9.2	199
LM D4P5	4.5±5%	13.1	9.2	199
LM D5	5 ±5%	12.6	9.2	199
LM D6	6 ±5%	12.4	8.9	199
LM D12	12 ±5%	10.0	8.3	199
LM D15	15 ±5%	9.0	7.9	209
LM D20	20 ±5%	7.4	6.5	209
LM D24	24 ±5%	6.7	5.8	219
LM D28	28 ±5%	6.0	5.2	219
LM D48	48 ±5%	4.1	3.6	239
LM D150	150 ±5%	1.1	0.90	254

PACKAGE E 4¹⁵⁄₁₆"x7½"x11⅞"	ADJ. VOLT. RANGE VDC	*MAX. AMPS 40°C	60°C	Price**
LM E3	3 ±5%	22.0	16.5	$269
LM E4	4 ±5%	21.0	16.5	269
LM E4P5	4.5±5%	20.0	16.4	269
LM E5	5 ±5%	20.0	16.4	269
LM E6	6 ±5%	19.0	15.6	269
LM E12	12 ±5%	15.0	12.3	269
LM E15	15 ±5%	14.0	11.5	269
LM E20	20 ±5%	12.0	9.8	269
LM E24	24 ±5%	11.0	9.0	269
LM E28	28 ±5%	10.0	8.0	269
LM E48	48 ±5%	6.0	4.9	299
LM E150	150 ±5%	1.4	1.2	299

PACKAGE F 3½"x19"x16½"	ADJ. VOLT. RANGE VDC	*MAX. AMPS 40°C	60°C	Price**
LM FA3	3 ±5%	31.5	24.0	$375
LM FA4	4 ±5%	31.5	24.0	375
LM FA4P5	4.5±5%	31.5	24.0	375
LM FA5	5 ±5%	31.5	23.7	375
LM FA6	6 ±5%	30.5	22.0	375
LM FA12	12 ±5%	22.0	16.2	375
LM FA15	15 ±5%	19.4	15.2	375
LM FA20	20 ±5%	16.0	12.6	350
LM FA24	24 ±5%	14.0	11.4	350
LM FA28	28 ±5%	13.5	10.4	350
LM FA48	48 ±5%	8.1	6.5	375
LM FA150	150 ±5%	2.4	1.8	410
LM F3	3 ±5%	48.0	34.0	425
LM F4	4 ±5%	48.0	34.0	425
LM F4P5	4.5±5%	48.0	34.0	425
LM F5	5 ±5%	48.0	33.0	425
LM F6	6 ±5%	47.0	32.0	425
LM F12	12 ±5%	33.0	22.0	425
LM F15	15 ±5%	28.0	19.0	425
LM F20	20 ±5%	23.0	17.0	395
LM F24	24 ±5%	20.0	14.0	380
LM F28	28 ±5%	19.0	13.0	380
LM F48	48 ±5%	10.0	7.5	425
LM F150	150 ±5%	3.1	2.1	460

PACKAGE G 5¼"x19"x16½"	ADJ. VOLT. RANGE VDC	*MAX. AMPS 40°C	60°C	Price**
LM G3	3 ±5%	95.0	62.0	$575
LM G4	4 ±5%	85.0	62.0	575
LM G4P5	4.5±5%	85.0	62.0	575
LM G5	5 ±5%	80.0	62.0	575
LM G6	6 ±5%	80.0	62.0	525
LM G12	12 ±5%	56.0	37.0	525
LM G15	15 ±5%	45.0	36.0	525
LM G20	20 ±5%	35.0	28.0	525
LM G24	24 ±5%	32.0	21.0	480
LM G28	28 ±5%	28.0	21.0	480
LM G48	48 ±5%	17.0	12.0	575
LM G150	150 ±5%	5.5	4.5	675

NOTE:
Space does not permit listing all LM Series fixed-voltage power supplies. In every package size there are models for each voltage range listed under the B package and all units are multi-current-rated for 40°C, 50°C, 60°C and 71°C. Call or write for data and prices.

* Current rating is from zero to I max. at ambient. Current rating applies over entire output voltage range.

Current rating applies for input voltage 105-132 VAC 55-65 cps.

For operation at 45-55 cps derate current rating 10%.

For operation at 360-440 cps consult factory for ratings and specifications.

** Prices F.O.B. Factory, Melville, N. Y. All specifications and prices subject to change without notice.

5 Year Guarantee

SEND FOR NEW CATALOG ON FIXED VOLTAGE AND WIDE RANGE MODULAR POWER SUPPLIES

LAMBDA ELECTRONICS CORP. A Veeco SUBSIDIARY

515 BROAD HOLLOW ROAD · MELVILLE, L. I., NEW YORK · 516 MYRTLE 4-4200

Now 2 oscilloscopes offer unique advantages of Tektronix split-screen bistable storage

1 NEW TYPE 549 DC-TO-30 MHz with sweep delay and > 5 cm/μs writing speed; accepts letter and 1-series plug-ins

2 EXISTING TYPE 564 DC-TO-15 MHz accepts 2 and 3 series vertical and time-base plug-ins

The exclusive Tektronix split-screen, bistable storage feature is now available in two oscilloscopes, the new DC-to-30 MHz Type 549 and the familiar DC-to-15 MHz Type 564.

Both offer the unique capability for simultaneous storage and conventional oscilloscope operation, *plus* general purpose convenience and plug-in versatility. These features add up to the kind of value you can expect from Tektronix.

Tektronix Bistable Storage Offers

Contrast of a stored trace independent of viewing time
Brightness of a stored trace independent of viewing time
Brightness of a stored trace independent of writing speed

Storage Scope		*Type 549*	*Type 564*	*Type 564 Mod 08*
Brightness		2.5 ft. L	6 ft. L	2 ft. L
Writing Speed	Normal	0.5 cm/μs	25 cm/ms	100 cm/ms
	Enhanced	>5 cm/μs	>125 cm/ms	500 cm/ms
Contrast Ratio		>4:1	2:1	2:1
Erasure		split screen full screen remote/Auto	split screen full screen	split screen full screen
Display Area		6 cm x 10 cm	8 cm x 10 cm	8 cm x 10 cm

- **3 display modes**—(1) split-screen combination of storage/conventional displays, (2) full-screen storage, or (3) full-screen conventional displays.
- **saves film**—extended viewing times of stored displays permit detailed waveform analysis in many instances without photography.
- **simplifies trace photography** — once initial camera setting has been determined, no further camera adjustments are necessary, regardless of conditions under which future stored traces are obtained.
- **beam locate**—locate pushbutton offsets beam into a non-store area on left edge of display, permitting precise vertical positioning of beam before signal is stored.
- **adapts easily to various applications**—accepts major plug-in lines for such applications as multi-trace, low-level differential, sampling, spectrum analysis, others.
- **Type 549 automatic erase**—can be selected for periodic or after sweep operation with selectable viewing times from 0.5 second to 5 seconds. In addition, Erase-and-Reset pushbutton—which permits erasing display and rearming single sweep—can be controlled remotely, if desired.

TYPE 564

Storage time — Bistable Storage provides a stored display for up to one hour.

Erase time — 250 ms full cycle at normal operating level.

Type 564 Storage Oscilloscope $875
Size is 13½" high by 9¾" wide by 21½" deep; net weight is 33 pounds. Uses 2-series and 3-series plug-ins.

Rack Mount Model RM564 . . . . $960
(same performance specifications, yet occupies only 7" standard rack height)
(Bandwidth DC-to-15 MHz with Type 3A5 Plug-in)

Plug-ins illustrated

Type 3B3 Time-Base Unit $585
(normal and delayed sweeps — 0.5 μs/cm to 1 s/cm, calibrated sweep delay — 0.5 μs to 10 sec, single sweep, 5X Magnifier, full passband triggering, flexible, easy-to-use — simplified trigger logic)

Type 3A6 Dual-Trace Unit $540
(Dual-Trace—10mV/cm at DC-to-10 MHz, 5 display modes)

U.S. Sales Prices, f.o.b. Beaverton, Oregon

TYPE 549

Storage time — Bistable Storage provides a stored display for up to one hour. When applications require maximum writing speed, viewing times of 20 minutes or less are recommended.

Erase time — 200 ms maximum, complete cycle.

Time base features — **Sweep Delay** — from 1 microsecond to 10 seconds. **Sweep Range** — 5 s/cm to 0.1 μs/cm (Time Base A) and 1 s/cm to 2 μs/cm (Time Base B). X5 Magnifier extends fastest sweeps to 20 ns/cm (Time Base A) and to 0.4 μs/cm (Time Base B). **Single Sweep** — manually, automatically, or remotely. **Full Passband Triggering** — with flexible, easy-to-use facilities, and **Simplified Trigger Logic**— with lever control of trigger functions.

Type 549 Storage Oscilloscope $2,375
Size is 17" high x 13" wide x 24" deep; net weight is ≈ 67 pounds. Uses letter and 1-series plug-ins.

Type 1A1 Dual-Trace Plug-In Unit (illustrated) $600
(Dual Trace — 50 mV/cm at DC-to-30 MHz, 5 mV/cm at DC-to-23 MHz*. Single Trace — 500 μV/cm at 2 Hz-to-14 MHz. 5 Display Modes, front panel signal output)*

*When used in Type 549.

For information on how Tektronix can solve your measurement problem with a storage oscilloscope, call your Tektronix field engineer.

Tektronix, Inc.

Editorial

A dose of sugar and water

In Europe these days, the technological gap is receiving an increasing amount of attention as Europeans worry about the widening lead of the United States in advanced areas of technical activity. Statesmen in Europe are outdoing one another proposing solutions. In almost every one of these suggested cures, the U.S. will miraculously transfer its know-how to foreign countries and everybody will live happily ever after.

If it were not for their high positions, it would be tempting to label the proposers of these cures as crackpots. Technology does not transfer that easily. But even worse, the cures are being proposed before the would-be doctors know what the illness really is.

Technology is a broad rambling term that means the application of the principles of science. Europe does not trail the U.S. in every technical area; in fact, it leads in several. But what most Europeans mean by a technological lag can be restricted to what's happening in three major areas of activity: electronics, computers and space technology. Clearly, in these three areas, U.S. activity is outstripping that of Europe and the rest of the world.

What to do about the lag is not nearly so easy to see. Nobody knows for sure what causes a rapid rate of technological change [Oct. 31, p. 23]. Foreigners tend to look at only two factors: the amount of money spent for research and development and the number of engineers. Thus, almost all the plans offered to date suggest increasing the sums spent for R&D, hopefully to the levels of those in the U.S.

All the programs ignore what may be the real limiting factors: the sociological characteristics of society. People or society determine how technology is used even more than do engineers and scientists.

Probably the most important factor affecting the rate of change of technology is the attitude of a people toward change. How willing people are to accept change; how willing people are to pay for change; how willing people are to gamble on the risk of change—because technological innovation brings social ills as well as benefits.

The rate of technological change can be stimulated by demand; necessity is still the mother of invention. New ideas, new products and new services almost never come from unfettered research. Invariably they stem from a people's demand for them. And such innovations come mostly from established science, from scientific principles that were first propounded 40 to 50 years ago. So another important ingredient is direction or skilled management.

In the final analysis, the essential ingredient may not be how much money is spent on research and development but how the results of R&D are put to work.

In the United Kingdom, to cite one example, resistance to change and reluctance to apply technology developed outside Britain have been greater bars to technological advancement than the country's small investment in R&D. A shining example, on the other hand, is Japan which has speeded up its technological progress almost miraculously with a relatively tiny investment in R&D.

Other costs, for tooling and marketing, play more important roles than do R&D expenses. They make change even more expensive because costs in the short run are always high while the benefits all seem to be in the long run. The Japanese have been willing to pay the bill. They've gambled on innovation and accepted change; they've worked long hours, and they have set up an amicable relation among government, industry and labor to accept change. As a result, their country's technology has progressed rapidly, and with the advancement, its economy has grown rapidly and healthily.

Before an effective cure for the technology lag can be devised, the real disease has to be identified and understood. The current proposers of cures say, "The patient is ill, give him a shot" even though they don't know what the illness is. And the shot they are offering may be only sugar and water, no medicine for a serious ailment.

The tragedy of all this is that the government of the United States, which knows better, is willing to go along with this placebo, pressured by political considerations. To answer the angry howls from countries of Europe, Africa and Asia, the U.S. government is ready to dole out expensive doses of sugar and water to quiet the indignation, not to cure the technological gap.

From Avco:
Airborne Radio for Weight Watchers

Criteria for success in any new aircraft radio: Less weight, less space, higher performance.

To Achieve these goals in one step, engineers at Avco's Electronics Division outdid themselves. The 400 watt AN/ARC-123 high-frequency transceiver they developed for the U. S. Air Force goes into less than a cubic foot (0.95) and weighs 38 lbs. It includes a receiver-exciter, power amplifier, control box and mounting base, wide dynamic range, built-in test, solid state design, redundant power amplifier stages, and a guaranteed mean time between failure of 900 hours.

Specifications include: frequency range from 2.0000 to 29.9999 MHz., (280,000 channels 0.1 Hz) plus SSB, AM, and FSK operating modes.

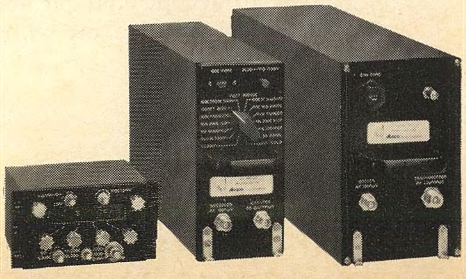
The AN/ARC-123 fulfills a need for a radio that will fit in any USAF aircraft using HF equipment. It is to be government-furnished equipment aboard the Air Force's F-111 and will be retrofit equipment for many military aircraft now in service.

P. S. Avco's Electronics Division also designed and is building the ALR-23 Counter-Measures Receiving System for the F-111A under sub-contract to the Fort Worth Division of General Dynamics Corp. *For more information, write: Director of Customer Requirements, Electronics Division, Avco Corporation, Cincinnati, Ohio 45241*

UNUSUAL CAREER OPPORTUNITIES FOR QUALIFIED SCIENTISTS AND ENGINEERS ... REGARDLESS OF RACE, CREED, COLOR OR NATIONAL ORIGIN ... WRITE AVCO ELECTRONICS DIVISION, CINCINNATI, 45241.

AVCO ELECTRONICS DIVISION

Circle 24 on reader service card



AN/ARC-123 control box, receiver-exciter, and power amplifier

Electronics Newsletter

November 28, 1966

Holographic tv: picture is bright

Despite the skepticism of such eminent scientists as Emmett N. Leith [Electronics, Nov. 14, p. 7] and Denis Gabor, some experts say the near-term prospects of holographic television appear bright. **Sometime in 1967, in fact, one company plans to unveil a prototype of a commercial holographic tv system that would require no more than the 6 megahertz of bandwidth that's needed for color tv.**

Says a top official of one research laboratory: "Give me 20 megahertz of bandwidth and I'll build you a holographic tv system right now—and without using a laser for recording or projecting a 3-D image."

The basic technology has been proved, adds the official. "All that remains is the engineering for shrinking the required bandwidth—and that appears to be well within our reach."

What's more, he says, the prospects appear bright for **the development of a consumer market for holographic tv within this decade.**

What's behind the recent spate of pessimism that surrounds holographic tv?

The men who have devoted years of basic research in the field, including Gabor—who's considered the father of holography—reportedly would rather see it bloom in a scientific field, not for such entertainment as the broadcast of a "Punch and Judy" show.

FCC settles ground station ownership row

Ownership of ground stations used in international satellite communications will be divided between the Communications Satellite Corp. and the international carriers on a flexible formula. That's the decision due any day now from the Federal Communications Commission, which has been studying the question of ownership for several months. **The decision may well set the precedent for domestic station ownership, too.**

Three-way split ends keen competition for radar contract

Competition for a study leading to development of ground-controlled approach (GCA) radar for tactical forces has ended in a three-way award, to ITT Gilfillan, a subsidiary of the International Telephone and Telegraph Corp., Raytheon Co. and Westinghouse Electric Corp.

The contract-definition awards for the TPN-19 were made by the Air Force Electronic Systems division, Hanscom Field, Mass. **Competition for the contract has been especially keen because the program will result in the first new family of GCA equipment since World War II.**

Also, Hanscom Field **is expected to decide next week on a production phase contract for new tactical air-control operations centers.** Litton Industries, Inc., and the Hughes Aircraft Co. are competing.

What happened on Wall Street

The colossal nosedive of electronic stocks during the past two months **is due to over-enthusiastic sales and earnings predictions and production problems in the two best publicized segments of industry: color television receivers and integrated electronics.**

At the start of 1966 tv set makers predicted sales of 5.5 million color receivers. But a shortage of labor and some components is holding this year's output down to an estimated 4.7 million. In addition, the explosive demand by consumers has shown signs of slowing.

Electronics Newsletter

In integrated electronics, word of production problems at the Fairchild Semiconductor division triggered a stock price collapse because Wall Street brokers were already concerned about rapidly falling prices of IC's. The real trigger was a warning by John Carter, chairman of the Fairchild Camera & Instrument Corp., that the company's fourth-quarter profit wasn't going to be as high as expected because of continuing production problems.

The background: a few weeks earlier Fairchild reported third-quarter earnings below the second-quarter results. Then, Carter told a private meeting of security analysts that fourth-quarter earnings would bounce back because the production problems had been solved. Admission they would not, caused alarm.

Meanwhile, Fairchild group vice president Robert N. Noyce blamed most of the difficulty on one product, the 709A operational amplifier. He maintains that the bulk of Fairchild's IC production is not in difficulty.

Bendix to show new air collision avoidance system

In a little more than a month, the Bendix Corp. is expected to unveil a new aircraft collision avoidance system that collides directly with the time-frequency approach preferred by the Air Transport Association. The system reportedly is a cooperative type in which both planes carry compatible electronics. It eliminates the need for highly accurate clocks and ground stations.

Meanwhile, the Collins Radio Co. has also indicated that it's about ready to announce its anticollision system, which uses time frequency.

The Air Traffic Control Committee of the ATA will meet in Washington on Dec. 14 to decide what system will best do the job and whether it should be flight-tested.

Proceeding on its own, the Federal Aviation Agency, in January, will flight-test three approaches designed to avert air collisions over the ocean: time frequency, a radar beacon transponder and distance-measuring equipment.

Tiny IBM cores need 60% less drive current

Although advances in thin-film technology continually produce new memories that threaten ferrite cores [See story on p. 42], cores refuse to fade out. Two International Business Machines Corp. scientists have found a way to produce cores only 7½ mils in outside diameter and 4½ mils in inside diameter. The cores consist of a 6-mil diameter magnetic toroid surrounded by a nonmagnetic strengthening shell. The technique was devised by James H. Brownlow and K.R. Grebe. The cores are so small they will pass through cores used in a memory shown last year by IBM and at the time considered the smallest ever developed [Electronics, Dec. 27, 1965, p. 36].

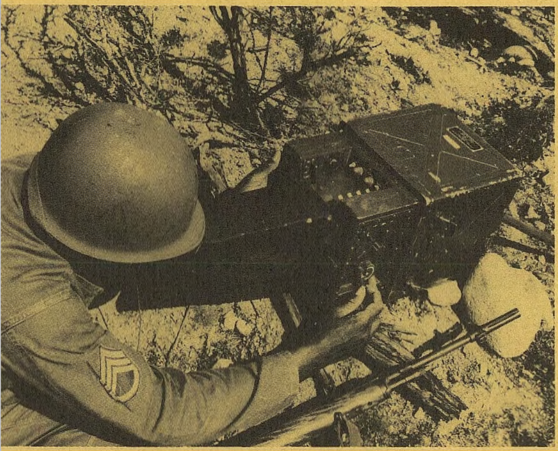
The new device's biggest advantage is that it requires 60% less drive current than larger cores for an approximately equal switching speed. With such a small current, the memory could be driven by ordinary logic blocks, instead of by special memory drive circuits.

The cores have been threaded with up to three 1-mil wires using conventional techniques, but their eventual application, in three to five years, is expected to be in two-dimensional memory arrays requiring only two wires to be threaded per core.

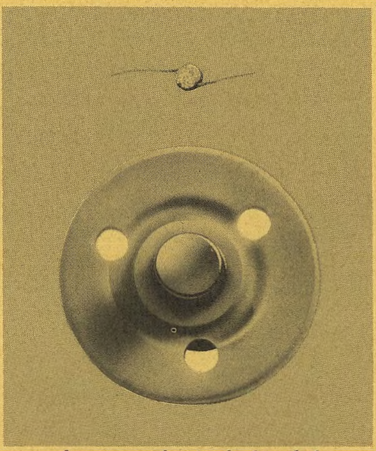
Component and Circuit Design **IDEAS** from SYLVANIA Electronic Components Group

CRTs

How low-power cathodes reduce size, save power, and decrease weight



AIL portable radar in field use



Low-power heater is dwarfed by conventional unit.

Often, in portable display systems and equipment, all the space, weight and power savings which come from conversion to solid-state circuits may be overshadowed by the high power requirements of conventional CRTs —power requirements which usually mean a large power source of significant size and weight. A cathode .050″ in diameter and .011″ thick is used by Sylvania to produce CRTs which consume only about 6 percent of the heater power needed by conventional tubes. Thus, the way to wider application of CRTs in portable equipments has opened.

By reducing heater power requirements to a bare 1/16 of that used in conventional CRTs, Sylvania's low heater power cathodes help to shrink the size of a wide range of portable units. The reduced wattage requirements lead directly to savings in the space and weight required for the portable equipment's power supply.

Needing only 0.21 watts (1.5 V, 140 mA) compared with 3.78 watts (6.3 V, 600 mA) for conventional heaters, these low heater power cathodes allow reduced equipment temperatures, upping life and reliability. This is another reason why they're finding use in military and industrial gear.

One military application of CRTs with this improved heater is in the new, lightweight, man-portable radars designed and built by Airborne Instrument Laboratory Division of Cutler-Hammer for the U.S. Army. The radar, the AN/PPS-5, provides area surveillance out to 10,000 meters for vehicles and to 5,000 meters for detecting people. It uses two Sylvania CRTs with low-drain heaters, the SC-3364P7B and 3BGP1.

Type SC-3364P7B is designed especially for the PPS-5 portable radar. With a square screen area of 2⅞″ by 2⅞″, this device has electrostatic focus and deflection. The 3BGP1 is a standard Sylvania low heater power unit. This compact, rectangular, direct view device has a 1½″ by 3″ screen and electrostatic focus and deflection.

Another standard low heater power tube is the SC-3511 used in Branson Instruments' Sonoray model 301 ultrasonic flaw/thickness tester. Other standard units include the SC-3551 and SC-3802. Both these, like the SC-3511, use helical-resistor post-deflection acceleration to achieve high writing rates and freedom from pattern distortion. The 3BMP is a 3″ direct viewed tube with round glass screen and flat faceplate. It has electrostatic deflection and focus with post-deflection acceleration.

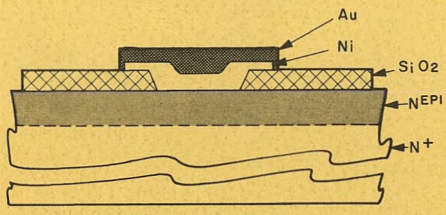
In addition to the many standard and special units now available from Sylvania, the low heater power assembly can be adapted to virtually any Sylvania industrial or military CRT to meet circuit needs.

CIRCLE NUMBER 300

This issue in capsule

MICROWAVE SEMICONDUCTORS

New Schottky mixer diodes MQM-packaged for S- and X-band

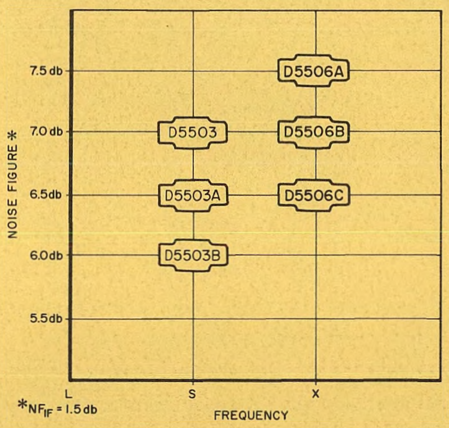


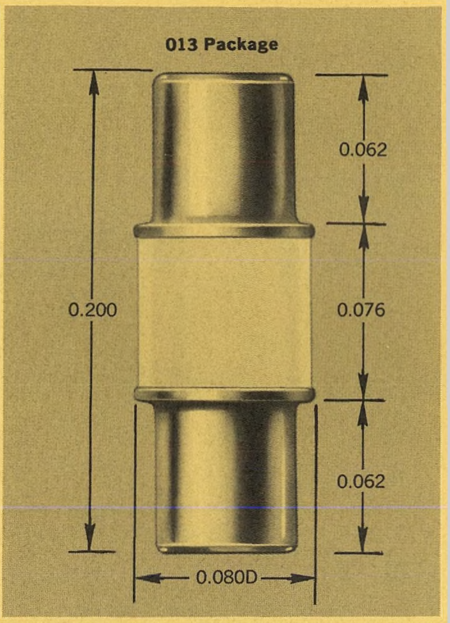
New Schottky barrier diodes from Sylvania provide improved broadband operation over the 2-4 GHz and 8.2-12.4 GHz microwave bands. A low-capacitance micro-miniature 013 package and a low junction capacitance are combined to achieve both broadband capability and low noise performance.

The new units, measuring only 0.08″ by 0.20″ overall, offer operation as mixers and video detectors at S- and X-band. Sylvania's series D-5503 S-band devices have maximum overall noise figures of as low as 6.0 db; while the X-band diodes, D-5506 series, are rated as low as 6.5 db.

Both the D-5503 and D-5506 lines are supplied in a versatile Sylvania MQM package which features a low dielectric glass hermetically sealed to the precision mounting pins. The result is a package capacitance of only 0.08 pf. In addition to this low capacitance, the MQM package features precise axial alignment of the mounting pins allowing precision design of miniature holders. Easy insertion and positive rf contact in holders is assured by package design having over 50% of its length devoted to circuit contact area.

Low junction capacitance comes from the superior alignment methods used in a new Schottky barrier diode processing technique. The new process employs epitaxial silicon to make devices with precisely controlled impurity distribution. This perfected method calls for a thin insulating layer and a relatively thick metallic contact layer over the barrier. The insulating layer and the superior mask alignment methods combine to assure the precise etching needed to produce low capacity barrier regions. The metallic contact and pinpoint mask alignment maintain the registration required during metallization to produce a reliable contact without increasing barrier region capacitance.





Improved manufacturing methods, batch processing, and a unique package are combined allowing Sylvania to deliver Schottky barrier diodes which have superior electrical performance in conjunction with a practical mechanical design.

CIRCLE NUMBER 301

INTEGRATED CIRCUITS

First: registers, counters and adders; now, a 16-bit IC memory array

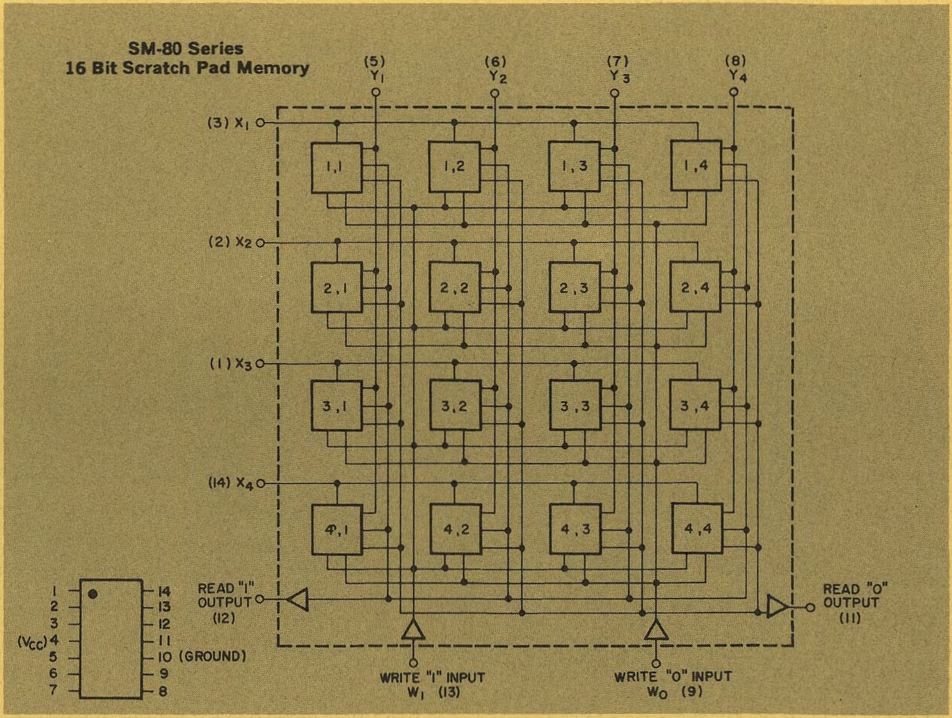
Availability of a 16-bit IC memory means Sylvania can now provide all the logic functions required by circuit designers. Like the register, counters and adders which preceded it, this newest addition to Sylvania's digital functional array series features complete compatibility with Sylvania's SUHL TTL devices. Now, more than ever, you can simplify your digital system requirements with ICs from Sylvania.

Sylvania's new 16-bit integrated circuit memory, the SM-80, is designed specifically for high-speed scratch pad memory systems with cycle times in the 100 nanosecond range. This new single chip device has 16 flip-flops arranged to form an addressable 4 x 4 memory matrix, permitting non-destructive readout of all 16 bits. Reading and writing is through four X and four Y lines brought out to eight external terminals. Read and write control is performed by four internal amplifiers; dual sense amplifiers for "1" and "0" reading, and dual write amplifiers for "1" and "0" writing. Each flip-flop in the four-by-four matrix is logically connected to its own X_M, Y_N address combination, and to the sense and write amplifiers.

Memory operation can be shown by tracing the cycle for writing a "1." With selection lines and write inputs normally at ground, the desired bit is addressed by raising the appropriate X_M, Y_N lines above 2.0 volts. Then, the "1" write amplifier input is pulsed above 2.0 volts and returned to ground.

The stored information may be read on the sense "1" output after the write pulse has been returned to ground. When reading, if a "1" is stored in a specific bit, the sense "1" amplifier will give the proper logic level (ground), while the sense "0" amplifier gives the complement.

The SM-80 series is word organized. It's a 16-word one-bit memory.



This means it can be used to build multiple-bit, multiple-word scratch pad memories. The number of bits per word can be expanded in columns where the X_M and Y_N selections of each unit would be addressed in parallel. For example, 64 of these units can form a 16-word scratch pad memory in which each word is 64 bits long.

Circuit-wise, the sense outputs of the SM-80 series are from a single transistor with no pull-up network. This permits the wired OR function, making word expansion simple. Such expansion requires that an external resistor be used to pull up ORed collectors. This resistor may be returned to any V_{CC} less than 6 volts.

These memories require only a single supply operating voltage of 5.0 V, and logic voltage levels are compatible with those in Sylvania's SUHL TTL devices. Power dissipation rating of each memory is typically 250 mW. Designed to operate over temperature ranges of 0° to +75°C, the SM-80 series is available in the standard Sylvania dual in-line package and the TO-85 flat pack.

CIRCLE NUMBER 302

TELEVISION

All-new 20″ monochrome tube to be ready for mid-'67 set models

Television set manufacturers are rapidly preparing for the effects of a recent Federal Trade Commission ruling. After January 1, 1967, wherever picture diagonal tube sizes are stated, the useful screen diagonal will be used. (Until now, the overall diagonal measurement was used.) Thus, 19″ sets, as we know them, will be 18″ sets with the advent of the new year.

The new 20″ tube is a 114° device which offers 1.06 inches more useful screen diagonal than similar tubes with 19″ diagonals. An additional 12 square inches of useful screen area is provided. This tube also includes the same advances in tube design, materials, and production techniques that are incorporated in all Sylvania monochrome picture tubes.

Available for sampling in January, production quantities will be available in March of next year.

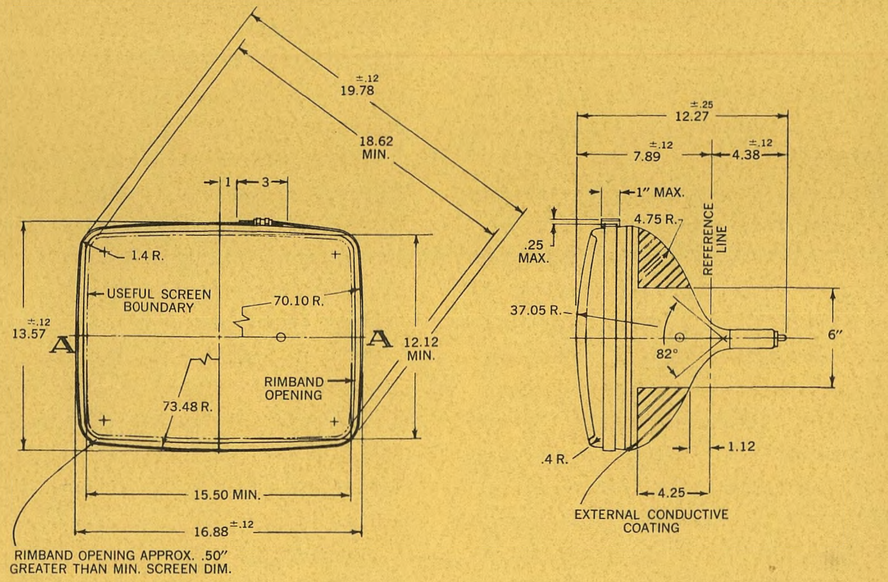
Sylvania's picture tube line is one of the most complete in the industry. Designers can continue to select from the wide range of tube sizes that comprise the full line.

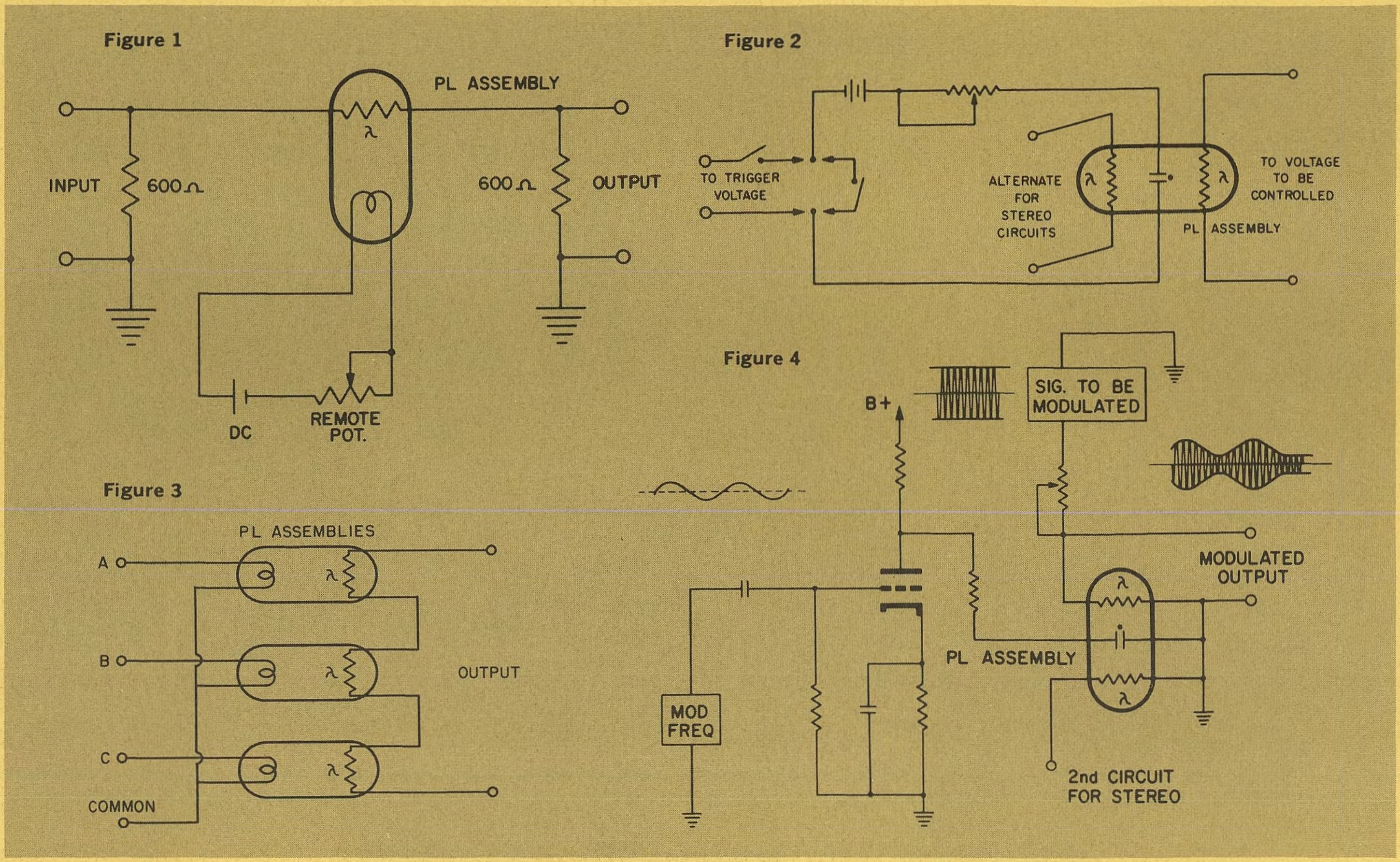
CIRCLE NUMBER 303

COMPARATIVE MEASUREMENTS

20″ 114° Dark Tint Bulb and 19″ 114° Dark Tint Bulb

	20″ 114° Bulb	19″ 114° Bulb
Nominal Outside Dimensions		
Diagonal	19.686″	18.625″
Major	16.726″	16.402″
Minor	13.452″	13.338″
Minimum Useful Screen Dimensions		
Diagonal	18.625″	17.562″
Width	15.500″	15.187″
Height	12.125″	12.000″
Area	184 sq. in.	172 sq. in.
Crown of Face to Reference Line Length	7.894″	7.250″





Signal switching and control problems solved with versatile PL assemblies

Photoconductor-Lamp (PL) assemblies provide an economical and simple solution to many of today's complex switching and control problems. Circuit applications of Sylvania's PL assemblies include: On-Off Switch, Sequential Switch, Logic Functions, Gain/Volume Controls, Electrically Controlled Circuit Functions (Delays, Oscillators, Filters), Linear Amplifier, Voltage Current Regulators, Motor Speed Regulator, Chopper, Special Musical Effects (Vibrato, Tremolo, Percussion), and Modulation.

Moderate power handling capability, noise-free operation, fast "on" time coupled with slow off time, and high circuit isolation all combine to make Sylvania's Photoconductor-Lamp assemblies ideal for many circuit applications. Heart of the assembly is a reliable light source (incandescent or neon lamp), optically coupled to cadmium sulfide photoconductors. Electrically, this means the PL assembly is basically a voltage- or current-controlled resistance ranging from a few ohms to infinity. It acts as both a switch and a potentiometer. Here are some of the applications of this reliable device.

When used in remote control applications (Figure 1), PLs allow amplifier circuits to be electrically isolated from interconnecting cables, thus eliminating extraneous signal pickup. In audio or video gain control circuits, besides giving automatic and remote control capability, the PLs also eliminate noise such as that generated by the contacting arm of the mechanical controls.

In the "on-off" switching circuit of Figure 2, remote or automatic operation is possible. By substituting a small variable voltage for the switch and decreasing neon lamp supply voltage to slightly less than the sustaining potential, the circuit can be made to trigger when the variable trigger voltage reaches a predetermined value. A series-connected switch inserted in the lamp circuit turns off the lamp.

Economical logic circuits may be constructed using a number of PL assemblies. Figure 3 shows a typical AND circuit where outputs of several PLs are connected in series. All lamps must be lit to reduce the output resistance sufficiently to turn on the controlled circuit. In an OR circuit, the output of the PLs would be connected in parallel. Then, lighting of any lamp drops the output circuit resistance to a low value and turns on the controlled circuit.

Low frequency modulation of audio or rf is achieved by Figure 4. Here, the modulating frequency applied to the grid varies the triode amplifier's plate voltage. Since the plate voltage fires and maintains the neon lamp in the PL, these variations cause corresponding current fluctuations through the lamp.

The resulting change in the lamp's light output in turn produces variations in photoconductor resistance, thus giving modulation of the output signal. Modulation envelopes produced using Sylvania's type PL-1823P with modulating frequencies of 1 and 10 Hz show a 40% modulation level with minimum distortion.

Easy design with the versatile new Dual Pulse Shaper/Delay AND Gates

Last month we described how external connections on an AND gate, a Schmitt trigger and a SUHL output network were combined to form Sylvania's versatile Series SG-80 Dual Pulse Shaper/Delay AND Gates. The specific applications described below—one-shot, delay, pulse absence detector and oscillator—attest to that versatility.

Each Sylvania Series SG-80 package contains two separate three-input multiple emitter AND gates (Figure 1). An external tie point permits connecting a capacitor to the bases of the input transistors of each gate. This means the AND function can be delayed until the capacitor charges through an internal resistor. Leads of this internal resistor are also brought out to allow use of an external resistor in place of, or in combination with, the diffused resistor. The AND gate is followed by a level-detecting Schmitt trigger which drives a typical SUHL output network.

By using the AND, level-detecting and capacitor point features of the SG-80 series, a variety of integrated circuit oscillators and pulse generators can be implemented.

The one-shot or pulse shaper of Figure 2 has output pulses ranging from less than 50 nsec to greater than one millisecond. In this circuit, input A must be of narrower pulse width than the pulse generated to avoid multiple pulses.

The SG-80 series can be used to delay either positive or negative input transitions. Figure 3 shows waveforms of a positive edge delay circuit. A negative edge may be delayed by using a NAND gate in series with the input and the SG-80. Positive and negative transitions of a pulse may be delayed independently by using both circuits in the SG-80 package. Figure 4 gives the logic wiring and waveforms.

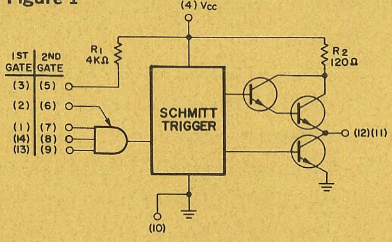
A typical logic diagram for pulse absence detector operation is shown by Figure 5. Here, the input pulse must be wide enough to fully discharge the capacitor each time it is applied.

When using the SG-80 series as a self-starting, free-running multivibrator, a potentiometer may be used to continuously vary the oscillating frequency. In Figure 6, the 3K limit resistor is required for proper operation. With small valued capacitors, the unit oscillates in excess of 20 MHz with a positive output pulse of about 20 nsec. A small resistor, R_2 (650 ohms), stretches the width of this pulse at lower frequencies. The oscillator may be gated to produce bursts of pulses by switching an unused SG-80 input between logic "1" and logic "0."

CIRCLE NUMBER 305

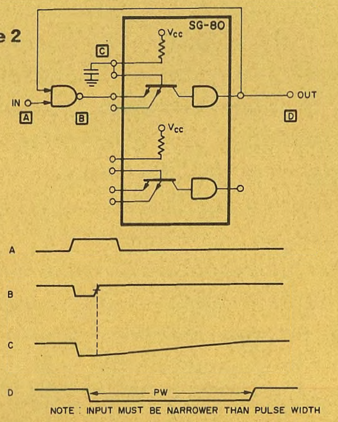
Functional Diagram of SG-80 Series Dual Pulse Shaper/Delay AND Gate

Figure 1



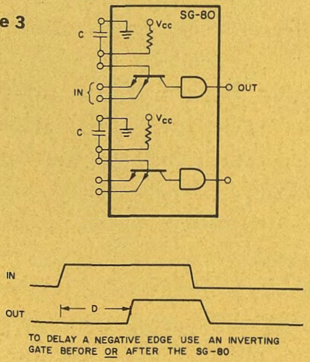
One Shot

Figure 2



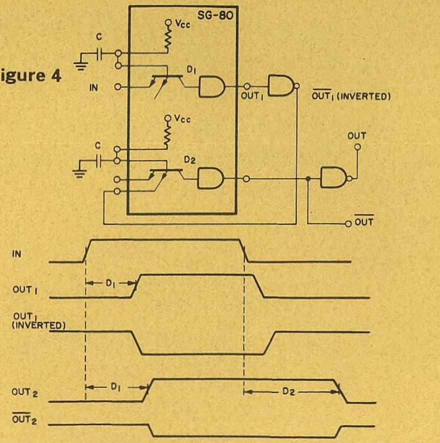
Delay Circuit To Delay A Positive Edge

Figure 3



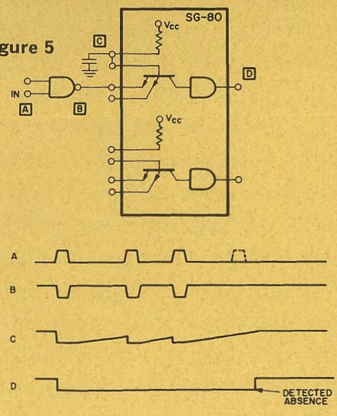
Delay Circuit To Delay Positive And Negative Edge Independently

Figure 4



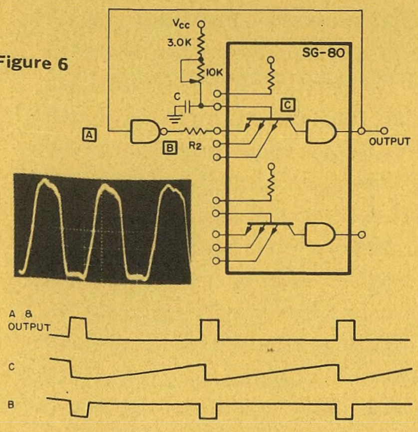
(Retriggerable Delay) Pulse Absence Detector

Figure 5



Free Running Multivibrator

Figure 6



Electronic Fashions Change Too

What's more fickle than a woman? Look no further than our industry.

As rapidly as fashions change in women's clothes, so do techniques in the realm of electronics...especially in *semiconductors!* It seems to me that the area of most rapid change is *microwave* electronics; practical microwave cooking, education through TV'd microwave beams, CATV, outer space signals to earth through microwaves, automotive safety devices by means of microwaves—to name just a few of the latest advances. To think we were nearly 100% military, only two to three years ago.

Now let's combine microwaves and semiconductors and examine some of the results. Don't stand in the way, the pace is fantastic! This combination gives us *an industry in itself* which combines the talents of solid-state physicists, chemists, electronics engineers, mechanical engineers, metallurgists, chemical engineers and technicians covering all these fields. And this list is not even complete.

What are some of the results over the past 20-odd years that make us feel we are jet propelled?

First, let's go back in history a bit. Semiconductor crystal rectification dates back to 1907, but did not become practical until the early days of radio communications when point-contact crystals were used as detectors. These were finally made obsolete by "thermionic" tubes for radios. How fashions change! Crystal diodes, still crude, were used until about 1940 as power monitors for UHF.

In the very early *microwave* receivers, mixer tubes were employed. But soon, because of noise and capacitance problems, they were made obsolete by crystal diodes. Then basic research and development and production began. The first microwave diodes were employed as mixers in S-band receivers. Later, others were developed as detectors for radar beacons. Soon frequency coverage was to K-band. The first specification for the S-band mixer (1N21) was a conversion loss of 8.5 db max. and noise ratio of 4 max. The first video detectors had typical figures of merit of 60.

Many hundreds of types of point-contact mixer and detector diodes later, Sylvania introduced epitaxial silicon for point-contact devices. Most of the recent point-contact silicon diodes introduced for L and S coverage have less than 5 db overall noise figure, *including* 1.5 db of IF amplifier noise figure. Figures of merit for video detector diodes approach 400 today.

Let's turn to other ideas for microwave transmission problems and see how the pace has been. Early amplifier tubes for 3000 mc (Oops! 3000 MHz) were developed at the MIT Radiation Laboratory in 1943. Noise figures achievable were comparable to receivers using crystal diodes of that time, and Torrey and Whitmer[1] stated, "It is unlikely that an rf amplifier can compete with crystals at higher frequencies."

What happened? The tube scientists went on to develop traveling wave tube amplifiers to obsolete that statement, but semiconductor varactor diodes are now obsoleting TWTs! Bell Telephone Laboratories' development of the varactor in 1957 caused a revolution in microwave "solid-state" amplification, harmonic generation, and switching. Sylvania contributed the idea of epitaxial varactors for very low noise amplification and highly efficient harmonic generators.

The high mobility of gallium arsenide semiconductor material has made possible low noise figures and high efficiencies in the millimeter wavelengths. We now sell gallium arsenide pellets with formed junctions that serve as the heart of integrated parametric amplifier structures. Soon after invention of the tunnel diode in 1957, Sylvania produced the first microwave tunnel diode for still another type of microwave amplifier as well as a microwave solid-state oscillator. Up to millimeter wavelength operation has been achieved. Klystron tubes and backward wave oscillator tubes are now being challenged and made obsolete by tunnel diode oscillators, harmonic generator chains made up from transistor oscillators and varactor multipliers, Gunn bulk semiconductor oscillators, and the newest diodes—the Read type and other avalanche diode oscillators. Gallium arsenide avalanche diodes and silicon avalanche diodes are available with X to Ku output power up to 10 mw on a commercial basis, with 500 mw reported in the laboratory. The pace is rapid; these devices were demonstrated to be practical only two years ago (although Read's paper described them theoretically in 1958).

We are now demonstrating avalanche diode amplification of 10-15 db at X-band in our laboratory.

Our industry certainly is moving forward. Even though our point-contact metal/semiconductor diode has been considerably improved, today it is giving way to the more sophisticated Schottky barrier type, which is made by evaporation or sputtering a metal onto a semiconductor to form the junction. This diode is modernizing many mixer applications, especially doppler radars and high voltage systems. Very low noise figure Schottky barrier diodes are being introduced by Sylvania for Ku and Ka bands.

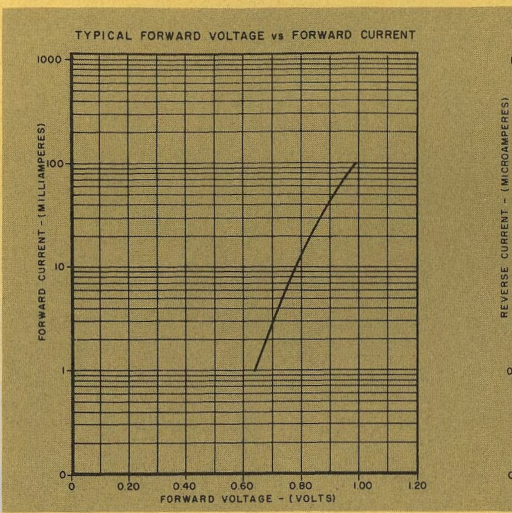
Device package design keeps pace with microwave transmission line technology advancement. Back in 1956 we introduced the tripolar multi-octave bandwidth diode package; in 1958 we developed the first miniature microwave diode for strip transmission line—the "Micro-min" glass package; Sylvania's "Pico-min" followed in 1961; and our precision miniature double-ended diode, the MQM, is fast on its way to becoming an industry standard.

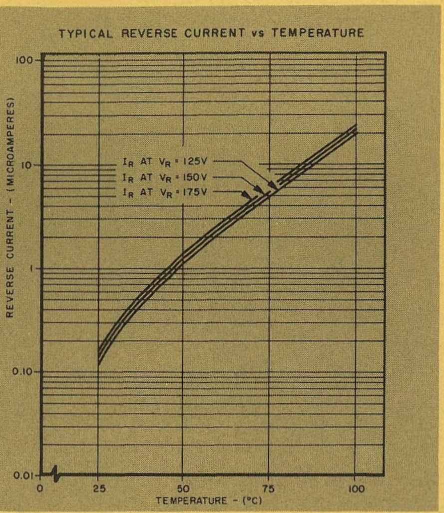
They say women are fickle? As fast as ladies' hemlines go up and down, microwave semiconductors obsolete microwave tubes. And "newest" microwave semiconductors replace both the "new" and the "newer."

GENE FELDMAN

1. Radiation Laboratories Series, "Crystal Rectifiers," Vol. 15

High-voltage, fast-switching silicon epitaxial diodes now available





Availability of high voltage, low capacitance silicon planar diodes is enabling TV and stereo manufacturers to replace some tube functions with these solid-state devices. A line of four improved silicon epitaxial diodes from Sylvania allows circuit designers to obtain the economy and reliability of solid-state construction in a variety of circuits requiring fast-or medium-speed switching.

Sylvania now announces the availability of four high-voltage silicon epitaxial diodes in DO-7 packages for a wide variety of applications in computers, instrumentation, communication and consumer products. The D-6718 and D-6719 are very fast switches with peak reverse voltages of 200 and 150 volts respectively. The companion D-6721 and D-6722 units feature reduced leakage currents with the same peak reverse voltages and good reverse recovery characteristics.

All types are rated at 250 mw power dissipation and are contained in Sylvania's hermetically sealed, all-glass DO-7 package. These improved voltage and switching characteristics are achieved with no sacrifice of the reliability and high performance levels which typify the Sylvania diode line.

A typical entertainment application of these improved DO-7 packaged diodes is color TV where D-6718 diodes are used as phase detectors in the color killer and color sync sections.

The color killer phase detector circuit requires two D-6718 diodes. In the presence of a color burst signal, this diode phase detector applies a negative potential to the grid of the color killer tube, holding it in cutoff. In the absence of the color burst signal, the phase detector allows the color killer tube to conduct. This action biases the bandpass amplifier to cutoff. With the bandpass amplifier at cutoff, color information is not passed to the picture tube.

Two D-6718 diodes are also used as the phase detector in the color sync section. Here, the diode detector compares the phase of the color burst signal with a 3.58 MHz reference oscillator signal. Any difference in frequency or phase is detected by the diodes and a correction voltage is generated. This correction signal adjusts the phase and frequency of the reference oscillator to the proper value.

Uniformity of characteristics from diode to diode makes these units ideal for applications requiring matched devices. This uniformity is a result of Sylvania batch processing techniques in which thousands of diodes are fabricated simultaneously. Reliability is enhanced by depositing a solid silver sphere on each epitaxial chip to assure forward current stability. Reliability is further improved by a double hermetic seal and 100% leak testing.

Absolute Maximum Ratings

Average Rectified Current, I_0	75 mA
DC Forward Current, I_F	115 mA
Forward Surge Current, $I_{F\,SUR}$ (1 sec)	300 mA
Power Dissipation, P_T	250 mW
Storage Temperature, T_{stg}	−65° to +175°C

CIRCLE NUMBER 306

ELECTRICAL CHARACTERISTICS

	Breakdown voltage @ 100 μA V min	DC Forward Current @ 1.0V mA	V_R volts	Reverse Current 25°C nA Max	Reverse Current 75°C μA Max	Reverse Recovery Time @ $I_F = I_R = 10mA$ Recover to 1mA nsec max	Capacitance @ OV pF max
D-6718	200	50	175	200	20	20	1.0
D-6719	150	30	125	300	30	20	1.0
D-6721	200	100	175	100	10	50	2.0
D-6722	150	50	125	200	20	50	2.0

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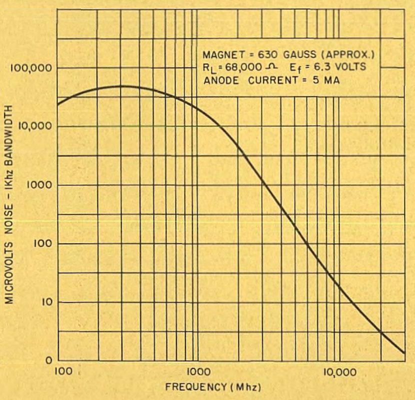
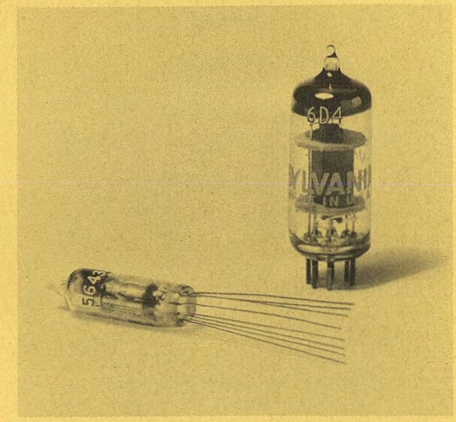
RECEIVING TUBES

Get the noise output you want, over the spectrum you want

Electrical noise is usually a liability in electronic equipment, and many sophisticated techniques have been implemented to overcome or reduce circuit noise. But there are applications where properly controlled noise can be extremely useful. Test and calibration equipment use noise generators to determine receiver sensitivity and the frequency response of amplifier and filter response. In the audio range, noise aids in measuring room acoustics and in testing microphones and loudspeakers. Two gas-filled thyratrons originated by Sylvania make it easy to obtain a constant noise output over a wide frequency band.

Readily available from your Sylvania distributor, tube types 5643 and 6D4 are the key elements in noise-generating circuits that have output





frequencies ranging from the audio band up to 20 MHz. Both type 6D4 (a miniature triode thyratron) and the 5643 (a premium subminiature tetrode thyratron) require only simple associated circuitry to generate noise.

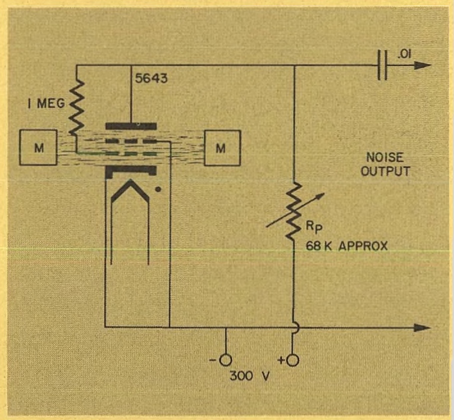
The circuit shows the rf noise connection for the 5643 and the resulting frequency response. Magnet M produces a steady magnetic field which is directed diametrically across the tube. This basic noise-generating circuit should be immediately followed by a buffer amplifier to prevent reactive loading. Frequency compensation and filter circuits can be included in the associated amplifier circuit to produce uniform noise output of the frequency range desired.

When used as an audio noise generator, the same circuit (but without the magnet) provides 10 millivolts noise from 1,000 to 20,000 Hz.

The 5643 provides long life and stable operation under conditions of severe shock, extreme vibration, high altitude and high temperature. It is made and inspected to meet the applicable MIL-E-1 specification for reliability.

Type 6D4 thyratron is an excellent source of wideband noise to out past 7 MHz. For noise generation, the tube is used as a diode with the grid connected to the cathode. Again, the noise generator circuit should be followed by a buffer amplifier to prevent reactive loading of the noise generator, and to facilitate use of any filter and compensating circuit which may be needed.

CIRCLE NUMBER 307



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BuWeps 11	1.062	4.4	10
BuWeps 15	1.437	9	19
BuWeps 18	1.750	17	16
Ordnance 23*	2.250	21	20
BuWeps 23	2.250	31	20
BuWeps 30	2.962	99	2
BuWeps 31	3.100	65	10
BuWeps 37	3.625	124	7

*MIL-S-12472, 16892, 20708, 2335; MS-51080, 51081, 51082, 51083.

Montrose Division

THE Bendix CORPORATION

November 28, 1966

Electronics Review

Volume 39
Number 24

Optoelectronics

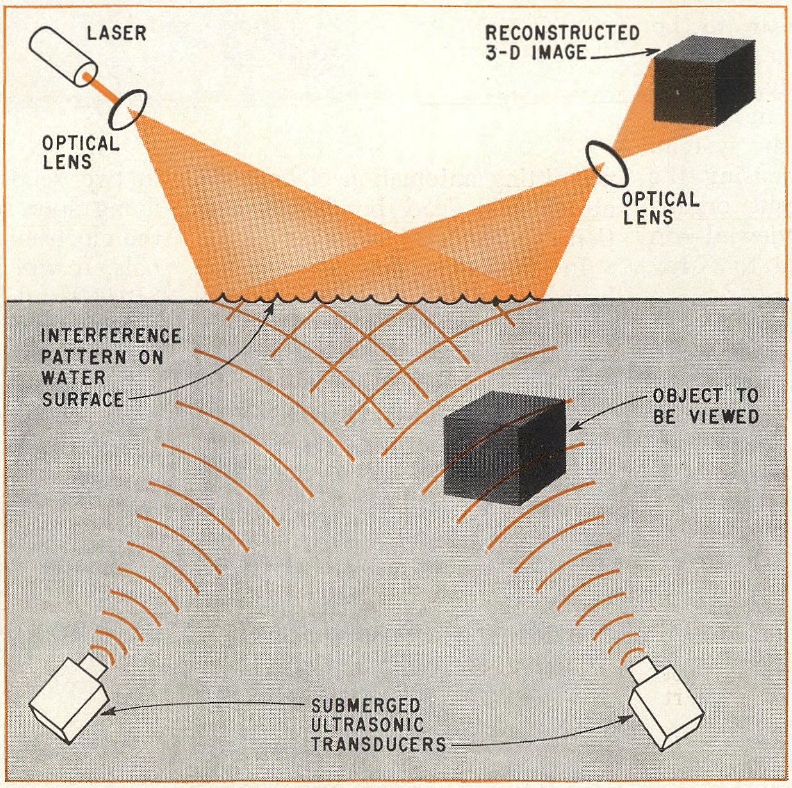
Sound picture

The traditional hologram starts with electromagnetic energy: interference patterns produced by light waves. But now a research group at the Bendix Corp. in Southfield, Mich., has developed a technique for producing holograms with ultrasonic waves. The result, says R.K. Mueller, manager of Bendix's general science and technical laboratory, is a technique that can produce, in real time, three-dimensional images of objects in murky water or, in the future, views of organs functioning in living persons. Further, he adds, the technique could be used for nondestructive testing of encapsulated electronic components. In all the cases, though, the object under study must be submerged in a liquid.

Like light. The theory behind ultrasonic holograms is the same as that behind laser holograms: it's based on the spatial relationship between two beams—a reference beam (be it light or sound) and a beam that reflects off the target (in the case of light) or passes through the target (in the case of sound).

In light holography, two phase-related beams are used—either one beam split in two or two separately generated beams. One beam is aimed at the target, with the reflected light captured on a piece of nearby film. The second beam, or reference beam, is aimed directly at the film. The reflected beam and the reference beam meet at the film surface. Since the phase of the reflected beam is shifted by the contours of the target, the result is an interference pattern. The dark portions of the pattern are out of phase and the bright portions are in phase.

The variation. In ultrasonic holography the same basic rules hold true, with some variation. Again, two beams are used: one is a reference beam and the other passes through the target. In the Bendix design, two ultrasonic transducers are placed under water—one aimed directly at the object and the other slightly to one side [see diagram]. The transducer under the object fires an ultrasonic beam through it and the beam's phase is shifted in a way related to the object's shape; the emerging beam strikes the water's surface. At the same time, the reference beam is fired directly at the water's surface; the two beams meet and interfere at the water's surface. At this area of interference, a ripple effect is created: ripples where the beams are in phase and nothing where the beams are out of phase. The pattern looks like the ripples caused by dropping rocks in water—but on a diminutive scale. The biggest ripple is no more than 1,000 angstroms high, hence a slight wave in the water would have little or no effect on the pattern created.



To create the image of the submerged object in real time the Bendix engineers aim a broad-beam laser at the water's surface; the laser strikes the water, picking up the information of the interference pattern. The light is then reflected off the water's surface and can be viewed by a telescope. Then, by adjusting the focus of the telescope, different layers of the three-dimentional object can be examined.

Picture that. To record the hologram on film, a slightly different technique is used. Incoherent light is used to illuminate the water's surface, causing each ripple to cast a small shadow. Then, a high-resolution camera snaps a picture of the surface, recording the actual ripple pattern. The Bendix engineers then simply illuminate the film with a laser to reconstruct the image.

The technique is not limited to laboratory use, explains Mueller. But if the system were to be applied to oceanography, he adds, some design changes would be necessary. For example, to picture an object submerged in murky water, a large inverted glass dish could be dropped over the object. The air trapped at the top of the dish would form the surface for the interference pattern and the transducers could then be positioned below the object.

Limited to liquid. Since the irradiating energy is acoustical, the subject being pictured must be in a sound-transmitting medium. And since the hologram is only seen through visible deformation of the medium surface, the medium must be a liquid.

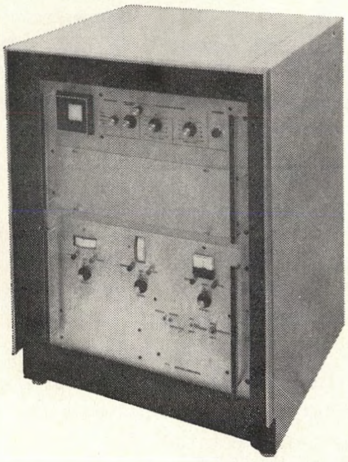
Certain targets appear to be naturals for this technique, explains Mueller. The human body, which is able to transmit ultrasonic waves, can easily be a part of the system. Thus, by selectively focusing the viewing objects, different organs within the body can be viewed—an ability currently limited to X-ray techniques.

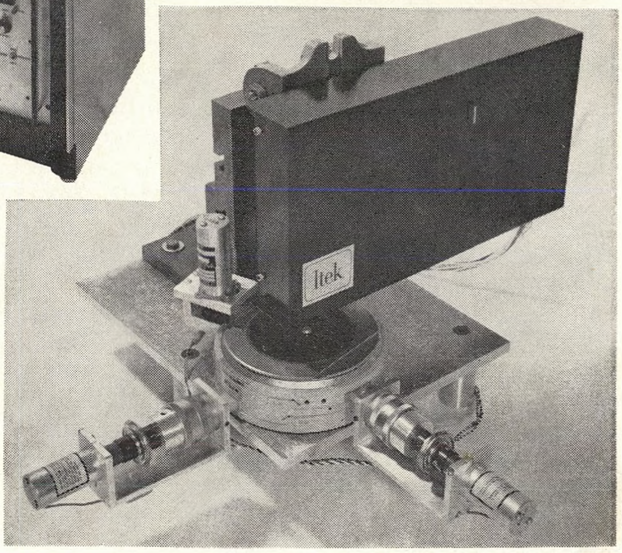
In the work performed so far, Mueller concedes, "the image quality is not very high. We feel that this is due mainly to the poor quality—that is, deviation from sphericity—of the acoustic reference beam."

Manufacturing

An Eye for accuracy

To attach a wire lead to an integrated circuit chip, first find your chip—and then make sure that the lead is bonded to the right pad. You may need accuracy of about a tenth of a mil. So far, machines haven't done this as well as people, which is why thousands of women are now bending over microscopes on semiconductor production lines. A method developed at the Vidya division of the Itek Corp., however, may put these girls out of a job by permitting automation of both die attach and lead bonding operations.





Itek's Electronic Eye accurately positions wire leads on integrated circuits. Photo at left shows correlator (with tiny tv screen at upper left) and manual controls. The circuit scanning and positioning gear are shown below.

In the Itek process, electron beams scan the chip and a reference photograph simultaneously, and output signals from photomultiplier tubes are correlated to derive error voltages in x, y and θ (angular shift) to drive a servo platform. Itek claims inherent accuracy of ± 1 micron, which is about 1/25th of a mil—a figure that indicates the application is aimed more at producing large-scale arrays than conventional IC's. Conventional IC's generally provide bonding targets several mils across the edges of the chips.

Classified order. The technique has applications far beyond those connected with semiconductor manufacture. Some of them are military; in fact, it was under a classified contract that Itek developed its correlation method some three years ago. For its first commercial product, however, the company decided that the precise positioning requirements of the semiconductor industry offered the best market.

The Itek Electronic Eye comes in two sections, one containing a flying spot scanner and the other the electronics to compare the signals. It will be priced at between $10,000 and $20,000.

Differences in the scanner's photomultiplier tubes could lead to signals with different amplitudes, which the correlator would read as an indication of displacement of the workpiece. But John Day, manager of Vidya's program office, says that the company has effectively eliminated tube sensitivity as a problem "by taking advantage of inherent weaknesses in the component." How these weaknesses are exploited is considered proprietary.

Equally as important to the correlation process is the necessity for the signals to start out in phase, since the correlator effectively superimposes one on the other.

No details. The correlator itself is circuitry—operational amplifiers and diode transistor logic integrated circuits. When it has compared the signals, it separates any difference into x, y and θ vectors which determine the d-c voltages. Again, Itek will not disclose how the vectors are achieved, except to indicate that the phase shift of the two signals is the third variable.

That they are effectively picked off, however, is evident to anyone who has watched the breadboard version at the company's laboratory. A small cathode-ray tube on the face of the correlator shows the chip, positioned at the center of a grid. As soon as the chip is moved off-center, the servo begins to whir, and it is hauled unerringly back. When it is in position, the scan area is automatically restricted, and the crt seems to zoom down on the chip, until actual device outlines can be seen.

The company says that nominal signal accuracy is 2 millivolts per micron of displacement in x and y, and 10 millivolts per degree in θ. The field of view can be varied from a square 10 mils by 10 mils to 250 mils by 250 mils, and the scanner can acquire and center the chip when as little as 5% of its area is within that field. The error signals themselves are actually more accurate, at ± 1 micron, than the scan pattern, which is 2½ lines per mil.

Swing design. In effect, Itek has built a signal generator, and any commercial application would have to be custom built. For example, in semiconductor manufacture, there would have to be provision for the scanning device to swing away and let the bonding machinery get at the chip. "Until now," says Day, "there has been no equipment with the capability of the Eye, and to my knowledge, there is no equipment that will take advantage of it yet."

The company does, however, have a contract with at least one semiconductor manufacturer, under which Itek will tailor an Eye; the customer is to develop his own automatic bonder. While Itek hasn't identified the application the accuracy specs seem to indicate that custom large-scale integration production is involved.

Itek says that the Eye would find applications anywhere precise positioning is necessary. That would hold for a number of manufacturing processes, and it also would prove useful in reconnaissance, automatic mapping and fire control, where radar return could be used as the input information.

Since the correlator compares two video signals, there are also possibilities in optical reading. Itek has already considered a method for fingerprint identification.

Consumer electronics

Lofty view

In a few months live color television coverage of local events will add a new dimension to electronic journalism. Millions will get a bird's-eye view of a spectacular fire, a riot scene or a police manhunt, thanks to the mobility of the helicopter and the compactness of a solid state, wideband tv relay system.

Up to now, televising news events live and in color required transmitting equipment too heavy for a helicopter to carry. But a new transmitter weighs less than 40 pounds and boasts a bandwidth of 6 megahertz. It can transmit high-quality color or black and white. Packaged in a cast aluminum housing, the unit measures 17 by 12 by 7 inches.

Only one station, KTLA in Los Angeles, currently uses a helicopter for black-and-white television news coverage. Its transmitter has tubes in its final output stages and the results are marginal. The station frequently resorts to broadcasting programs that were taped earlier on the helicopter.

Channel 9 (WOR) in New York purchased a system made by Microwave Associates, Burlington, Mass., and is installing a transmitter and antenna in its helicopter. The station is testing the system before actually putting it to work. The system is an adaptation of a very wideband reconnaissance-type link developed by the New England company [Electronics, May 2, 1966, p. 26]. Militarized versions are used by all the services and some units are already aboard helicopters in Vietnam.

Changeover. In Boston, WHDH recently completed tests of the system aboard its skyway patrol helicopter, now used to broadcast radio reports of traffic conditions. The station has ordered a high-speed helicopter for tv news coverage and has filed a petition with the Federal Communications Commission for authorization to use the television relay.

Compact color-tv transmitter, light enough to ride in a helicopter, is strong enough to beam signals to the ground.

Station KTLA has tested both the Microwave Associate's equipment and a system made by the Alto Scientific Co., Palo Alto, Calif.

Wide range. In the systems being installed by tv stations, an omnidirectional antenna is mounted on the helicopter, leaving the tracking to the ground part of the system. A 6-foot parabolic antenna stands at the receiver terminal on the roof of the studio building. A servosystem linked to a signal-strength indicator automatically steered the dish in the Boston tests.

The relay system has a range of about 10 miles and the company says a high-power amplifier can stretch this to 30 or even 60 miles.

The final stage of the transmitter is a varactor diode chain driven by silicon transistors. Transmitter output is 2 watts and a second model puts out 20 watts.

Industrial electronics

Keeping track

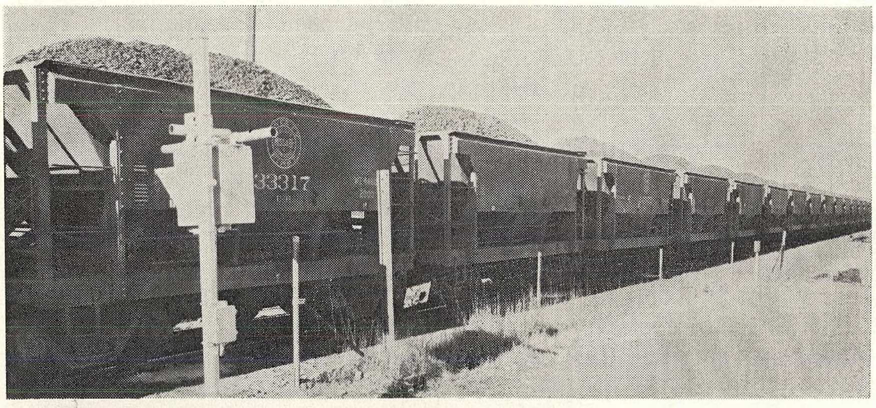
Misplacing a railroad freight car seems about as likely as losing track of an elephant in a three-room apartment. But it happens all the time.

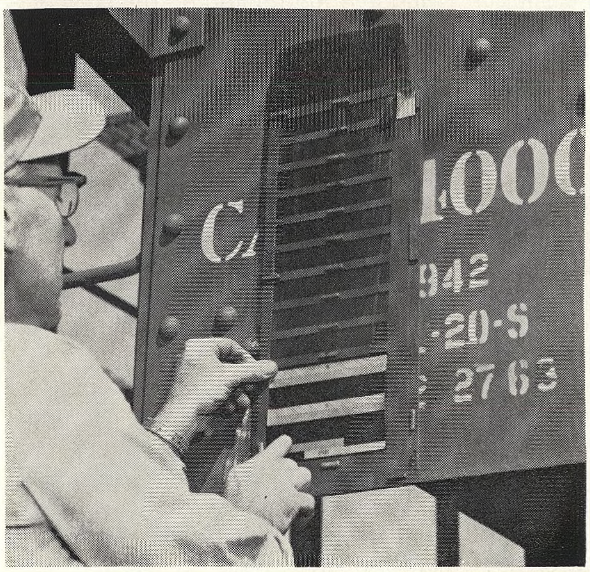
To the nation's railroads misplaced freight cars cost time and money. And after years of indecision, rail managers are finally doing something about the problem of keeping tabs on their cars; the solution hinges on electronics.

This month an industry group, the Association of American Railroads, will start testing three electronic systems and the one that's chosen will become a nationwide standard. It will replace the current method of laboriously recording the identification numbers of the 1.8-million U.S. cars as they pass designated checkpoints.

Active approach. The field tests, which will last for about six months, are taking place on a section of Pennsylvania Railroad track near Tyrone, Pa. The three systems each use an active approach—electromagnetic energy is reflected from information tags fastened to the side of the car. However, each system does this job in a different way:

- A helium-neon gas laser emits a beam that is reflected from retroreflective strips in the system designed by the Union Switch & Signal division of the Westinghouse Air Brake Co. (Wabco), Pittsburgh.
- Microwave energy is reflected from corner reflectors die-cast into strips of aluminum in the system designed by the Railroad Products division of the Abex Corp., New York.
- Light from a xenon lamp is reflected from red, white and blue retro-reflective strips in the system designed by Sylvania Electric Products, Inc., a division of the General Telephone & Electronics Corp., New York.





Sylvania's Katrrak system uses unmanned trackside scanner to read automatically information contained in coded retro-reflective tabs stuck to side of freight cars as they move by at operational speeds. Information is sent to central location where decisions on the control and movement of the cars are made.

For the railroads, the savings from an automated car identification system could be astronomical. For example, if cars could be located automatically and sent to their next job by the quickest route, turnaround time for each car would be handily increased. A rise of only 10% in turnaround time, the association estimates, would mean that the railroads would need 10% fewer cars to haul the same amount of cargo; at about $15,400 per car, that savings alone would amount to more than $3 billion.

On the road. Of the three systems to be tested only the helium-neon design has not seen active service on a railroad; it was recently developed by Wabco [Electronics, Sept. 19, p. 25]. The other two systems have been in limited service in some railroad yards since about 1963.

Each company claims that its system will withstand the severe elements faced by the railroads—blinding rain and snowstorms, thick coatings of snow, ice and dirt. All three claim their systems can read the tags as cars speed by at 100 miles an hour.

The payoff for the company whose system is selected would be handsome. First, all the 1.8-million freight cars would have to be labelled with identification tags; this should cost no more than $10 per car. Then wayside scanners, including logic and signal conditioning circuitry, would have to be installed around the country; these would have to cost less than $10,000 each, according to the association. Between 2,000 and 5,000 scanning units will be needed. The actual transmission equipment—Teletype or microwave relay, for example—to central data gathering stations is not included in the price.

Laser sweep. In the Wabco scanner, the beam from a 300-microwatt laser is reflected off a multisided

14-60

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TRW CAPACITORS

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mirror rotating at 3,600 revolutions a minute. It is swept through a vertical arc of 45° which is traced out against the side of the freight car. The car tag reflects the light back into the scanner where it is reflected by a second mirror and focused onto a photosensitive field effect transistor.

The output pulses from the transistor, corresponding to the presence or absence of retro-reflective material are fed into integrated circuit logic. Code groups of alphanumeric characters, arranged on the car tag in standard Teletype form, can operate a five-level printer without code conversion.

Color tagged. Sylvania's system, called KarTrak, also uses a multisided rotating mirror. It reflects a beam of light from a xenon lamp onto the side of the car. Each numeral on the car tag is represented by two colored stripes in a two-out-of-four code.

Back in the scanner, the reflected light passes onto a dichroic mirror. Red and blue light is filtered and passed onto either of two photomultiplier tubes. White light, containing red and blue components, is detected in both photomultipliers. Black—the absence of a reflector—is the fourth color code.

Solid state logic circuitry identifies the numeral from its particular color combination and stores the pulses. Letters are represented by a four-digit numeral.

Radar, too. In the Abex radar system, a klystron operating at 36 gigahertz supplies energy to a vertically polarized transmitting waveguide. The beam focuses at a point where the identifying tags, consisting of aluminum strips, ½ inch wide and 2⅜ inch high, will pass. The strips, fastened to the car in a horizontal row, are die-cast with a corner reflector imprinted in them. Five strips make up a character.

The reflectors rotate the beam 90° so that only horizontally polarized energy is picked up at the scanner. Vertically polarized energy radiated from the surfaces of the car is rejected.

Once again, solid state logic circuitry receives and stores the pulses. Three recirculating magnetostrictive delay lines in the system can store data from more than 400 cars. The other systems can store a comparable amount of information.

Computers

Think thin

Thin-film memories may be getting ready to challenge the ferrite core for a large percentage of the mass memory market. With the announcement at the Fall Joint Computer Conference of the delivery of a large high-speed magnetic film memory to a Government agency, Texas Instruments Incorporated has signaled that it has solved the problems that have kept film memories from the production line and is ready to take orders at prices competitive with cores.

Inherently faster than cores, thin films have been touted as the way to break through the microsecond barrier for high-speed computer memories, but difficulties in getting reproducible large-scale production, combined with a lack of stable, magnetic film materials, have delayed progress. Meanwhile, core technology hasn't lagged—manufacturers have been able to squeeze more speed out of cores by making them smaller and wiring them up in new array configurations like the 2½-D design. Now core memories are available that have cycle times of less than a microsecond, but this is approaching ultimate limits set by ability to thread wires [Electronics, July 11, p. 135].

According to H.D. Toombs, manager of memory systems at TI's Semiconductor Components division, materials technology and production techniques have advanced to the point where thin-film memories can compete in price with cores, at least in the mass memory market.

The reason for Toomb's optimism is the 204,800-bit memory that TI has just delivered; it can operate with an access time of 105 nanoseconds, and a complete cycle time of 350 nsecs. [Access time is the time it takes for data to be available at the output of the memory after the read command is given. Cycle time is the minimum time between read commands. The cycle time is larger than access time because the memory has destructive readout, and the data must be reentered after each read command.]

Resists creep. Toombs says that much of the new memory's successful operation is attributed to the use of a nickel-iron-cobalt alloy for the magnetic film. The addition of cobalt gives desirable magnetic properties that are reproducible, and also resists creep, a slow change in the magnetic orientation of the magnetic film which adversely affects the operation of the memory by introducing errors.

The film is vacuum deposited in thicknesses up to 2,200 angstroms on polished aluminum substrates, 3 inches square. Each plane has a capacity of 128 words of 25 bits each. The memory stack comprises 64 of these planes. It is organized as 4,096 50-bit words.

The complete memory includes peripheral circuitry such as input/output registers, an exerciser, emitter-coupled logic gates and word drivers built with high-speed switching transistors.

Now Toombs feels TI is ready to take on the core in the commercial market: "We think we can supply something that systems people will really be interested in—a high-capacity memory that can operate at twice the speed of core memories, and at the same price." He cites a range of 6 cents to 20 cents per bit, depending on the size of the peripheral circuitry, as the user cost for a TI thin-film memory. The company is now working on developing a commercial line of memories for delivery in late 1967 or early 1968. The basic size will be 400,000 bits, expandable in blocks of 32 kilobits. Cycle time for a 600 kilobit memory will be 250 nsecs.

Toombs says TI will definitely build two more memories in 1968 for Government customers, and hopes to build four for commercial customers.

Not unanimous. Despite Toombs' enthusiasm, core memory makers queried at this month's computer

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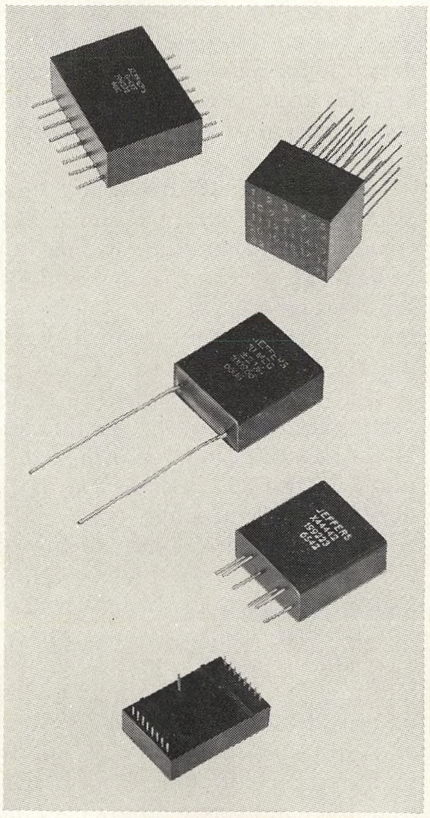


Pre-assembled and tested discrete resistor networks also offer reliability levels many magnitudes higher than those achievable with individual assemblies.

Another important advantage of networks is that manufacturing and performance cost factors can, in most cases, be surprisingly reduced.

As we noted above, these advantages (and others) will accrue no matter what brand of metal film resistor you happen to be using. On the other hand, we would be remiss not to remind you that our Jeffers Electronics Division's JXP resistor has a definite edge over every other brand. Which means that networks incorporating this "white room" precision resistive element can really give you something extra in the way of increased satisfaction.

We therefore suggest that you don't just investigate metal film resistors networks, but that you investigate our JXP precision networks specifically. Mail us the coupon—and discover just how satisfying resistor satisfaction can be.

Please try to ignore the surplus performance that components sometimes deliver

You probably read the editorial on this subject that one of the industry magazines published not long ago. Nevertheless, the message is worth repeating:

A component designed to meet one set of specifications may also test out to more rigid specifications. And engineers have been known to cut costs by designing such a component into equipment for which it wasn't intended.

The only trouble is—they're putting themselves out on a limb (not to mention their supplier). Subsequent lots of the component may very well turn out to perform much closer to the claimed specifications—for a variety of reasons.

Speer components are among those that sometimes deliver this surplus performance. (The operative word here is "sometimes," incidentally. There are also areas in which our components always outperform their specifications. But that's another story—one we'll get into in a future issue.)

Your continued cooperation in this matter of under-specifying is much appreciated. We suspect that it's a little chilly out there on that limb.

Typical Error #8 in the testing of inductors

We're referring specifically to the testing procedures for measuring inductance and Q, as outlined in MIL-C-15305.

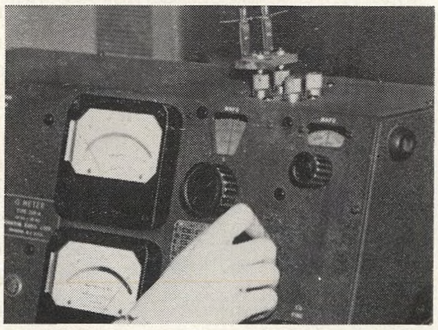
We heartily recommend these procedures for all commercial, industrial and military users of inductors (even users of our superb Jeffers inductors). But, as our headline suggests, there are more than a couple of commonly made test errors to watch out for.

There are eight.

Error #8, for example, consists of extreme variations in test area environment. Solution? Make sure that your measurements are made at room ambient temperature, relative humidity and pressure.

In future issues, we'll cover the other seven errors and indicate how to avoid them also.

So watch this space.



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Circle 43 on reader service card

conference in San Francisco, appeared unconcerned about the potential impact of thin films on their markets. Herbert Nelson, engineering manager of product applications for the Ferroxcube Corp. of America, doubted that thin-film mass memories could be produced which would compete with comparable core memories operating in the 1-μsec range. He said that complete memory systems of this type built with cores were going for about 6 cents a bit, including all the peripheral electronics.

Another Ferroxcube engineer, E.L. Posiadlo, manager of memory systems, said his company wasn't in the race for higher speeds, but was seeking instead to broaden the market for its core memories by encouraging their use in new noncomputer applications. Process controls, machine tool controls, and other industrial applications where low costs, not high speeds, are paramount, will keep cores in business a long time, according to Posiadlo.

Safe bet. At least one company, Fabri-Tek, Inc., of Minneapolis is keeping its hand in both cores and films as a hedge against the future. Although the bulk of this company's business comes from its core line, it is also marketing its 300 series of thin-film memories for cycle times below 500 nsecs. One company representative said that Fabri-Tek would deliver a large, random-access thin-film computer memory to a commercial customer next year, but declined to give performance details.

Meanwhile, both core and thin-film proponents may soon be looking over their shoulders at a new challenger coming up on the outside—semiconductor memories. While the new memories are presently very costly and relegated to the small-capacity class, rapidly declining production costs and new technology, such as large-scale arrays, may make them competitive very soon. And they are indisputably fast.

Fairchild Memory Products, a department of Fairchild Camera & Instrument Corp., displayed a MicroCell integrated circuit memory at the conference capable of cycle times from 50 to 100 nsecs with a capacity of up to 8,000 bits. And the champion of the lot is an integrated circuit scratchpad memory described at the conference by engineers of Motorola, Inc.'s Semiconductor Products division. With capacity for storing 64 words of 8 bits each, it has a nondestructive read cycle of only 17 nsecs.

Military electronics

New wave

On Camranh Bay, some 190 miles from Saigon, a converted seaplane tender, the USNS Corpus Christi Bay, is on station as a floating maintenance depot for helicopters and other aircraft fighting over Vietnam. The old vessel may be the forerunner of a fleet of modern, electronics-crammed floating depots that could be dispatched anywhere to provide maintenance backup for all kinds of military gear—from rifles to complex computers.

The experimental project, called Flat-Top, was established for the mobile forces of the United States Strike Command. Crucial to its operation is a complex of closed-circuit television, facsimile, microfilm, data-retrieval, computer and satellite-communication gear. With such equipment engineering drawings of many of the mechanical parts that make up the Vietnam-theater fighting planes can be reproduced in minutes. And with that data, the mechanics aboard the ship are able to repair or reproduce any mechanical part for a disabled aircraft.

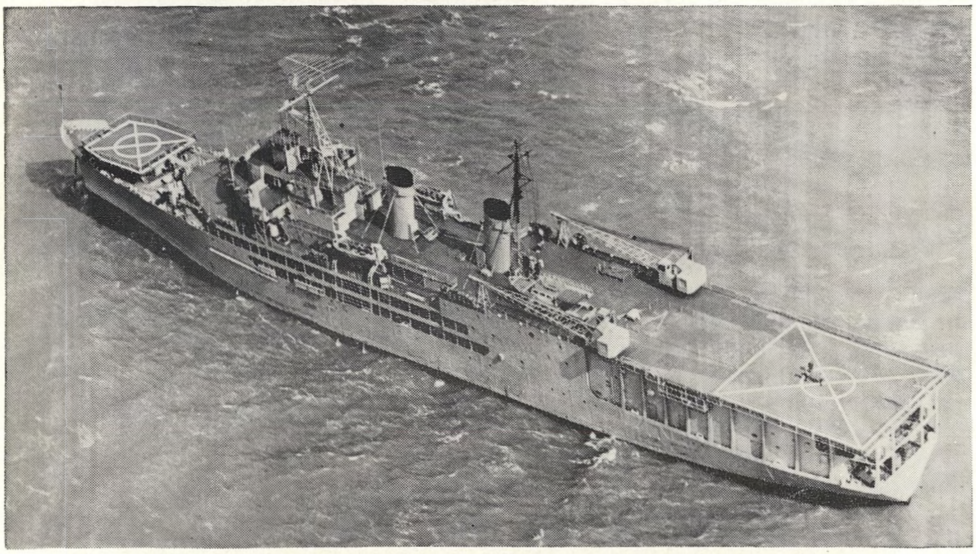
More to come? By year's end, Pentagon officials will have finished their evaluation of the test project. If they are impressed by the Corpus Christi Bay's performance, a second maintenance depot may be ordered to sea.

That vessel, probably a converted aircraft carrier, will be capable of testing and repairing complex electronics systems on both airplanes and missiles.

To provide for swift repair of aircraft, the Corpus Christi Bay makes use of a central microfilm library that keeps records on all mechanical aircraft parts. A requested engineering drawing can be quickly retrieved by the system and projected on closed-circuit tv to the shops on the ship so mechanics can verify that it's the part they need. The detailed drawing is then sent via fast-scan facsimile to the shop.

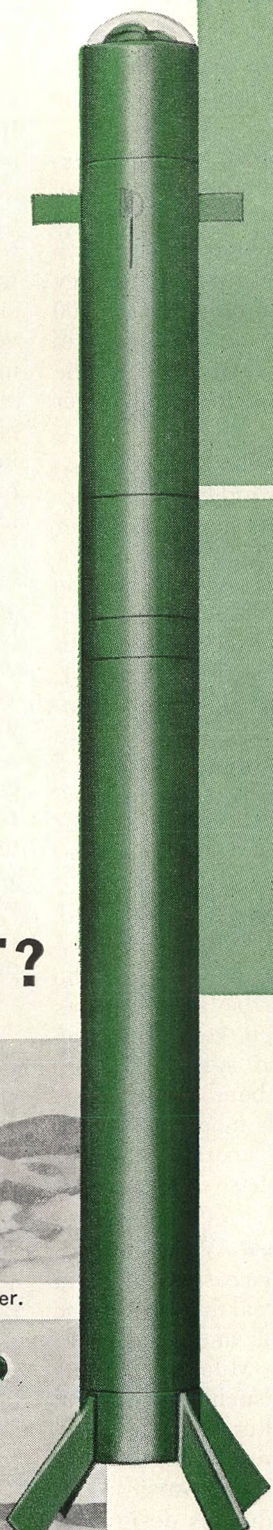
In addition, by hooking into the military communication satellite network, the depot ship can be kept up to date with new engineering drawings transmitted from the Pentagon.

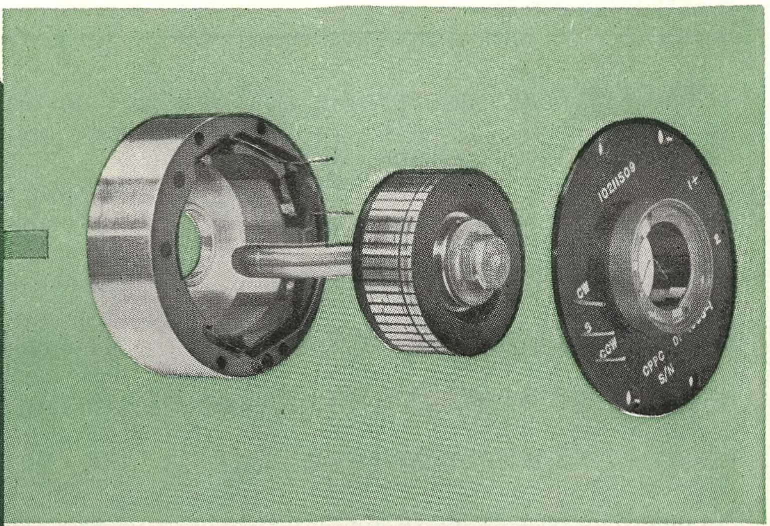
New dimensions. The military is

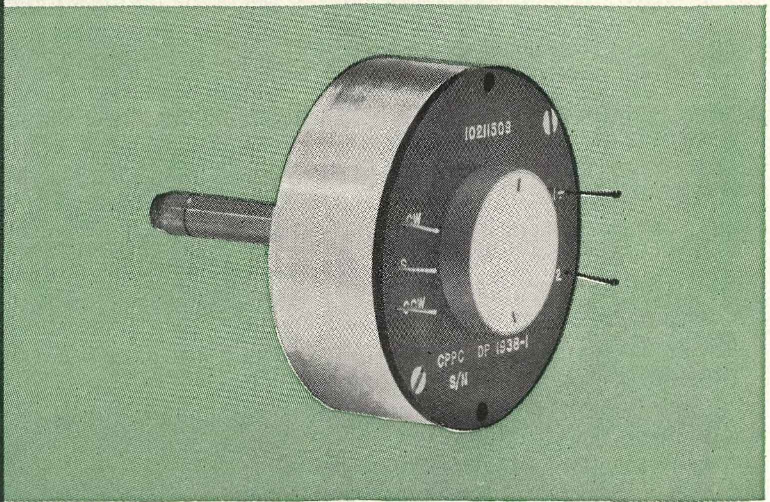


Floating maintenance depot, anchored in Camranh Bay, South Vietnam, provides a test bed for data-retrieval system.

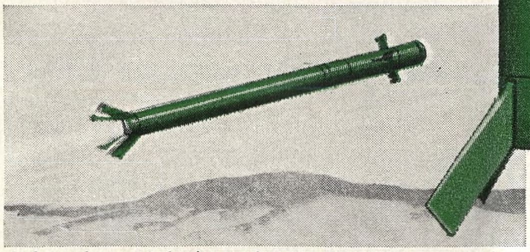
DO YOU HAVE A PARTICULAR TORQUE MOTOR REQUIREMENT?



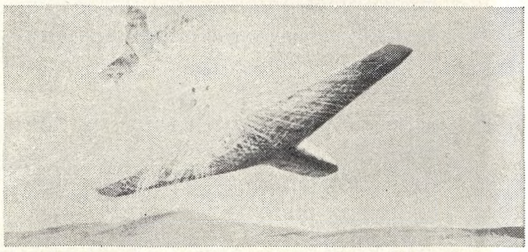




Infantryman with Redeye in launcher.



Infrared sensor locks on target. Miniature computer directs steering fins to guide Redeye.



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steadily expanding and speeding up the information retrieval system for Flat-Top. For example, the Army's Missile Command, which is in charge of this aspect of the project, last month demonstrated a new system, developed by the Alden Electronics and Impulse Recording Equipment Co. of Westboro, Mass., and the Eastman Kodak Co. of Rochester, N.Y.

The system marries a Kodak high-speed microfilm search-and-retrieval unit to an Alden facsimile scanner that records an engineering drawing first onto magnetic tape. A technician is able to feed a microfilm picture into a facsimile processor without tying up projecting time in the microfilm unit. Once the required document is located, it's placed on tape and can be transmitted via facsimile.

But the military isn't fully satisfied with such a system. It's experimenting with more exotic gear—for instance, a laser storing-and-projecting technique that should be ready for testing next spring [Electronics, Nov. 14, p. 52].

Further, the military would like to add automatic check-out and fault-location systems to Flat-Top. The Radio Corp. of America has proposed a computer-based system similar in concept to the depot equipment developed for Army missile and communications and mobile land combat support systems [Electronics, Aug. 23, 1965, p. 88, and Sept. 19, 1966, p. 45].

Communications

Fast talk

To anyone who has to send gigantic amounts of data over conventional telephone lines, time means money. The Milgo Electronics Corp. of Miami, Fla., well aware of this, has developed a modem that sharply boosts data-transmission rates.

The Milgo modem can transmit 2,400 bits per second on a bandwidth of only 800 hertz. In contrast, the Bell System's Dataphone, its highest-speed operational modem, transmits only 2,000 bits per second and it requires the entire 3,000-hz bandwidth that's available on the lines.

The Milgo modem, which is expected to reach the market by March, should prove to be more error-free than wider bandwidth systems. Since the unit's frequency spectrum extends only from 1,300 to 2,100 hz, noise and variations in line characteristics won't affect the data signals as much as on wider bands.

New market. Although Milgo expects the nation's independent telephone companies to be a major market for the unit, an even broader potential market is possible: anyone who has a telephone could conceivably send digital signals with the modem. The signals, however, would first have to be converted into sound and then coupled into the telephone's mouthpiece. A Bell spokesman concedes this is possible, providing the data signals don't interfere with signals on other lines.

Sang Y. Whang, Milgo Electronics' technical specialist who was instrumental in designing the modem, says that the basic aim was to concentrate a larger proportion of the modulated signal's energy into a narrower band. Milgo uses differential phase modulation that carries coded information as one of eight allowed phase shifts on a carrier signal.

Unique not new. Whang notes that the eight-phase scheme is, in itself, not a breakthrough since others have used the same technique. However, Milgo has some unique features, such as a special band-limiting filter and a new method of obtaining synchronizing information from the wave.

Whang won't discuss design details of the modem but he says that it's the filter that allows the 3-to-1 ratio of bit rate to bandwidth. "The filter is different from any known conventional filter," says Whang. Such well-known filters as the Chebishev, Butterworth or elliptical would not work, he adds.

Even though the eight-phase modulation scheme concentrates a larger portion of the energy into a narrower band, band-limiting is necessary because modulation components still exist at all other portions of the spectrum. This is a typical characteristic of a frequency-modulated or phase-modulated, system. Milgo's special filter reduces the transmission bandwidth without destroying the modulated signal's phase information. "We're very close to the theoretical minimum bandwidth for such a system," adds Whang. "Anything much narrower than 800 hz will result in intersymbol interference, which prevents the modem from recognizing the bits," he explains.

Other high-capacity modems are on the horizon. Milgo is working on a unit that will transmit 4,800 bits per second on a 1,600-hz bandwidth over leased lines. And in 1967 Bell Telephone Laboratories will test a modem which includes an automatic equalizer that will be capable of transmitting 3,600 bits per second over a conventional telephone line. Unlike Dataphone, which is a four-phase differential phase system, Bell's design will employ multilevel vestigial sideband transmission.

Space electronics

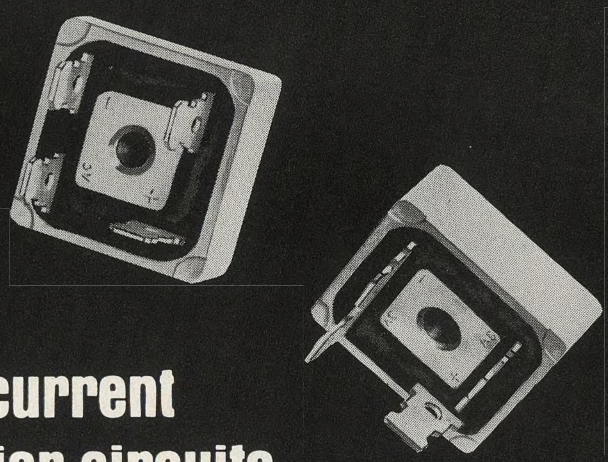
End of an era

When astronauts James Lovell and Edwin Aldrin rode their Gemini 12 spacecraft to a near-perfect landing in the Atlantic, it marked the end of the Gemini program and the end of an era in space electronics.

It was the last major space program to depend entirely on discrete components. Integrated circuitry is being introduced gradually into the three-man Apollo spacecraft and is expected to account for 70% of all space electronics by 1970. Despite several setbacks, Gemini has provided confidence in the electronic equipment needed to control every aspect of flight—from finding another vehicle in space to landing the spacecraft on target under computer control.

Problems. Communications was one of the major problem areas for

Circle 47 on reader service card→



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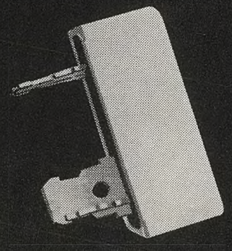

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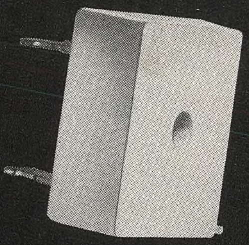

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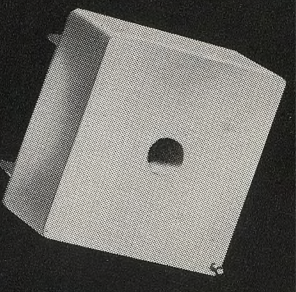

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Gemini. To improve the voice link, the Collins Radio Co. increased the flexibility of conventional equipment by adding logic circuitry and redundancy selections. Electro-Mechanical Research, Inc., and the Radio Corp. of America increased the telemetry data rate by introducing pulse-code modulation techniques for both real-time transmission and later playback of data accumulated on the onboard tape recorders.

There were other troubles. The guidance computer, built by the International Business Machines Corp. early in the program, proved too limited for the demands of Gemini and an auxiliary tape memory unit was built by Raymond Engineering Laboratories that provided a backup to the primary memory. To obtain the better attitude reference system needed to stabilize Gemini experiments, the Advanced Technology division of the American Standard Corp. developed a horizon sensor using sweeping heads similar to antennas.

On to Apollo. These and other electronics innovations are being adopted in the Apollo program. RCA is building a rendezvous radar similar to the Gemini system to aid docking between the Apollo command and lunar modules in orbit around the moon. A more advanced inertial guidance and navigation system, this time using integrated circuitry, has already been developed for Apollo.

When the Gemini program ended on Nov. 15, the astronauts had added 1,940 man-hours of space flight to the 54 hours accumulated in six manned Mercury missions —at a cost of $670,000 per man-hour.

Gemini was planned as a quick and cheap program to fill the gap between Mercury, which was created in a panic to match Soviet space advances, and the Apollo program, established earlier in 1961 to send men to the moon. It proved to be neither. The $1.3 billion final cost was double the initial estimate, and the first manned flight on March 23, 1965, was more than a year late. But by the end of the program, Gemini had proved that man and equipment can survive the hostile environment of space for as long as two weeks.

Far-out decision

As an unmanned spacecraft nears a planet, tracking signals from earth grow less accurate and course corrections eat up fuel—factors that could endanger the mission. But an onboard guidance system may steer spacecraft to safe landings without help from earth.

The Jet Propulsion Laboratory has awarded a $1-million contract to Electro-Optical Systems, Inc., a Pasadena, Calif., subsidiary of the Xerox Corp., to build a prototype of the onboard guidance system. The laboratory will evaluate it for use on the Mariner mission of 1969.

Conceptual. The project is just beginning and no design concepts have been selected. Armand Tanguary, manager of the information systems division at Electro-Optical, says the primary sensor will probably be some sort of an image-dissector tube, vidicon or image orthicon, mounted on the spacecraft's frame. A set of gimbaled prisms or mirrors will acquire the target and reflect it to the tv tube. Depending on what kind of tube it is, the image will then be scanned and the data fed into a computer.

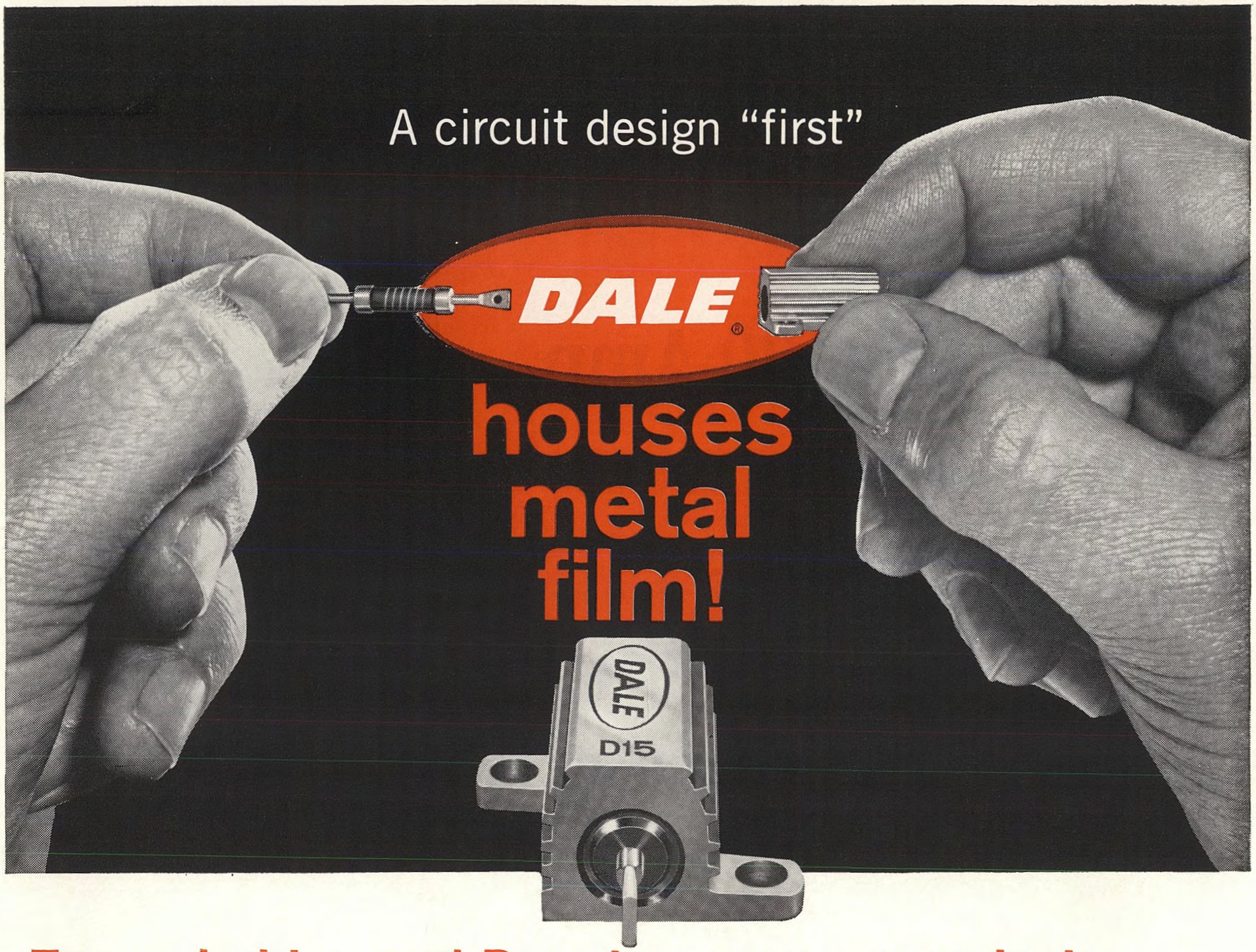
The computer first determines the curvature of the planet's circumference and intersecting radii are calculated to pinpoint its geographical center. Even if part of the planet is obscured, trigonometric calculations can still determine the center. Once the center is found the landing area can be calculated.

More accuracy. "We cannot, as yet, say just how accurate our subsystem will be," says Tanguary, "but we know it will have to be more accurate than present Canopus star trackers, which means it will have to be better than 30 arc-seconds. Naturally, we would like to see accuracies in the magnitude of a few arc-seconds, but this will be extremely difficult."

The first flyable design will probably not be a closed-loop system, but will telemeter data back to earth for computation and comparison with earth tracking data. Eventually, when the system is proved and used to control missions, data will be fed to an onboard computer that will generate control signals. The computer will also be able to calculate target range by comparing a calculated radius with the known radius.

Electronics notes

- **Laser memory.** The Precision Instrument Co. of Palo Alto, Calif., has developed a way to produce a digital data mass memory that can store up to 645 million bits per square inch. The process uses a 1-watt continuous-wave argon laser to burn 1-micron holes in opaque polyester tape. A modulator gates the laser's beam to produce bits that correspond to the digital data input. For readout, a light passes through the holes, onto a photomultiplier and then is translated into electrical impulses. One 2,400-foot reel of tape can store as much data as 47,500 similar reels of magnetic tape.
- **Speed is the aim.** When it comes to hitting the target quickly artillerymen are little better off today than in the days of World War II or Korea. But automated help is on the way. The Army believes that with modern data-processing equipment artillery fire could be much more effective than it is today. Toward that end, the Army has commissioned the development of Tacfire, for tactical fire direction system. To start development of this program, field data systems headquarters at Fort Belvoir, Va., has notified electronics companies that it is interested in receiving proposals. Two or three companies will be chosen soon to compete in the contract-definition phase. Next year one company will receive a total package contract.
- **Light blast.** Space Ordnance Systems, Inc., of El Segundo, Calif., has devised a method of setting off explosives by laser energy pulsed through fiber optic pipes. The most immediate advantage: light pipes aren't susceptible to radio-frequency interference.



Expanded housed D series opens new design areas for precision power metal film resistors

Dale's expanded D Series combines heat sink housings already proven by Dale Wirewounds with precision power metal film elements. The result:

1. As FILM RESISTORS, Dale's D Series offer power/size ratio unmatched by conventional parts (see chart).

2. As HOUSED RESISTORS, Dale's D Series offer higher maximum resistance values and low reactance at high frequencies.

FILM RESISTOR POWER/SIZE COMPARISON

CHARACTERISTIC	D SERIES			2-WATT METAL FILM	5-WATT CARBON FILM	4-WATT TIN OXIDE
SIZE	W, L, .32			3/8, 2-1/16	7/16, 4	5/16, 2-1/16
	D5 .334 W X .600 L	D10 .420 W X .750 L	D15 .550 W X 1.062 L			
Power Rating	4 Watts	8 Watts	12 Watts	2 Watts	5 Watts	4 Watts
Volume	0.064 in.^{3}	0.123 in.^{3}	0.320 in.^{3}	0.242 in.^{3}	0.600 in.^{3}	0.145 in.^{3}
Power Density (25° C)	62.0 w/in.^{3}	65.0 w/in.^{3}	37.5 w/in.^{3}	8.3 w/in.^{3}	8.3 w/in.^{3}	27.6 w/in.^{3}
Power Density (125° C)	20.4 w/in.^{3}	21.4 w/in.^{3}	12.4 w/in.^{3}	8.3 w/in.^{3}	2.1 w/in.^{3}	13.8 w/in.^{3}
Life Stability (Typical) *	.1%	.1%	.1%	0.5%	0.5%	3%
Temp. Coefficient	25 or 50 ppm/° C			50 ppm/° C	500 ppm/° C	300 ppm/° C
Max. Operating Temp.	175° C	175° C	175° C	175° C	150° C	200° C

*Maximum resistance shift in 1000 hours of operation at rated power.

D SERIES SPECIFICATIONS

- **Resistance Range:** 50 Ω to 1 Megohm (D5), 50 Ω to 2 Megohms (D10), 50 Ω to 2.6 Megohms (D15)
- **Tolerance:** ±0.1%, 0.25%, 0.5%, 1% and 2%
- **Power Rating:** D5=4 watts, D10=8 watts (mounted on 4"x6"x.040" aluminum chassis) D15=12 watts (mounted on 5"x7"x.040" aluminum chassis).
- **Temperature Coefficient:** ±25 and ±50 ppm/° C (−55° C to +175° C). Higher T.C.'s on request.
- **Maximum Working Voltage:** 500 (D5), 600 (D10), 700 (D15)
- **Dielectric Strength:** 1000 VAC (D5), 1500 VAC (D10), 2000 VAC (D15)
- **Construction:** Aluminum screw-mount radiator housing with resistance element molded inside for complete environmental protection. Meets all applicable requirements of MIL-R-18546C and MIL-R-10509E.

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Washington Newsletter

November 28, 1966

Shift of Voyager to NASA centers due in early '67 . . .

The National Aeronautics and Space Administration will not confirm the transfer of the Voyager spacecraft and capsule out of Jet Propulsion Laboratory [Electronics, Nov. 14, 1966, p. 25], **but hints at it by noting an announcement concerning "alternate management assignments" on Voyager is due after Jan. 1.** JPL currently is busy with Surveyor and Mariner and the shifting of work would keep the Langley Research Center, Hampton, Va., and Marshall Space Flight Center, Huntsville, Ala., busy. Both now have a declining work load. Of JPL's 4,250 employees, only 114 are working full time on Voyager.

JPL will continue to manage the scientific instrumentation for the Voyager capsule.

The bidder's package on the Voyager capsule study, which was due to go to industry in November, is completed but is being held up pending final determination of the budget and management. Some changes in the proposal request may now occur, since Langley, which would manage the landing capsule, reportedly differs with JPL on some aspects of capsule design.

. . . but budget will determine program's pace

The future of the Voyager unmanned planetary exploration program will be settled when the National Aeronautics and Space Administration's budget is hammered out at the LBJ Ranch in Texas in mid-December. While it continues to appear that space agency chief James E. Webb, won't get enough money to accelerate his program and aim for a 1973 Voyager flight instead of one in 1975, it seems likely he will get enough funds to keep the program going at the slower pace.

Pentagon expects favorable reaction to IC directive

Comments solicited from industry associations and military departments on the proposed Pentagon microelectronics directive [Electronics, Oct. 31, p. 26] will favor its adoption, officials in charge believe. **The directive would specify that all new military research and development projects must consider the use of integrated circuits.** The deadline for comments, originally Nov. 23, has been extended to Dec. 1 to give all groups time to answer.

Panel recommends new agency to study frequency problem

Chances are better than ever that funds will be forthcoming to study the critical problem of electromagnetic spectrum utilization. **An independent study made for the Commerce Department recommends that a new agency be set up to carry out research to improve the over-all effectiveness of frequency usage.** Other study groups have asked Congress to do something about the problem but have never been successful. An industry official, familiar with these efforts, expects the Commerce Department to push hard for creation of the new agency. Noting that the Federal Communications Commission failed several times to initiate its own research effort, he comments that "maybe Commerce can pull it off."

The panel's report states that research and engineering on frequency usage has been "remarkably small and grossly inadequate." It says that an annual budget of $50 million would not be excessive for the proposed agency, which would contract part of the research with industry.

Washington Newsletter

Hughes works hard for satellite job

Selection of the contractor to build a tactical communications satellite for a 1968 demonstration flight is expected momentarily. **The Air Force Space Systems division has been negotiating with the Hughes Aircraft Co., which looks like the winner since it reportedly was first among the six bidders in the technical and management ratings.** Hughes was also said to have been low bidder on the satellite, which is expected to cost about $20 million. With its communications satellite work load dropping off, the company is said to want the new program badly. If the negotiations with Hughes aren't successful, the Air Force probably would move on to the General Electric Co.

Man on the moon still on schedule

The recent reshuffling of the early phases of the Apollo flight schedule —which included a delay of the first manned flight to February at the earliest and the cancellation of the second manned flight—is not expected to delay the lunar landing date. NASA always builds plenty of padding into the timetables of its major programs. The first manned Gemini flights began more than a year late, for example, but the full program was completed ahead of schedule. The changes—blamed on nonelectronic development problems—do not affect the first mission capable of landing on the moon. It's still on for 1968.

It's budget time: the squeeze is on

The squeeze is on those research and development programs which are not aimed at limited war hardware: in fact, they are likely candidates for deferment or cancellation. Pentagon chiefs now are going over work plans line by line as they try to keep the fiscal 1968 defense budget down. **Even contractors with money already designated for their projects are getting nervous.** Recently, public relations men representing about 16 companies involved in the Polaris and Poseidon missile programs attended a meeting at which the prime contractors asked them to scrutinize their programs for possible items to publicize, thus making the public aware of them.

Hardware study due on orbiting antenna

Early results of feasibility studies on erecting a 30-foot parabolic antenna on a satellite in a stationary orbit look so good that NASA is expected to go ahead with the hardware definition phase next spring. Three companies, Fairchild Hiller Corp., General Electric Co., and Lockheed Aircraft Corp., will finish the feasibility studies in December.

Shift in strategy could mean new military programs

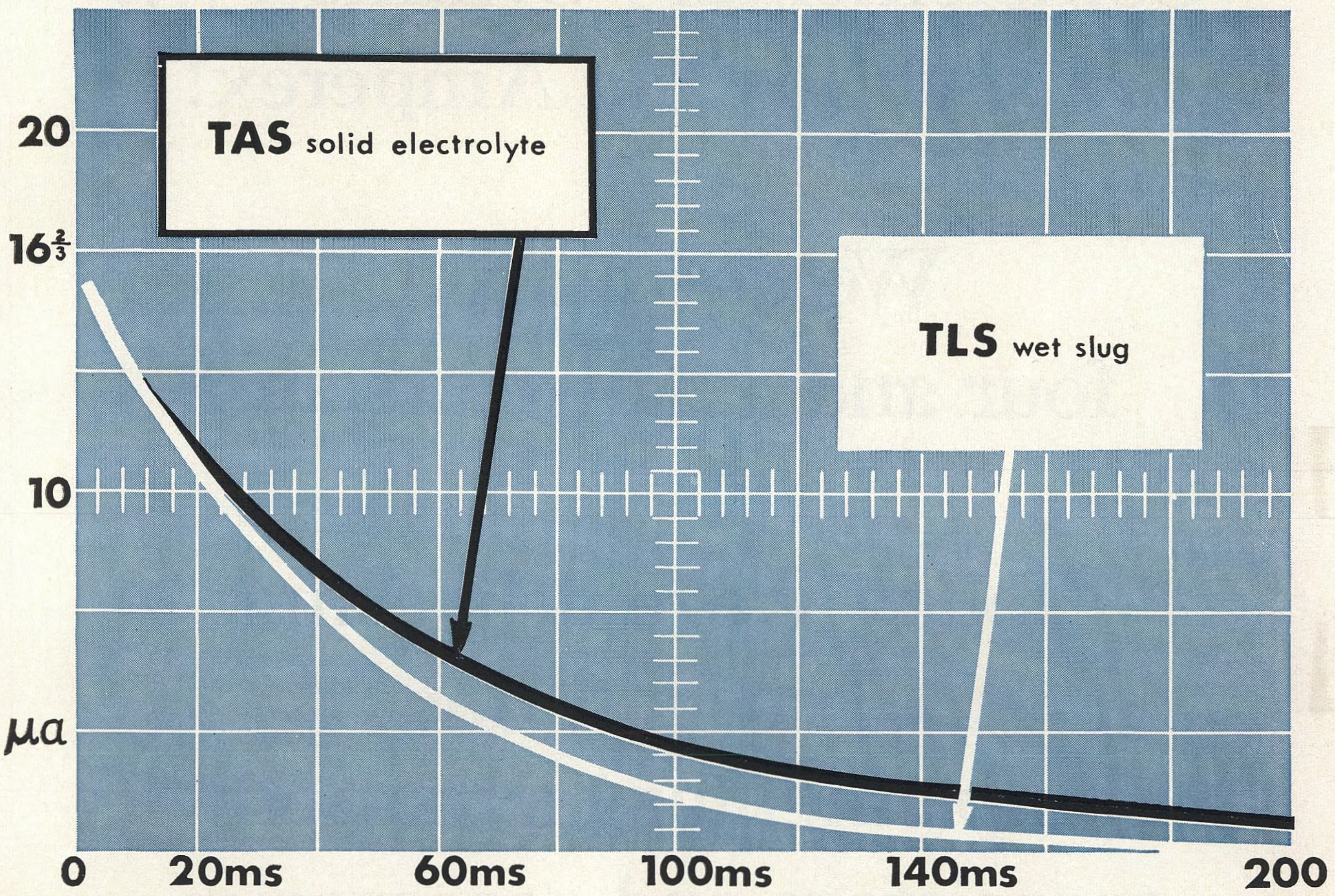
Pentagon strategists are reevaluating U.S. military policy in the face of the deployment of an antimissile system by the Soviet Union. **Prospects are that military strategy will be shifted and some major new programs for electronics equipment will get the go-ahead.**

The crux of the current debate is this: would U.S. "assured destruction" capability be best maintained by an antiballistic missile, such as Nike X; by a new bomber, the advanced manned strategic aircraft; or by the improved Minuteman intercontinental ballistic missile?

One consideration is the countermoves that will be made by the Soviets. Deployment of Nike X would force the Soviets to increase their expenditures for penetration aids. A new bomber would probably force the Soviets to spend money on both aircraft and missile defenses.

Why specify Mallory wet slug tantalum capacitors?

One reason: higher precision in timing circuits



Compare Charging Current-Time Traces reproduced from scope photographs.

Sweep speed: 20 millisec/div   Vertical sensitivity: 3⅓ μa/div

DC leakage of a capacitor acts as a parallel resistor. In an RC timing circuit, Mallory wet slug tantalum capacitors produce less time error than solid electrolyte types, because they have only about 10% as much DC leakage.

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Circle 53 on reader service card

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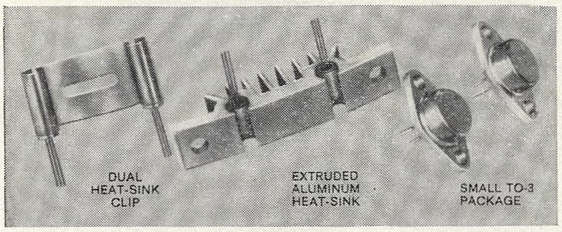
Today Amperex is delivering the broadest line of Complementary Symmetry transistors in the business... off the shelf, in production quantities, at production prices. We have the matched transistors, heat-sinks, circuits and application reports. Where required, breadboarded prototypes will be provided.



Complementary Symmetry achieves enormous manufacturing savings with no sacrifice in reliability, by using transistors as they should be used—as low voltage, low impedance, low temperature devices for Class B push-pull.

Low voltage eliminates need for bottom plates, interlocks, etc. Low temperatures mean longer, more reliable component life. Simple mounting clip eliminates need for expensive heat sinks, mica insulating washers and mounting hardware. Low output impedance of emitter follower output circuit obsoletes impedance-matching output transformer and related protective devices.

2N2707 matched pair 2N2430 (NPN) and 2N2706 (PNP) for power up to 1 watt for low cost phonos, amplifiers and radio; TO-1's in dual heat-sink clip.

2N4136 matched pair 2N2430 (NPN) and 2N2431 (PNP) for power up to 2.5 watts; TO-1 cases in dual heat-sink clip.

2N4107 matched pair 2N4105 (NPN) and 2N4106 (PNP) for power up to 7 watts; TO-1 cases in extruded aluminum heat-sink.

2N4079 matched pair 2N4077 (NPN) and 2N4078 (PNP) for power up to 12 watts; TO-3 cases.

FOR AUTO RADIO OUTPUTS
(5 watts at 13.6 volts)
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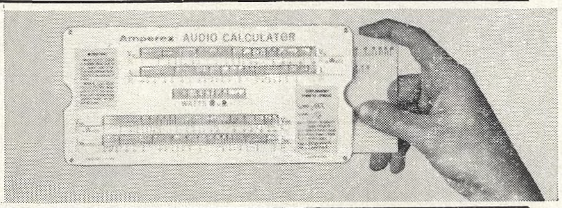

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PCA-1LDC-14	PCA-1-9 less rectifier and filter capacitor
PCA-1-14	2W, 14V D.C., 4 Transistor Amplifier
PCA-2-9	3/4W, 9V D.C., 3 Transistor Amplifier
*PCA-2SLDC-9	Same as PCA-2-9 with off-on switch, less rectifier diode and filter capacitor
PCA-2-14	1W, 14V D.C., 3 Transistor Amplifier
PCA-2S-14	Same as PCA-2-14 with switch
PCA-2LD-14	Same as PCA-2-14 less rectifier diode
PCA-3B-18-1	4W/Channel Stereo Amplifier
PCA-6B-18	PCA-3B-18-1 with pre-amp for ceramic
PCA-4-9	1W, 9V D.C., 4 Transistor Amplifier for radio and ceramic cartridge
PCA-4-9A	Same as PCA-4-9 with tone control circuit
PCA-4-14	2W, 14V D.C., 4 Transistor Amplifier for radio and ceramic cartridge
PCA-4-14A	PCA-4-14 with tone control circuit
PCA-5A-14	2W/Channel 14V D.C. Stereo Amplifier with balance tone volume
PCA-6A-25	8W/Channel Stereo Amplifier
PCA-6A-25SCS	PCA-6A-25 with separate control strip
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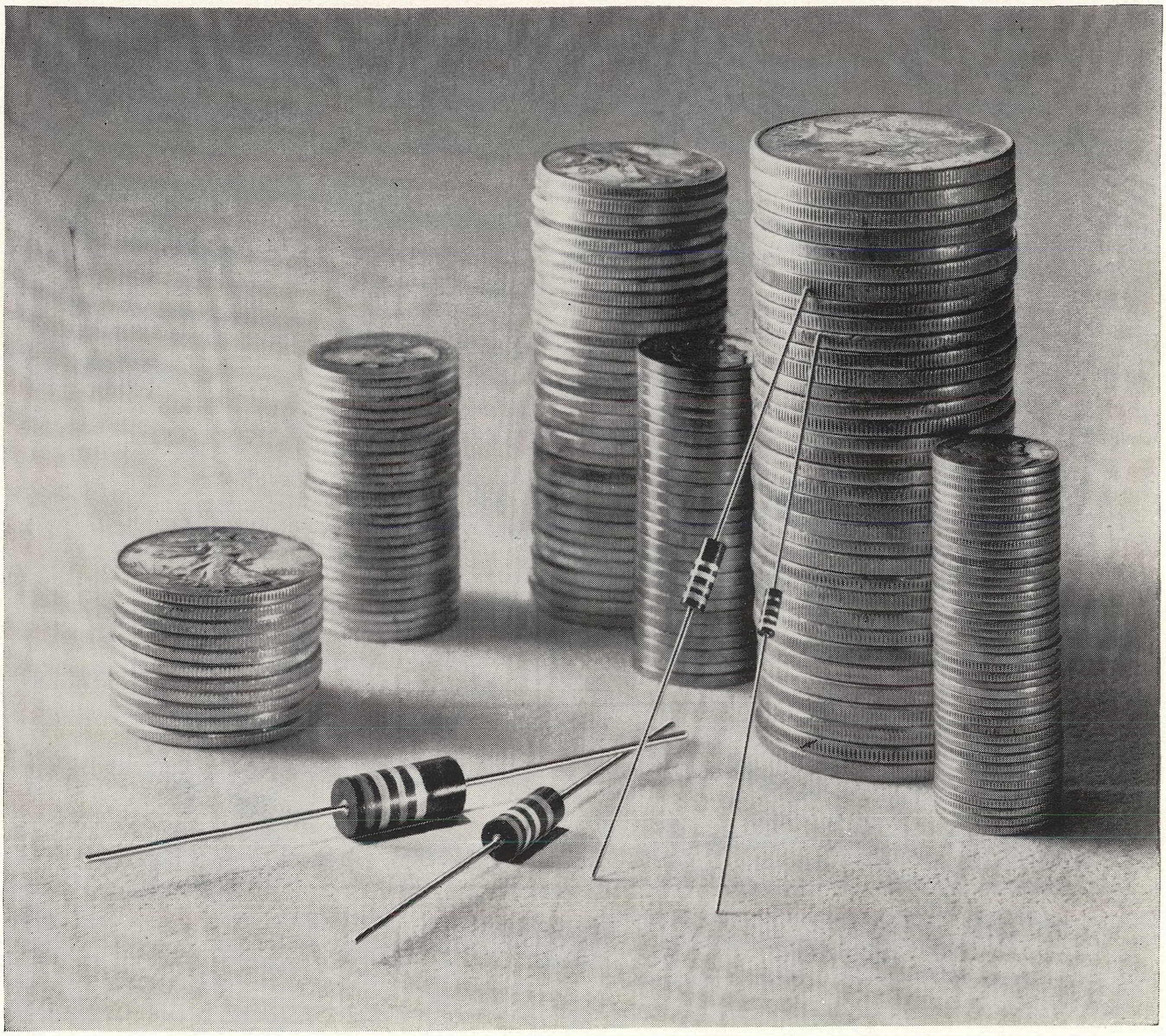

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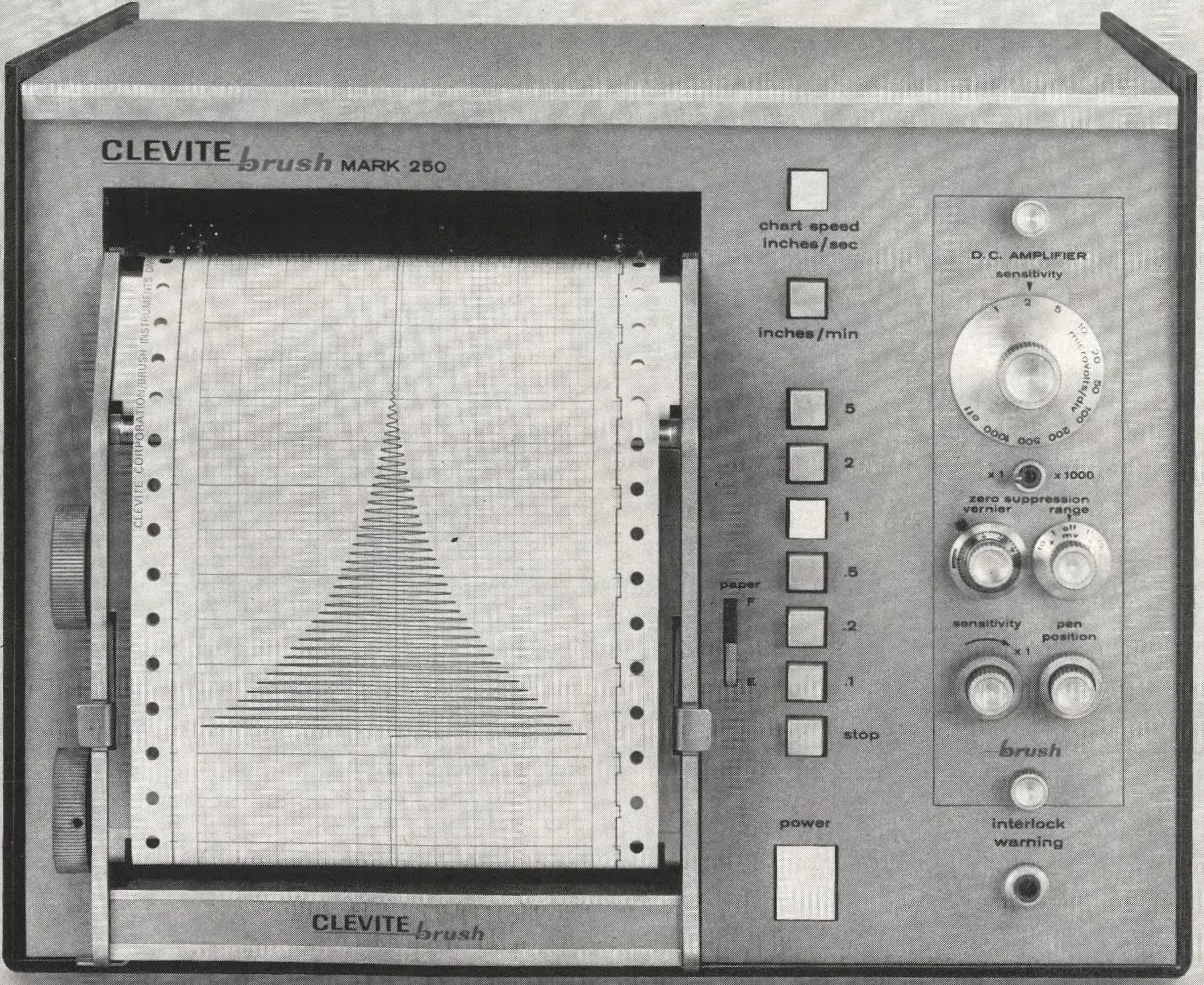
Shown with 1 μv preamplifier RD 4215-70; event markers optional.



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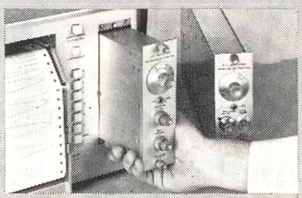

3 Crisp, clean rectilinear writing. Patented, pressurized inking system puts smudge-proof trace *into* the paper not just on it.

4 Contactless, non-wearing feedback system. Same one used in our multi-channel Mark 200 recorders. (No slide wires!) Accuracy? Better than ½%!

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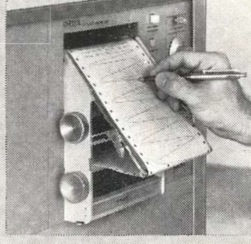

6 Portable or Rack mounting. And either way you get the exclusive new dual position writing table.

7 Removable chart paper magazine. Great for desk top record reviews. Man-sized manual winding knobs let you roll chart forward *and* back. Chart reloading is a cinch.

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The Brush Mark 250 First recorder for perfectionists

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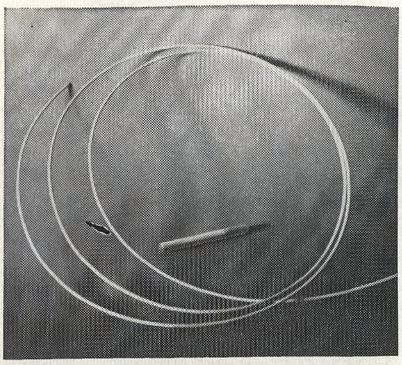
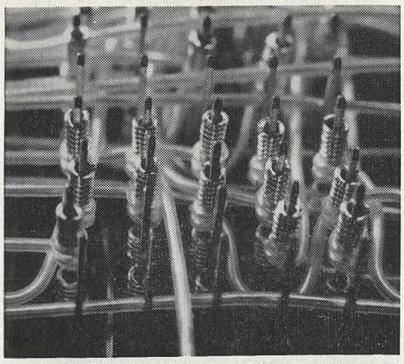
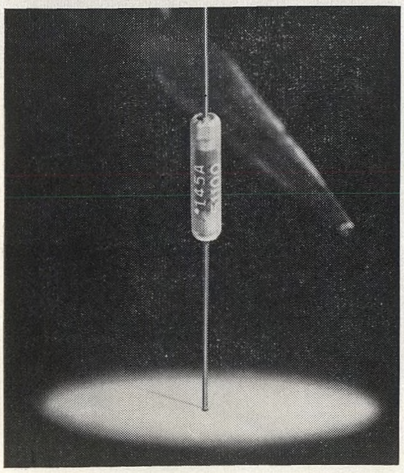


cable jackets



hook-up wire



component sleeves

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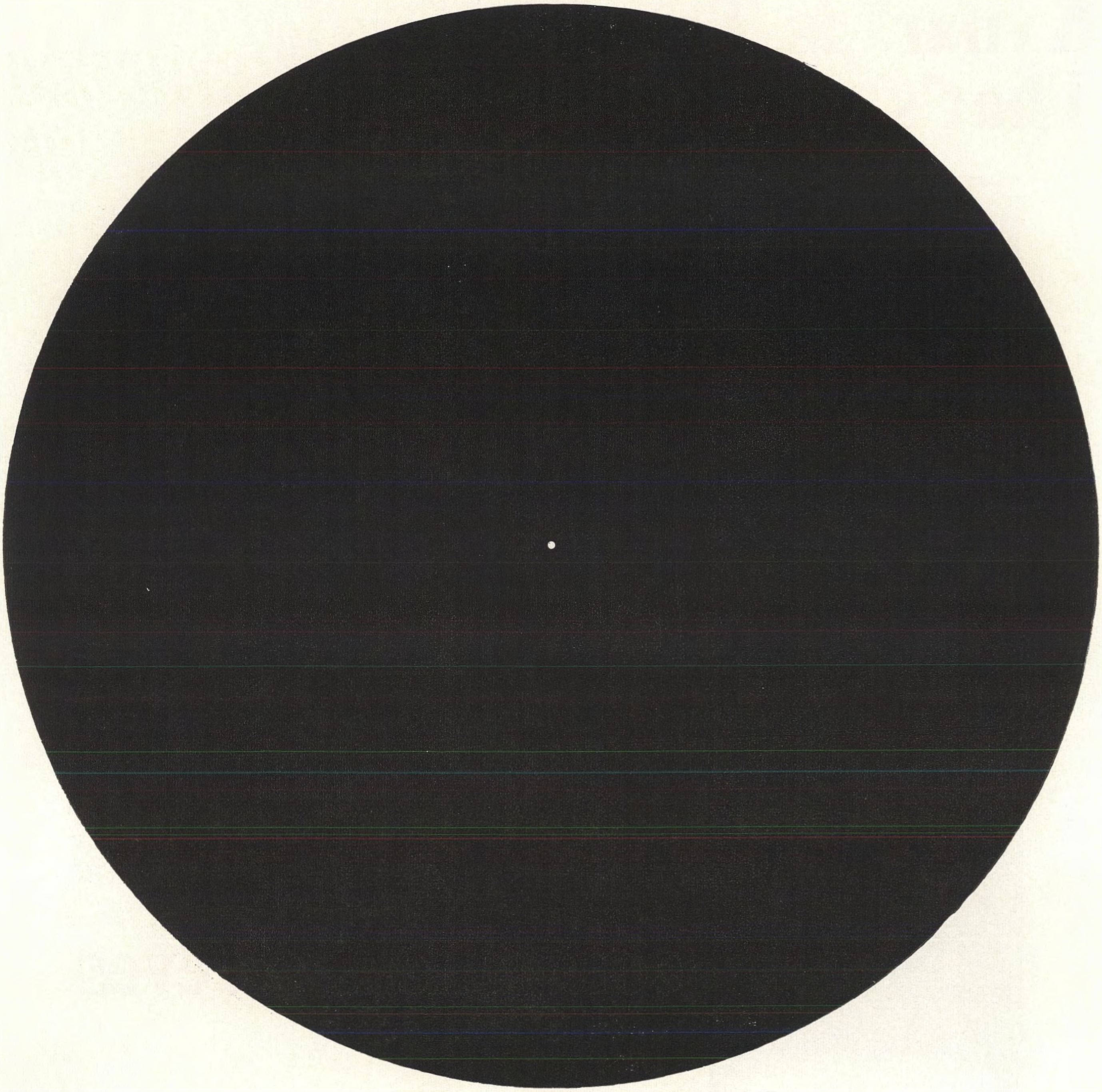

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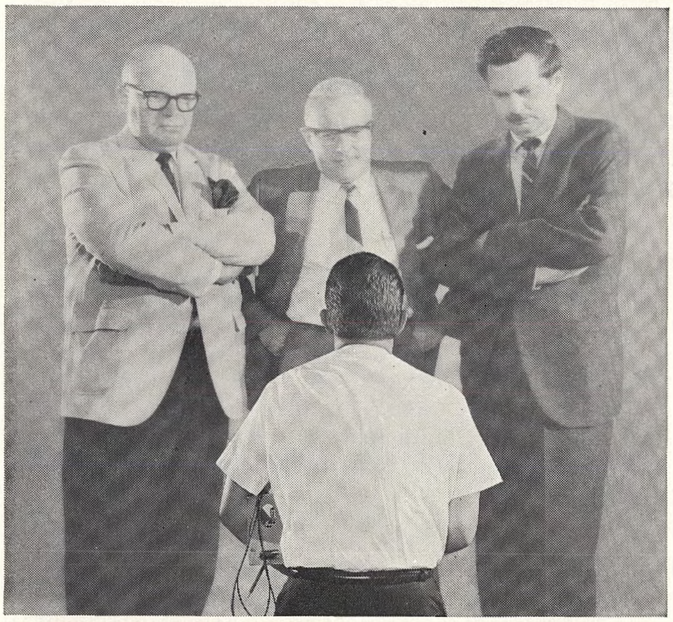
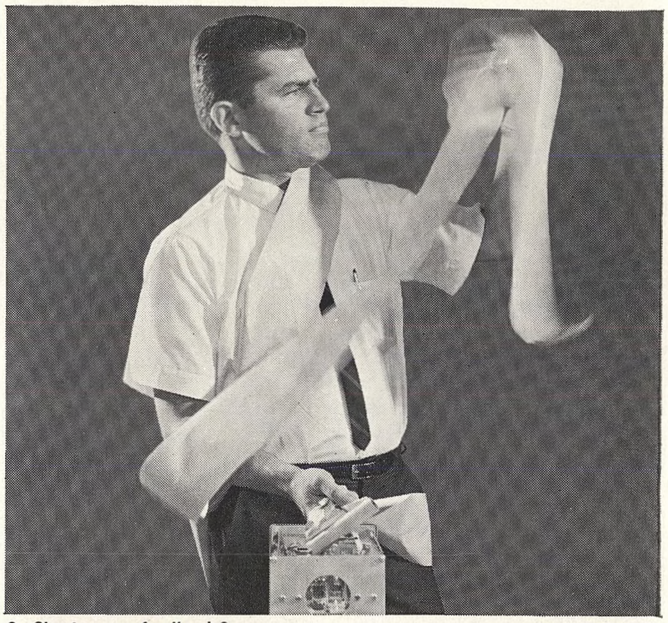
Are you haunted by these recording nightmares?

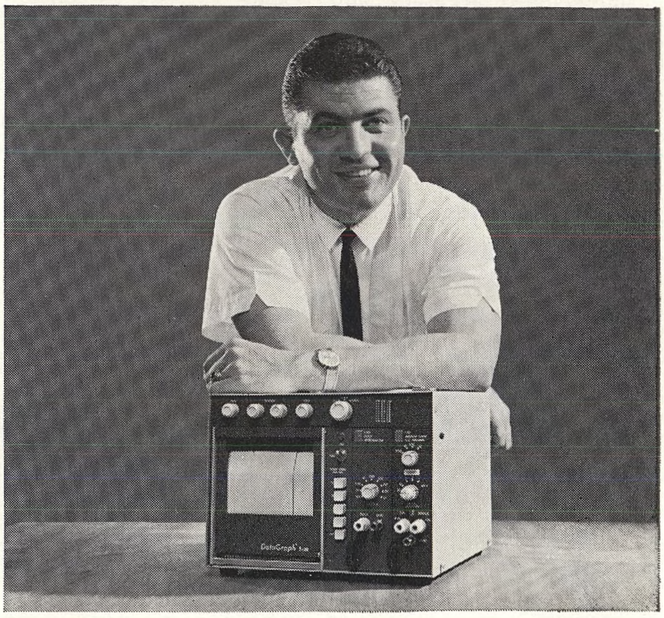


1. Big moment — wrong instrument?



2. Chart paper feedback?

3. Smeared traces — inky hands?



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Technical Articles

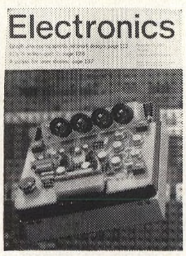
Computer-aided design, part 2; design programs: page 68

Computers excel at some design tasks but fall short in others. A computer is not yet a substitute for the experienced circuit designer who can come up with circuit ideas. However, once the basic circuit is conceived by the man, the machine can do a good job of analyzing and optimizing the design. Computer programs that assist the designer have five levels of complexity—they range from programs which perform specific tasks to those capable of handling on-line graphic analysis and design changes.

Two Schmitt triggers lower hysteresis: page 75

Pairs of Schmitt triggers and combinations of trigger circuits and differential amplifiers are better than conventional circuits for detecting low-level signals. A surprising advantage of this new family of switching circuits is that they provide high switching speed and fast cycling with extremely low hysteresis—a combination that doesn't exist in conventional Schmitt triggers.

Integrated circuits make $100 digital instrument: page 88



Miniature digital voltmeter and counter demonstrates the feasibility of building automatic volt-amp-ohm meters and counters as cheaply as conventional electromechanical instruments. Off-the-shelf integrated circuits convert input analog voltages into numerical values by a pulse-width modulation technique known as up-down integration. To dramatize usefulness of the design in control equipment, photographer Richard Saunders placed the instrument on a sheet of plastic and suspended it before a patchboard.

Fleets of balloons to probe the weather: page 98

With the aid of tracking and telemetry equipment that weighs only a few ounces and costs only a few hundred dollars, meteorologists are testing balloons that will circle the earth, reporting atmospheric data. In the future, thin-film circuits on thousands of balloons will detect the data and transmit it to satellites. The satellites will collect the data and relay it to earth where giant computers, programed with mathematical models of the atmosphere, will prepare long-range weather forecasts.

Coming December 12

- **Special report on the Apollo program**
- **Distortion in field-effect transistor amplifiers**
- **Japanese communications systems**

Computer-aided design: part 2
The computer excels as analyst

Key steps in circuit design range from conception to fabrication. Computer-aided design programs can be classified according to their versatility and ability to peform at each step of the design cycle

By Arnold Spitalny
Norden division, United Aircraft Corp., Norwalk, Conn.

Can the computer conceive new circuit designs or does its chief virtue lie in its use as a super slide rule? The consensus seems to be that as a machine for unburdening the designer from a mass of repetitive detail work, it is hard to beat, but when matching wits with the designer at the initial, creative stage of circuit design, the computer has a lot to learn.

An examination of the design cycle, along with a look at how computers have assisted at each stage of the cycle, should prove helpful.

The design process can be divided into four broad categories (see opposite page): synthesis, analysis, optimization and fabrication. The term analysis is usually used loosely to include development of a model that represents the circuit, generation of equations to define the model, and testing of the model to determine response and sensitivity. The strength of the computer now lies in analysis and optimization. So far, the man, not the computer, is charged with coming up with the idea for a circuit which is likely to meet a given set of functional specifications.

Yet, the very fact that the designer does not start from scratch, but rather calls upon his experience and recollection to synthesize a design—in as big chunks as possible—suggests that ultimately the computer can be instructed to perform the same type of synthesis. It seems even more likely that the computer, currently lagging in its potential for helping fabricate electronic systems, will assume a dominant role in that area, too.

The first article in this series, an overview of computer-aided circuit design, appeared in the Sept. 19, 1966 issue. It covered techniques, practices and implications for the future. Subsequent articles will explain how programs are developed and applied.

A look at the system

Many of the techniques that the designer can exploit in using the computer to aid him in circuit design can be used to advantage at the earlier, conceptual stage for the entire system into which the circuit or circuit subsystems will fit. And what he finds at the systems analysis stage may bear upon his choice of attack upon the circuit problems. The system flow chart on page 71 shows how over-all system requirements effect the selection and design of circuits.

Simulation of the system by computer enables inexpensive comparisons of many alternative designs. Costly construction of prototype equipment is avoided. Experiments can be performed through computer simulation that would be prohibitively expensive or dangerous in real life.

For example, an automatic steering and diving control system for submarines was designed and tested on an analog computer system, with the computer simulating the response of the submarine to control signals. As a result, no adjustments were needed when the control equipment was installed and operated aboard a high-speed nuclear submarine.

In early experiments in which complete systems were simulated and checked out by computers, analog computers were widely used. They had elements that corresponded directly to the functions of portions of the equipment under study. While that approach worked well for relatively small, uncomplicated systems, it proved much too cumbersome for today's more complex systems, and digital computers have largely supplanted analog machines for systems studies.

New or old circuits

A successful systems analysis will provide the circuit designer with functional black box specifications describing circuits that are needed. One key question asked by the circuit designer at this point is, "does a previously designed circuit or circuit module exist that matches the black box in question?" Unfortunately, information on previously designed circuits and modules is often not readily available and neat libraries of existing designs are scarce. The human memory as the primary information storage medium is reasonably effective when all projects are channeled through one small design group, but as a company grows reliance upon human memory becomes outmoded and foolhardy.

Instead, a carefully planned and diligently maintained combination of summary catalogs, rapid-access, computer-maintained status files, and detailed design and performance data files is needed to expedite search for and selection of standard units.

The flow chart at the top of page 72 shows how a search for a standard circuit is carried out. Steps that can be computer-aided are shown in color. Rectangular boxes in the flow charts represent processing steps; diamonds indicate decision points; ovals are human functions; half-cylinders represent information files; the torn sheet of paper represents a readout step and the symbol having a point on one end and a curve on the other represents a graphic interpretation step.

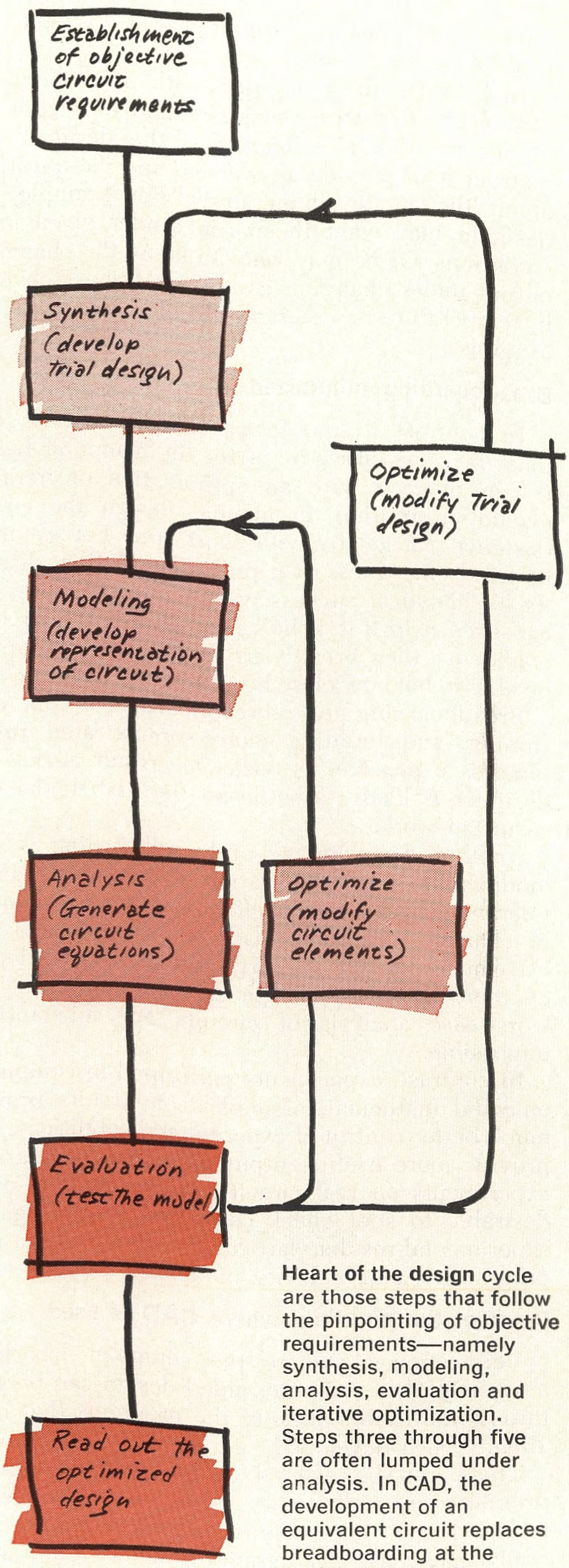
The standard circuit status files should indicate the range of application conditions for which a circuit is considered as a standard or preferred design. It should also list recommended alternatives. Commercially available standard circuits should be identified in such a file. New circuits and modules should be designed only when satisfactory alternatives are not available; they in turn should be added to the files and made available for use in future equipment designs.

Designing new circuits

When a wanted circuit does not exist or cannot be found, the designer embarks upon a fresh design. Basic steps involved in design and development of new circuits are shown in the flow chart at the bottom of page 72. Here again, the steps which lend themselves to an assist from the computer are shown in color.

The computer can excel in both analysis and optimization, yet it is not always exploited in both areas. Analysis follows synthesis in the design cycle, and, strictly speaking, begins with breaking the circuit into its component parts. A key to this analysis is modeling, or representing the physical elements of the circuit by equivalent circuit elements so that an equivalent circuit or model can be constructed. Then the circuit loop equations

The design cycle



Heart of the design cycle are those steps that follow the pinpointing of objective requirements—namely synthesis, modeling, analysis, evaluation and iterative optimization. Steps three through five are often lumped under analysis. In CAD, the development of an equivalent circuit replaces breadboarding at the modeling stage. Steps to which CAD can be applied are shown in tinted blocks—those most amenable are deeper in tone.

must be generated. Often these steps are performed for the computer by the designer, in which case whatever analysis the computer makes is limited to evaluating the model.

In essence, the computer, with or without the aid of the designer, must simulate or model the circuit in such a fashion that the designer can instruct it to provide answers to specific questions about the circuit under study. For example, the designer may want the output under given input conditions. Or he may want to know the change in output under changing circuit conditions (changes in temperature or deterioration of components, for example).

Breadboarding minimized

In contrast to the formal circuit analysis that must be done either by or for the computer before it can proceed with an optimization or iterative evaluation routine, in manual design the circuit designer can get by with short cuts. For example, he need only guess at a probable solution, discuss its likelihood of success with a few associates (he can even skip this if he's lazy, in a hurry, or very confident), then breadboard it. But he's not apt to be able to tell how close he is to an optimum design.

Breadboarding and rebreadboarding is time consuming, and building more sophisticated prototypes is expensive, as well. One result is that the designer is likely to settle on the first model that seems to work.

Another disadvantage of breadboarding is that modification and optimization of parameter values, tolerance checks, failure effect tests, and evaluation of changes in source, load, or power supply are extremely difficult to carry out with any degree of thoroughness and speed. And statistical and worst-case analysis of circuits are substantially impossible.

In contrast, experiments performed in computers on valid mathematical models of circuits provide much better control of experimental conditions, and provide more useful output data than comparable experiments on real circuits. However, it is often desirable to spot check computed results against experimental results, particularly when using a new program or a new device model for the first time.

Proof of the pudding: where CAD is used

Verification of where the computer has been most helpful in computer-aided design can be seen through an examination of the programs that have already been developed.

These can be classed in five groups: class 1 programs are rudimentary while class 5 programs include today's most sophisticated techniques. Generally, each class of program overcomes a limitation of the previous class, and together the classes illustrate the evolution through which computer-aided design has already passed. The five classes are as follows: class 1, specific purpose programs; class 2, general purpose programs requiring equation inputs; class 3, linear general purpose; class 4, nonlinear general purpose and class 5, on-line graphic analysis programs.

Rating the classes: how programs stack up

Class 1: Special purpose CAD programs may be strong in the optimizing stages of the design cycle, but they fall short in modeling and analysis because each program is restricted to a narrow class of circuit.

Class 2: Equation input general-purpose programs gain strength in the modeling phase of design, but only in the sense that they are geared to accept a wide variety of designer-developed circuit models. This class is weak in the mathematical analysis phase of design, since the user must write his own equations.

Class 3: Linear general-purpose programs rate well in both analysis and evaluation, because the computer both derives and solves the circuit equations.

Class 4: Nonlinear general-purpose programs, through their ability to handle nonlinear models, stack up even better in analysis and evaluation.

Class 5: On-line graphic-analysis programs rate best in optimizing routines since modifications can be made without waiting for the final readout.

Most existing programs fall into the class 1 category. These programs are written for a specific circuit configuration or for a limited class of circuits, such as passive linear filters. Since development of a new computer program for every circuit is out of the question for the average designer, a more generalized approach is clearly needed.

Class 2 programs allow all circuits to be described by sets of simultaneous mesh or nodal equations, in accordance with standard circuit theory. General purpose computer programs were evolved that accept these simultaneous equations, or their sets of coefficients, as input data. Two of the better known examples are the Sparc program,[1] developed by Autonetics, a division of North American Aviation, Inc., in 1962 for its Recomp computer, and some programs developed at Arinc Research Corp. [Electronics, Sept. 19, 1966, pp. 113-114].

Computers write equations

It became apparent at most installations where class 2 programs were used that designers rebel at deriving equations and sometimes make mistakes in the process.

A third class of system was thus needed in which the input data to describe any circuit consisted only of the identification of all components and a description of how they are connected. The computer could then derive the simultaneous equations as well as solve them. Several truly general purpose circuit analysis programs of this type have been developed.

One of the best known and most widely used of these is the Electronic Circuit Analysis Program (ECAP) [Electronics, Sept. 19, 1966, p. 112]. It provides a very simple user-oriented language in which an engineer can describe any circuit or equivalent circuit which is made up of linear passive and active elements. He can then use the same language to call for d-c, a-c or transient analysis and a large variety of optional routines.

These optional routines include a sensitivity analysis which is used to evaluate the effect of changes in each parameter on every voltage in the circuit. In addition, a statistical routine combines these sensitivities with component tolerances to determine the worst case and standard deviation of variations from nominal output conditions as the components vary within their tolerance ranges.

The standard deviation calculation uses a direct moment method[2] to provide essentially the same information that would require much more computer time by a Monte Carlo analysis, in which hundreds of complete circuit solutions are calculated as all components are varied at random within their tolerance ranges. The Monte Carlo approach is preferable only when the component error distributions are very unsymmetrical. The linearity assumptions of ECAP are usually valid for the small signal changes involved in tolerance studies, even when they are not adequate for analysis of the complete range of operating conditions.

Unfortunately, the world is full of nonlinear devices such as transistors and diodes that cannot be represented accurately by linear equivalents over their full operating range. Though ECAP offers some limited nonlinear capability in the form of piecewise linear approximation in its transient mode, this is far from adequate in transient analysis and useless for d-c or a-c analysis.

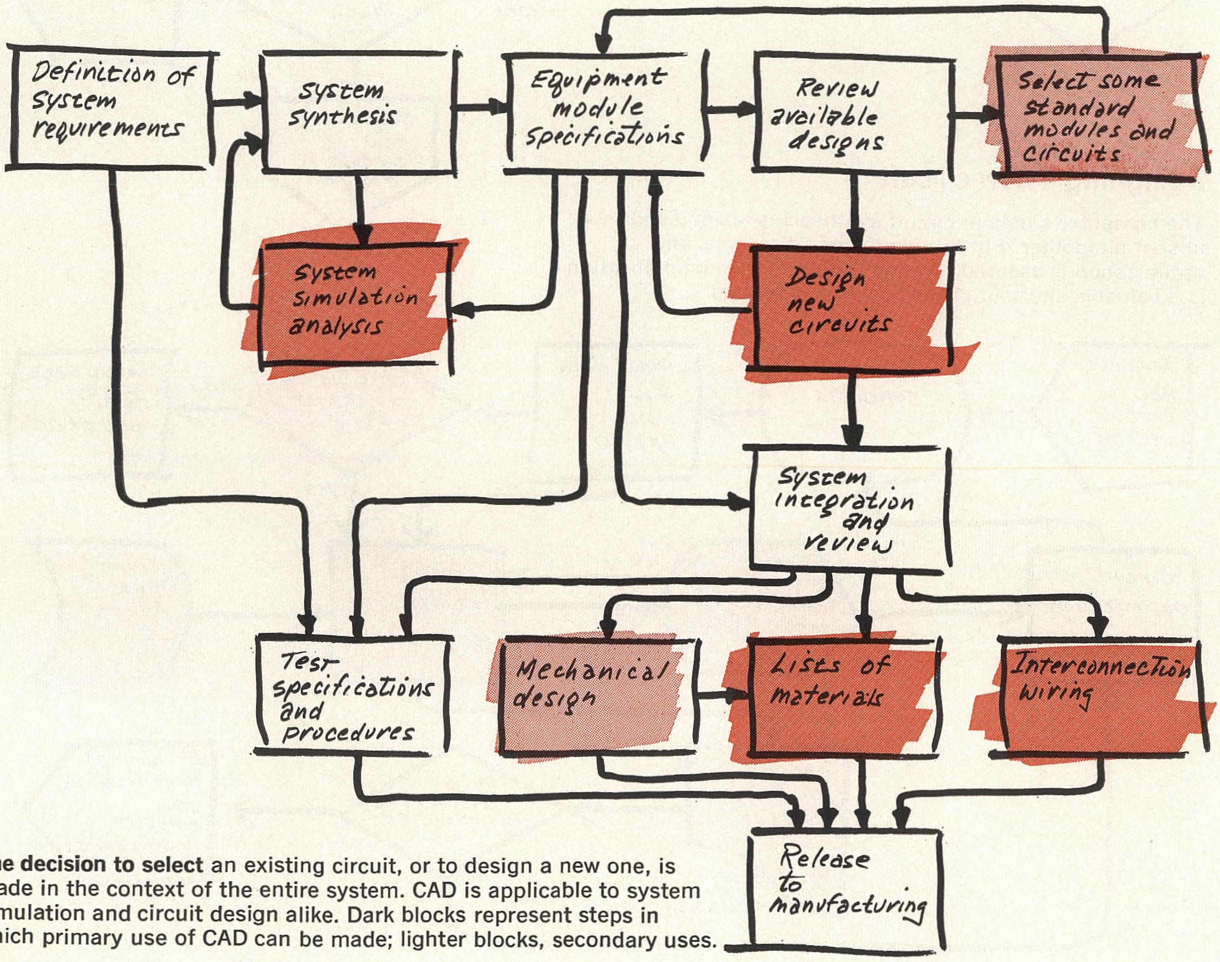
An ECAP equivalent circuit for a transistor is valid only at a single operating point. It must be changed and the analysis repeated if the circuit does not operate the transistor at that level. Nonlinearity can thus be accommodated by repeated trial and error model modifications, and requires many computer runs.

Nonlinear methods

Class 4 programs for computer-aided design account automatically for nonlinearities by using nonlinear mathematical models, while preserving the input simplicity of ECAP. Ideally, the designer merely specifies a transistor or diode type, and the computer extracts the appropriate nonlinear model from its files.

One class 4 program is the widely used general purpose network analysis program, NET-1 [Electronics, Sept. 19, 1966, p. 112]. NET-1 uses a version of the Ebers-Moll nonlinear model for transistors, with a tape file of model parameters for some commonly used transistors. It is appropriate for transient and d-c analysis so long as the designer limits himself to components that are in the file. Otherwise, ponderous laboratory experiments are

System design flow chart



The decision to select an existing circuit, or to design a new one, is made in the context of the entire system. CAD is applicable to system simulation and circuit design alike. Dark blocks represent steps in which primary use of CAD can be made; lighter blocks, secondary uses.

required to determine equivalent circuit parameters for new components.

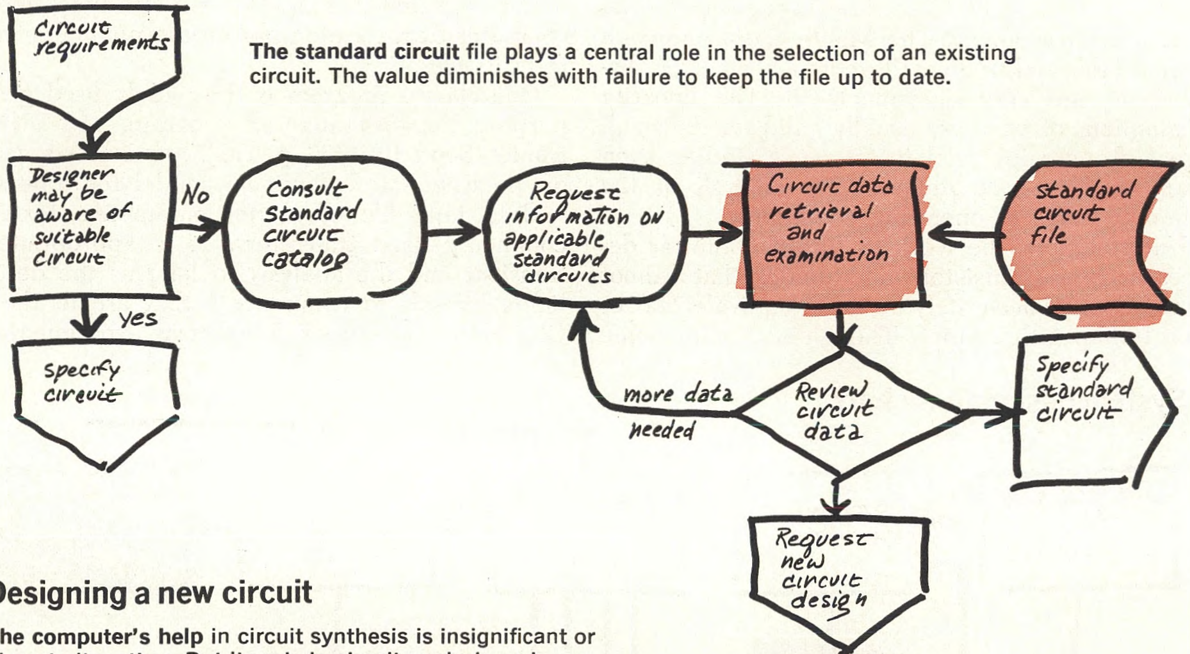
A serious limitation of NET-1 is that it was first written in machine language for the Maniac 2 computer. It has since been translated into versions for the IBM 7090 and 7040 class computers, but still is highly machine-dependent and is designed to occupy the full machine. Thus, it is not compatible with the operating control systems of many large-scale computer facilities. The simplicity achieved by standardizing equivalent circuit format also carries the disadvantage of being unable to introduce other equivalent circuits where they may be more appropriate.

Another approach to nonlinear circuit analysis was taken by engineers at Norden, a division of United Aircraft Corp., who have developed a d-c nonlinear system that can accept an almost unlimited range of arbitrary nonlinear models. It can also use standard stored models for transistors, diodes, zener diodes, and strings of diodes in series. Optional routines have been added to aid initial design as well as reliability review.

In addition, many other companies have developed circuit analysis programs, and a few general purpose programs are also in circulation. Each user must choose the method that is most appropriate, based on the nature and extent of the problems

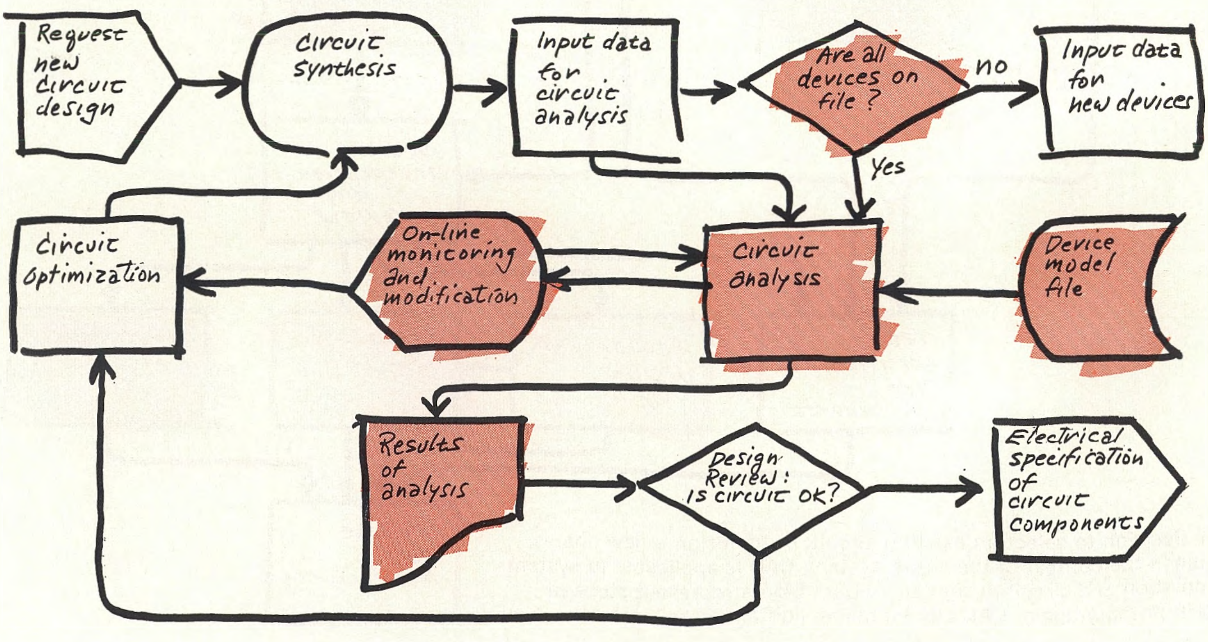
Searching for standard circuit

The standard circuit file plays a central role in the selection of an existing circuit. The value diminishes with failure to keep the file up to date.



Designing a new circuit

The computer's help in circuit synthesis is insignificant or absent altogether. But its role in circuit analysis and optimization is assured. On-line monitoring and modification is a valuable shortcut in the optimizing routine.



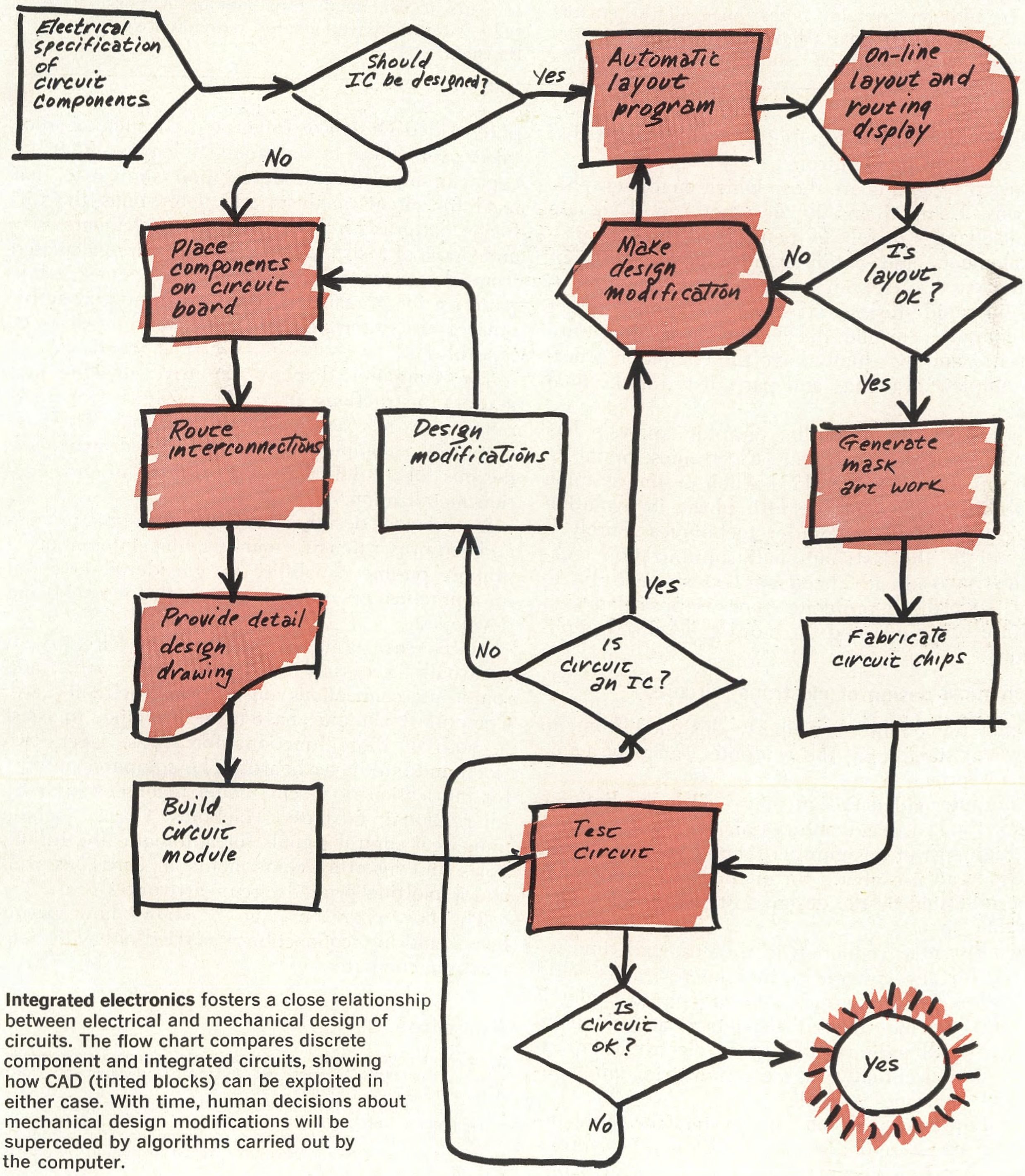
to be handled and such factors as equipment limitations, availability of proprietary programs, prejudices of designers and availability of talent and funds for new developments. At Norden, all of the methods discussed here have been used.

Drawbacks overcome

The foregoing programs share the limitation of all off-line computer techniques. The designer submits his data and instructions and then must wait while his problem is keypunched, takes its turn in an input queue at the computer facility, and is finally run in the computer and returned to him. The total cycle time for a single run that requires only one minute of operating time on a high speed computer can consume from an hour to more than a day. This delay is a serious problem to the designer who often must study numerous variations before settling on a final circuit design.

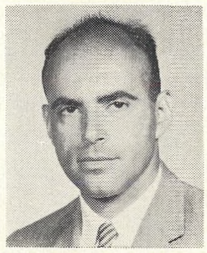
Speed could be increased if he could work on the computer model of his circuit directly without waiting for keypunching and delay caused by other computer users. This means he needs his own computer, or more realistically, a remote terminal on a large time-shared computer. For better man-machine communication, the terminal should have

Circuit layout and interconnection



Integrated electronics fosters a close relationship between electrical and mechanical design of circuits. The flow chart compares discrete component and integrated circuits, showing how CAD (tinted blocks) can be exploited in either case. With time, human decisions about mechanical design modifications will be superceded by algorithms carried out by the computer.

Computer-aided design: more than meets the eye



Computer-aided design, says author Arnold Spitalny, who is chief of the engineering computer branch for Norden division of United Aircraft, is too often confused with computer-aided circuit design. In this article he emphasizes the latter, but stresses that the development of a computer-aided man-machine system to do engineering work can go far beyond its use in circuit design. One glance at the system design chart on page 71 should confirm his conviction.

In addition, Spitalny notes, once all the circuits and other system parts have been selected or designed anew, plenty of detailed work still remains to combine them into modules and boxes and generate the necessary design instructions. The shop must be told what to buy, what to make, how to put it together and how to test it. Keeping track of the vast numbers of parts and interconnections for today's large electronic systems can be an almost impossible job without the help of the computer.

Besides reducing design time and expense, computer storage and processing of design data has cut down on careless manual errors. It also permits fast, accurate introduction of design changes. As changes are introduced on the production lines, tapes can provide a permanent record of how each delivered system was made and what generation of parts it contained, thus making it possible to tailor later modifications for individual systems in the field.

graphic input-output capability, such as a crt display and light pen control.

Class 5 programs are those which enable graphic analysis. Using them, the designer can designate circuit changes merely by pointing at the appropriate elements and obtain results in the form of plotted curves. He can try many circuit modifications in rapid succession, study the results, direct the computer to file the better ones for future reference and eventually have the computer generate complete drawings and parts lists for the final design.

The feasibility of on-line graphic analysis has already been demonstrated [Electronics, Sept. 19, 1966, pp. 110, 115, 118, 123]. Such on-line graphic capabilities represent the fifth phase in evolution of circuit analysis computer techniques. Surely it will not be the last; automatic optimization techniques have already been applied successfully to some specialized problems such as optical design and are being adapted for more generalized applications.

Mechanical design of electronic circuits

Once the circuit is properly designed from an electrical standpoint, the computer can play a role in its fabrication.

Computer-aided design may well help eliminate one of the last disadvantages of integrated circuits, the high cost of designing a limited volume circuit. Widespread use of IC's for analog applications has been inhibited by the design cost [Electronics, Oct. 17, 1966, p. 73].

A substantial reduction in the cost and time required for development of new microcircuits could shift the economic trade off enough to make it practical to enjoy the full benefits of IC technology in nearly all military and space electronic equipment and eventually in most industrial and consumer electronics as well.

An improved man-machine system for rapid design of microcircuits is being developed by Norden under Air Force sponsorship.[3] The system, Computer-Aided Design of Integrated Circuits (Cadic) takes over where circuit analysis leaves off. It accepts an input circuit description similar to that used for circuit analysis and determines the diffusion patterns needed for all circuit elements. Size and shape of resistors and capacitors are calculated from design rules and parameter values, while patterns for transistors, diodes and other active devices are stored in, and retrieved from, disks or tape files.

The computer displays tentative designs and accepts instructions from the designer for rearrangements to reach an optimum layout. The final output is a complete set of machine drawn mask designs for all diffusion steps and for interconnection metalization.

Since layout design is basically a graphic process and requires extensive man-machine interaction, a graphic on-line capability is considered essential for a practical operational system; this is now being developed.

In the case of discrete component circuitry, it is usually necessary to locate components and route interconnections on a printed-circuit card. Computer techniques have been developed to assist in both of these functions for single layer, two sided and multilayer boards. The computer outputs for fabrication of recent model machines built by International Business Machines Corp., include numerical control signals for automatically drilling holes and inserting components in cards, as well as for plotting printed circuit artwork.

The flow chart on page 73 shows how circuit layout and interconnection is carried out with help from the computer.

References

1. "Recent developments in computer techniques for circuit design and analysis," report by Autonetics division of North American Aviation, February, 1963.
2. D.D. Mark and L.H. Stember Jr., "Variability Analysis," Electrotechnology, July, 1965.
3. "Final report on development of techniques for automatic manufacture of integral circuits," Technical report AFML-TR-65-386, November, 1965.

Circuit design

Pairing Schmitt triggers produces lower hysteresis and faster switching

Unique circuit arrangements prove that two Schmitts are better than one for detecting low-level signals

By Thomas Weisz*
Philips Laboratories, Briarcliff Manor, N.Y.

Pairs of Schmitt trigger circuits, or combinations of Schmitt triggers and differential amplifiers can form a unique family of circuits for detecting low-level signals at high frequencies. The surprising thing about these circuits is that they exhibit high switching and cycling speeds with extremely low hysteresis—two characteristics that are mutually exclusive in conventional Schmitt triggers. The new circuits are attractive as sense amplifiers in high-speed computer memory systems.

In general, a Schmitt trigger operates with a finite difference between the set and reset levels at which the input voltage will trigger the circuit to switch. This hysteresis characteristic limits the smallest signal the circuit can detect. Theoretically hysteresis may be reduced to zero if the circuit loop gain is made to equal unity. However, one can only approach zero hysteresis at the sacrifice of high switching speed.

Feedback control regeneration

In a conventional Schmitt trigger circuit such as on page 76, unity loop gain can be achieved by proper selection of the relative values of resistors R_1, R_2 and R_5. Unity loop gain in a positive feedback arrangement like this means that the output state of the circuit will always be just maintained, even with the input voltage removed. However, any small change in the input starts regeneration by virtue of the feedback, and the output switches to the alternate state.

At the top of page 76 is the equivalent circuit of the trigger, represented as an amplifier with gain, G, in a positive feedback arrangement. The graph is an idealized plot of output versus input for the amplifier with the loop open. So long as the static loop gain (represented by the slope of the line between points A and B) is unity, the circuit exhibits zero hysteresis. However, a circuit designed to operate with small hysteresis and fast switching cannot achieve fast cycling speed because of the presence of capacitor C. This capacitor is necessary to produce fast switching time by increasing the loop gain dynamically. The capacitor needs time to charge and discharge to new voltage levels for each of the two circuit states.

Without C, loop gain is unity and the circuit acts as an integrator; switching time depends on the waveshapes of the input signals. If both C and R_4 were omitted, switching and cycling speed would be improved; but hysteresis would be large because of static-loop gain increase.

Reducing hysteresis

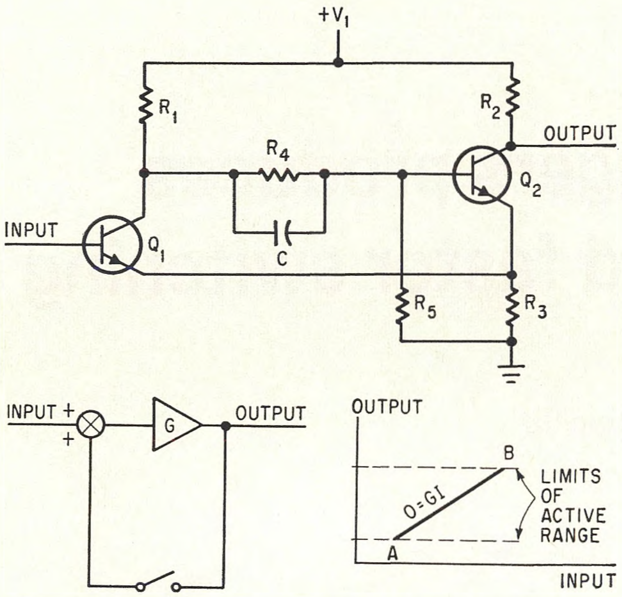
One way to reduce hysteresis in the conventional circuit is to select a high ratio of R_2/R_3 values. However, if R_3 is too small, the loop gain is reduced prohibitively; if R_2 is too large, the switching time will increase because it forms a large time constant with the output capacitance of transistor Q_2, limiting the output rise time.

What is needed, then, is a circuit that has unity static loop gain for low hysteresis with very high

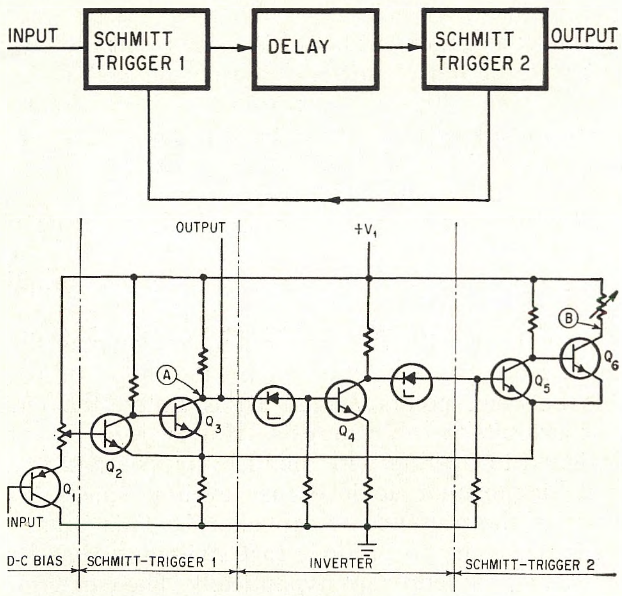
* Now at the University of Michigan, Ann Arbor

The author

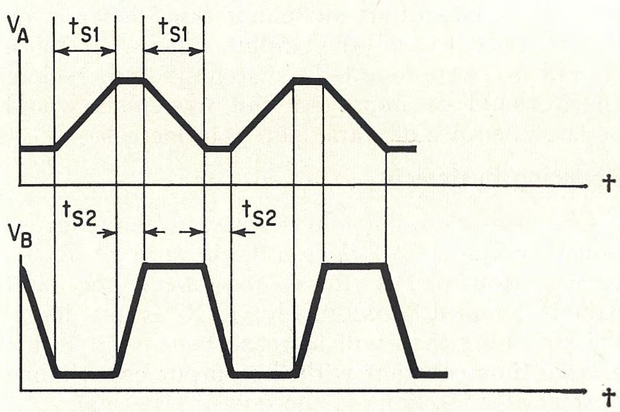
Thomas Weisz, who was a senior engineer at Philips Laboratories, recently returned to the University of Michigan to seek a doctorate. He received his master's degree in control engineering there in 1964.



Standard Schmitt trigger circuit can be represented by amplifier with positive feedback. Open loop characteristics are shown for unity loop gain.



Two Schmitt circuits separated by appropriate delay and with negative feedback reduce hysteresis to near zero, yet maintain high switching speed.



Idealized waveforms of voltages at points A and B of circuit above show theoretical limits of cycle speed.

dynamic loop gain during switching for high speed, while also eliminating the delay introduced by the coupling capacitor C. This is accomplished by a circuit that essentially consists of two Schmitt trigger circuits connected in series with a delay circuit between them, as shown in the block diagram, left. Both Schmitt triggers are direct coupled for maximum loop gain to produce short switching time. As expected, this introduces large hysteresis into the circuit. To overcome this, the second Schmitt trigger is arranged so that directly after the first trigger switches the voltage at the emitter of the first trigger's output stage is restored to a level at which near-unity loop gain is established, resulting in almost zero hysteresis. The delay is introduced so that resetting the emitter voltage does not interfere with the switching cycle itself. An additional benefit of this arrangement is that settings of the tripping point and the hysteresis can be made independently.

In the circuit at the left, transistor Q_1 is part of the input d-c bias circuit and also provides temperature compensation for Q_2 to keep the trigger level constant. Transistors Q_2 and Q_3 form the first Schmitt trigger, Q_4 is an inverter and Q_5 and Q_6 form the second Schmitt trigger. The necessary delay is provided by the propagation delay of the second Schmitt trigger. For maximum switching speed, this delay should be never less than the switching time of the first trigger, or very little more.

Theoretical cycling speeds

At the lower left are waveshapes of voltages at points A and B, produced at maximum cycling speed. Here the rise and fall times of a stage are assumed to be equal; t_{s1} and t_{s2} are the switching times of the first and second stages, respectively.

The theoretical maximum cycling speed of the circuit is then

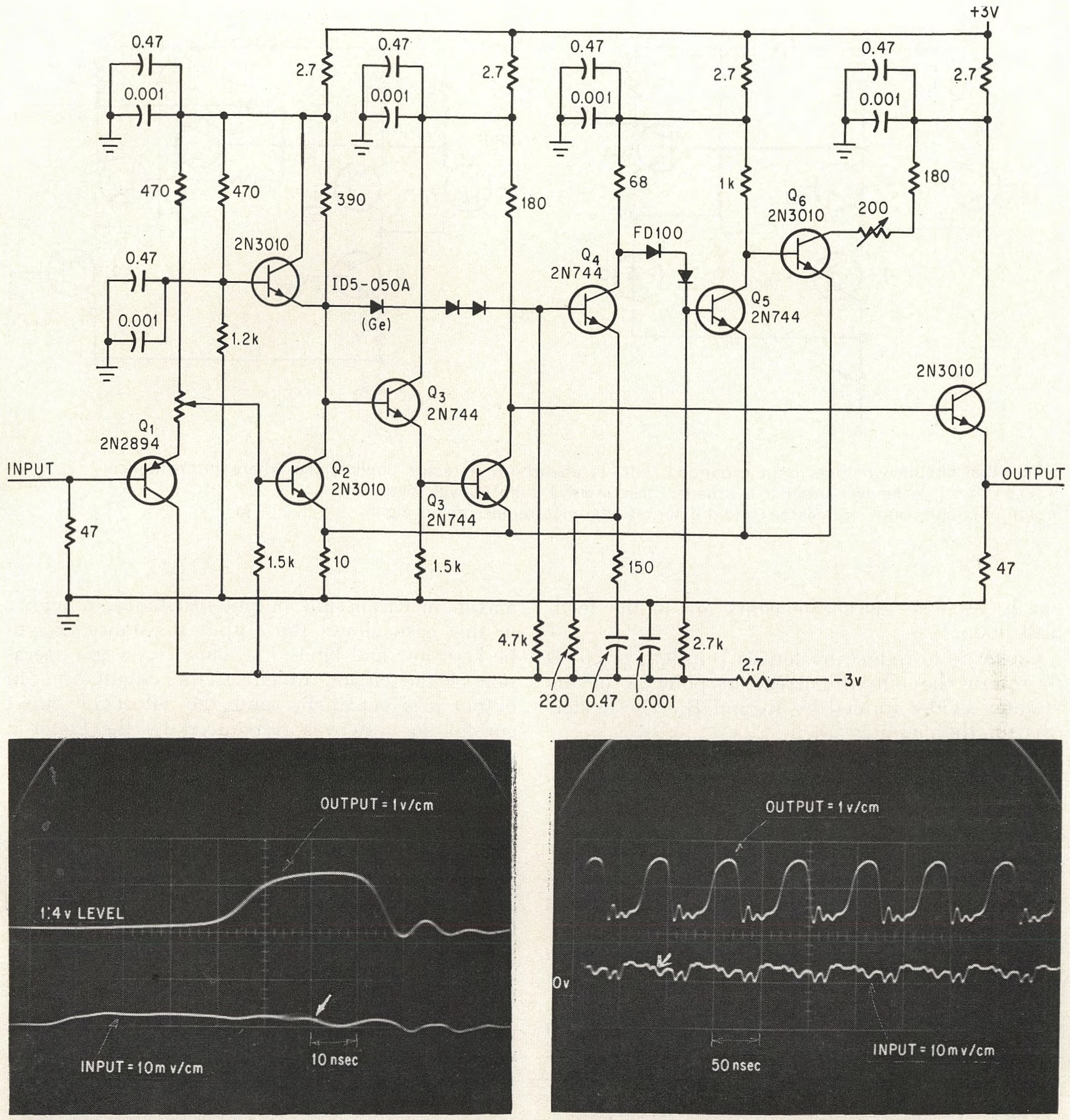
$$f_{max} = \frac{1}{2t_{s1} + 2t_{s2}} \tag{1}$$

When the circuit was actually implemented as shown above, right, t_{s2} was measured and found to be approximately half of t_{s1}. This is because the inputs to the second stage are of relatively large magnitude, while the inputs to the first area are in the millivolt range. Thus for these conditions

$$f_{max} \cong \frac{1}{3t_{s1}} \tag{2}$$

It can be shown that with a hysteresis of 1 mv for an ordinary Schmitt trigger, $f_{max} = 1/50t_s$. Thus, the cycling speed represented by equation 2 is at least 10 times larger than that of the ordinary Schmitt trigger operating at a 1-mv hysteresis.

In actuality, the highest attainable speed of the circuit on page 77 was considerably below the theoretical maximum. It was limited by the



Actual circuit implementation of block diagram on page 76 falls short of maximum theoretical speed, but is at least 10 times faster than conventional Schmitt trigger. Oscillograms show input and output waveforms.

stability of the clamping voltage applied to the collector of transistor Q_3 to prevent saturation. This voltage decreased at higher frequencies, causing the voltage across R_3 to rise and resulting in the failure of small signals to trigger the circuit. Even with this limitation, the circuit performed satisfactorily at 13 megahertz, with a hysteresis of only 2 mv. Input and output waveshapes are shown on the oscillograms above.

Second approach offers simplicity

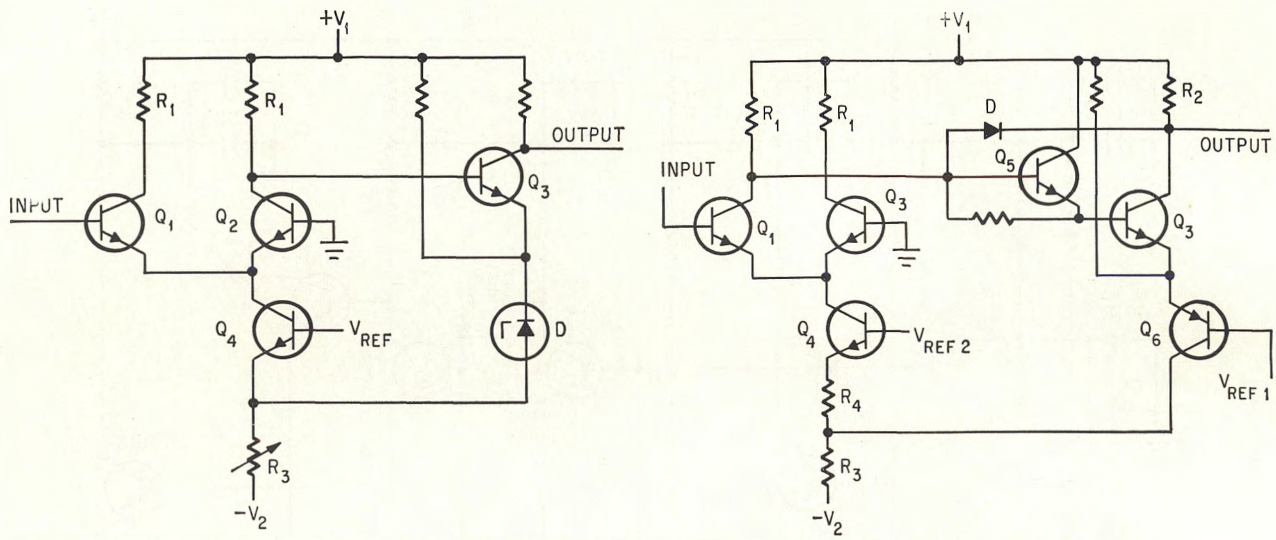
A simpler single-input detector circuit results if a differential configuration like that on page 78 is used. The relative simplicity of this circuit compensates for somewhat poorer performance. In this circuit a differential amplifier with one input grounded replaces the direct coupled Schmitt trigger previously described.

The hysteresis of the circuit is approximately

$$H = \frac{I_o}{2} R_{be} \qquad (3)$$

where R_{be} is the base-emitter resistance of transistor Q_2 as seen from the emitter, and I_o is the output current.

The switching speed is somewhat slower than that of the first single-input signal detector, pri-



Differential circuit with one input grounded (left) is useful for detector applications where performance is less critical. Whenever input 2 is smaller than input 1 then Q_3 will switch off.
In actual circuit, right, transistor Q_6 and external reference replace zener diode.

marily because more transistors are in the feedback loop.

One way to reduce hysteresis [top left, p. 79] is to return the output current to point A of the voltage divider formed by R_3 and R_4. The hysteresis for the circuit is then

$$H = \frac{I_o}{2r} R_{be} \text{ where } \frac{1}{r} = \frac{R_4}{R_3 + R_4}$$

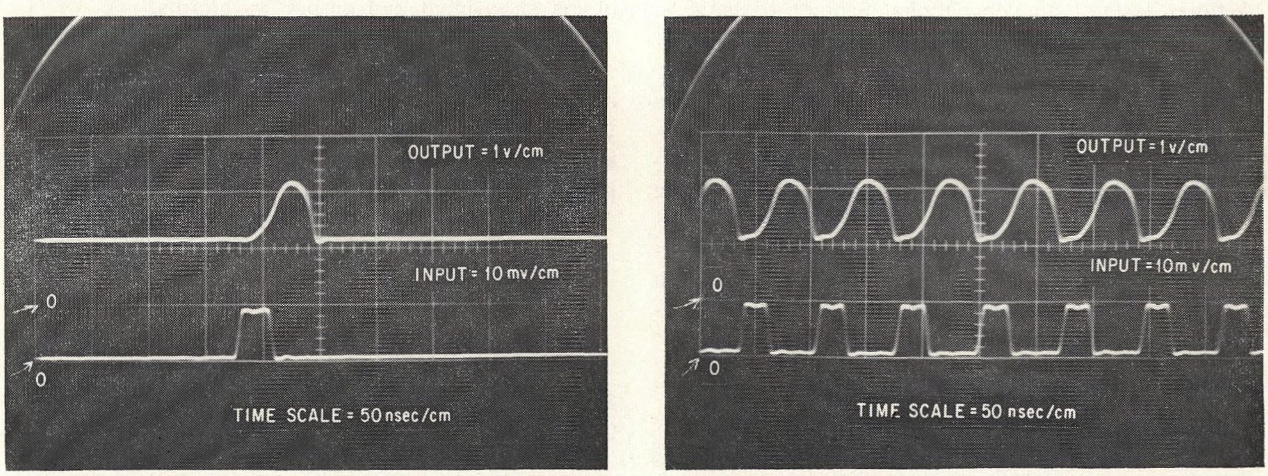
The loss in loop gain due to r is restored by adding a transistor Q_5, as shown in the full circuit above, right. The upper limit of r corresponds, of course, to the point where the over-all loop gain is reduced to unity.

The ability to reduce hysteresis in this way is an important attribute of the circuit in addition to its capability of detecting difference signals. High values of r correspond to a high R_2/R_3 ratio in the circuit on page 76, except that in the previous circuit, the value of R_3 is limited by the maximum permissible output resistance. A high r in this case allows the output resistance, R_2, to be kept low and limits its influence on the operation of the circuit. In effect, the circuit sees an output resistance rR_2, and the effect of ouput current on hysteresis is reduced by the factor r, while loss in loop gain due to this factor is restored with transistor Q_5.

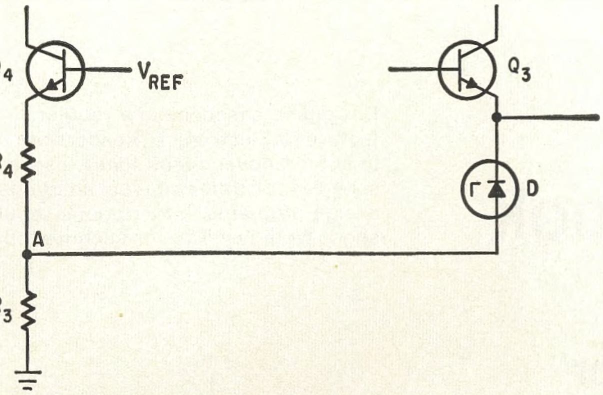
In the implemented circuit the zener diode was replaced by transistor Q_6 and an external voltage reference $V_{ref\ 1}$. When the circuit operates as a single-input signal detector, it can detect 8-mv pulses at a 14-Mhz repetition rate. Typical performance is indicated by the oscillograms shown below.

Differential detector

If the base of Q_2 of the circuit above is disconnected from ground and connected instead to a second input, the circuit will detect the difference



Sensitivity of differential detector, left, is somewhat less than that of direct coupled version at the right.



When the output current is returned to point A of the voltage divider formed by the two resistors, it reduces the hysteresis in the differential detector circuit shown at the top left of page 78.

between input 2 and input 1—that is, Q_3 will switch off whenever input 2 is smaller than input 1. The magnitude of the smallest resolvable difference depends on the circuit hysteresis. A practical realization of the circuit, called a differential input-signal detector, is shown at the lower right of this page.

Transistor Q_7 is an added grounded-emitter output stage to provide low output impedance. The circuit is capable of detecting differences as small as 10 mv at 14 Mhz riding on a common-mode input signal of 0.5 volt peak to peak.

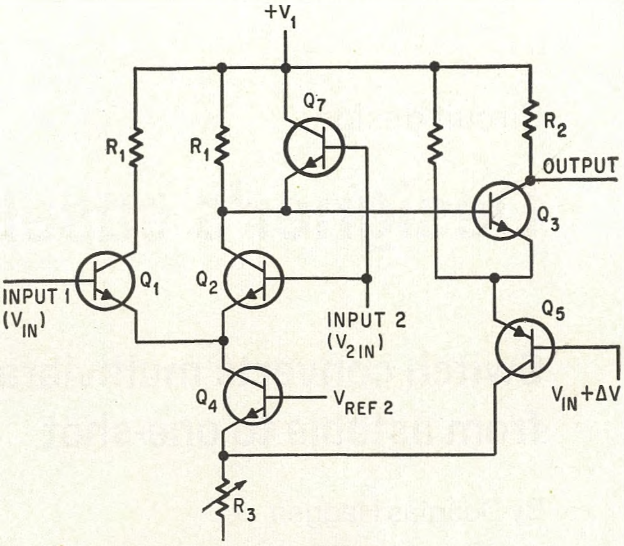
Improved detectors

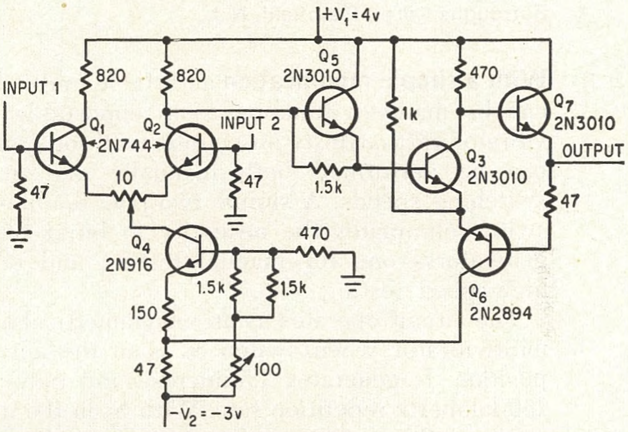
The differential input-signal detector can be employed in the configuration shown in the diagram at the top right. It is similar to the Schmitt trigger configuration discussed on page 76. The hysteresis of the detector circuit can be reduced approximately an order of magnitude by using this arrangement.

The block diagram shown below is another modification of the basic differential detector circuit. The modified circuit can detect the absolute value of the difference between two input signals. Two diodes are connected to the collectors of the transistors in the differential input stage. This circuit detected an absolute difference value of 15 mv between the two inputs at a repetition rate of 14 Mhz. The common-mode noise was 0.5 volt peak to peak.

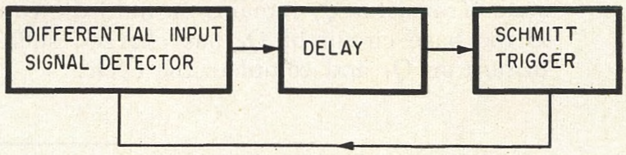
Band detector

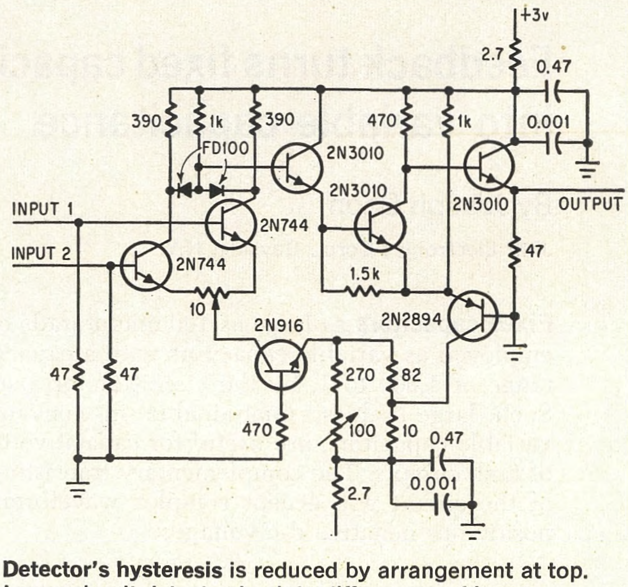
In a useful modification of the circuit shown at right, center, transistor Q_7 serves to reset Q_3 when input 2 reaches a certain value. The sequence of operation is as follows: when input 2 is less than input 1, then Q_3 is turned on. When input 2 rises above input 1 by some preset margin, Δ, then Q_3 will be turned off. When input 2 again exceeds input 1 by Δ, it will turn on Q_7 and output transistor Q_3 will be switched on again. The circuit thus operates as a voltage band detector. It produces an output (Q_3 switched off) when input 2 is within predetermined limits that are above the voltage at input 1.





Differential input detector at top is formed by removing from ground the base of Q_2 in circuit on the top left of page 78 and providing a second input. Additional modification below converts circuit to a voltage band detector.





Detector's hysteresis is reduced by arrangement at top. Lower circuit detects absolute differences of inputs.

Circuit design

Designer's casebook

Designer's casebook is a regular feature in Electronics. Readers are invited to submit novel circuit ideas, packaging schemes, or other unusual solutions to design problems. Descriptions should be short. We'll pay $50 for each item published.

Switch converts multivibrator from astable to one-shot

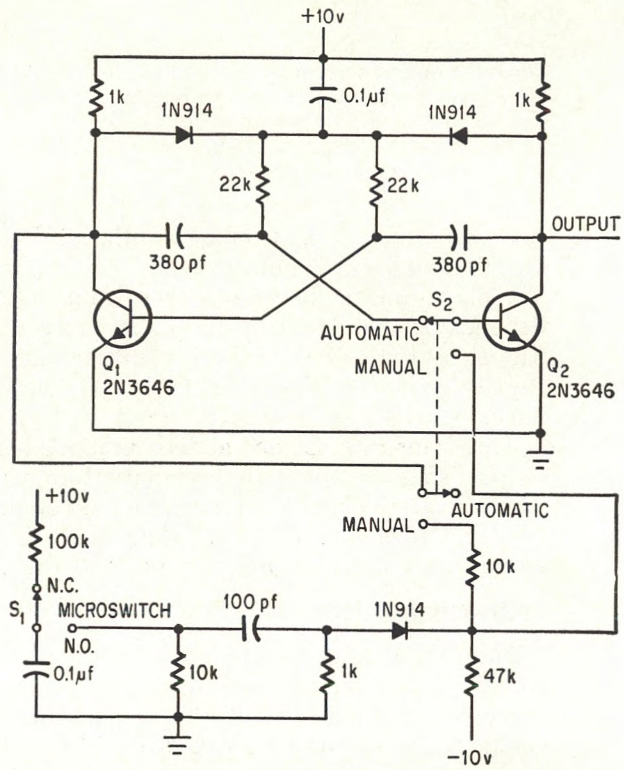
By Douglas Haggen

Burroughs Corp., Plainfield, N.J.

With a simple modification an astable multivibrator can be made to function as a monostable multivibrator so that tests on counter and logic circuits can be performed both manually and at high switching speeds. A simple two-pole double-throw switch eliminates the necessity to build two test generators—one for manual testing and one for high-speed testing.

The circuit operates as an unsymmetrical astable multivibrator when switch S_2 is in the automatic position. It generates 1.5-microsecond pulses at a 150-kilohertz repetition rate. With S_2 in the manual position, the resistance-capacitance coupling to Q_2 is disconnected and the circuit becomes a monostable multivibrator with transistor Q_2 held off.

Microswitch S_1 turns on Q_2 and produces a pulse that triggers the monostable from its stable state. Transistor Q_2 remains on until the capacitor in the base circuit of Q_1 has charged sufficiently to turn on Q_1 and complete the cycle.



Two-pole double-throw switch S_2 allows the circuit to operate as either an astable or monostable multivibrator. Thus, manual and high-speed testing is performed.

Feedback turns fixed capacitor into variable capacitance

By Joseph Gaon

JMR Electronics Corp., Bayside, N.Y.

Fixed capacitors as large as 100 microfarads can be employed as variable capacitors with a capacitance range of 1,000 to 1, by the circuit at top page 81. Such large values, unattainable in conventional variable capacitors, are useful for capacitive tuning of tank circuits. The complementary transistor pairs of the circuit will accept complex waveforms and positive or negative d-c voltages.

If the capacitance control element of the circuit, potentiometer R_1 is replaced by a thermistor or other voltage-controlled resistor, the circuit will act as a voltage-variable capacitor.

Capacitors far smaller than 100 μf can be used. The lower capacitance limit depends on the junction capacitance of the transistors, usually less than 30 picofarads. If the capacitor approaches the junction capacitance, the circuit won't work.

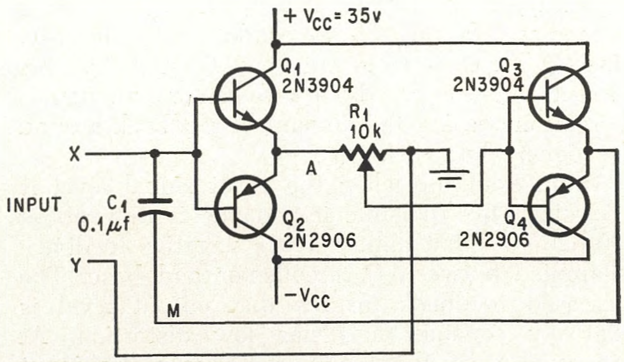
The capacitor, C_1, appears across the input terminals, XY, as a fixed capacitance. The capacitance value is reduced by applying a feedback voltage to the bottom plate of C_1. The feedback voltage is in phase with the input, but its amplitude is lower.

Potentiometer R_1 controls the amount of feedback. With R_1 at point Y the emitters of Q_3 and Q_4 are essentially grounded. This also grounds terminal

M and allows the full magnitude of C_1 to appear across XY. When R_1 is set to point A, the voltage applied to terminals XY also appears between terminals AY and MY. Since the voltages across XY and MY are identical in amplitude and phase, no potential difference exists across C_1. Since no current flows through C_1, the effects of this capacitance across XY is the same as having no capacitor in the circuit.

With R_1 set to its midpoint, half the voltage applied to XY appears across MY and half across MX. This causes half the original current to flow through C_1 reducing C_1 to half of its original value.

Similarly, different settings of R_1 will produce different fractions of C_1's capacitance, according to the relationship $V_{XY} - V_{MY} = V_{XM}$.



Potentiometer R_1, buffered on both sides by complementary emitter followers, reduces the effective capacitance value of fixed capacitor C_1. This reduction is accomplished by applying a feedback signal to the bottom plate of the fixed capacitor, C_1.

Agc amplifier handles 60-db range

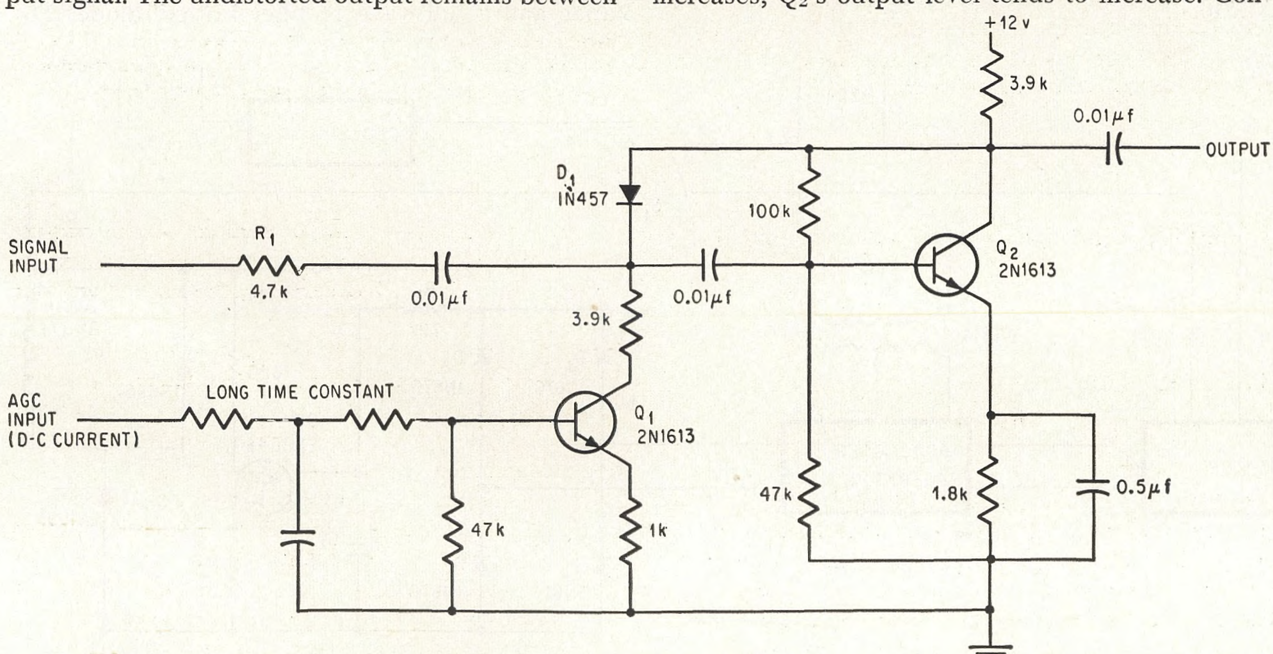
By Murray F. Feller

M.F. Feller Industries, Santa Maria, Calif.

The automatic gain control circuit shown accepts a larger range of input signal levels than conventional circuits and produces a low-distortion output signal. The undistorted output remains between 0.5 and 1.5 volts while the input signal varies over a 60-db range from 0.5 millivolt to 0.5 volt. Input signal frequencies range from 20 hertz to 100 khz.

Designed as a low cost agc amplifier for pleasure-craft sonar, the circuit also has applications in communication receivers and control systems. Basically the circuit operates by controlling the negative feedback between the collector and base of Q_2. The amount of feedback depends on the dynamic impedance of diode D_1, which in turn depends on the collector current of Q_1.

A d-c voltage proportional to Q_2's output is applied to the terminal. As the input signal level increases, Q_2's output level tends to increase. Con-



Automatic gain control circuit maintains a relatively constant output level by varying D_1's dynamic impedance, which controls the negative feedback around Q_2.

sequently, the proportional d-c voltage also tends to increase, forcing Q_1 to conduct more heavily. Since Q_1's collector current flows through D_1, this current reduces the diode's dynamic impedance, thereby increasing the amount of feedback around the region of transistor Q_2.

As an example, when the input signal level is 1.5 volts, D_1's dynamic impedance is only about 100 ohms so that almost 100% negative feedback is applied between Q_2's collector and base. The increased feedback insures that output level is relatively constant and has low distortion. At the same time the feedback reduces the input impedance to amplifier stage Q_2. As a result, the input signal produces a larger voltage drop across resistor R_1 and allows larger input signals.

In contrast, at low input signals there is only a small d-c current flowing through D_1, so that Q_2 operates as a high gain, common emitter stage. At the same time, Q_2's input impedance is high so that the voltage drop across R_1 is negligible. Therefore at low input levels, the circuit provides the maximum possible gain.

For 60-db control, the input current ranges from 0 to 0.1 milliampere. This corresponds to a voltage of approximately 0 to 2 volts at Q_1's base. The coupling capacitor must be selected for the desired frequency of operation. Usually, the time constant of the RC circuit at Q_1's base is made longer than the lowest period of interest.

Time will tell how fast a motor revs up

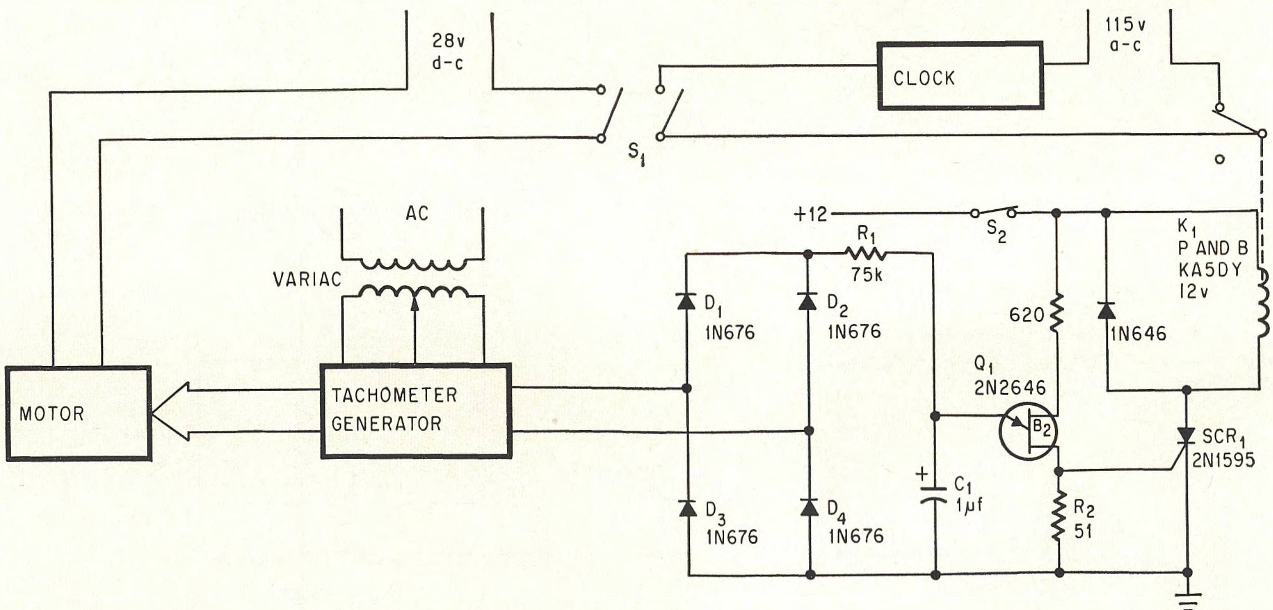
By Richard Traina

Airborne Accessories Corp., Hillside, N.J.

Clocking the time a motor takes to reach a known speed is an easier way to find its average acceleration than poring over oscillograms. The motor being tested, such as one for an aircraft actuator, will clock itself with the help of an electric tachometer generator and a unijunction transistor, such as a 2N2646.

To set up the test, the circuit shown below is adjusted by using a motor of known speed and the Variac to establish the tachometer voltage output that causes the unijunction transistor, Q_1, to trigger the silicon controlled rectifier, SCR_1, and close relay K_1. Then, the standard motor is replaced by the motor to be tested, the circuit is reset with switch S_2 and the motor and the clock are turned on with S_1. The clock runs until K_1 trips. Then by dividing the known motor speed by the elapsed time, the average acceleration of the motor under test can be calculated.

Except for adjustment during setup, the circuit operation is essentially the same for clocking. The tachometer generator's a-c output goes through the Variac and a full-wave rectifier bridge, diodes D_1



Clock runs until tachometer output increases beyond the peak point voltage of Q_1, firing SCR_1 and tripping the relay. Elapsed time is used to calculate motor acceleration.

through D_4. The bridge output voltage is applied across R_1 and C_1. As long as the peak voltage is below the peak point voltage, V_p, of Q_1, the unijunction transistor's emitter is reverse biased. The value of V_p is obtained from the relationship,

$$V_p = NV_{BB} + V_D$$

where N is Q_1's intrinsic standoff ratio, V_{BB} is the voltage between base one and base two of Q_1 and V_D is the forward voltage drop of the emitter base one diode.

When the motor speed starts to go above the preset speed, the peak output voltage of the generator rises above V_p. The emitter of Q_1 becomes forward biased and delivers a voltage pulse across R_2. The pulse turns on the silicon controlled rectifier, scr_1, which transfers and latches K_1, stopping the clock. Both the motor and clock have power supplies.

Scr triggered by capacitor lowers cost of oven control

By Dale E. LaPlante*

Consolidated Electrodynamics Corp., Pasadena, Calif.

Varying the charge on a capacitor, to control the firing angle of a silicon controlled rectifier regulates an oven by proportionally controlling the time current flows through the heating coil. The circuit, shown below, is compact, easily packaged, and costs less than circuits that trigger the scr with a unijunction transistor and zener diode.

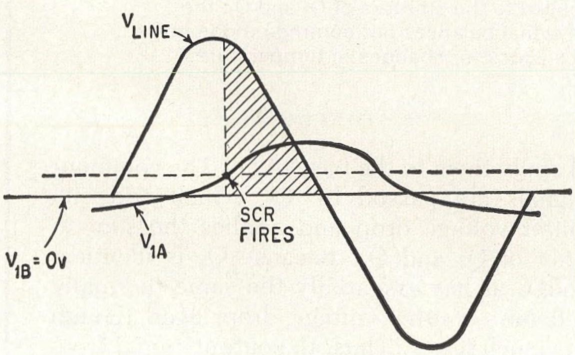
The scr, in series with the heater, is forward biased only during positive half-cycles of line voltage. It restricts heater current to the shaded area of the cycle shown under the V_{LINE} curve. The point at which the scr fires is controlled by voltage V_1, at capacitor C_1.

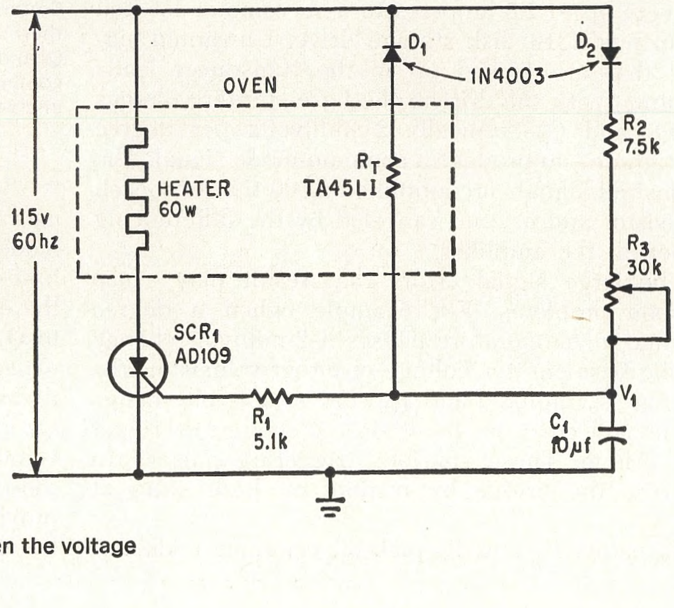
V_1 consists of a line frequency component V_{1A} and a slowly-changing d-c bias level V_{1B}. The capacitor's reactance shifts phase of V_{1A} 90° forward with respect to line voltage and its time constant determines the slope of V_{1A}'s waveform. As C_1 and its time constant increase, it limits the peak voltage charge of C_1 during each half-cycle. Larger values of C_1 reduce the amplitude of V_{1A}.

As the waveform shows, small changes in the level of V_{1B} will bias V_{1A} above or below the zero voltage reference. This vertical displacement of V_{1A} changes the point in the interval at which V_{1A} crosses the 0.5-volt line, firing the scr. When the d-c level is so low that V_{1A} drops below zero, the scr never fires and the heater is fully off. When V_{1B} increases so that all of V_{1A} is biased above 0 volt, the scr is no longer controlled by V_1. The positive half-cycle of line voltage turns the scr on and off and the heater gets full power.

The amplitude of V_{1A} is fixed by the value of C_1. The scr firing point in the interval is controlled by V_{1B}, the slowly-changing d-c bias on capacitor C_1. Imbalance in the charging current produced by the positive and negative half-cycles of line voltage determines V_{1B}. In positive half-cycles, current flows through D_2, R_2, R_3 and C_1 to ground, charging C_1 plus on the top plate. In negative half-cycles current flows up through C_1, R_T,

* Now with Datex Corp., Monrovia, Calif.





Scr_1 is triggered by the voltage V_1 across capacitor C_1 when the voltage reaches the 0.5-volt level indicated by the dotted line.

and D_1, charging C_1 plus on the bottom plate.

Oven temperature is selected by adjusting potentiometer R_3 so that the series resistance of R_2 and R_3 equals the resistance of thermistor R_T at the desired temperature. The oven temperature is stabilized when the current through D_2 and C_1 on the positive half-cycle and through C_1 and D_1 on the negative half-cycle are the same; there is no net charge on C_1, and V_{1B} is zero.

When the oven is too cold, the resistance of R_T exceeds that of R_2 plus R_3, so less current flows through C_1 and D_1 on the negative half-cycle. The resulting positive charge on C_1 vertically displaces V_{1A}, causing it to fire the scr earlier in the positive half-cycle. More current then flows in the heater.

If the oven gets too hot, the resistance of R_T becomes less than R_2 plus R_3. (R_T is 50 kilohms at 25°C and decreases as temperature rises.) The current imbalance places a negative voltage on C_1, dropping the level of V_{1A}. This delays the firing of the scr and reduces the heater current.

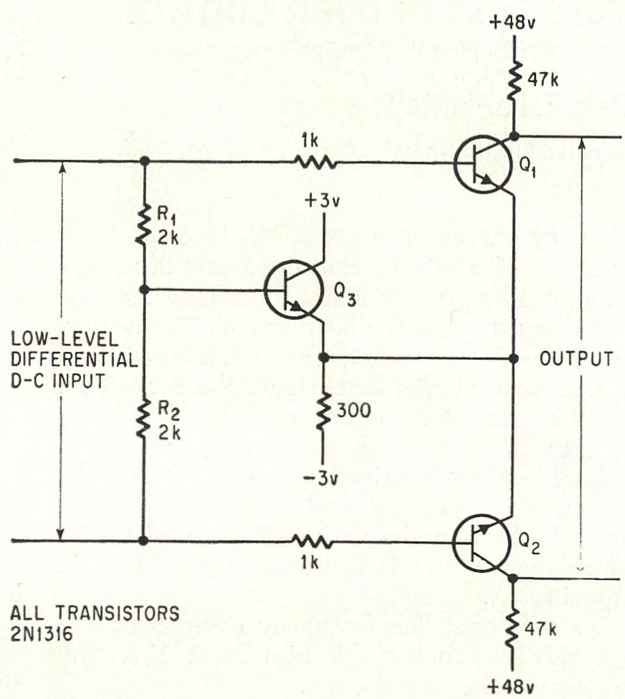
After the scr fires, its gate voltage rises slightly, tending to charge C_1 positively. This effect is minimized by R_1.

Forward feed stabilizes d-c differential amplifier

By F.J. Sordello

Systems Development Division,
International Business Machines Corp.,
San Jose, Calif.

Common-mode noise and thermal drift are canceled out in d-c differential amplifiers when the input signal is fed forward. This technique allows the amplifier at the right to be operated in a stable manner at a gain of 2,000. The conventional approach, feedback of the amplifier signal, causes instabilities because distortions of the signal by constant current generators are also fed back within the circuit.

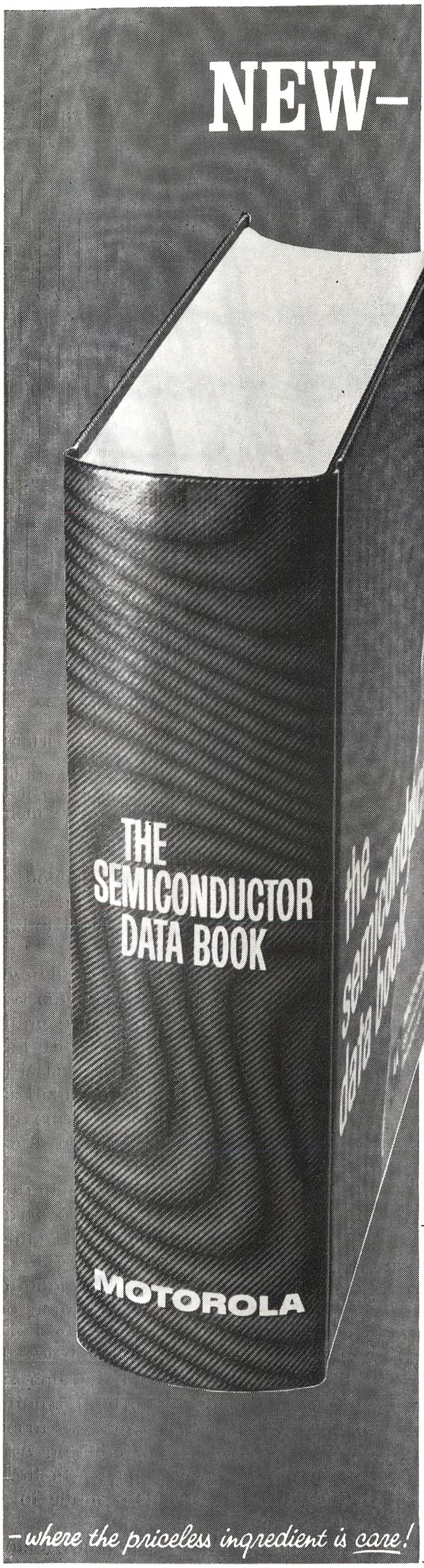


Common-mode signals are combined with the thermally generated base-emitter voltage of Q_3 and applied to the emitters of Q_1 and Q_2; the combined signal balances out common-mode noise and compensates for changes in temperature.

Designed as a high-gain d-c preamplifier, the feed-forward circuit amplifies differential d-c signals of low level from a velocity transducer and applies them to a bridge power supply. The bridge circuit delivers up to 2.5 amperes to a servomotor located in an IBM 2310 disk storage drive. Unwanted signals that are picked up in the transducer leads combine with the drift in the base-emitter voltages of Q_1 and Q_2—typically 2 millivolts per degree centigrade—to produce a common-mode signal. The undesired signals are amplified 2,000 times by each transistor and are not canceled by the differencing action of the amplifier.

The large signal errors that result may cause serious problems. For example, when a degree change in temperature causes a 2-millivolt change in the base-emitter voltage of either transistor, the change is amplified and appears as a 4-volt change at the collector; the 4-volt shift is enough to trigger the bridge. These spurious triggering pulses can destroy the bridge by turning on both sides at once.

Resistors R_1 and R_2 pick off common-mode signals and apply them to the base of Q_3. The common-mode signals are passed by Q_3, which adds its base-emitter voltage drop and applies the sum to the emitter of Q_1 and Q_2. Because Q_3 is identical to Q_1 andQ_2, it has essentially the same thermally generated base-emitter voltage drop, even though its bias is much lower. Thus, the output signal from Q_3 includes both the thermal-drift voltage and the common-mode noise. The combined signal cancels those at the base of both transistors Q_1 and Q_2 and provides a locked-in temperature compensation for the circuit.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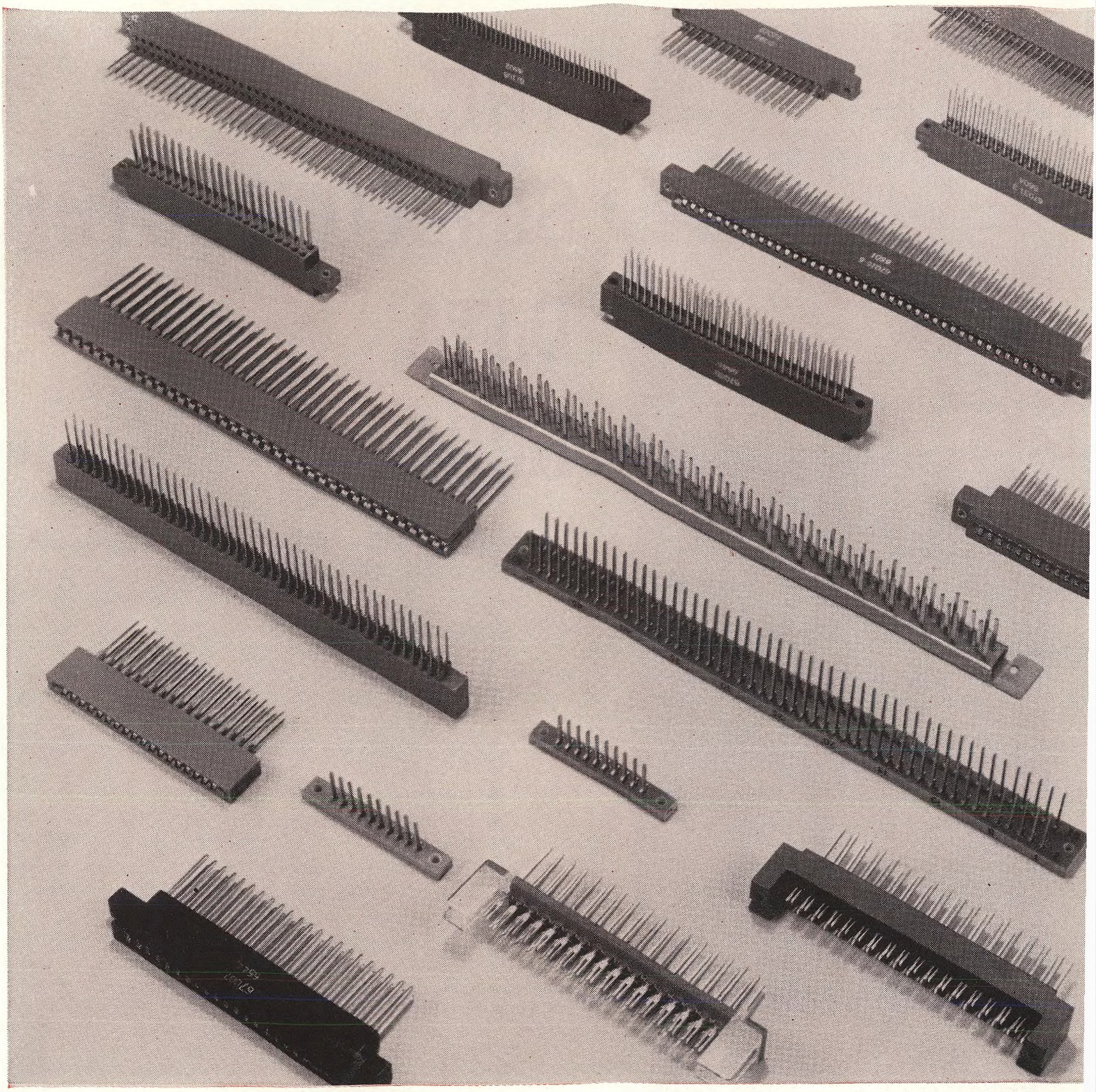

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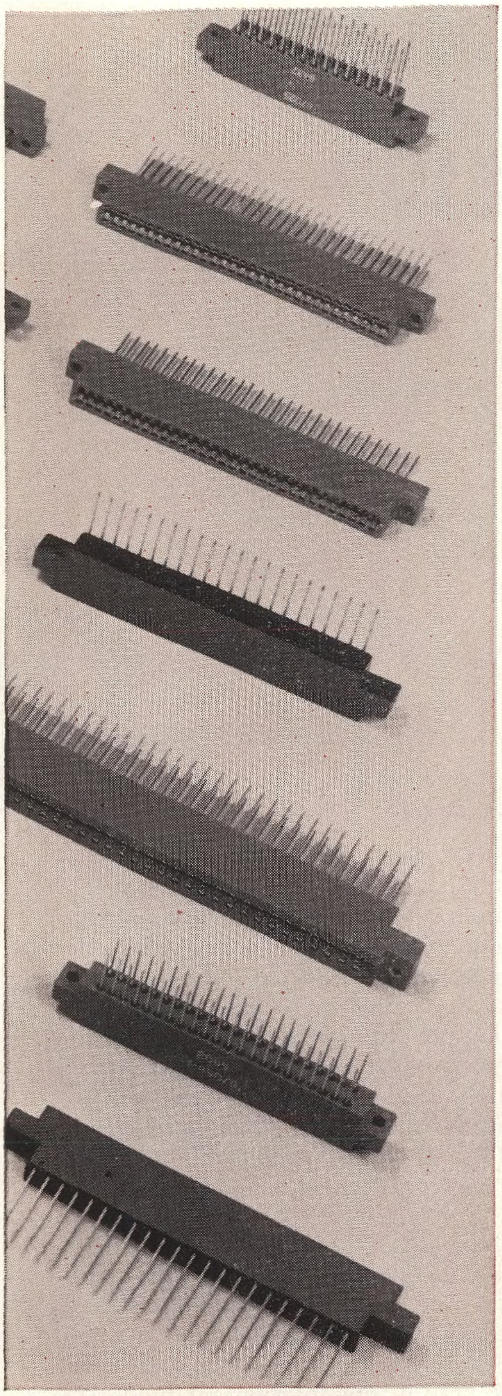

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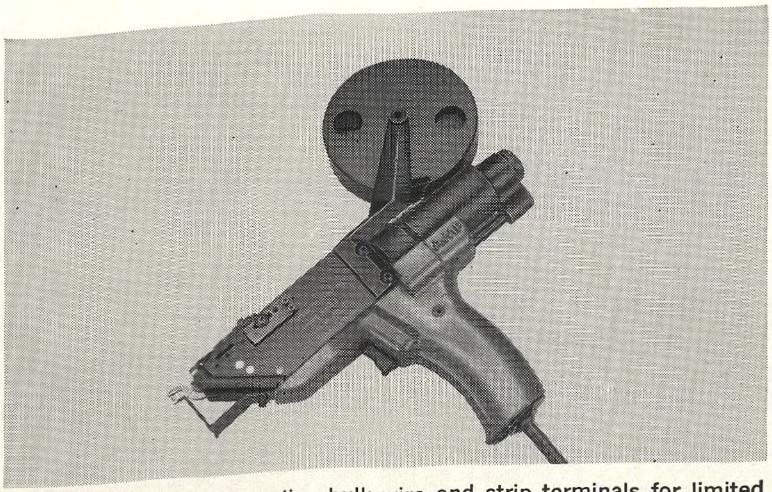
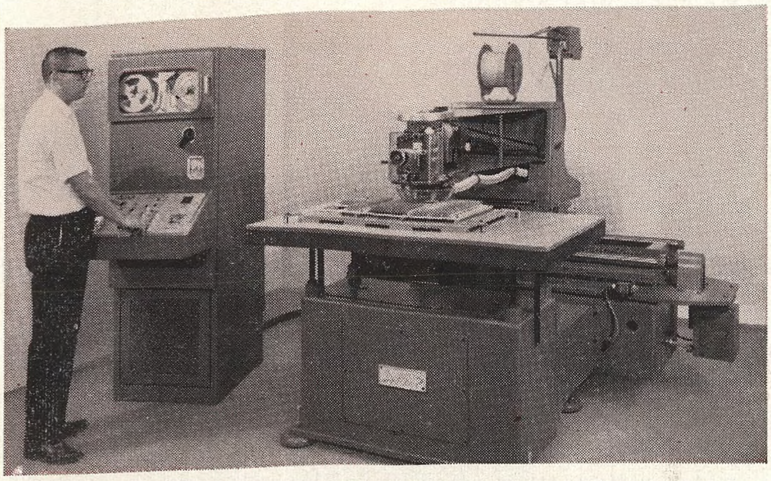


Lightweight hand tool applies bulk wire and strip terminals for limited volume production.



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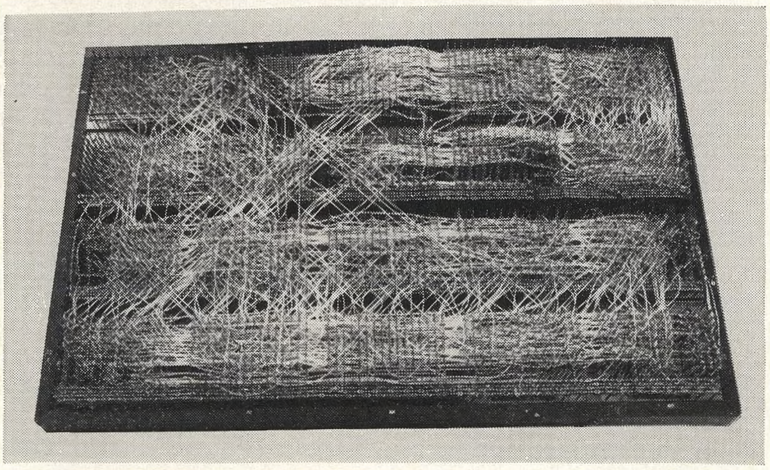

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Circle 87 on reader service card

Digital meters for under $100

Miniature voltmeter and counter, built for one-tenth the usual cost, points the way to using IC's for digital multimeters that everyone will be able to afford

By Hermann Schmid

Defense Electronics Division, General Electric Co., Utica, N.Y.

Soon, engineers and technicians—even students and hobbyists—will be measuring voltage, current, and resistance on miniature electronic instruments with numeric readouts. The small size and low cost of linear and digital integrated circuits makes it possible to build digital volt-amp-ohm meters that are as small and as inexpensive as conventional electromechanical multimeters.

To prove this point, the author built a digital instrument, called the Miniature Digital Voltmeter and Counter (MDVC). It is only 4½ inches square by 2 inches high. With the rapid decrease in prices of integrated circuits, it should soon be possible to build a multimeter version of the MDVC that would sell for less than $100. It could measure currents and resistances as well as voltages, with minor changes in the design—shunt instead of series resistors and external instead of internal input resistors.

Recent and anticipated developments in integrated electronics should allow further reductions in size and cost of the instrument, as described on page 94. The integrated circuits are those available off-the-shelf a year ago and the design represents a minimum amount of engineering effort, so it is not indicative of what can be achieved in the future. It takes little imagination to predict digital multimeters the size of a cigarette package that can be slipped into a shirt pocket similar to a transistor radio.

The author

This is Hermann Schmid's third byline in Electronics this year. In the Jan. 10 issue, he told how integrated circuits could replace electromechanical resolvers and in the Nov. 15 issue, he described the design and use of an integrated circuit current divider as an analog-to-digital converter. An armament computer engineer at the General Electric Co., Schmid's productivity is demonstrated by 13 patents and 11 patents pending on analog, hybrid and digital computers.

Prototype digital meter

Most of the MDVC's circuitry is composed of off-the-shelf monolithic IC's—three linear amplifiers and 20 logic circuits. The monolithic logic IC's are primarily multifunction types having more than one circuit in a single package.

The values of the analog input voltages are converted into proportional pulse-width signals by the up-down integration technique, a form of pulse-width modulation that makes measuring accuracy independent of the integration time constant.[1,2,3] The pulse width is converted to a digital value by a four-decade counter and is displayed on numerical readout tubes.

In the MDVC, three voltage ranges—1, 10 and 100 volts—and one time-interval counter range—0 to 10 milliseconds—are provided. Measurements are made at a rate of 50 per second to an accuracy within ±0.02% of full scale as a voltmeter and within ±0.01% as a time-interval counter. The input impedance is 156 kilohms on all voltage ranges and, since the MDVC is battery powered, the input is truly differential. The prototype has mercury batteries, but rechargeable nickel-cadmium cells would be preferred in future instruments.

Except for input impedance, the performance is comparable to that of conventional four-digit voltmeters costing $1,000 or more, weighing at least 25 pounds and requiring more than 1,000 cubic inches of space.

The MVDC proves that digital multimeters need no longer be limited to laboratory applications. Small size and low cost will prompt wide use of such instruments for bench testing in factories, homes and schools, and will mean portable instruments for commercial and military servicemen. They

Battery powered digital voltmeter and counter is small enough to go into a technician's kit for field servicing of equipment. The circuitry, shown on page 92, is made up mostly of off-the-shelf integrated circuits.

will also be built into commercial, industrial and military control and computation equipment as displays and limit detectors of analog variables. Built-in test equipment is expected to be an important military application.

Up-down integration

Successive approximation or voltage-to-frequency conversion techniques are commonly used in digital voltmeters to change analog voltages to digital values. But designers are switching to techniques more suited to IC's, such as up-down integration.

The instrument's pulse-width modulator converts the unknown input voltage V_x [see diagram p. 91], into a pulse-width signal, t_x. In turn, t_x transfers the content of the continuously operating master counter to the buffer and readout circuits. At the beginning of the period represented by t_x, the counter is reset to 0. At the end of the period, therefore, the number in the counter is proportional to V_x. Converted from the binary-coded decimal value in the counter to a decimal value, the voltage is read directly on the Nixie tubes.

Unlike the widely used ramp type of pulse-width modulation, which requires a single period, up-down modulation requires two periods. These are shown as T_1 and T_2 under the waveform (which gives the up-down technique its name) in the diagram on page 91.

During T_1, which has a precise and constant duration, input V_x is integrated so that at the end of T_1 the output voltage of the integrator is directly proportional to V_x. That is

$$V_{01}(T_1) = \frac{1}{RC}\int_0^{T1} V_x\,dt = V_x\frac{T_1}{RC}$$

in which RC is the integrator time constant and t is the independent variable.

During the second period, T_2, a reference voltage, V_R, opposite in polarity to V_x, is integrated until the integrator's output is again zero. Therefore, the following relationship is valid

$$V_{02}(t) = V_{01}(T_1) - \frac{1}{RC}\int_0^{T1} V_x \, dt$$

Solving for $t = t_x$ and setting $V_{02}(t_x)$ equal to zero gives

$$V_{02}(t_x) = 0 = V_x \frac{T_1}{RC} - V_R \frac{t_x}{RC}$$

where

$$t_x = \frac{V_x}{V_R} T_1$$

The final equation shows that t_x is completely independent of the integrator time constant, RC. While this is the greatest advantage of the up-down technique over the ramp technique, there are other advantages:

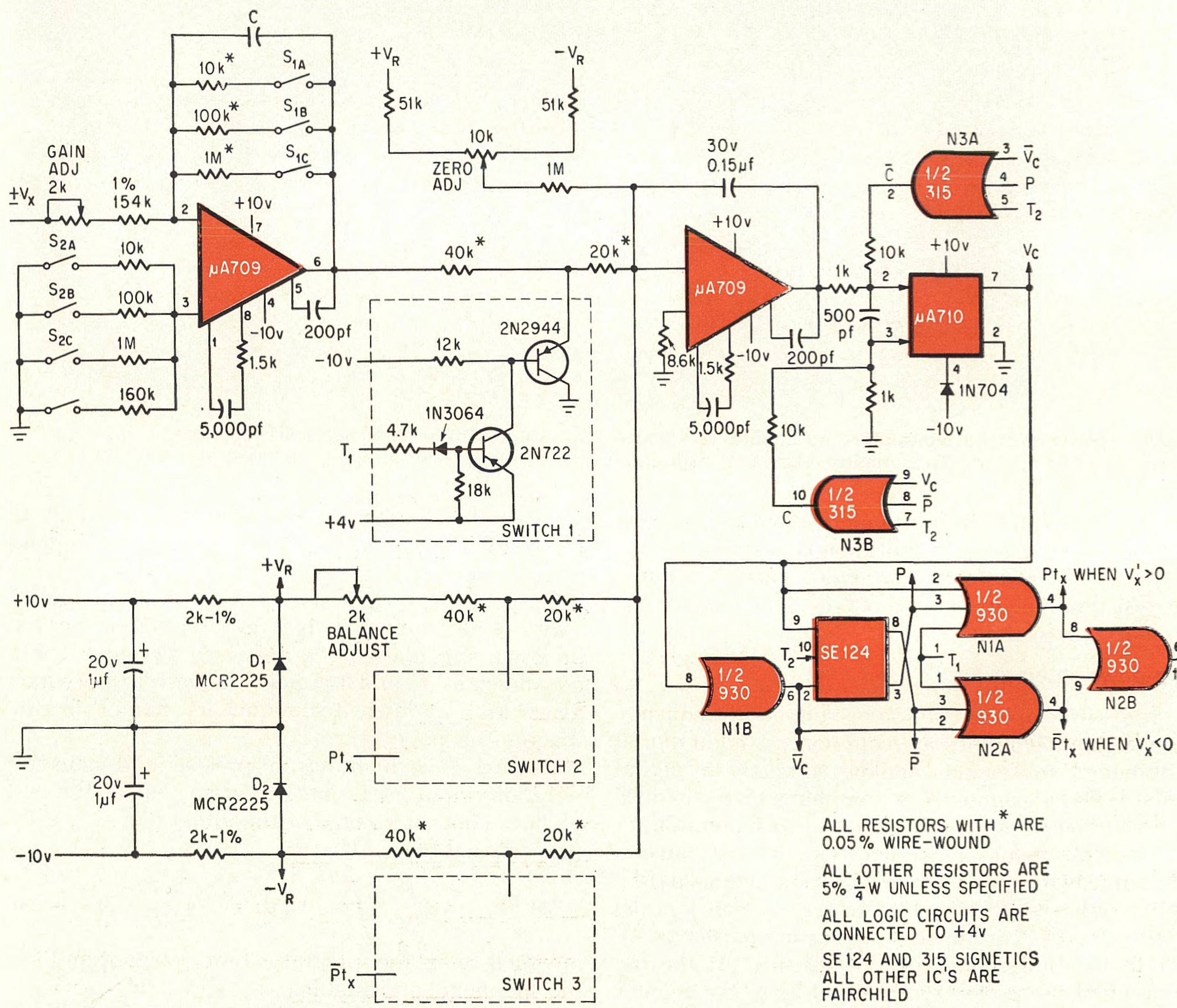
- t_x is independent of the initial integrator voltage.
- t_x is only a function of the ratio V_x/V_R and of T; T can be held extremely constant.

Pulse-width modulator

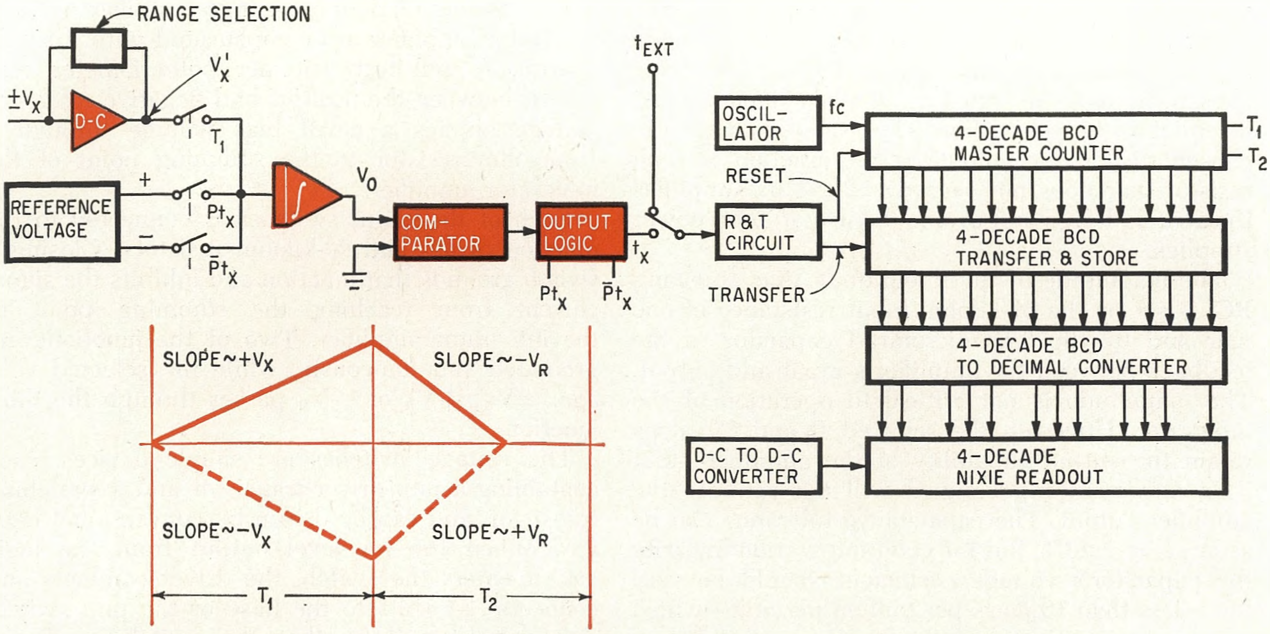
The analog portion of the MDVC, its pulse-width modulator, is mounted on one printed-circuit board. Another board carries the digital portion. There are six basic types of circuits in the modulator diagram shown below—range selection, integrator, comparator, three solid state shunt switches, output logic and reference voltage.

The modulator accepts a bipolar input voltage, $\pm V_x$ and produces a pulse-width signal, t_x, on one output line and on-off polarity signals on two other lines. The timing signals, T_1 and T_2, are generated by the master counter in the digital portion.

The modulator's accuracy is high for all positive and negative inputs, except for a small region around zero, ±10 millivolts. The reason for this is indicated by the up-down, integration waveform on page 91. As V_x becomes smaller, the slope of



Pulse-width modulator forms the analog portion of the digital voltmeter. Range amplifier, integrator and comparator are based on linear integrated circuits, the colored blocks at the top. Digital IC's form the output logic section at the lower right.



Up-down integration technique is indicated by the waveforms in color. Pulse-width modulator, the circuits in color at the left, provides a pulse that is proportional to the input voltage. Width depends on the time required to return the voltage to zero. Digital circuitry at the right converts the pulse width to a numerical indication of the voltage.

the integrator output voltage, V_0, approaches zero until V_0 is smaller than the minimum voltage required to trigger the comparator. The zero deadband can be eliminated by appropriate biasing of the comparator, with an insignificant loss in output resolution.

The analog and digital waveforms at the various points throughout the pulse-width modulator for various input signal amplitudes are illustrated at the right.

Range selection

Voltage ranges are manually selected by attenuating or amplifying V_x, by inserting one of the precision resistors at the top left of the schematic into the feedback path of the first IC amplifier. This is done with one pole of a two-pole, three-position switch; the other pole connects identical impedances—the resistors at the left—to the noninverting input of the amplifier.

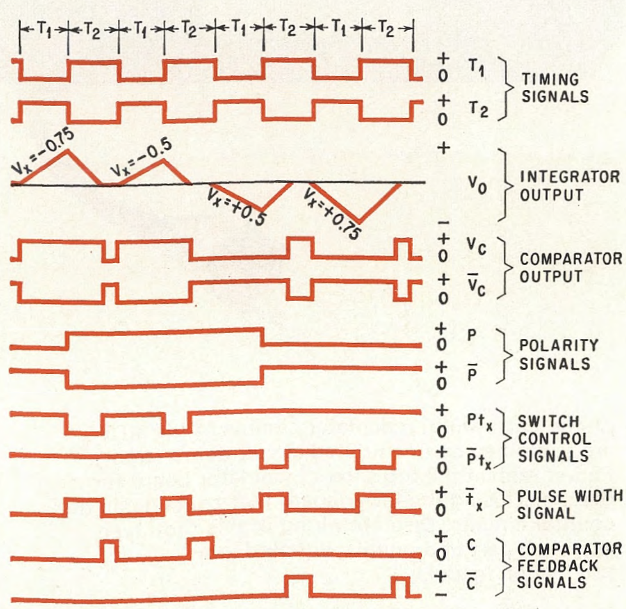
A constant input impedance on all ranges is obtained by changing feedback resistors rather than input resistors. Input impedance, approximately 156 kilohms, can be varied ±2% by the trimmer potentiometer to obtain small variations in gain. With 156 kilohms in the input and 10, 100 of 1,000 kilohms in the feedback (corresponding to input ranges of 100, 10 or 1 volts), the range amplifier's output is always about 6.4 volts, the magnitude of the reference voltage.

The reference voltages play an important role in the pulse-width modulator, since it is the ratio V_x/V_R that solely determines the value of the output signal, t_x. The reference circuit of the prototype MDVC has only two zener diodes, a potentiometer and two resistors. The zener current is determined by the 2-kilohm resistors. The 2-kilohm trimmer potentiometer provides a control to balance the positive reference voltage with the negative reference voltage. The zener voltage of the low-current diode (MCR 2225) is 6.4 ±5%.

Integrator operation

The second IC amplifier integrates V_x', the range amplifier's output, during T_1 and then integrates $+V_R$ or $-V_R$, depending on V_x polarity, during T_2.

The voltage to be integrated is selected by



Waveforms at the points indicated in the block diagram above and the schematic of the pulse-width modulator on page 90 are shown for various signal amplitudes.

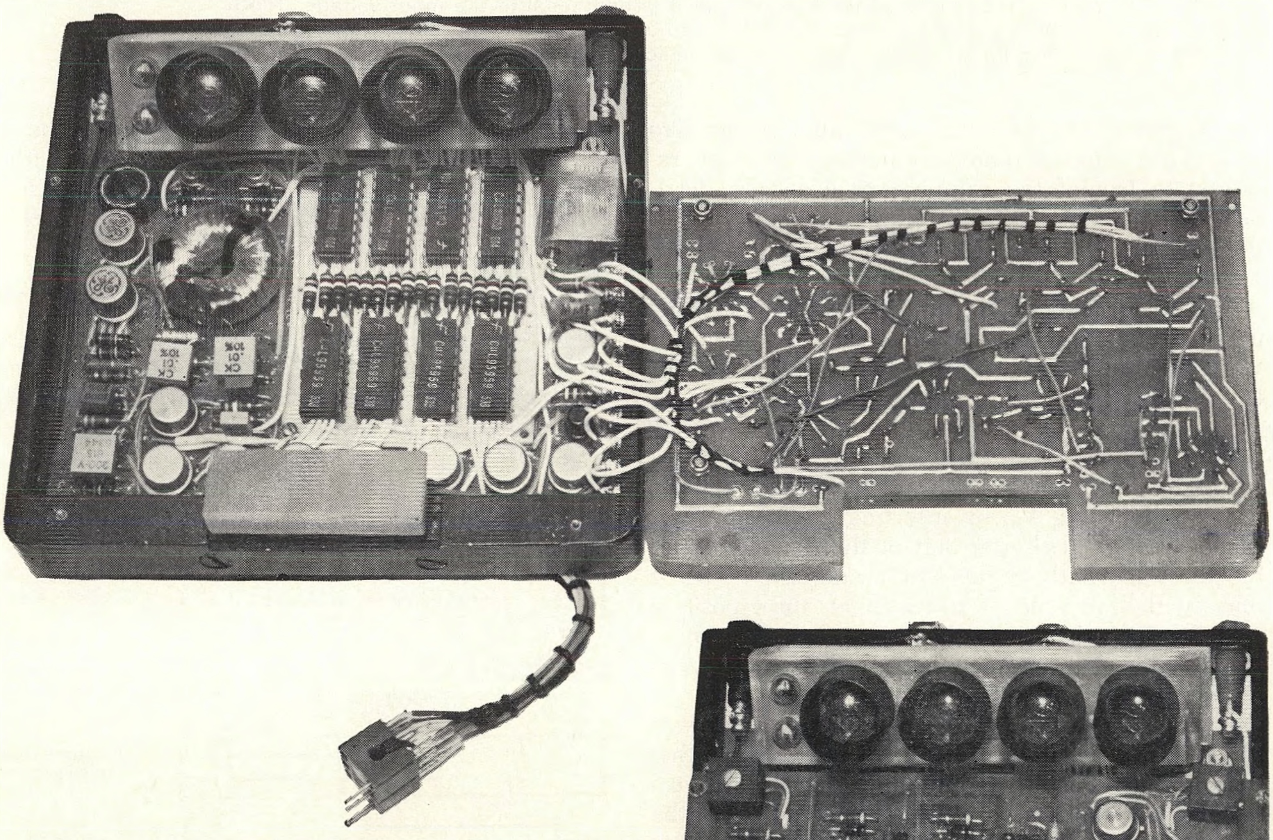
grounding two of three resistor pairs with three shunt switches, under control of the output logic and the master counter. Precision resistors were chosen, because the sums of the resistor pairs must be equal for proper scaling. The resistor values were chosen so that the voltage at the junction of each resistor pair does not exceed ± 2v. This simplifies the switch design and avoids the use of extra power supplies.

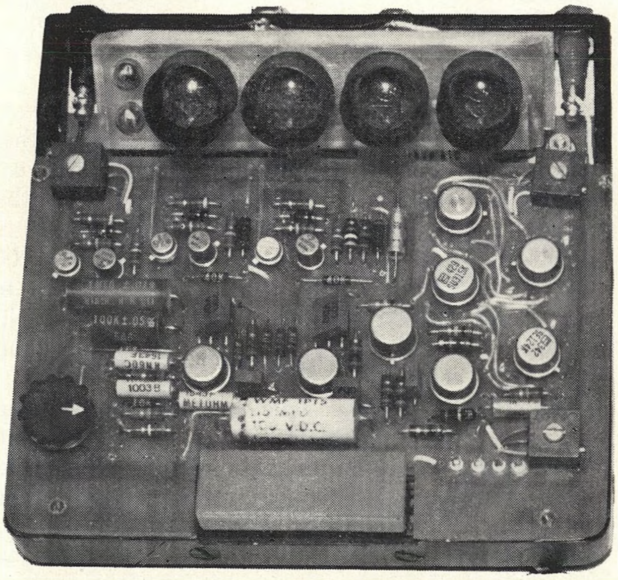
The magnitude of the integrator's time constant, RC, is set by the 60-kilohm input resistance of one pair and by the 0.15-microfarad capacitor in the feedback between the amplifier's input and output. The magnitude is not critical to operation of the integrator. However, the selected R and C values retain the output capability of the amplifier—that is, a maximum input signal will not saturate the amplifier output. The capacitance tolerance can be as large as $\pm 20\%$, but for good integration linearity the capacitor's voltage coefficient should be very low—less than 10 parts per million per volt—which is true of most paper capacitors.

Zero offsets of both the range amplifier and the integrator amplifier are compensated with a single control. A multiturn trimmer potentiometer connected between the positive and negative reference voltage applies a small bias voltage through a 1-megohm resistor to the summing point of the integrator amplifier.

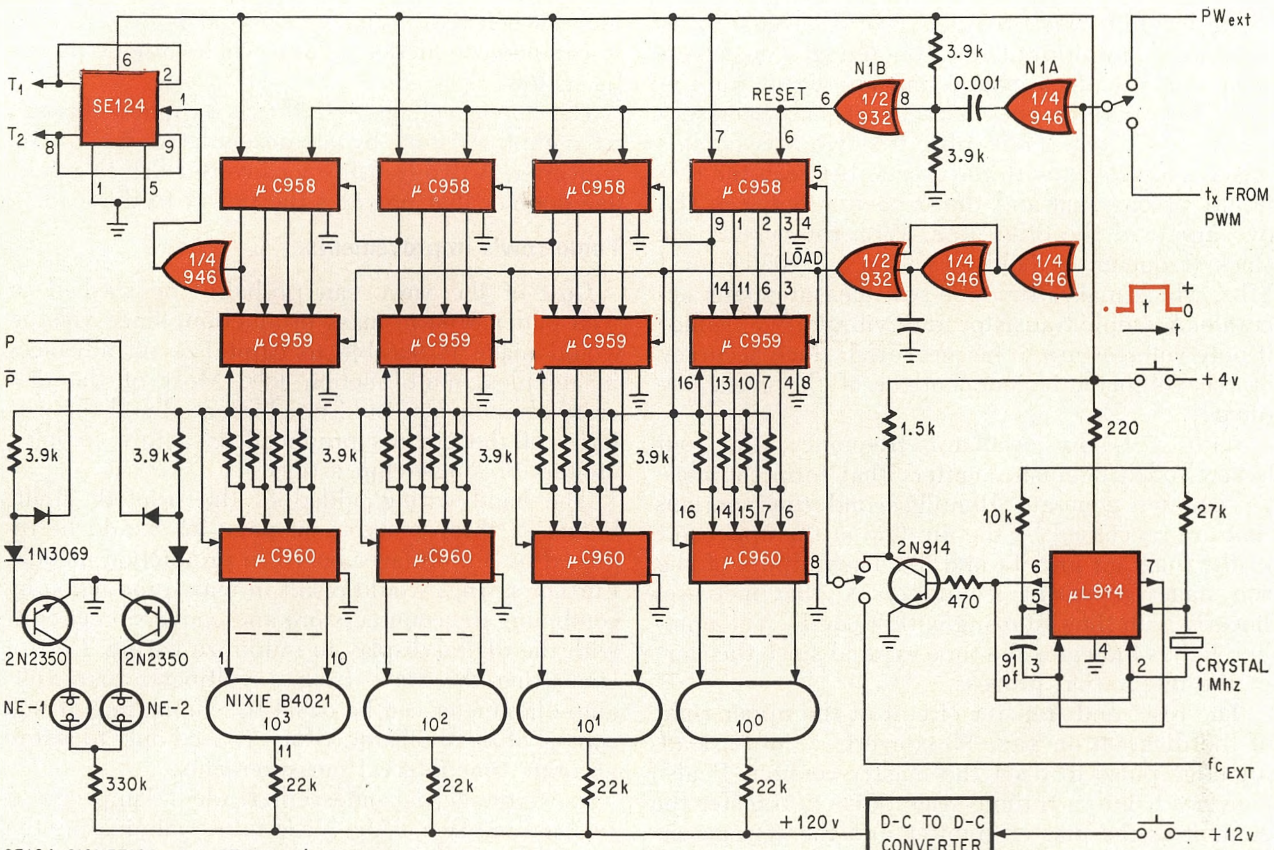
Each of the shunt switches is connected to the junction of 40- and 20-kilohm resistors. Closing a switch grounds that junction and inhibits the signal current from reaching the summing point of the integrator amplifier. Two of the junctions are grounded simultaneously, while the selected voltage, $\pm V_x'$, $+V_R$ or $-V_R$ passes through the third junction.

The voltage switches are simple devices, each containing a pnp driver transistor and a switching transistor, and can be driven by conventional logic IC's. When the low-level output from the logic circuit enters the switch, the driver conducts and connects +4 volts to the base of the pnp switch, reverse-biasing it so that the switch is closed.





All the pulse-width modulator circuits of the MDVC are contained on one printed-circuit board (right). Photograph at the top shows modulator board turned over, disclosing the lower board that contains all the counter circuits. Discrete wiring of this prototype would be part of a multilayer board in a production model.



SE124 SIGNETICS; ALL OTHER IC's FAIRCHILD

Counter section is built with digital integrated circuits and an oscillator. It converts pulse width into a digital indication of input voltage. With the switch at the upper right in the position shown, this section can function independently as a time-interval counter.

However, when the input to the shunt switch is high, the pnp driver is reverse-biased and the switching transistor conducts, shorting the resistor-pair junction to ground.

The circuit provides firm switching action with low offset voltage and low offset current. Typically, the offset voltage in the switching transistor is less than 1 millivolt—provided that the ratio of load current to base current (I_B/I_L) is larger than 2 and smaller than 10 and if I_L is less than 1 milliampere. The transistor's offset or leakage current is typically less than 10 nanoamperes, even at temperatures up to 125°C.

Polarity of the integrator output signal, V_0, and the instant at which the polarity changes are detected by the comparator circuit. This circuit consists of an IC comparator, two NOR gates in a single IC package and the discrete components shown.

With V_0 connected into the noninverting input of the comparator, its output is high for $+V_0$ and low for $-V_0$, where high and low define standard IC logic levels. The NOR gates connect a positive voltage into the comparator inputs to insure that a definite switching action occurs when V_0 falls from some positive or negative potential to zero and remains at zero. The instant at which V_0 becomes zero signifies the end of an up-down integration.

To reduce high-frequency noise, a low-pass filter consisting of a capacitor and resistors is connected between the comparator's inverting and noninverting inputs.

Output logic

The final stage of the modulator is the output logic circuit. First, the circuit processes the logic signal from the comparator into the two-line output signal required by the integrator's voltage selection switches. Then it provides the three-line output needed by the digital portion of the MDVC.

When V_x, the original input signal to the instrument, is positive, the pulse width output signal is Pt_x; when V_x is negative, output is $\overline{P}t_x$. This is accomplished by storing the polarity of V_x in a flip-flop during T_2. Also, the output of the comparator V_c and its complement $\overline{V}_c$ are gated with T_2 and the polarity outputs P and $\overline{P}$ from the flip-flop.

The three-line output for the digital portion of the voltmeter consists of the pulse width signal, t_x, and the on-off polarity signals, P and $\overline{P}$. The latter two are produced by combining Pt_x and $\overline{P}t_x$ in the final NOR circuit.

Digital Counter

As the basic timing reference, the master counter, the upper portion of the diagram above, generates T_1 and T_2. It also produces the binary-coded-decimal (BCD) signals that are read out as a decimal number, X(t), of the input voltage.

An accurate clock frequency of 1 megahertz is obtained from an oscillator containing a dual two-input NOR circuit, a crystal and an output transistor. The operation of this circuit has been described elsewhere.[4] Basically, the two NOR circuits are cross-coupled, with the crystal between the two inputs of one NOR and the capacitor between the two inputs of the other NOR. With the crystal, the clock frequency is held to within $\pm 0.0025\%$ of 1 Mhz, which makes time-interval measurements accurate. A simple transistor multivibrator will suffice if only voltages are to be measured, since accuracy of the voltmeter is independent of the clock frequency.

With a 1-Mhz oscillator frequency, the four binary-coded decimal counters that form the master counter generate 10-millisecond time periods that are processed by the flip-flop at the upper left of the diagram into T_1 and T_2. The outputs of the BCD stages represent a number, X, that increases linearly with time, starting with T_1 or T_2. The number X thus indicates the time expired since the start of the integration process.

The reset and transfer circuit at the upper right of the diagram on page 93 converts t_x into a leading-edge pulse to reset the master counter. It also converts t_x into a trailing-edge pulse to transfer the content of the master counter into the storage circuits, the bank of IC's below the counter. The leading-edge pulse is generated by biasing the differentiated t_x pulse so the IC driver (N1B, half of a DTμL 932 circuit) is normally off; only a negative-going pulse)—the direction of the modulator output during T_2—can turn the IC driver on. The trailing-edge pulse is generated by gating the normal and the delayed inverted t_x pulse into another IC driver, the other half of N1B.

The reset and transfer input need not be t_x from the modulator. It can be any other pulse, shown as t_{ext} in the diagram on page 91. The counter will determine the duration of such an input.

Digital readout

When the trailing-edge pulse arrives, the number, X(t), then present in the counter is transferred into the bank of storage circuits. These circuits are IC's containing four simple latch circuits and input gating, to which load resistors are added externally.

The lower bank of IC's converts the stored binary-coded-decimal number into its decimal equivalent, $X(t_x)$, and drives the Nixie tubes. The driving is done by a bank of 10 high-voltage drivers in each IC.

Polarity of the number displayed is indicated by the neon lamps at the lower left, depending on whether P or $\overline{P}$ is generated by the modulator's output logic.

Miniature Nixie tubes, made by the Burroughs Corp., were chosen as readouts because the converter-driver IC was available for this tube. A Nixie is a cold-cathode glow lamp. It has 10 cathodes, in the shape of numerals 0 through 9. Each cathode is controlled by one of the 10 outputs of the IC and glows when that output's potential is low. Anode-to-cathode conduction is high when cathode potential is low.

The anode voltage, +120 v is supplied through 22-kilohm resistors by an unregulated d-c to d-c converter. A two-transformer inverter drives a voltage doubler that provides the power to the load.

Tomorrow's improvements

Cost of the MDVC can probably be slashed to well under $100 in mass production, since volume would make it feasible to capitalize on advances in complex, multifunction IC's. Most of the discrete components could be eliminated and the majority of the circuits produced as a few complex circuits or single-chip arrays.

The hand wiring added to the printed circuit boards of the prototype, on page 92, would be replaced by a multilayer board in production models. Further savings would result in mass production by combining the counter, store and conversion circuits with the digital display to minimize wiring. Cost of converting the MDVC from a voltmeter to a volt-amp-ohm meter can be offset by eliminating crystal control of the oscillator, which is used only to assure accurate time-interval measurements.

Low-voltage, incandescent readout lamps could be used in place of the Nixie tubes, eliminating the need for a high-voltage power supply and the d-c to d-c converter. Special-purpose, low-power, large-scale integrated circuits could replace the off-the-shelf linear and digital IC's to further reduce power requirements, size, weight and cost.

An automatic offset correction circuit will bring the greatest improvement. Consisting of only two AND gates and a few discrete components, this circuit accurately measures the offset in the complete system, stores it and feeds it back with inverted polarity to the input.

This will completely eliminate the largest error source—zero offsets and their drift due to changes in environment, component characteristics and power supplies. A zero adjustment control and high-performance, low-drift d-c amplifiers will no longer be needed. Since input impedances need no longer be kept low, series of metal-oxide-semiconductor (MOS) analog voltage switches can be used and all precision resistors can be eliminated.

Ultimately, these changes will lead to a monolithic IC pulse-width modulator.

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2. H. Schmid and B. Grindle, "Pulse-Width Modulator Offers Precision Performance," Electronics, Oct. 11, 1963, p. 29

3. Specification for Digital Volt-Ohm-Ratiometer Model 7100, Fairchild Semiconductor division of Fairchild Camera & Instrument Corp.

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Instrumentation

Low-frequency noise predicts when a transistor will fail

Improved reliability studies may result from the use of noise measurements instead of statistical values to forecast the lifetime of the device

By Albert van der Ziel and Hu Tong
University of Minnesota, Minneapolis

A new method for predicting the life expectancy of a transistor—based on measuring the device's noise at 1,000 hertz—could make transistor reliability studies simple and more accurate. Our preliminary work for the U.S. Army Electronics Command shows that transistor noise serves as an indicator of when the device will fail because this parameter changes drastically toward the end of the transistor's life.

Transistor noise at frequencies higher than 1,000 hz are not good indicators of the transistor's condition. This noise is produced by shot noise currents flowing across the transistor junctions and by thermal noise of the series resistances, mostly of the base resistance.[1] [Shot noise is caused by random variations in the number and velocity of electrons and thermal noise by the thermal agitation of the electrons in the semiconductor.] Although these noise sources change with age during a transistor's operating life, they do so in the same manner as the currents and h-parameters, therefore limiting their usefulness as an independent indicator of the impending failure of the transistor.

Low-frequency noise, on the other hand, is known to be very sensitive to changes in a transistor's surface conditions and the gas ambient atmosphere within the transistor package. Therefore, noise at 1,000 hz could be expected to give a better indication of the life expectancy of the device than any other parameter.

Of two methods, one is direct

Low-frequency (1/f) noise values are usually derived from measurements of the spot noise figure, F, of the device. The measurement is most often made in a common emitter connection with an emitter current of 1 milliampere at 1 khz and 1,000-ohm source impedance. Because commercial equipment is readily available, this is the handiest way of measuring noise figure at 1 khz, and for studying a large number of devices. [1/f noise is so named because of its inverse relationship with frequency].

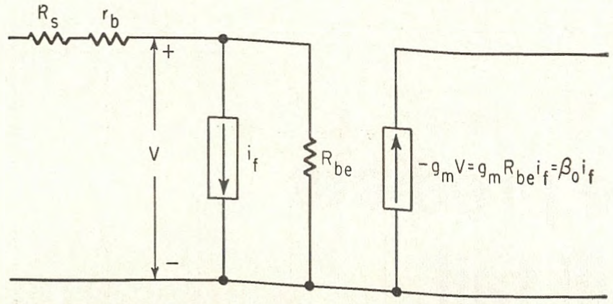
We chose a different approach because the relationship between noise figure and 1/f noise is quite complex, and a more direct measurement of 1/f noise was desirable. The equivalent saturated diode current, I_{eq}, measured at the output of the transistor in a common emitter connection is an effective, direct indicator of 1/f noise. Measurements are made at 1 khz and an emitter current of 1 ma, with a very high source resistance R_s in the base lead.

As shown in the upper figure on next page, the 1/f noise of a transistor can be represented by a current, (the square root of the average value of i_f

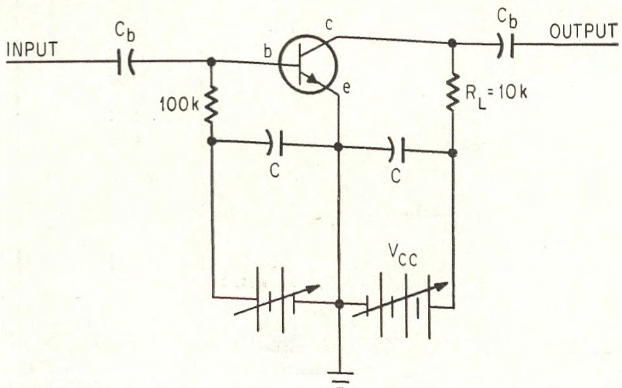
The authors

Albert van der Ziel has written many books and papers on noise phenomena and is considered an authority on the subject. He has been professor of electrical engineering at the University of Minnesota since 1950.

Hu Tong received a bachelor of science degree from National Taiwan University in 1961. He continued his studies at the University of Minnesota and received a master of science degree in 1965. He is now working for his PhD in electrical engineering at the university.



Equivalent noise circuit of a transistor. The output current, β_o i_f is the amplified noise source current. A measure of the device's equivalent saturated diode current at the output terminals is related to the amount of noise generated.



Test circuit for performing noise measurements is a common emitter amplfier, tuned for a maximum gain at 1,000 hertz. The circuit's effective current amplification factor and the time constant of the indicating instrument determine the relative accuracy of the noise measurement readings.

squared) $\sqrt{\overline{i_f^2}}$, in parallel with the emitter junction.[2] If a large wirewound resistor R_s is connected in series with the base, the transistor's output current is

$$\beta_o \sqrt{\overline{i_f^2}}$$

where β_o is the current gain of the transistor.

To measure the value of the noise current, a noise diode is connected in parallel with the transistor output and the diode current increased until the current generated by the transistor doubles.

Therefore:

$$\sqrt{\overline{\beta_o^2 \, i_f^2}} = 2q \, I_{eq} \, \Delta f$$

where q is the charge of an electron and Δf is an incremental frequency range over which the measurement is made. The current I_{eq} is the equivalent current of the diode noise source. Therefore I_{eq} is a direct measure of the 1/f frequency noise current generator.

The test circuit for measuring 1/f noise in transistors is shown above. Other amplifying stages follow in the actual test setup. Usually the equivalent saturated diode current I_{eq} is so large that it is inconvenient to use a noise diode as a standard for its measurement. Any other calibrated current generator can serve as well. If enough signal current is added so the amplified power output of the device is doubled, then it is a simple matter to calculate I_{eq}.

For example, let i_c be the known signal from the current generator, then

$$\overline{i_c^2} = 2qI_{eq} \, B_{eff}$$

where B_{eff} is the effective bandwidth of the measuring system. The current I_{eq} can be determined from this relationship.

The factor B_{eff} is defined in the following way. The function g(f) is the voltage gain versus frequency characteristic of the tuned amplifier used in the experiment. If the amplifier is tuned for a maximum gain, g_o, at 1,000 cycles, then:

$$B_{eff} = \frac{1}{g_o^2} \int_0^{\infty} g^2 \, (f) df$$

This is a constant value for the particular amplifier used and need only be calculated once.[3]

It is often assumed that B_{eff} should be small compared to the center frequency of 1,000 hz. However, it is inconvenient to choose a B_{eff} that is too small since the rectified noise will then cause fluctuations in the output meter, reducing the accuracy of the measurement.

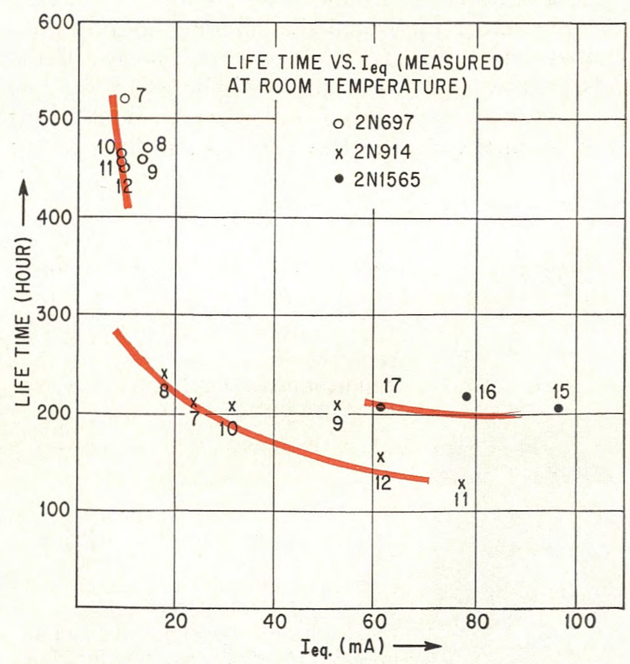
The relative accuracy of a single measurement is given by

$$\frac{100\%}{\sqrt{2B_{eff} \, \tau}}$$

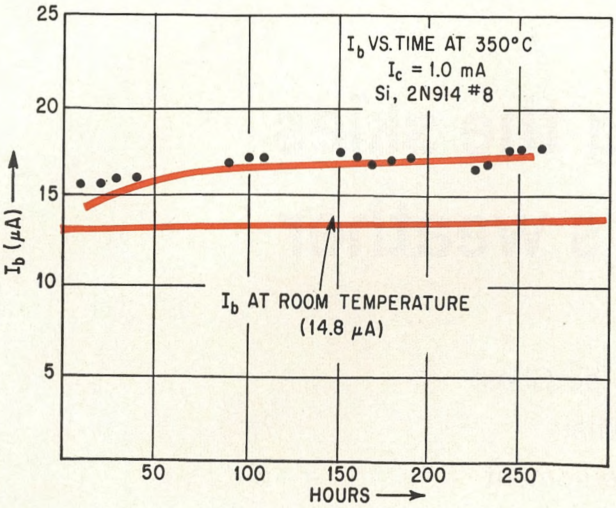
where τ is the time constant of the indicating instrument.[3] A reasonable compromise is obtained with $B_{eff} \approx 500$ hz and $\tau = 2$ seconds.

Artificial aging

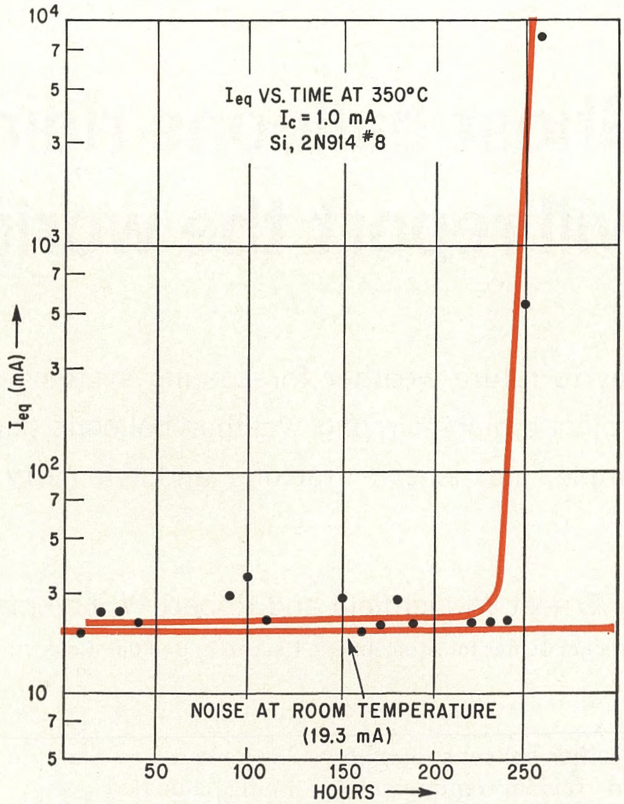
The transistors are aged at an elevated temperature for 10 hours and then allowed to cool and



Comparison of the operating life of different transistor types indicates that those with initial low noise achieve longer life spans.



Plot of results demonstrates how the equivalent saturated diode current, I_{eq} measured at the output of the test circuit changes drastically just before a typical device fails. A measure of the base current, above, of the same transistor does not supply any such warning.



remain at room temperature for another 10 hours. This stress was employed to accelerate failure mechanisms in the devices. The 1/f noise was then measured and the cycle repeated.

It was found that the choice of aging temperature and the duration of the rest period at room temperature are critical. For instance, if the aging temperature is too low, the lifetime of the transistor would be so great that the time required to complete the study would be prohibitive.

On the other hand, if the temperature is too high, the transistor's lifetime is foreshortened and the device would fail before a sufficient number of data points could be taken. An aging temperature of 350° C is a good compromise for most silicon transistors; at that temperature, the device lifetime is a few hundred hours and a reasonable determination of the lifetime can be obtained with measurements made every 10 hours.

A suitable rest period between aging cycles is important, since it takes about 10 hours before complete equilibrium is reestablished within the transistor after it has been exposed to elevated temperatures.

What has been found

The figure above shows a typical plot of the measured noise for a 2N914 silicon transistor as a function of time. Even though I_{eq} remains practically constant until the end of the transistor's life, it does increase by two to three orders of magnitude just before the transistor fails. A plot of the base current as a function of the aging time for the same transistor does not warn of the impending failure even after hundreds of operating hours.

These measurements were repeated many times for a variety of types of silicon transistors with the same results—the base current hardly changed but the low-frequency noise increased very rapidly when the transistors were about to expire.

Low noise, long life

The graph at the left is a plot of lifetime as a function of the initial value of I_{eq} for transistor types 2N697, 2N914 and 2N1565 aged at 350°C, and indicates that transistors initially exhibiting low noise have longer life spans than high-noise units. Therefore, by measuring the low-frequency noise of new transistors, it is possible to make a reasonable prediction about life expectancy of the devices.

Obviously this method needs much more testing before it can be generally accepted. It is hoped that the results presented might stimulate such a large-scale test to discover how reliable low-frequency noise measurements are in predicting the life expectancy of new transistors.

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Ghost balloons riding the skies will report the world's weather

Key to future weather forecasting system will be Ghost project's globe-circling weather balloons and their simple, inexpensive tracking and telemetry equipment

By Ernest W. Lichfield and Robert W. Frykman
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Weather balloons dangling solar-powered telemetry and tracking equipment are being launched every few days at Christchurch, New Zealand, in a program to develop a global weather forecasting system. By the time summer ends in the southern hemisphere in March, meteorologists will know whether their most pressing development problem has been solved.

The test flights are part of a project called Ghost for Global Horizontal Sounding Technique. It is a plan, still years from completion, to have satellites gather atmospheric data from thousands of balloon-borne telemetry systems. The satellites would relay the data to ground stations and a computer containing a mathematical model of the world's atmosphere would prepare long-range forecasts [see "Meteorologists' 40-year-old dream," p. 102].

With adequate data, mathematical models and methods of altering atmospheric temperatures on a huge scale, it may be possible one day to prove that Mark Twain was wrong—that somebody is doing something about the weather.

However, even the data collection plan won't work unless balloons are made that can remain aloft, at selected constant-density altitudes, for an average of six months. A global system will require 10,000 or more balloons. Without long-lived balloons, the cost of replenishing the fleet will be prohibitive and the system problems too complex.

Related programs of the Environmental Science Services Administration (ESSA), the National Aeronautics and Space Administration and a French program known as EOLE will also require reliable balloons.

Balloons launched early this year at Christchurch came close, but not close enough to the design goals [see "Around the world in much less than 80 days," p. 101]. The improved balloons now being flown have theoretical life expectancies up to two years and results from a few preliminary flights are encouraging.

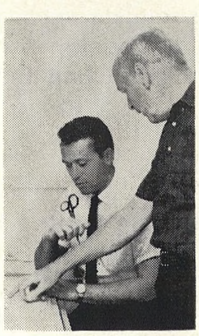
Nor does the telemetry equipment seem to pose insurmountable problems. Signals have been received at ranges beyond 4,000 miles with present sensing, coding and transmitting equipment. This equipment, costing less than $300 per balloon, provides data on balloon performance and allows simple ground stations to track the balloon.

Operational balloons could determine their own positions with the aid of radio navigation systems, such as Omega, and would telemeter data such as wind direction and velocity (determined from position changes), temperature, humidity and atmospheric pressure. To avoid hazards to aircraft, the electronic equipment can be mostly thin-film components on the skin of the balloon.

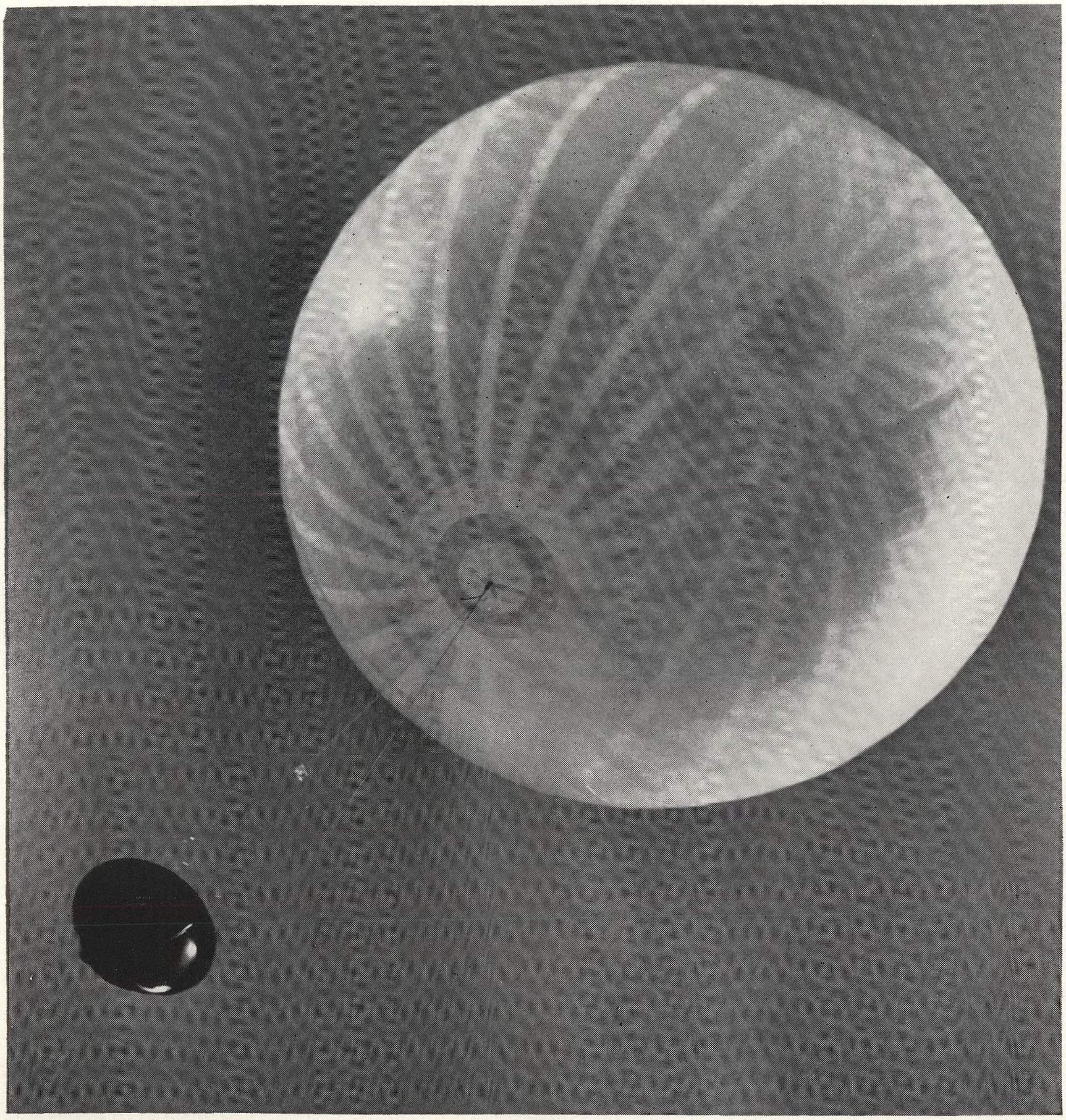
Global system plans

The Ghost project stems from proposals made nearly 10 years ago by Vincent E. Lally and others.[1,2,3] Lally now heads the Ghost project at the

The authors



Ernest W. Lichfield, left, has degrees in electronic engineering and meteorology. He directs the instrumentation section of the global atmospheric measurements group at NCAR. Robert W. Frykman, right, did balloon electronics work at G.T.Schjeldahl Co. and General Mills, Inc., before coming to NCAR four years ago. He directs the launch facility at Christchurch, New Zealand.



Ghost balloon, with pendant electronics package encased in its black thermal-control cover, is silhouetted against the sky as it rises toward its assigned altitude. The package is suspended from the transmitter's antenna.

National Center for Atmospheric Research (NCAR) and he supervised the design of the balloons. The tests are a joint effort of NCAR, ESSA and the New Zealand Weather Service.

Plans are now being made by NCAR and ESSA for the next phase of the project—experimental interrogation of balloons by satellites. NASA satellite specialists are helping; NASA plans to launch suitable satellites in 1968 and 1969. A conceptual drawing of this system is at the bottom of page 100.

Eventually, Ghost would become part of a proposed Global Meteorological Observation System. The balloons would be supplemented by ground stations and ocean buoys, or even balloons tethered to floats. The ESSA Scomo project (Satellite Collection of Meteorological Observations) is a related program.

All of the projects are focused on overcoming a problem that often forces meteorologists to base weather forecasts on educated guesses. The forecasts cannot always be accurate because conventional weather stations and radiosondes provide accurate data for only about 10% of the earth's atmosphere. Weather satellites have alleviated the problem by detecting cloud masses and temperatures, but they haven't solved it.

Because the balloons are considered a first step in creation of a global data-collection system, Ghost has been endorsed by the World Meteorological Organization, a United Nations agency. A dozen tracking stations in southern hemisphere countries are participating in the tests.

Operational system

In one respect, Ghost is already an operational system. Simply plotting the course of each balloon as it is tracked over the earth indicates the wind velocity and direction at the balloon's altitude.

One of the authors [Lichfield] is spending most of November and December in Antarctica—while the other [Frykman] is supervising the flights in New Zealand. Six balloons are being launched at McMurdo Sound, Antarctica, to observe the air circulation around the South Pole; the first is already transmitting loud and clear.

Continually tracking 50 balloons could provide useful synoptic (mass air movement) data. Quickly relayed to weather bureaus, the information would help fill in the vast blank spots in world weather maps. Three or four real-time tracking stations could cover the southern hemisphere.

Telemetry transmitter

The telemetry system in the flight tests demonstrates that an extremely simple electronic system can perform the complex job of tracking and telemetering simultaneously. It does this by adding a few new tricks to the coding techniques invented by Samuel Morse and the keyed, continuous-wave, modulation method credited to Guglielmo Marconi.

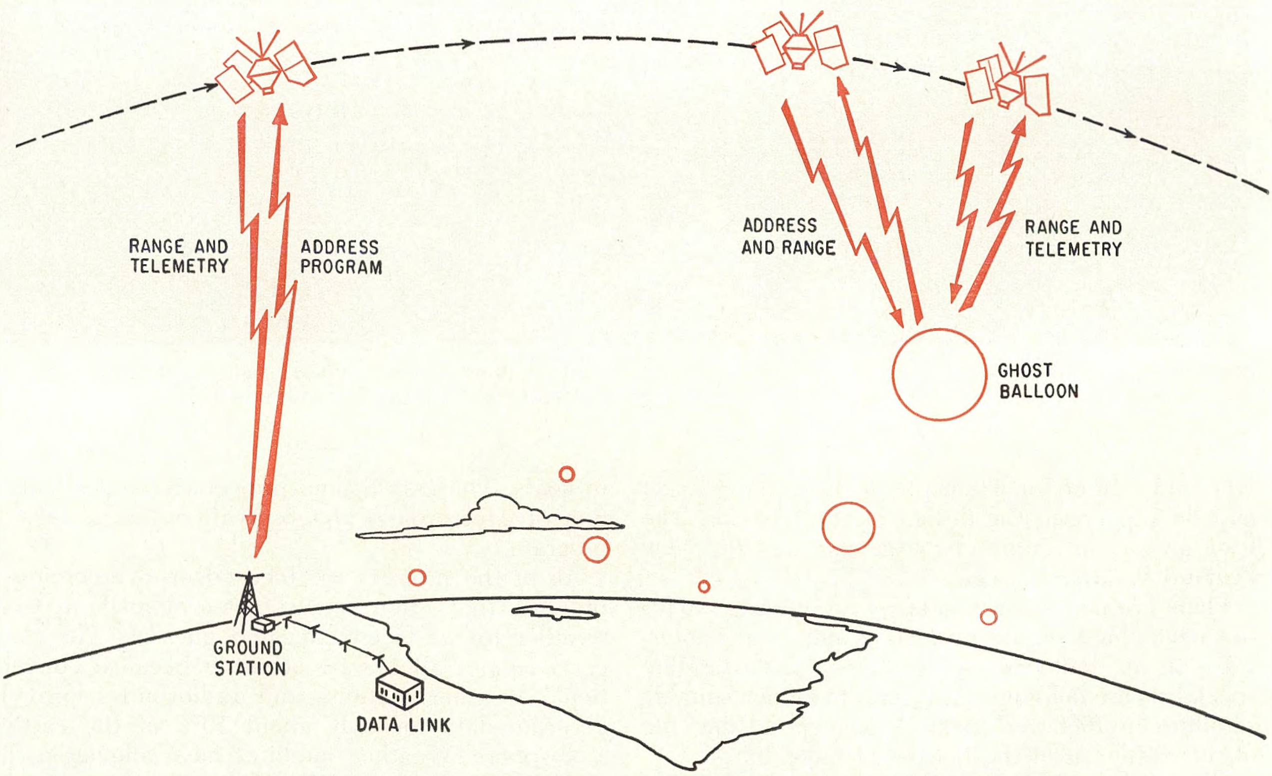
First, the frequency of a unijunction-transistor pulse generator, in the upper left of the diagram on page 104, is varied according to the resistance of a sensor. The oscillator's output varies the period of a Morse code signal that identifies the balloon being tracked. For tracking, the sensor is a solar cell whose resistance varies with the elevation angle of the sun.

A suitable radio receiver, stop watch, sun-angle tables and an instrument calibration curve are all that is needed to plot the location of any balloon to an accuracy within ±100 miles at a range of 4,000 miles. The accuracy has been as good as 50 kilometers and the range as great as 8,000 kilometers in some cases.

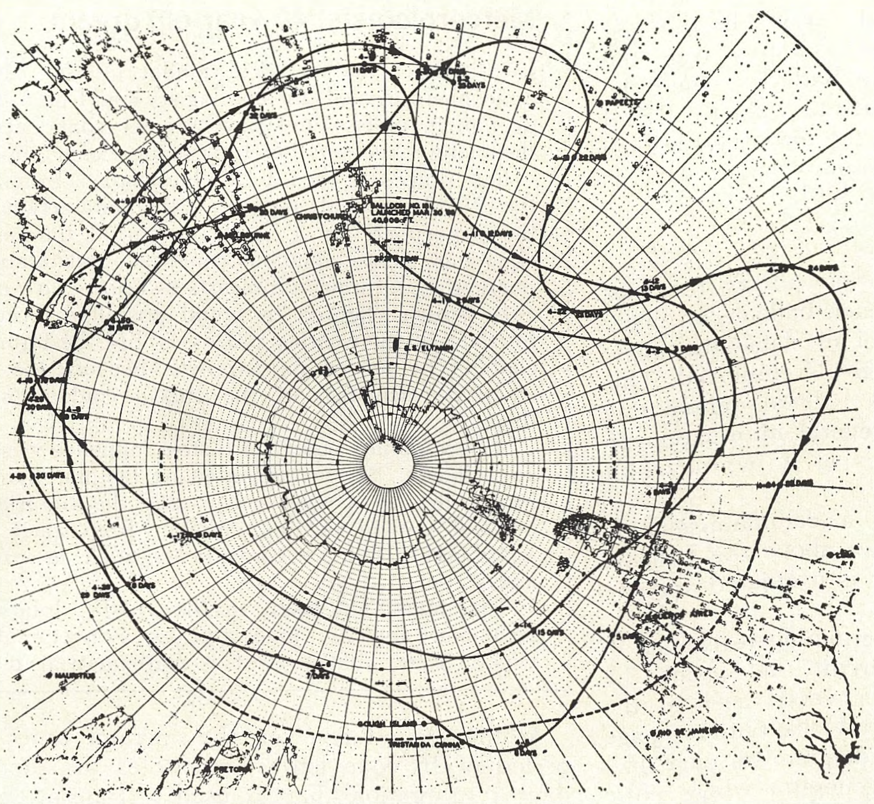
Although the system is simple, the performance and design criteria seemed almost impossible to meet at first. The telemetry equipment had to cost less than $300, weigh less than 6 ounces including power supply, operate at temperatures as low as —55°C and transmit for about a year. Four telemetry channels were required and each unit had to transmit a unique identification code so that up to 20 balloons could share a single channel.

The result is the system shown in the launch photograph on page 99. The package is hung from the balloon by the antenna of the 15-megahertz transmitter. The antenna is a center-fed dipole consisting of a quarter-wave section above the package and an equal section trailing freely below the package.

Power is supplied by a panel of 26 solar cells



Operational fleet of Ghost balloons would form the information gathering arm of the Global Meteorological Observation System. Satellites in polar and equatorial orbits would query each balloon as it came within range and store the data for transmission to ground stations. On the ground, the data would be fed to a central computer, programed with a mathematical model of the atmosphere, to prepare worldwide weather forecasts.



Path followed by the Ghost balloon in making the first around-the-world flight and the two subsequent circumnavigations. On the last lap, radio contact was lost four days, shown by the dotted line.

Around the world in much less than 80 days

On April 10, 1966, a Ghost balloon completed the first nonstop around-the-world flight ever made by a balloon. The flight took 10 days, clipping 70 days off Phileas Fogg's fictional record.

After it was launched at Christchurch, New Zealand, the seven-foot-diameter sphere rose to a preselected altitude of 40,000 feet. Propelled by air currents, it drifted across the South Pacific, South America, the South Atlantic and Australia, before passing north of New Zealand, over the Fiji Islands, to complete the circuit.

Its progress around the southern hemisphere was tracked by stations in New Zealand, Mauritius Island, Australia, South America and Africa. It made six trips around the world in 74 days before radio contact was lost. Other Ghost balloons have remained aloft for more than six months and one has circled the earth 17 times.

Wide open spaces. The southern hemisphere with its vast expanses of ocean, serves as a huge test range for the Ghost program. When the first tests were made in 1964 in Japan, only short flights were possible—the balloons had to be equipped with timed cut-down devices to make sure they would not overfly Iron Curtain countries.

Long flights are essential in the test program. The balloons' telemetry can be checked out quickly and their ability to stop rising at a preselected altitude can be verified by radar. But long flights are vital to determine the life expectancy of the balloons and the equipment.

Life expectancy of the balloons is uncertain because the design is new. These are superpressure balloons, not the conventional zero-pressure balloons whose altitude is regulated by releasing or jettisoning gas to counteract for gas expansion in the daytime and contraction at night.

Stretched tight. The Ghost balloons are only partially inflated with helium; they rise until the helium fully distends the balloons and the density of the balloon and its payload equals that of the atmosphere at the designated altitude. Thus, the balloons float at a constant-density—or approximately constant atmospheric pressure altitude—providing a good starting point for the analysis of atmospheric data.

The balloon skins must be strong, inelastic and impermeable to gas. They are made of two-ply Mylar, to block pinholes, in diameters ranging from 5 to 34 feet.

Nearly 50 balloons were launched between March and August, when bad weather, short days and other problems curtailed the flights. Those flights were made at density levels of 500 and 200 millibars—roughly 18,000 and 40,000 feet. The 200-millibar balloons have set the longevity records; the longest a 500-millibar balloon stayed aloft was 19 days. Icing probably contributed to the shorter life of the 500-millibar balloons.

Deicers. In the present test series, flights are planned at 300 and 30 millibars as well as at 200 and 500 millibars. Some balloons will fly well above icing levels, while telemetry packages trailed on long tethers will probe the icing conditions below.

Icing can cause the balloons to drop, just as leaks do. To counteract leaks and other flaws, manufacturing quality control has been improved. To counteract icing, coatings of wax and other substances are being tried and free lift is being increased to help the balloons carry ice. Theoretically, the improved balloons can stay aloft two years and it is hoped that they will meet the six-month goal.

and this limits tracking and telemetry to daylight hours. This limitation is not serious in the test because of the long days of summer near the South Pole, but rechargeable batteries would be needed in operational equipment. A solar-cell and battery equipped version of the airborne package is being used to gather ground weather data as part of the experiment [see p. 106].

Tracking by telemetry

Although the instrumentation allows for four channels of telemetry from each balloon, on many flights only a single channel of data—the angle of the sun above the balloon—is employed. This is sufficient for tracking the balloon, pinpointing its position and obtaining general information on the circulation of air masses as a byproduct of the tracking data.

The sun-angle sensor is a cadmium-selenide photocell. The higher the sun above the balloon, the more directly the sensor is irradiated and the lower its resistance.

The sensor is the rate determining resistance in the unijunction-transistor circuit that forms the resistance-controlled oscillator (RCO) seen at the upper left of the main circuit diagram on page 104 and in the four-channel diagram on page 103. The RCO serves as a pulse generator whose pulse rate is proportional to the sun's elevation angle. The time it takes the coding circuitry to generate the Morse code letter identifying the balloon is also proportional to the sun angle.

At the ground receiver, the operator times the period of 10 code letters and notes the time of day. A calibration chart is used to translate code period to sun angle. With an ephemeris table that gives the time of solar transit and solar declination, the balloon location can be plotted on a map such as in the example below.

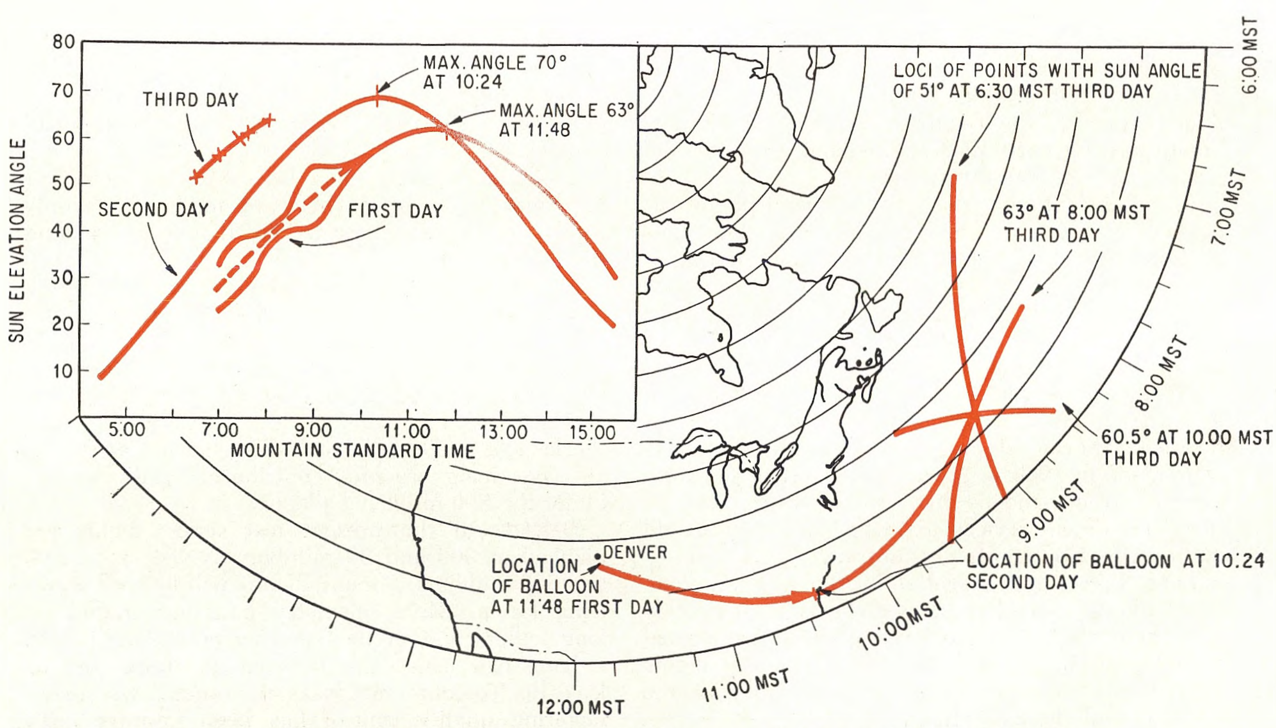
Meteorologists' 40-year-old dream

If a perfect mathematical model of the earth's atmosphere existed, meteorologists could be a great deal more precise and have greater confidence in their long-range weather forecasting. Such a model —first proposed by L.F. Richardson, a Briton, in the 1920's—would represent the interactions in the atmosphere by a series of partial differential equations. These equations could manipulate atmospheric data to provide forecasts of up to two weeks.

Richardson figured he could postulate formulas for some of the weather processes, but the formulas couldn't be proven or disproven because the mechanical calculators of the 1920's couldn't solve them.

A bewildering variety of factors influence weather and climate. Besides the obvious factors, there is heat exchange between oceans and the air, friction between ground and air, radiation from space, the distribution of trace constituents such as ozone, and so on.

Too much, too soon. In the 1950's, John von Neumann and his associates at Princeton University were able to test a mathematical model



Tracking data for a typical Ghost balloon flight. As shown by the curves at the left, with continuous reception on the first two days, position was determined by the time of day of the maximum sun-angle reading. The two irregular trackings at the beginning of the first day were caused by the swinging of the package as the balloon rose during the early part of its flight. On the third day, when data was incomplete, the intersection of the loci of all points with sun angles transmitted at three different hours gave the balloon's position. This balloon was flown from Boulder, Colo., in April 1965.

with an electronic computer, but it was too simple a model to be practical. After 10 more years of progress in computers, atmospheric scientists still lack a comprehensive model. Important factors must be omitted from the model because there isn't enough data available to formulate the equations. Millions of bits of data are needed. Modern computers are too small to contain the model and the data and are 100 times too slow for the processing task. If the simulations of atmospheric events are to be of value as forecasts, they have to be completed before the actual events occur.

The painted desert. The need for simulation has been summed up by Walter O. Roberts, director of the National Center for Atmospheric Research.

"We must model, mimic nature, and theorize, in order to decide whether and how to experiment in the real atmosphere. For this to succeed, we must of course find ways to formulate models equal to the complexity of nature, and discover the means of testing them on computers fast enough for us to live long enough to evaluate results. We must paint the Mojave Desert black, by means of a numerical model, and use computers many times the speed of nature's computer, the atmosphere. . . . And we will want to perform other simulations, too, like buildings dams across the Bering Straits, or pouring lamp black on the Arctic Sea. We must build laboratory mountains, oceans and continents, with the magnitude and quality of effort that the stakes justify."

Supercomputers. The Illiac 4, a computer being developed at the University of Illinois, may do the trick. [Electronics, April 4, p. 36]. It is being designed to perform a billion computations a second. Scientists at the National Center for Atmospheric Research are working with the development group and computer manufacturers.

While supercomputers are a partial answer, the lack of data is still severe—a failing that the Ghost program should help overcome. There is already international cooperation in this field, stemming from a United Nations resolution in 1961 urging development of satellite weather observation as one of the peaceful uses of space. As part of this effort, the Ghost program has been endorsed in the United States by the National Academy of Sciences. Among the sponsors of the work at the Atmospheric Research Center are a number of universities and the National Science Foundation.

An approximate track of the balloon can be made by recording the data several times a day.

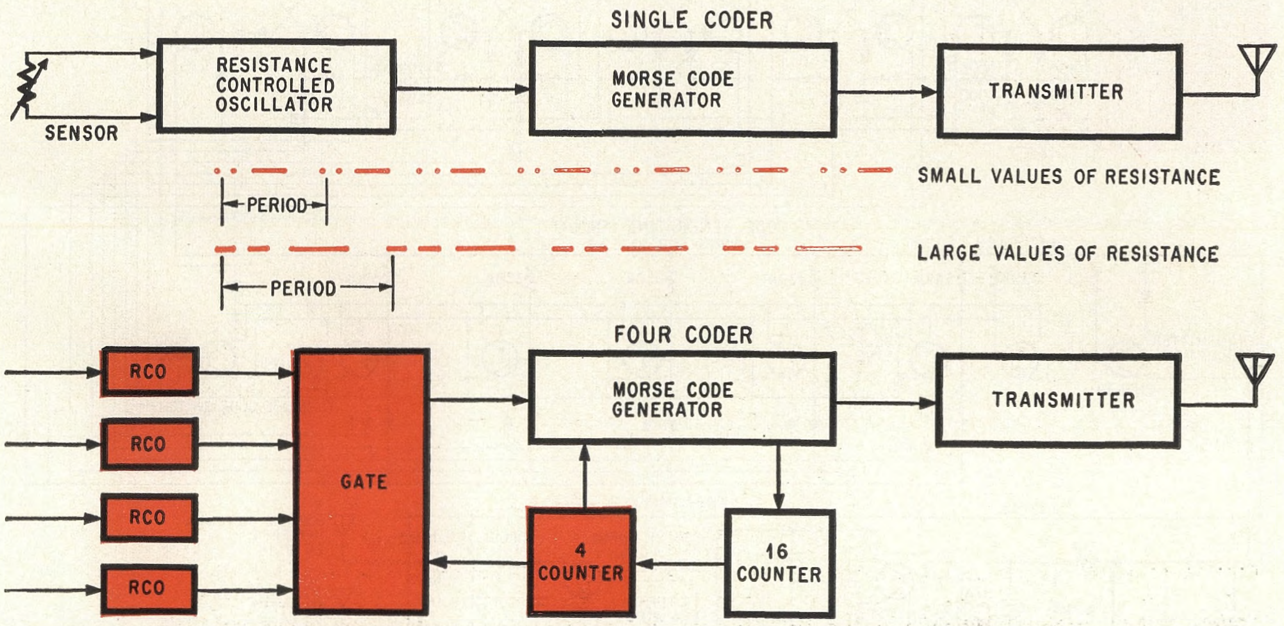
The Christchurch facility receives data from the other tracking stations and plots the balloons on a large globe. The station also sends all the data to the NCAR laboratory in Boulder, Colo., where a computer determines balloon locations.

Four-channel telemetry

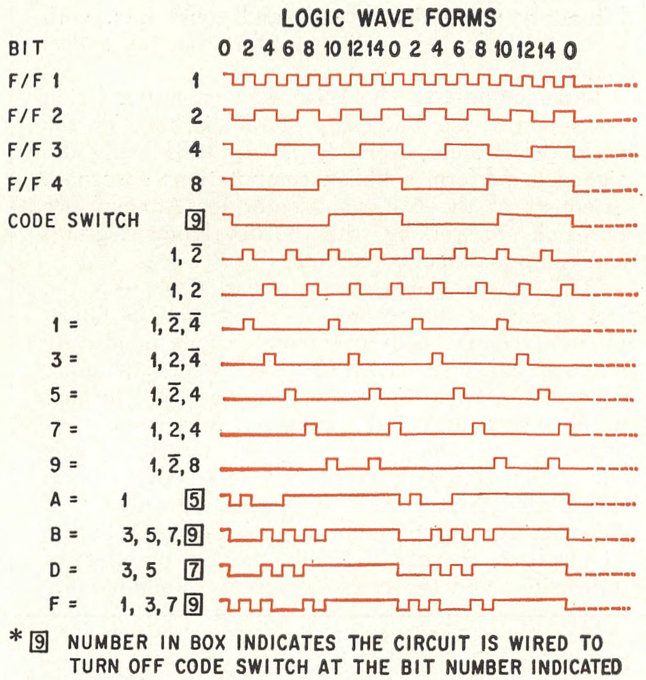
Any sensor whose resistance varies in proportion to the data sensed can be substituted for the photocell. The only restriction of the present RCO design is that the sensor be limited to a resistance range of approximately 3 to 500 kilohms.

The arrangement in the block diagram shown below allows four sensors to share a transmitter. In test flights, these primarily check on such factors as stress in the balloon's skin, temperature of the helium gas and temperature of the electronics, but air temperature has also been measured and other atmospheric data, such as humidity, could easily be obtained.

To convert the equipment to a four-channel system requires an additional circuit board. Then each of the four assigned code letters is transmitted 16 times, with the sequence repeated after every four



Addition of a four-counter, gate and three more resistance in controlled oscillators (the colored blocks in the lower diagram) converts the basic Ghost circuitry (top) in a four-channel telemetry system. Any variable resistance sensor, such as a thermistor, can be used .



Ghost balloon's telemetry system contains the simple circuitry shown below. Four identical flip-flop stages in a 16-counter, five NAND gates and a multivibrator switch make up the code generating and repeating circuits. Code letter period is governed by the oscillator of diagram (upper left, below) whose frequency varies with the sun-angle sensor's resistance. Above are output waveforms of the counters, gates and switch and sample Morse code waveforms of some of the combinations.

letters. The letter identifies the data channel and the sensor data is calibrated by the same technique used to determine sun angle.

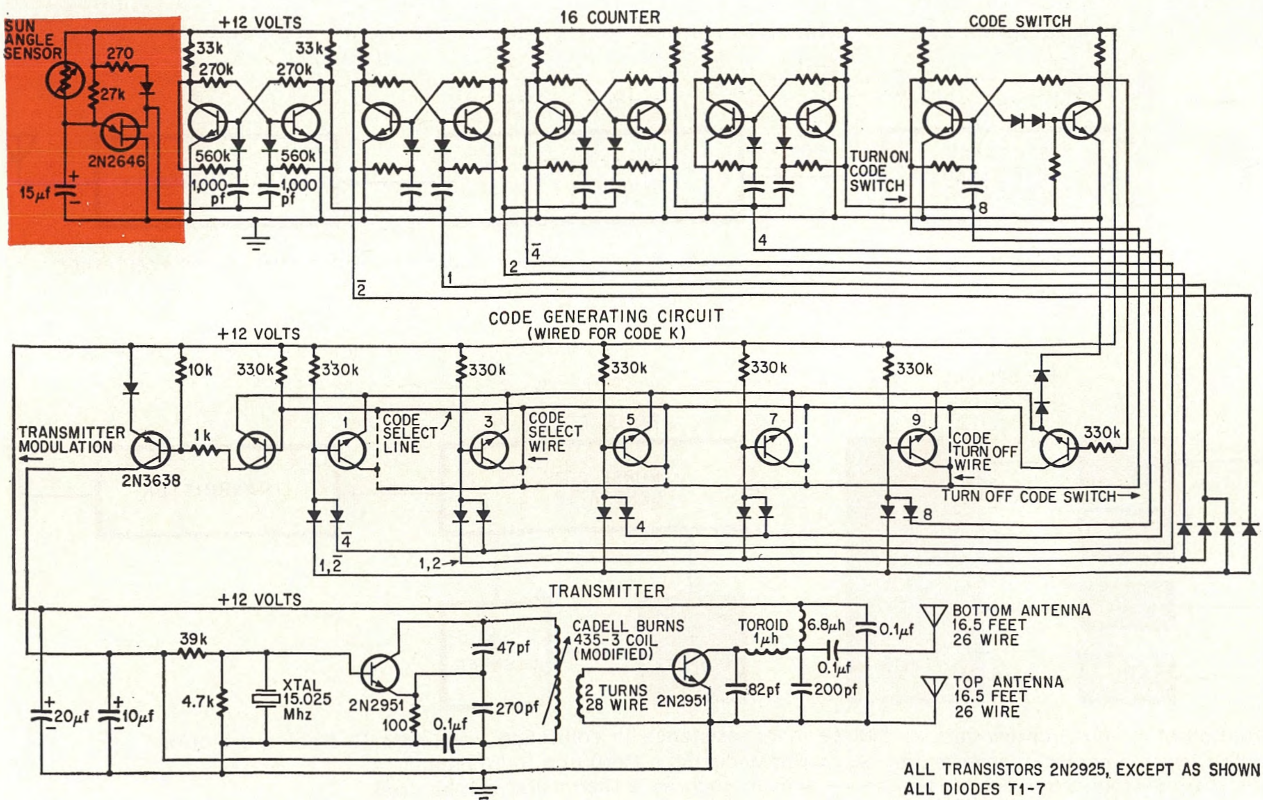
A 16-counter and a group of gate circuits produce the code letter that keys the transmitter output. The letter can be changed by modifying the gate wiring pattern. The wiring pattern in the diagram shown below produces the letter K.

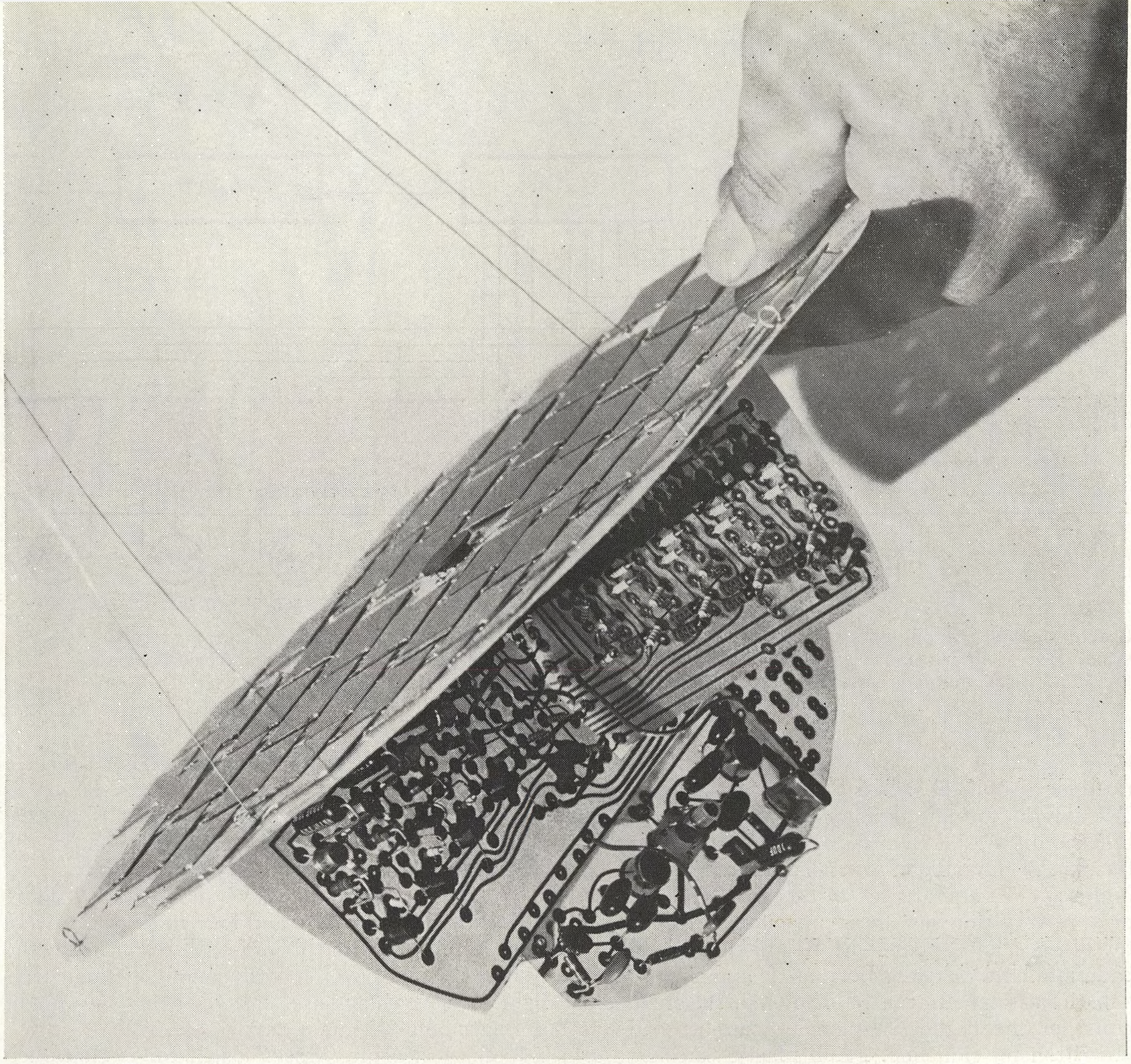
The coder takes advantage of the fact that Morse code uses a 1-bit length for a dot or a space and 3 bits for a dash. If a letter is started on the beginning of a zero bit, the spaces always occur on the odd-numbered bits and the letter ends at the beginning of an odd-numbered bit.

Therefore, five NAND gates are wired to give negative-going outputs on the odd-numbered bits: gate 1 on bit 1; 3 on 3; 5 on 5; 7 on 7; and 9 on 9, as the logic waveforms shown in color on the diagram indicate. The gates are timed by counting the RCO's pulse output with the 16-counter, which consists of four flip-flops. An OR function turns off the transmitter if the code switch is in the off state, or if any NAND gate connected to the code-select line has a negative output.

The NAND gates and the OR function can be wired to produce any code letter, as the lower set of waveforms indicate. The NAND gate outputs can be connected to the code-select line, to the turn-off switch or left unconnected. For example, if gate 5 is connected to the turn-off switch, the transmitter will turn off at code bit 5 and remain off until it is turned on by the 16-counter at bit 0. To produce the letter D, for instance, gates 3 and 5 are connected to the code select line and gate 9 to the turn-off switch.

Signals with frequency differences as low as 100





Basic Ghost electronics circuitry is on the semicircular printed-circuit board. Circuitry for four-channel telemetry is on the smaller rectangular board; sun-angle sensor is in the middle of the solar-cell panel.

hz can be separated by keying a c-w transmitter at low bit rates—a handy feature of the telemetry system if large numbers of balloons are to be used. For the tests, a frequency in the 15-megahertz band was selected, because of the consistent long-distance propagation at this frequency.

Reception at a range of 4,000 or more miles is regularly achieved, although even at noon the solar panel supplies only 150 milliamperes at 12 volts. Because there is no battery, transmission power ranges from a maximum of 1 watt at noon to 50 milliwatt just before sunset. These power levels, ranging from "flea" to "gnat" would seem to be too weak to carry the signal to receivers beyond the horizon.

The long range is credited to the narrow bandwidth and the excellent skip propagation at 15 Mhz during the daytime. NCAR uses a three-element beam antenna and a Collins Radio Co. 51S1 communications receiver as the ground station. This receiver has a 500-hertz intermediate frequency. Even if the reception is so noisy that the operator can identify only some of the code letters received, he can still time the code period and obtain useful data.

To keep the circuitry warm at high altitudes, a black plastic cover, seen in the photograph on page 99, is fitted over the electronic assembly shown above. The solar radiation soaked up by the cover maintains the internal temperature at about 15°C at 40,000 feet, where the air temperature is —50°C.

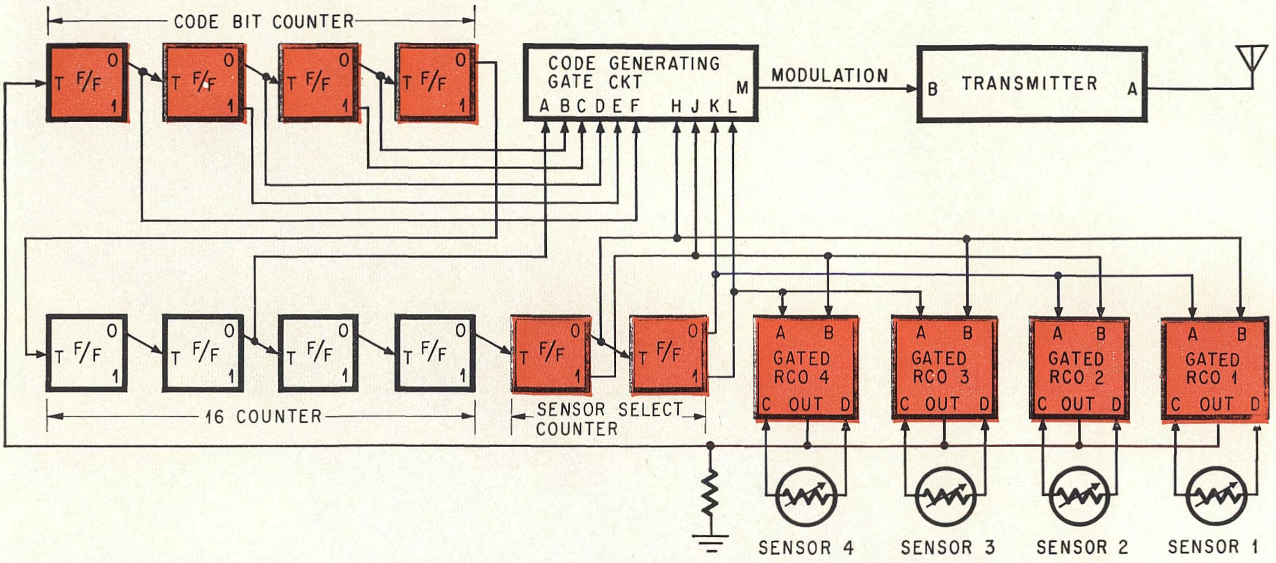
At first, this warmup technique was too efficient—the circuits heated up to 40°C at 20,000 feet and to 30°C at 40,000 feet. A small ventilation hole in the cover solved the problem.

The circuitry is assembled on epoxy-glass printed circuit boards; the assembly weighs 24 grams and the solar-cell panel 45 grams. The solar-cell panel is atop the unit, facing the sun.

Tomorrow, thin films

The Ghost balloons are only a negligible hazard to aircraft. The balloon skins, stretched taut and only 1 to 2 mils thick, would virtually disappear if they collided with an airplane. The electronics packages weigh as little as 4 ounces, a fraction of the 5 pounds that the Federal Aviation Agency considers a hazard to aircraft.

However, since many thousands of Ghost bal-



Ground weather station, Moses, is also based on the Ghost electronic circuitry. Addition of a battery storage system and a larger solar-cell panel makes it capable of a round-the-clock-transmission. Color blocks indicate four-channel telemetry circuits that may be duplicated to increase information capacity.

loons would be aloft in an operational system, precautions should be taken to avoid an air disaster. The solution proposed years ago by Lally was thin-film circuitry.[2, 3] The circuits could be spread over the skin of the balloon, so size of the circuitry is no limitation. There are no foreseeable problems in making very thin resistors, capacitors, semiconductor devices and solar cells. Relatively thin nickel-cadmium batteries have been made and circuits that substitute for coils can be designed. Resonant circuits for the higher frequencies can be made as strip transmission line. Foam plastic can serve as the dielectric.

Ground-based cousin

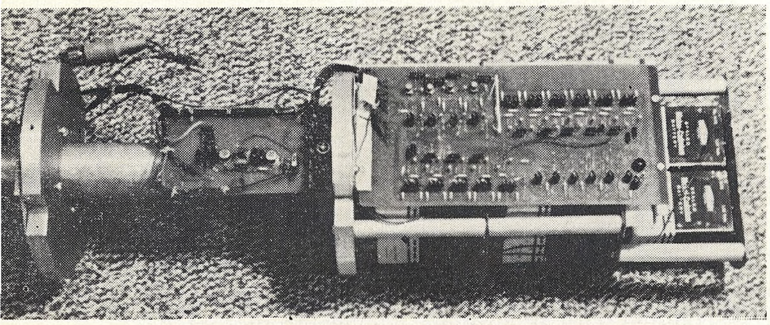
A ground-based version of the system was installed at Christchurch to transmit atmospheric data to Melbourne, Australia. Dubbed Moses, for Meteorological Observing Station, Extremely Simple, it is a four-channel model with an enlarged solar panel (90 cells) and a rechargeable nickel-cadmium battery. The panel is tilted at an angle to receive maximum radiation from the sun. The circuitry is housed in a section of 6-inch pipe on a pole and the antenna is a simple ground plane formed by the pole's guy wires. The pole is 4 meters high.

To shorten the transmitter's duty cycle, coding periods were lengthened and four code groups were used, rather than the Ghost's 16, resulting in the system shown above. It will operate without sunlight for seven days and can get along if sunlight averages only 3 hours a day.

In the test setup, Moses' oscillator is controlled by two thermistors—for air and package temperatures—a reference resistor and a battery-voltage monitor. With one exception—a simple, reliable, wind-velocity transducer—the sensors needed to make Moses an operational weather collection system are available. Extra channels could be added for little additional cost, and power consumption could be cut 80% with low-power logic modules.

The high cost of present automatic weather stations, and the logistics of maintaining them, often precludes their installation on small islands and other out-of-the-way places. Moses could easily and inexpensively collect weather data from remote locations, since its range is 6,000 kilometers and its cost is less than $1,000.

Solar-powered Moses-type stations would require little maintenance and a network of them could be monitored by one receiving station. Since transmission is continuous, data readout could be handled by automatic timing circuitry.



Moses electronic package, shown without its protective cover, has sufficient battery capacity for a week's operation without sunlight. With weight no longer of primary concern, the added batteries and enlarged solar-cell panel can insure a long operational life.

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1. T.O. Haig and V.E. Lally, "Meteorological Sounding Systems," Bulletin of the American Meterological Society, Aug., 1958, p. 401.
2. V.E. Lally, "Satellite Satellites—A Conjecture on Future Atmospheric-Sounding Systems," Bulletin of the American Meteorological Society, Aug. 1960, p. 429.
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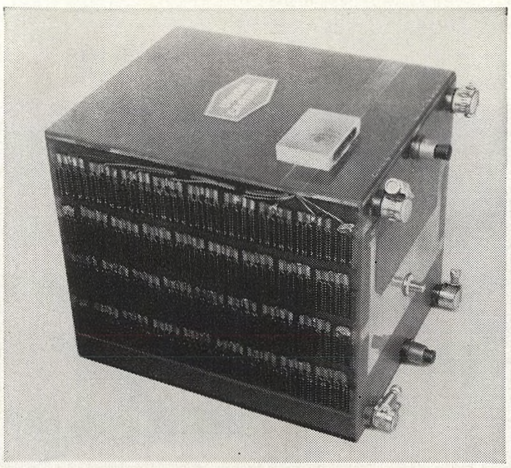

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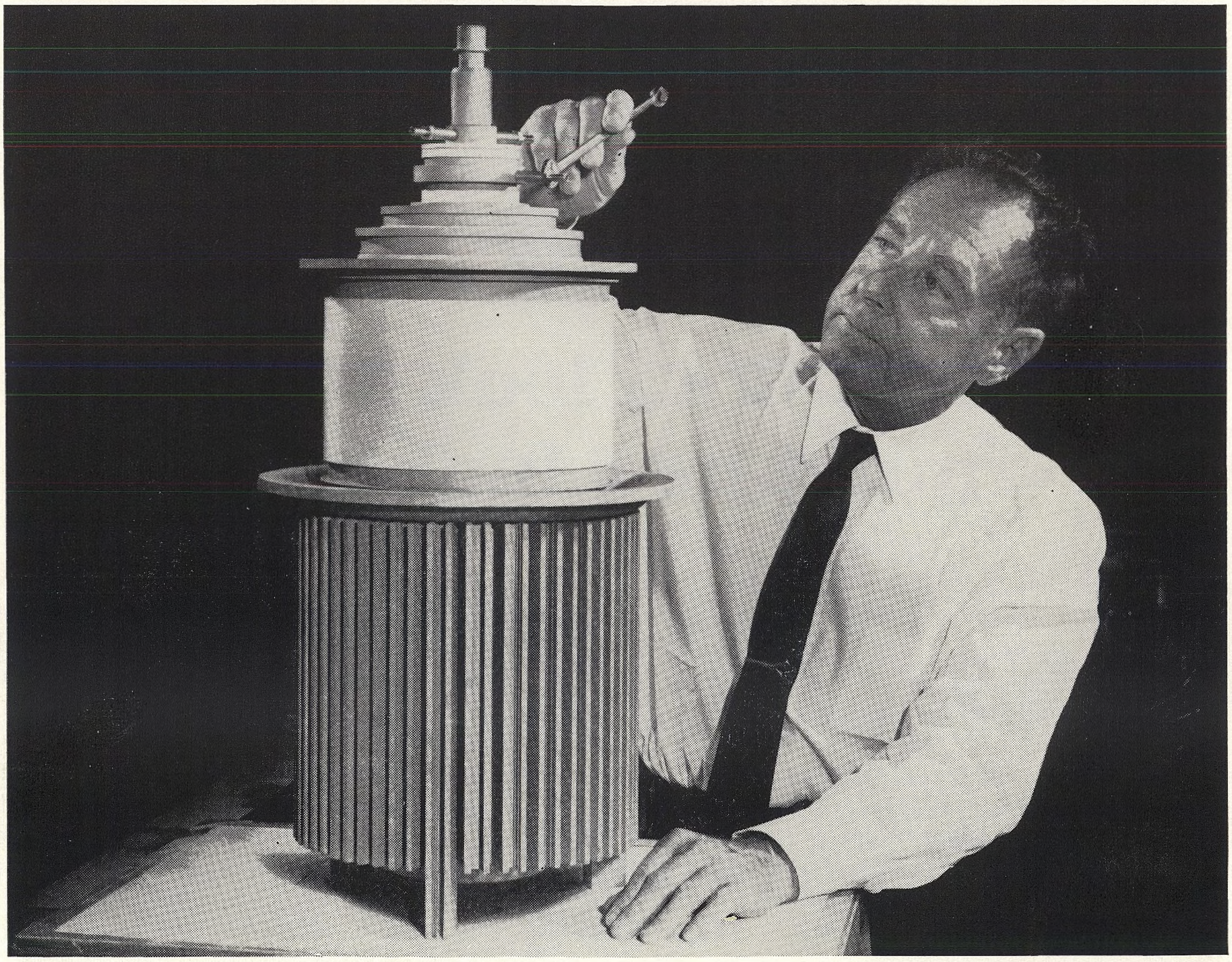
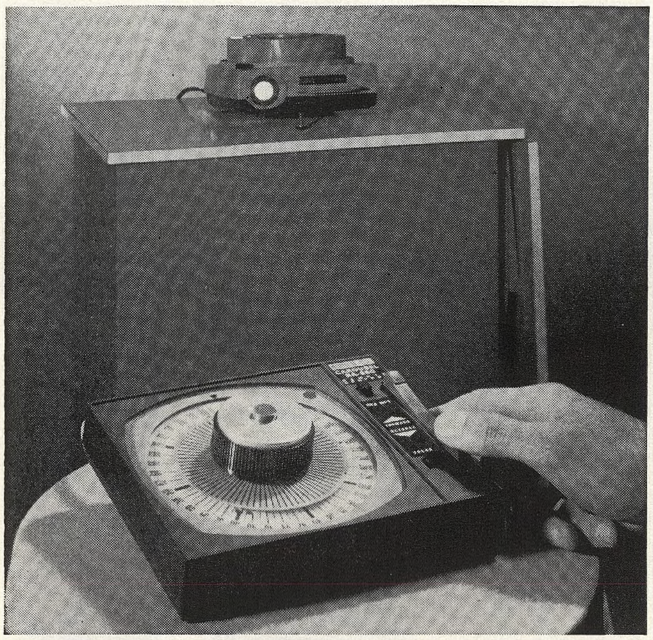


Random access at a distance



80 thin-layer chromatograms	**80 psychotic patients**
80 airports	**80 disc-electrophoresis patterns**
80 bubble-chamber events	**80 antenna radiation patterns**
80 stratigraphies	**80 common skin lesions**
80 microcircuits	**80 uncommon minerals**
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Learning together

At this late date in the history of microelectronics and of the role therein of the KODAK High Resolution Plate for mask-making, a certain phenomenon of physical optics may still need to be pointed out. Unlike the situation in the more venerable branches of photography, where oldtimers with oldtime lenses developed the habit of always stopping down the lens to sharpen up the picture, that's the wrong way to go to keep the fine lines on the plate from fuzzing out beyond their widths calculated from the reduction ratio. With a lens of proper design for the job, like a microscope objective, it is the wave nature of light that limits sharpness; the broader the cone of light from lens to plate, the less the influence of that limitation.

It requires a material as special as the KODAK High Resolution Plate to get down to where this ultimate limitation takes over. To avoid assumptions about the lens you use, however, it is well to make a series of tests with it under fixed photographic conditions where the only variable is exposure time and you note how that affects the broadening of lines of various widths beyond what the simple geometry predicts. You may learn something useful.

You may also be pleased to learn that we are starting to manufacture for your very special needs a photographic plate that is not of the silver halide persuasion. Over the glass base is a layer of chromium $<0.15\mu$ thick, bearing a light-sensitive resist of its own $<0.6\mu$ thick, bearing in turn a water-soluble protective layer that must be removed just before exposure in vacuum-aided contact with a KODAK High Resolution Plate carrying the image. Processing and etching leave a mask of chromium or no-chromium which is far less susceptible to abrasion damage from a few brushes with epitaxial crystals than is the gelatin of the High Resolution Plate when used directly as the mask, as now.

We have a lot to learn about manufacturing the forthcoming KODAK Photosensitive Metal Clad Plate, as do electronics people about using it. To get your technique ready, we have put together some kits containing 10 2″ x 2″ specimens of our present concept of these plates, some chemicals and spray units, and some directions from which to start.

The kits can be ordered from our photofabrication dealers. If around $100 sounds like too much for one of these kits, take it as a sign that you don't need one. You can get the names of a few photofabrication dealers from F. O. Beuckman, Eastman Kodak Company, Rochester, N.Y. 14650.

Range with x-rays

Politics may be too important a subject to be left to politicians, but radiography, while also of some importance, had better be left to the radiographers. Except that, busy minding their own business, they might overlook slipping you an item of technological news you might find useful: that the new importance of their craft in reliability control of modern micron-scale circuitry has led us to make them an x-ray film capable of 35× useful enlargement.

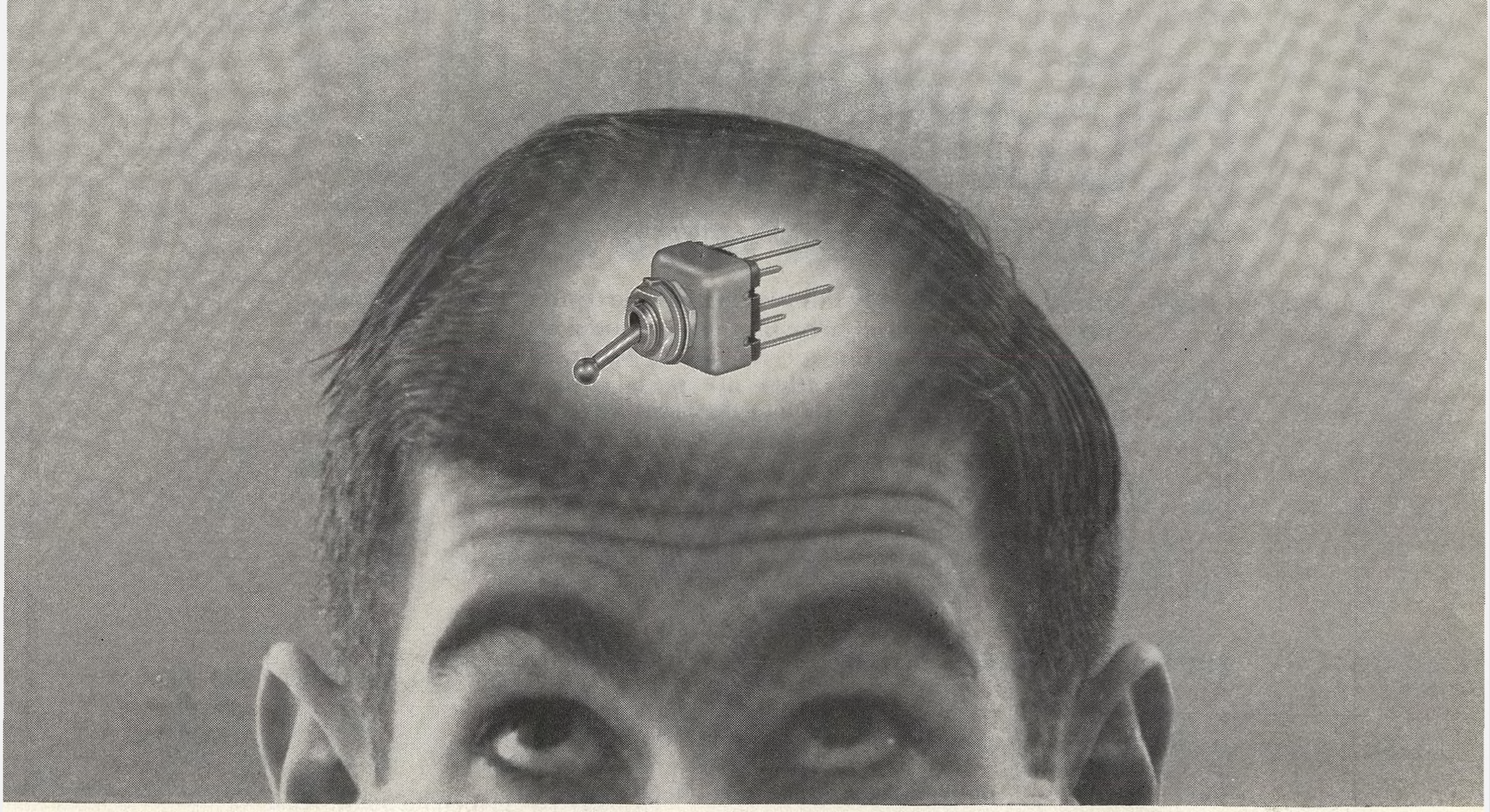
If you want some, order it from a dealer in x-ray supplies and equipment as KODAK *Industrial X-ray Film, Type R (Single-Coated).*

Don't write to ask about the resolving power of this film. Radiography is three-dimensional and doesn't lend itself to clear-cut two-dimensional answers. We'll hem and haw and tell you that some electronics people are using this product routinely to check on the integrity of buried wires only .0005″ thick. We'll inform you that this is one-third the thickness of a human hair and conclude by magnanimously brushing aside whatever shyness you may feel about calling on us if we can be of any further service. It's the slowest x-ray film we make and the one to choose for fighting off insomnia from worry about the dreadful possibility of tiny hidden solder balls.

By omitting the parenthetical "(Single-Coated)" on the order, you'll get twice the film speed at the expense of parallax that will restrict magnified viewing. From this point up the scale of speed we go on by factors of roughly two, with consequent trade-off on fineness of grain, continuing to Type M, Type T, Type AA, and Type F, which for direct Pb-screened 200-kv x-rays is 2^5 times as fast as Single-Coated Type R.* Actually Type F is usually amplified in speed by a further factor of 15 to 30 through use of intensifying screens that transduce x-rays to visible light. If you can't accept what this does to fineness of detail, you might prefer to skip the screens and use our rather coarse-grained Type KK, which is of the order of 100 times as fast as the film with which this discussion started. It has fewer fans than any other in our line.

* Some people stack four or five of these types together in a single exposure, saving time and money by extending range.

The hope of doing each other some good prompts these advertisements



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FREON® TF (boiling point*: 117.6°F.)
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FREON® TA (boiling point: 110.5°F.)
A patented azeotrope of FREON TF and acetone, compounded for increased solvency toward a broader range of more polar and higher molecular weight contaminants such as polymeric materials. Its uses include removing mold release agent from plastic and elastomer parts and cleaning electrical and electronic components.

FREON® TMC (boiling point: 97.7°F.)
A patented, very stable azeotrope of FREON TF and methylene chloride particularly well suited for removing rosin-type flux from electrical and electronic components. It is stronger than FREON TF, but gentle enough for use with most metals, plastics and elastomers.

*All boiling points given at one atmosphere pressure.

FREON® TC (boiling point: 117.3°F.)
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FREON® T-P 35 (boiling point: 120.0°F.)
A patented blend of FREON TF and isopropyl alcohol, good for both organic and polar soils. It is highly compatible with very active metals, an excellent drying agent and ideal for flushing hydraulic piping.

FREON® T-WD 602 (boiling point: 112.0°F.)
A water-in-oil emulsion for cleaning both water and oil-soluble soils. It is compatible with most plastics, elastomers (except silicones), coatings and metals.

* * *

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We've been keeping an eye on Richard. He seems to know exactly which order of Celanar Polyester Film should be shipped with impact recorders. What special roll lengths and gauges each customer wants. Exactly who gets what, when and where.

In fact, everyone from plant manager to shipping clerk seems to have developed extrasensory perception when it comes to making Celanar the best polyester film for electrical applications.

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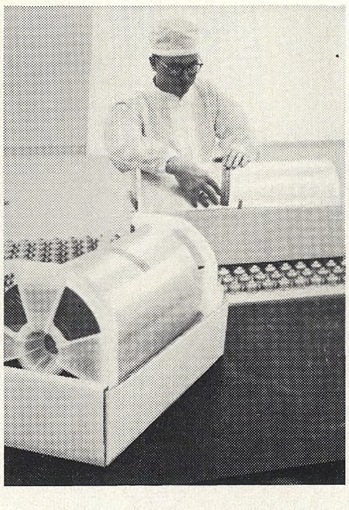

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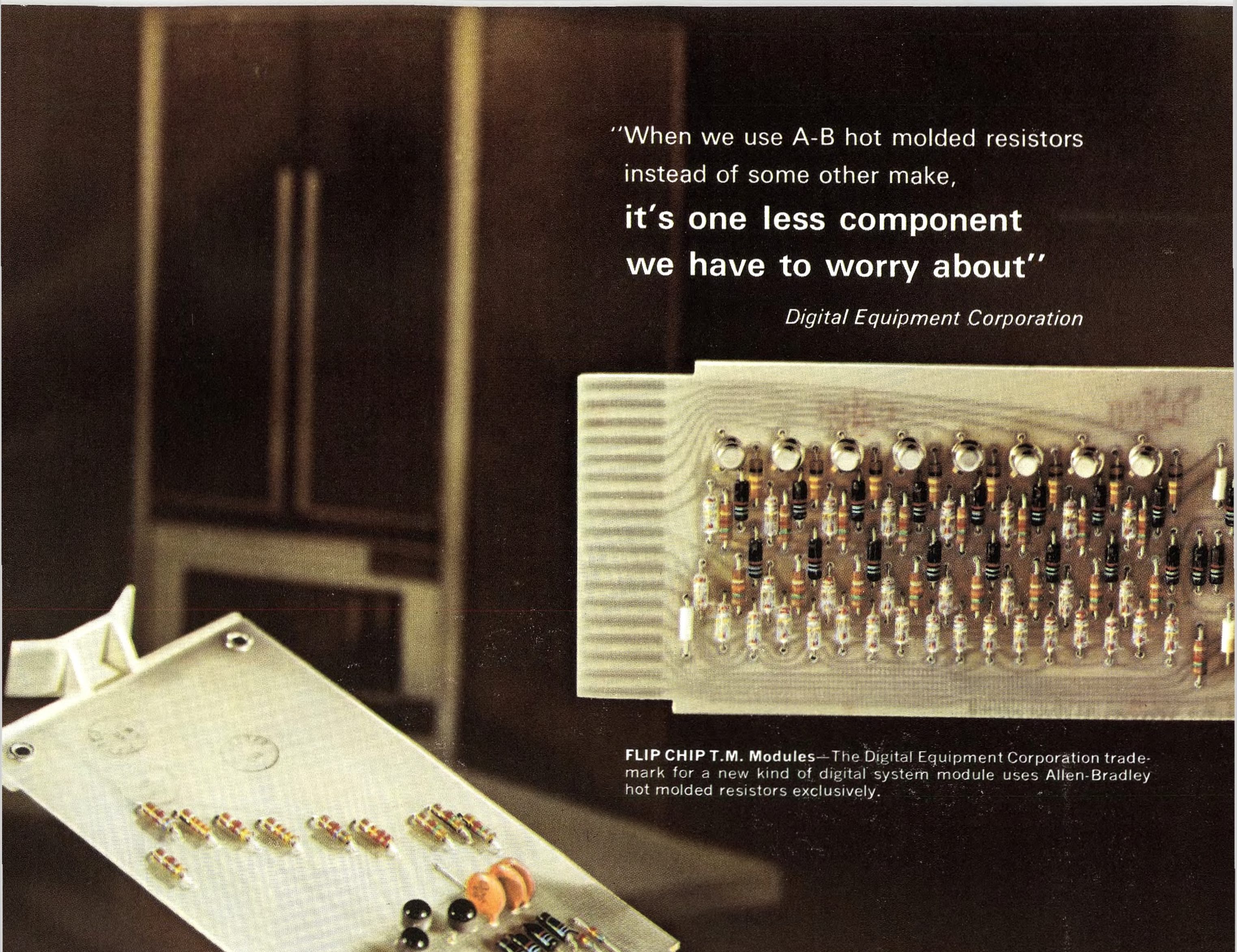
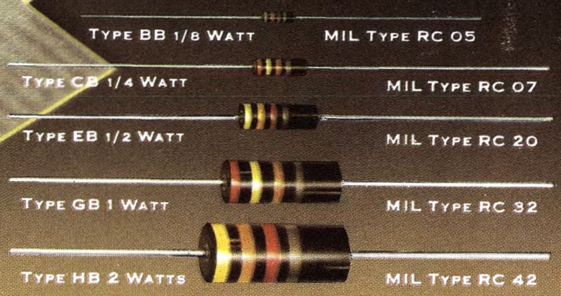


FLIP CHIP T.M. Modules—The Digital Equipment Corporation trademark for a new kind of digital system module uses Allen-Bradley hot molded resistors exclusively.

Digital Equipment Corporation's PDP-8 programed data processor, in which these modules are used, is a compact general purpose digital computer with a high speed, random-access, magnetic-core memory for engineering, scientific, and educational applications.



HOT MOLDED FIXED RESISTORS are available in all standard EIA and MIL-R-11 resistance values and tolerances, and can usually also be furnished in values above and below standard limits. Shown actual size.

■ Allen-Bradley hot molded resistors have established such a consistently superior performance record over the years that Digital Equipment Corporation uses them exclusively in their computers—with no substitutes permitted under any circumstances!

While Allen-Bradley quality is the number one reason for this standardization, Digital reports that *excellent service* from Allen-Bradley is an advantage of vital importance to them, too. For example: "Recent expansion of FLIP CHIP production to meet the demand for PDP-7 and PDP-8 computers quadrupled our component needs. With Allen-Bradley's help there wasn't a single hitch in the production speedup."

The unvarying quality of Allen-Bradley resistors—million after million, year in and year out—results from an *exclusive* hot molding process. The precision automatic equipment developed and used only by Allen-Bradley produces such uniform properties that long term resistor performance can be accurately predicted. Please note, Allen-Bradley hot molded resistors have never been known to fail catastrophically in service.

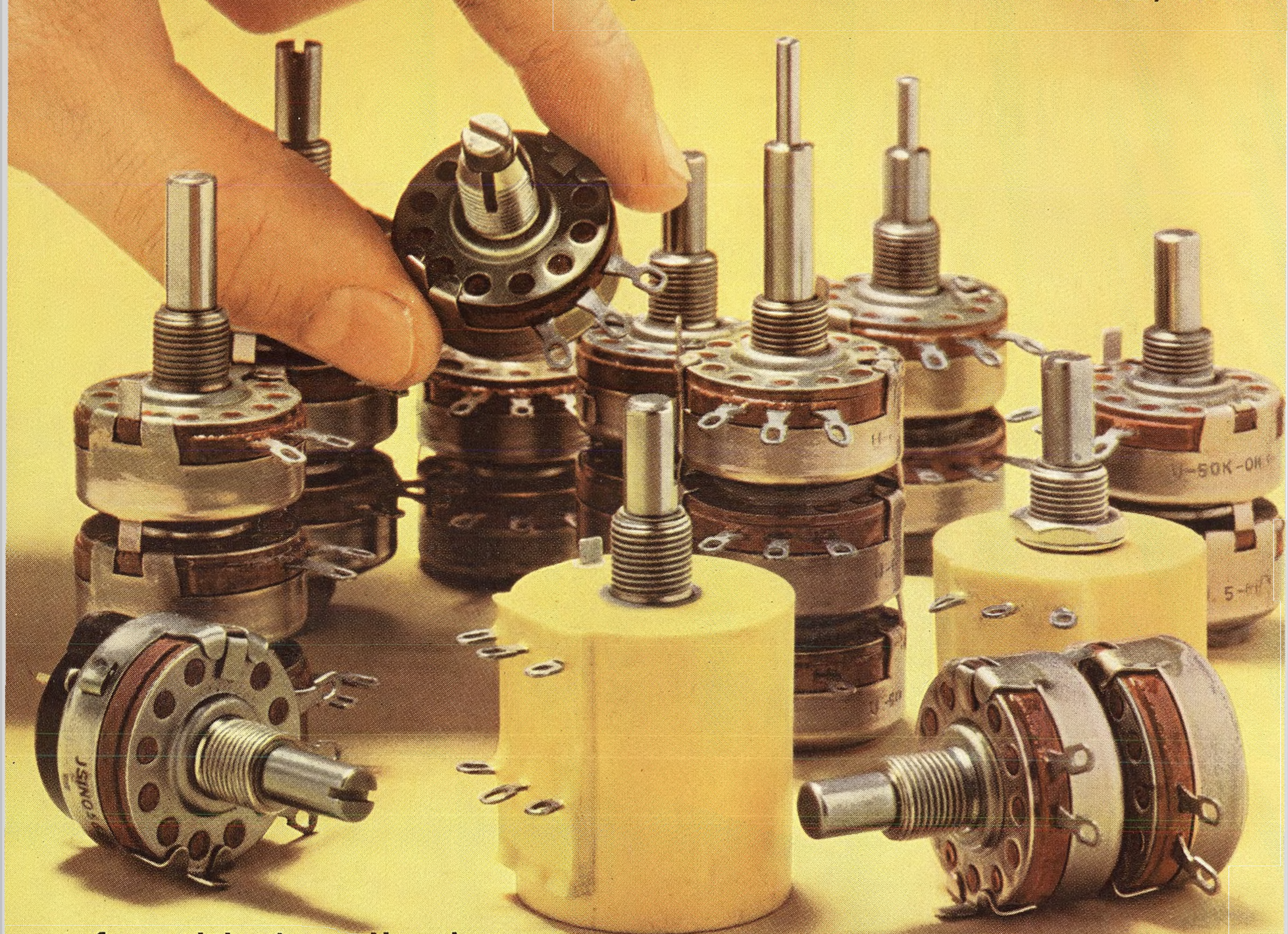
For complete specifications on Allen-Bradley hot molded fixed and variable resistors, please write for Technical Bulletin 5050: Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Ave., New York, N.Y., U.S.A. 10017.

65-08-6E

A-B QUALITY

ALLEN-BRADLEY
QUALITY ELECTRONIC COMPONENTS

Yes—Allen-Bradley hot molded potentiometers cost more, but—



for critical applications they prove themselves far superior—and well worth the price

When a potentiometer in your equipment does not provide the kind of service expected of it—or fails completely—it is only natural for the user to blame you, the manufacturer of the respective instrument. After all, you selected the lower cost component, and your engineer or your purchasing agent decided that "it was good enough." Correcting the mistake usually runs into real money—it does not necessarily eliminate your customer's dissatisfaction. However, you can protect yourself and your customers against such potentiometer failures by joining the ever growing list of the nationally recognized equipment manufacturers who are standardizing on Allen-Bradley potentiometers.

The resistance track of all Allen-Bradley potentiometers is hot molded—a process developed and used only by Allen-Bradley. Resistance adjustment is always smooth—never an abrupt change. Though the initial noise level is very low, it is still further improved with use. The long life of all A-B potentiometers is a fact, established by performance during the many years that these controls have been on the market. For instance, on "speeded up" tests this "life" will exceed 100,000 complete operations, with less than 10% resistance change. And during the 30-year history of this control there has never been recorded a single catastrophic failure.

Protect your reputation as a quality equipment manufacturer by having your purchasing specification call for Allen-Bradley hot molded potentiometers. They are available in single, dual, and triple units. Can be equipped with a 2 ampere 125 volt line switch. Dual units can be supplied with vernier control that provides 20 times finer setability than obtainable with a single control. Units for T, L, and Bridged T and H attenuators are also available. Yes—Allen-Bradley controls *cost slightly more*, but they are *worth much more*. For more details please write: Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee, Wisconsin 53204. In Canada: Allen-Bradley Canada Ltd. Export Office: 630 Third Ave., N.Y., N.Y., U.S.A. 10017.

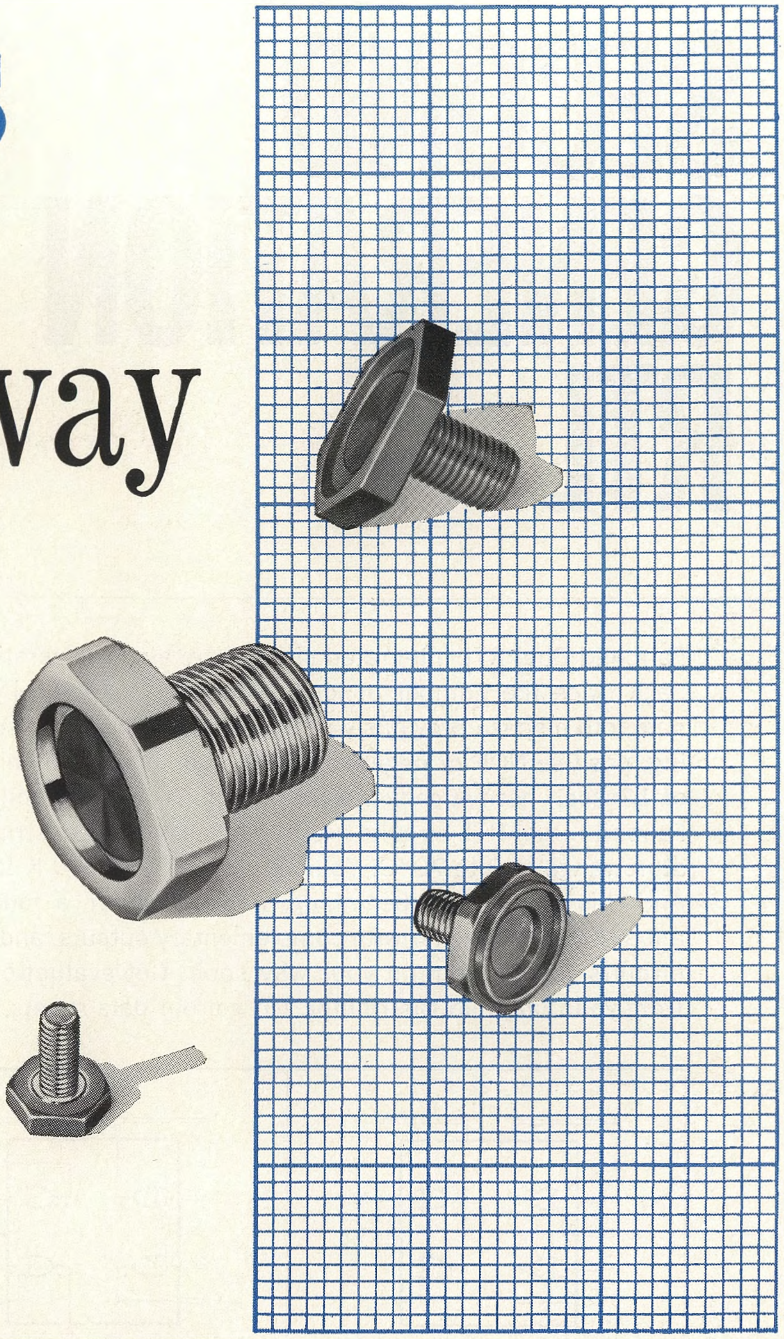
62-04-6E

A-B QUALITY

ALLEN-BRADLEY

QUALITY ELECTRONIC COMPONENTS

What's the easiest way to make this part?



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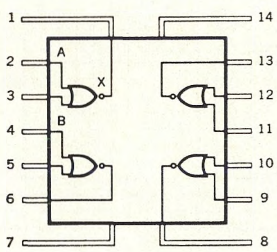
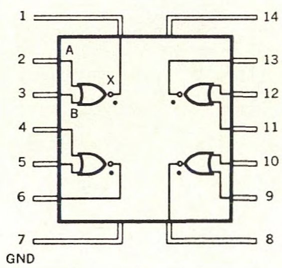
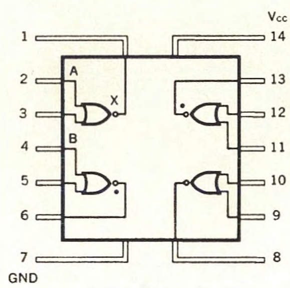


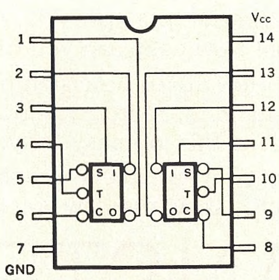
9991
Quad 2-input gate



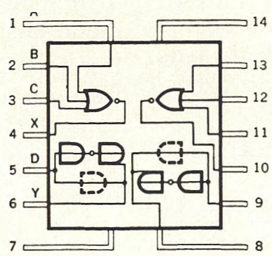
9992
Quad 2-input extender
• Collector Node Resistor not connected.



9993
Dual 2-input gate and dual expander
• Collector Node Resistor not connected.



9994
Dual 923 J-K flip-flop



9995
Dual buffer, dual 3-input gate

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Space electronics

For engineers, a satellite of their own

Space agency set to test Applications Technology Satellites that will establish design guides for future systems

By Robert W. Henkel
Electronics Washington Bureau

Meteorologists have Tiros and Nimbus. Communicators have Relay and Syncom. Scientists have dozens of satellites from the tiny Explorer 1 to giant observatories. Now, the engineers who design satellite electronics and control systems are about to get their own—the Applications Technology Satellite.

The series of five satellites will start with the launch of ATS-B on Dec. 6. It will constitute the most significant and comprehensive flight test yet undertaken to prove new satellite engineering developments. How the many experiments fare on ATS flights during the next two or more years will have a direct impact on much of the equipment design for future satellite systems with a variety of civilian missions.

Waggishly dubbed "Oleo"—for orbiting large engineering observatory—ATS is also expected to provide design guides for military satellites. The applied technology program will extend the state of the art, or will flight test for the first time, equipment shown in the accompanying box.

Goddard Space Flight Center in Greenbelt, Md., runs the ATS project for the National Aeronautics and Space Administration. Hughes is building the spacecraft and conducts the main communications experiments. GE is the prime contractor for the gravity-gradient stabilization systems going into three of the five satellites.

By the end of 1966, $114.8 million, excluding the cost of the improved Atlas Agena launch vehicles, will have been spent on the ATS program by NASA. Of this total, $66 million is for the spacecraft, $29.5 million for experiments and $19.3 million for three ground stations and their operation.

Hughes is building three versions of the ATS: a spin-stabilized, synchronous-orbit model; a medium altitude orbit, gravity-gradient stabilized craft; and a synchronous-orbit, gravity-gradient stabilized satellite.

I. Pacific station

The spin-stabilized ATS-B will go up on Dec. 6 from Cape Kennedy, Fla. It will take two weeks for the satellite to reach its final location, a stationary orbit over the Pacific Ocean, east of the Christmas Islands. Before it gets there, communications tests will begin and the first photograph of the entire earth made from a spacecraft will be taken on Dec. 8. Three ground facilities will conduct ATS tests: an 85-foot antenna station at Rosman, N.C., a 40-footer at Mojave, Calif. and a transportable, 40-foot ground station near Toowomba, Australia.

Each of the five satellites will carry two microwave transponders, primarily for redundancy, which can run separate experiments simultaneously. The transponders carry a pair of Hughes-built traveling-wave tube final-power amplifiers,

> **Firsts on ATS series**
>
> Electronically despun antenna, developed by Hughes Aircraft Co. (ATS-B)
>
> Mechanically despun antenna, developed by Sylvania Electric Products, Inc.'s Electronic Systems Division (ATS-C)
>
> Three-axis gravity gradient stabilization system, developed by General Electric Co.'s Missile and Space Division (ATS-A, D and E)
>
> Multiple access into a satellite by several ground stations simultaneously, developed by Hughes (all five satellites)
>
> Very-high-frequency communications relayed by a satellite from aircraft in flight to ground stations, transponders built by Hughes (ATS-B and C)
>
> Television originating from a spacecraft transmitted in real time to ground stations (ATS-A, D and E)
>
> Spin-scan television system that uses the satellite spin for horizontal line scan, built by Hughes' Santa Barbara Research Center for a University of Wisconsin experiment (ATS-B)
>
> Computer-directed acquisition and real time processing and reduction of experimental data from a satellite. Equipment developed by Westinghouse Electric Corp.

. . . A dozen ground stations will transmit simultaneously into one satellite . . .

each able to deliver 4 watts of radio-frequency power to the antenna. Frequencies will be in the 6 gigahertz band for the uplink and 4 Ghz for spacecraft-to-ground transmissions.

The transponders will operate in three different modes: multiple access with frequency-division single sideband transmissions accepted and retransmitted as a single phase-modulated carrier; wideband frequency-modulated transmissions received, converted to an intermediate frequency, amplified, translated to the downlink r-f carrier frequency and retransmitted; and transmitting wideband spacecraft sensor data to ground stations.

The frequency translation mode is designed primarily for television or such other wideband applications as high-speed data transmission in which one ground transmitter takes over the complete channel. Wideband circuitry is used throughout the signal chain to furnish a 25-Mhz usable band.

II. Color television experiments

Color television relay experiments are expected to begin shortly after ATS-B reaches its station. A wideband 10-kilowatt f-m transmitter will be used for the uplink. Color transmission will go only to the Rosman station since Mojave's and Toowoomba's smaller antennas are only feasible for black-and-white experiments.

Number please. The multiple access experiment will be the first real demonstration of a "telephone switchboard" technique that is vital for any communications satellite operating simultaneously with more than two ground stations. With the ATS system, more than a thousand telephone-quality channels can be handled, says Robert H. Pickard, ATS spacecraft manager at NASA. About a dozen ground stations would be able to transmit simultaneously into the ATS equipment.

For the ATS experiments, Rosman is the only ATS ground station that has sufficient gain to utilize the full multiple-access mode bandwidth of 600 duplex voice channels (1,200 total). The two 40-foot stations can handle up to 120 duplex or 240 channel operations. An automatic level controlled 1- to 4-kilowatt single sideband ground transmitter sends up the frequency-division multiplex channels using a 5.6-Mhz base bandwidth. The system utilizes narrow bandwidth by going single sideband, where just the carrier is transmitted. ATS amplifies linearly in the intermediate frequency. "There are no cross modulation products to foul things up," Pickard says.

The ATS satellite transponder converts the signals into phase modulation of a single carrier. The composite 25-Mhz-wide signal is received by all ground stations, each demultiplexing the p-m signal to receive the channels in which it is interested. In ATS tests, the three ground stations will load the base band.

With this multiple-access approach, small and large stations alike can work together through ATS as long as everyone keeps his link narrow.

Keeping the ground stations on their frequencies is a real problem in frequency-division multiple access. Stations must transmit precisely on frequency. But crystals do drift, so there has to be a correction put in the system, Pickard says. Thus, one master station continuously transmits a side tone that all ground stations lock onto.

The medium altitude ATS-A will also check on how the doppler shift affects the ATS multiple-access scheme. This phenomenon, however, will prevent any satellite but a stationary orbit craft from providing multiple access, some engineers maintain.

III. Vhf experiments

The two spin-stabilized Applications Technology Satellites called B and C—will carry a very high frequency transponder for several experiments. The active frequency translation repeater will receive at 149.22 Mhz and transmit at 135.60 Mhz, without changing the modulation. These frequencies were selected to make maximum use of existing hardware. The ATS transmitter puts a total of 40 watts of r-f power into the antenna. Minimum bandwidth is 90 kilohertz.

The results of the test involving the vhf transponder will determine the feasibility of employing satellites to relay communications between aircraft and ground stations.

IV. Despinning the spin

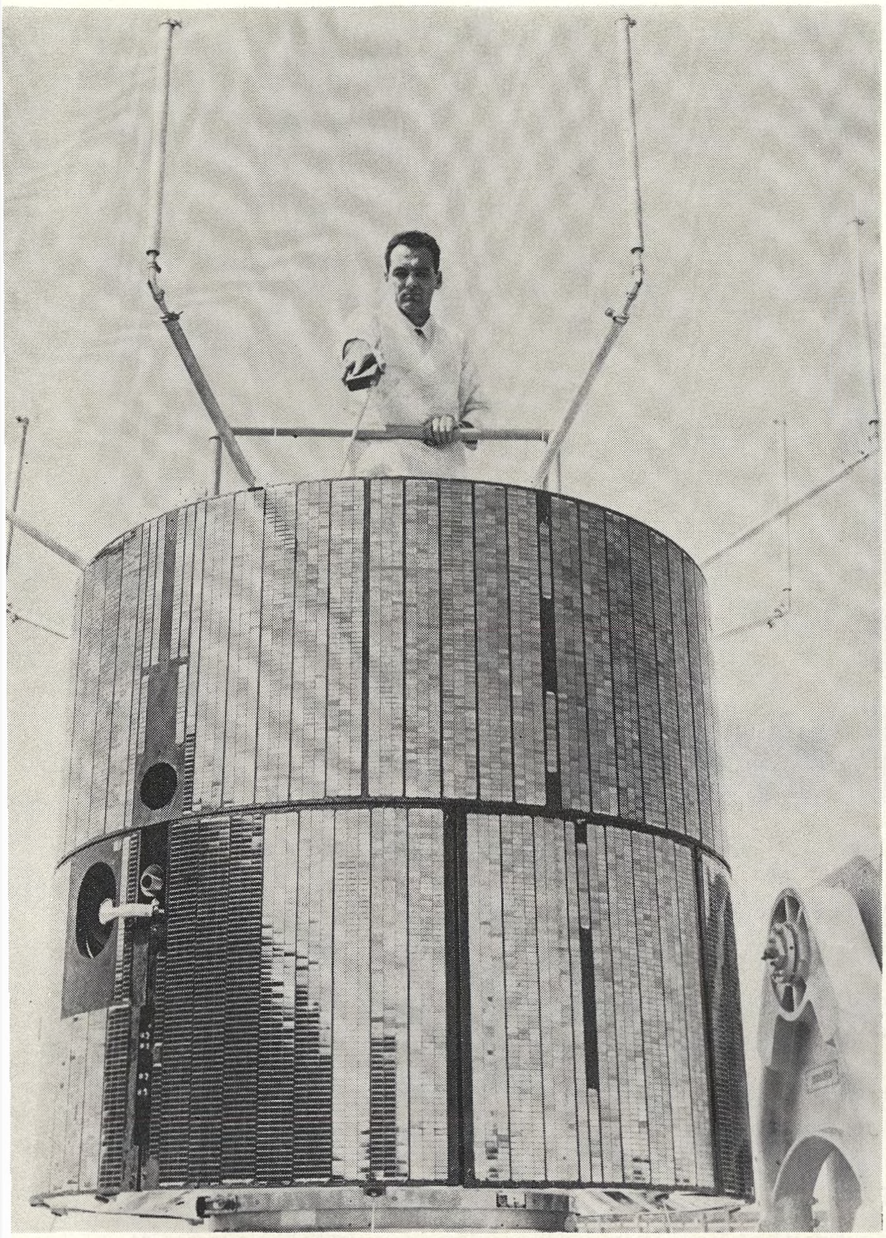
New microwave antennas will make their first flight tests aboard the ATS series.

The first gravity-gradient satellite, ATS-A, will carry standard microwave directional horns for transmitting to earth but subsequent gravity-gradient synchronous spacecraft will carry planar arrays. An eight-element, vhf-phased array will also be flown in the spin-stabilized satellites. The control signals to form and despin the vhf-phased array beam will come from the electronics used to control the despun microwave-phased array. Gain of the vhf despun antenna will be about 8.5 decibels.

The solution to the problem of focusing most of the radiated power of a satellite antenna toward earth, rather than dissipating it in space, could be one of the most important rewards of ATS experiments. Proponents of both gravity-gradient stabilization and despun antennas on spin-stabilized satellites are predicting vindication for their approach. But many engineers feel there will be room for both techniques on future satellites—provided they can prove their operational feasibility.

If gravity-gradient stabilization works, it will be another competitor of the despun antenna, one NASA engineer predicts, not a replacement. ATS-B will be the first flight demonstration for an electronically despun antenna—which generates the antenna pattern with no moving parts.

Reverse spin. The system developed by Hughes produces a conical-shaped beam which is rotated electronically at a speed equal to the spin of the satellite. It operates in reverse so it will cancel out the satellite spin. The r-f energy is fed into a power divider where it is split into eight equal amplitude signals to drive the eight ferrite r-f power shifters. The array is made up of 16 collinear stacks of linearly polarized radiators arranged in a circle around the satellite spin axis.



Spidery vhf antennas are part of the equipment to be tested on Applications Technology Satellite-B, the first of five satellites.

The beam is despun by controlling the phase-shifter drive currents. The pancake-shaped beam which throws energy in all directions in a single plane wastes most of the r-f power. Only 5% or 10% of the energy reaches the earth. The Hughes despun antenna still has a back lobe, but it is 10 decibels less than the front lobe. Total losses in the antenna system, including loss in the power splitters and the pattern gain of the antenna, run about 1 db, Pickard says. It focuses about 10% of the twt power on earth, and has a gain of about 15 db.

The mechanically despun antenna due to go on ATS-C has a total power loss of only 2 db due to the elimination of the power splitter. But the trade off here is mechanical reliability—the bearings required to despin the antenna could freeze in space. This antenna, being built by Sylvania, puts over half of the satellite's power on the earth. The antenna does not require as much weight or power as the electronically despun unit, but its moving parts make it difficult to assure long life. The antenna is being designed for a minimum life of one year, but NASA is hoping for a five-year span. Including drive-motor electronics, the antenna weighs nine pounds. Its parabolic antenna is illuminated by receiving and transmitting radiators mounted on the spin axis of the spacecraft. A stepping motor drives the antenna at a rate synchronous with the spacecraft spin rate, but in the opposite direction to despin the beam. Antenna gain is about 17 db.

The medium altitude gravity-gradient system horns will provide a gain of 10 db, lower because of the 45° beam width needed to cover the entire earth at the 6,000 mile altitude. The horns will be on both sides of the satellite because of experiments planned to invert the satellite to simulate perturbations and measure how long it takes the damping system to stabilize the satellite. The planar arrays on the D and E synchronous-altitude models will be located on only one side of the satellite and will provide a 16-db gain.

V. Taking a look at the weather

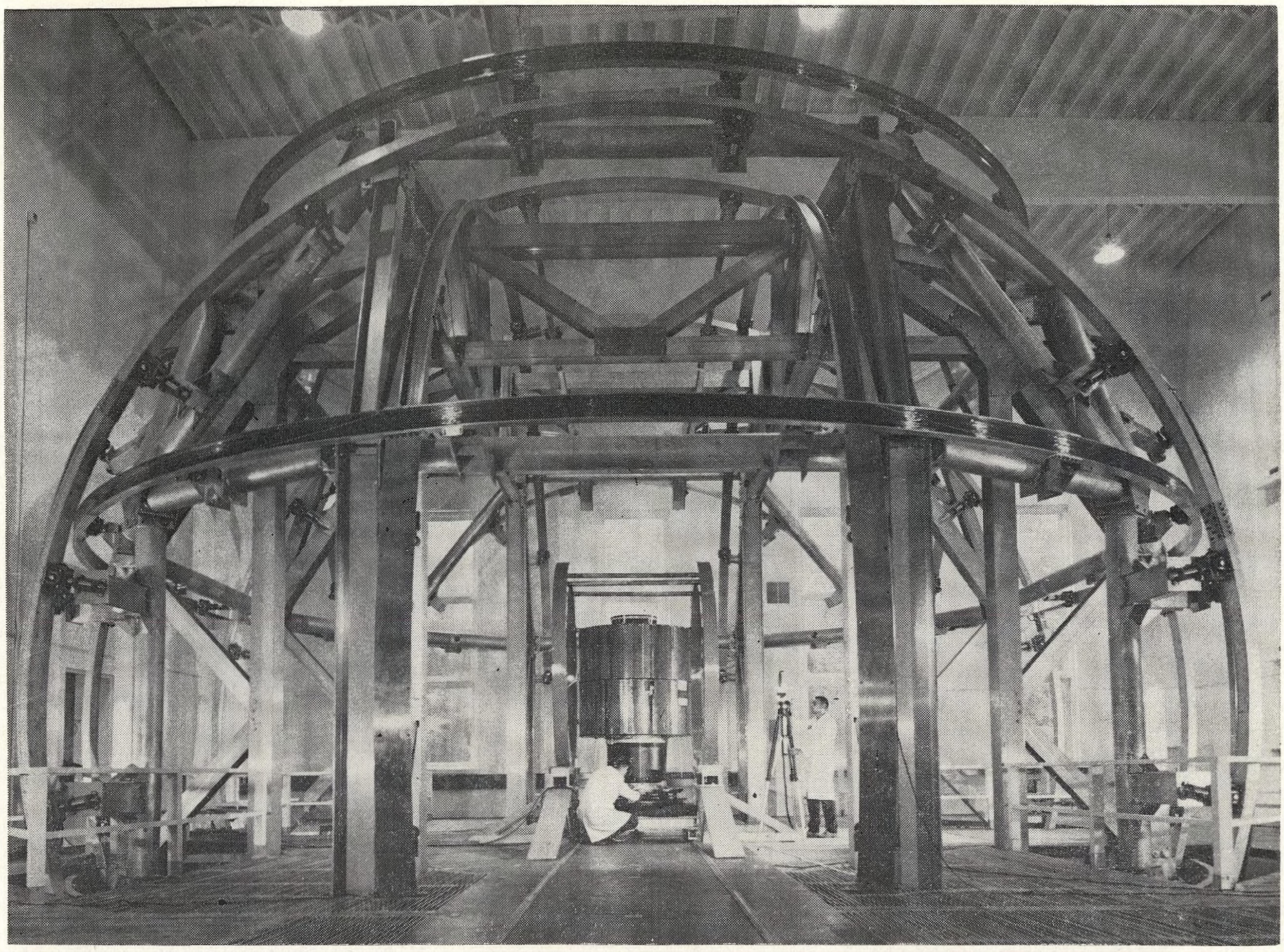
The first pictures from a synchronous orbit will be taken by ATS-B with a new camera system that uses the satellite spin to provide horizontal line scan. Space television systems now operating counteract satellite spin with complex despinning or image motion techniques.

Hughes' Santa Barbara Research Center has developed a new mechanical scan camera which is simpler and more reliable than existing systems. Hughes says that it has scan stability, wide coverage and high resolution, and can be adapted for infrared. A 5-inch Cassegrain-type reflecting telescope passes light through a .001-inch pinhole aperture onto a photomultiplier light detector tube.

Since the satellite is spinning at 100 revolutions per minute, the camera scans 100 horizontal lines each minute. The pivot-mounted telescope tube is stepped vertically by a sun sensor which generates a signal to switch on a motor momentarily to index the camera down to the next scan line. Scanning a line 2.2 miles wide on earth, the system is expected to produce an earth picture showing details as small as two miles. The camera takes 20 minutes to scan its 2,000-line picture, which is transmitted to earth stations by the ATS microwave transmitter.

VI. Pointing with gravity

Making the satellite a stable platform with a gravity-gradient system takes advantage of the fact that a long object in space will



Applications Technology Satellite-B is being demagnetized at Goddard Space Flight Center in preparation for launch Dec. 6. The spacecraft and others in ATS series will have major impact on engineering design for future satellites.

align itself vertically with the earth. This is due to the gravity gradient, or the point at which the gravitational attraction decreases with distance from earth. This method of stabilizing the satellite excites engineers because it would permit the use of conventional parabolic or directional antennas to focus a pencil beam on the earth.

But more information is needed as to how such systems perform in space, particularly at higher altitudes where the pull of gravity is much weaker. The Navy has effectively used two-axis stabilization in its low 500-600 mile orbit navigation satellite. But only one test has been made at near-synchronous altitude—General Electric Co.'s axis gravity-gradient test satellite for the Air Force.

Goddard engineers wanted to launch the medium altitude, or 6,000 mile orbit, gravity-gradient stabilized ATS-A first so that they could verify their calculations for the high-altitude system. They could then extrapolate their data to design the synchronous altitude gravity-gradient system for the ATS-D and ATS-E spacecraft.

Design departure. However, the gravity-gradient stabilization system confronted project engineers with the biggest stumbling block so far in the program. A thermal problem necessitated a complete structural redesign of the three gravity-gradient satellites. This major slip caused NASA to move the first spin-stabilized satellite, the B craft, ahead of ATS-A, which was previously scheduled for first launch. It won't go up until mid-April 1967 at the earliest.

The redesign problem was in the solar cell power system. The side of a satellite which does not rotate or spin is exposed to solar radiation for long periods while the other side is continuously radiating in space. The unequal heating produces temperature ranges that adversely affect solar cell conversion efficiencies.

The solar cells in the original ATS gravity-gradient design, however, would have been subjected to a temperature range of minus 200° to plus 300° F, according to Goddard ground tests—a swing that would have drastically reduced the power output.

The unexpected wider temperature ranges were due to the insulated electronics compartment on which the cells were mounted. It didn't permit the sun-exposed cells to get rid of enough of their heat, or the shaded cells to pick up sufficient heat from the spacecraft. This large temperature swing could not be tolerated. Hence, redesign.

New packages. Electronics were repackaged in a two-foot high, eight-foot diameter center unit. Two-foot high hollow cylinders were added on each side of the center equipment unit to mount the solar cells. The heat from the sun-exposed cells now radiates across the open cylinder to the cold side. This reduces the temperature swing to a range of minus 70-80° to plus 130-150° F.

Even so, it will take 33,000 n-on-p

solar cells on the gravity-gradient bird—50% more than the 22,000 cells on the spinning satellites. Both power systems will generate about 150 watts. But the ATS power budget is set at a maximum of 125 watts. Above this, Pickard notes, "the peak temperature will go out of spec."

Applications Technology Satellite program

Spacecraft	Launch date	Orbit	Stabilization	Weight in Orbit
ATS-B	Dec. 6, 1966	Synchronous	Spin	790 Lb.
ATS-A	Mid-April 1967	6,000 mile	Gravity gradient	702 Lb.
ATS-C	November 1967	Synchronous	Spin	790 Lb.
ATS-D	May 1968	Synchronous	Gravity gradient	670 Lb.
ATS-E	September 1968	Synchronous	Gravity gradient	670 Lb.

To take advantage of the gravity gradient to stabilize the satellite, long booms will be carried that will unreel after the spacecraft gets into orbit. Four booms in the shape of an X extend from the spacecraft cylinder. Goddard engineers settled on 100-foot long booms with 2.5-pound tip weights for the medium altitude system and 125-foot length and eight-pound tip weights for the synchronous version. A 90-foot damper rod coupled to the satellite through a damping unit reduces satellite oscillation.

Tight tolerances. The primary booms and the damping rod are made of spring tape which is rolled flat on a drum for storage. When extended in orbit, they will assume a tubular shape. This boom, developed for ATS by de Havilland Aircraft of Canada, Ltd., has had to meet rigid specifications. In straightness, for example, the tip of the boom cannot be outside a 1.5-foot cone that is in a direct line from the other end of the 100-foot boom. The booms are "having a little difficulty meeting this requirement," one NASA engineer admits. The booms are the only components of the 132-pound gravity-gradient stabilization system not yet delivered for ATS-A, he notes.

The de Havilland metal tape booms are also experiencing so much difficulty in another area—thermal bending—that the Westinghouse Electric Corp. is developing an improved tape boom for the ATS-E. When exposed to the solar heating, the tape boom builds up a high temperature gradient from the sun-exposed side to the cold side which causes temporary bending. The bending increases the instability of the system. By perforating the metal tape and coating the inside of the tube with a reflective material, Westinghouse has given its boom the capacity to pass the radiation through the exposed surface and out the other side of the tube, thereby equalizing the temperature difference that causes the bending. Even so, ATS gravity gradient experiment manager, Anthony H. Sabelhous, expects that the ATS booms will probably undergo three-foot thermal bends at least part of the time.

The medium altitude gravity-gradient system is expected to provide a pointing accuracy of 2.7° in pitch, 1.4° in roll and about 4.6° in yaw, he says. The synchronous system, in the worst case mode when the satellite is stationkeeping (small engines exerting a tiny thrust), is expected to have an accuracy of 4.8° in pitch, 3° in roll and 14° in yaw—the axis most affected by stationkeeping.

To damp the gravity-gradient system's oscillations, Goddard engineers chose passive magnetic systems—a hysteresis-type developed by TRW, Inc., and an eddy-current version by GE. Each damper can be used separately for evaluation against the other. The GE model sets up eddy currents in the material to get rid of energy, and the TRW unit reverses the dipoles in the material to take the energy out. Both units consist of a disk of highly conductive material with magnets on the top and bottom of the disk.

VII. Nonscanning i-r sensor out

A new type of infrared sensor, which did not have the conventional mechanism and which had no moving parts, was to have gone on the ATS gravity-gradient system to help determine satellite orientation. But TRW Systems which developed the earth sensor, could not deliver flight hardware, according to a NASA spokesman.

A conventional, two-axis scanning i-r earth sensor, built by the American Standard Corp. and similar to the one used on the Orbiting Geophysical Observatory series, will be installed instead on ATS-A. The scanning sensor will measure the horizon's location only and will not effect the accuracy of the stabilization since it is not locked into the system. A sun sensor built by GE will also furnish satellite altitude data.

Two television cameras, conventional 525-line units built by Lear Siegler, Inc., will be flown on ATS-A to view the ends of the gravity-gradient booms to determine how much bending is caused by the solar-induced thermal gradients and thermal shocks when the spacecraft enters or leaves the earth's shadow. The cameras may also be used as a back-up system to the earth and sun sensors to generate attitude data. The camera's 30 pictures-a-second transmissions will be sent back to earth stations in real time—the first instantaneous tv picture from space.

VIII. Ion engine misses ATS-B

One subsequently scrubbed experiment scheduled for the first ATS launch was a 10-micropound ion thrustor system being developed at Lewis Research Center, Cleveland, Ohio. But Lewis couldn't deliver the flight model system on time and the engine has been tentatively scheduled for the ATS-C that will be launched late next year. The contact ionization engine weighs about six pounds and uses 15 watts of power. With the experimental duty cycle planned, the propellant will last about three years. This is to be NASA's first orbital flight test of electric propulsion. The change in spin speed of the satellite after the engine is fired would have been measured to evaluate the engine for such future applications as satellite stationkeeping.

Flying instead on the ATS-B is an ion engine competitor—a resistojet thruster built by Goddard. It is essentially a gas nozzle which adds heat to the gas from a resistive heater, thereby increasing the system's specific impulse and reducing gas consumption. The tiny thruster puts out a total of 1 millipound of thrust from its two nozzles.

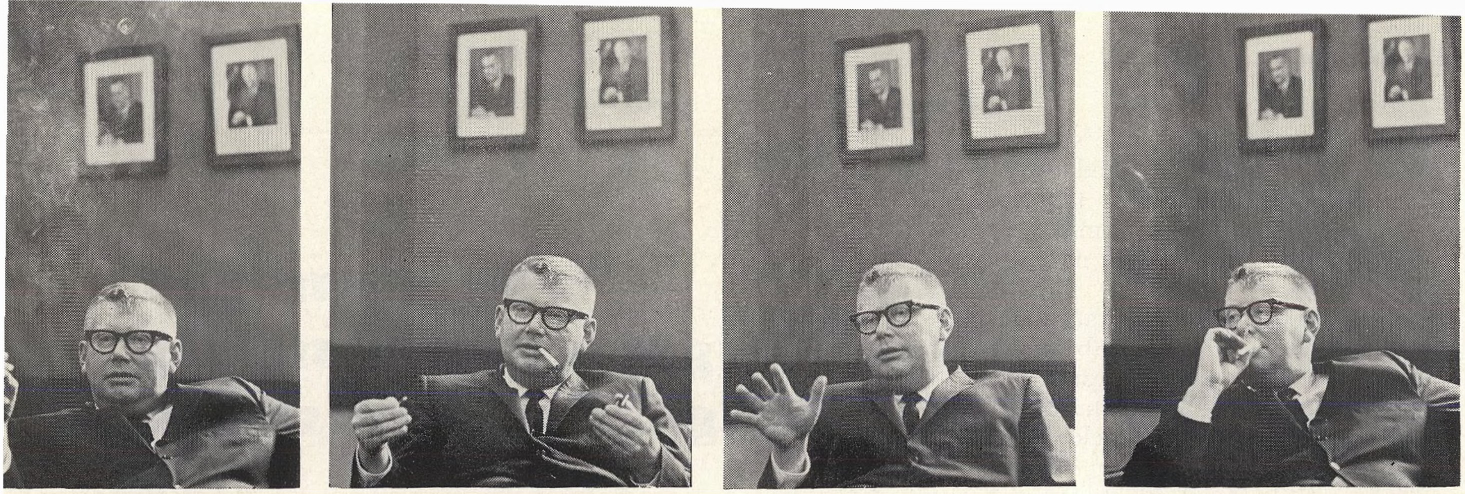
ATS-B will also carry a nutation sensor to measure the wobble about its spin axis. This wobble must be kept to a minimum in a spin-stabilized satellite if the spin-scan cloud cover camera and the despun antennas are to be used effectively. Also on board next month's launch will be a scientific package of seven different experiments that will measure the orbital environment of the satellite and determine the effects of this environment on the satellite.

IX. Real-time processing

The mountains of manually acquired test data have been one of the biggest problems in communications experiments conducted with previous satellite systems. The recording and reduction of this data proved to be time consuming, resulting in delayed evaluation and analysis.

Westinghouse has developed and built a system for automatic acquisition, real-time processing and reduction of data for microwave experiments on ATS-B. Accordingly, each ATS ground station will have a communications test and evaluation console and data processing system which, under the control of a stored program, absorbs the test data, reduces the quantity and performs real-time computations to yield system parameters in engineering units. This will cut the time needed for conducting the microwave experiment and allow more time for other ATS-B experiments. The microwave experiments will require only an average of four one-hour periods of spacecraft time a day.

Current plans call for an initial data analysis report 75 days after launch with reports following at 30 day intervals. This means everything from data acquisition, through data analysis and documentation must be done in one month. In the past, data systems for similar programs have required turn-around times "in the order of years" before it was possible to publish meaningful experimental results, Westinghouse says.



Russell W. McFall, president, describes the changes taking place at Western Union.

Companies

The message from Western Union

Delivered enthusiastically by engineer-president Russell McFall, it concerns a national information utility that may revitalize the century-old organization

By Paul A. Dickson

Staff writer

In the dark corridors and wheezing elevators of Western Union's penitentiary-style, red-brick headquarters in lower Manhattan, serious young men in shirtsleeves speak of hardware delivery dates, debugging, information retrieval, time-sharing and Phase-1 completion.

These eager engineers and technicians—a far cry from the employee who awkwardly delivered the singing telegram—are part of the new Western Union Telegraph Co. whose guiding spirit is 45-year-old engineer-president Russell W. McFall. A large man with a crew-cut, McFall speaks of his company's future with the optimism and determination of a football coach whose team, after a long losing streak, is starting to win some games.

I. Germ of an idea

In his spacious office, seated beneath photographs of Lyndon B. Johnson and Hubert Humphrey, McFall recalled his first days with Western Union. He joined the corporation in 1963, smack in the middle of hearings by the Federal Communications Commission on the tariff rates and rate structures of Western Union and the Bell System. McFall's arduous assignment was to study the mountains of testimony and documents that the investigation produced. He says it was while reading about his company's problems that he realized the need to "pinpoint the next cycle in communications."

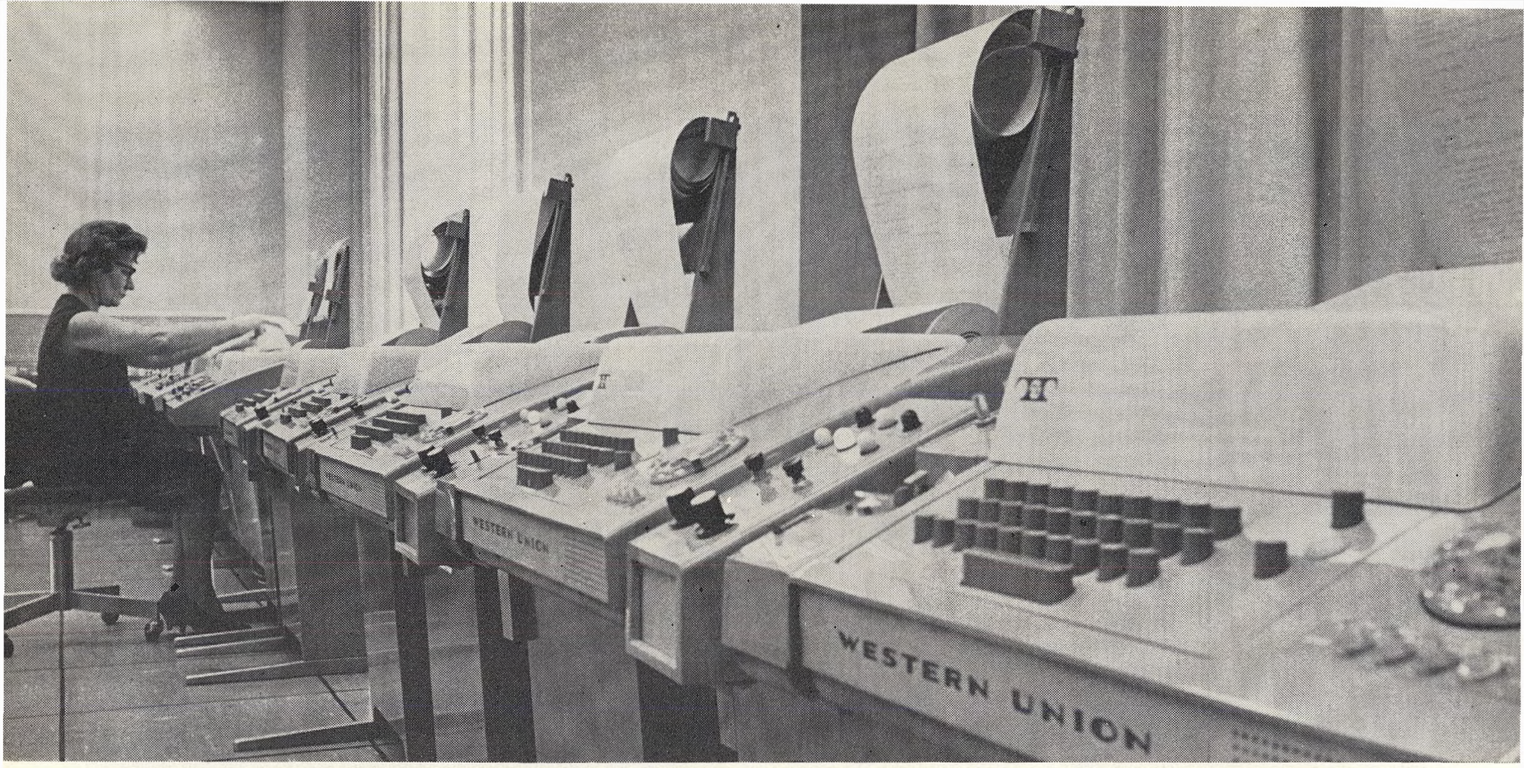
McFall was convinced that the answer lay in a system that would supply customers with information—quickly, efficiently and inexpensively. Western Union had already entered the computer field in partnership with the Department of Defense and McFall started thinking of a way to link the Western Union communications system with computers to form a national information utility.

McFall sees both national and regional competitors for the information utility but to him competition in this expanding area where there is room for everybody, "is a vote of confidence showing us we're going in the right direction."

The national information utility, already in operation on a limited basis, is not the only objective of the new Western Union. It has embarked on a large-scale program of supplying custom-tailored data systems and it is working on the full integration of its nationwide public message relay network with the direct-dial Telex (Teleprinter Exchange) to form a single computer operated system.

Western Union 'boys'. McFall, who holds a degree in electrical engineering from the University of Maryland, headed General Electric's 3,500 man ballistic missile program. As vice president of Litton Industries, Inc. and general manager of its Radcom division he was responsible for radiation and communication equipment. Understandably, McFall turns to top engineers to get his programs rolling. Among them are two operating vice presidents: Robert W. Hodgers Jr., 45, in charge of data processing and Peter J. Schenk, 46, in charge of government systems. Before coming to Western Union, Hodgers had been managing engineer for GE's X-ray department; Schenk had been executive vice president of the Mitre Corp.

"The opportunities for the technician at Western Union are unlimited," says McFall, sounding like a recruiter, "As I've said be-



Telex consoles like these are integral part of two new computer communications systems being developed by Western Union; a national information utility and an integrated message network system.

fore, we may only be limited by our human resources."

McFall's coworkers say he sets a pace that is tough to follow. His workday begins at 6:30 or 7:00 and he seldom leaves the office before 5:30. He travels after office hours and splits his time between Washington, the home office "where they know the problems" and the field, "where they know the answers."

II. Information utility

Of the three objectives of the new Western Union, the most dramatic and revolutionary is the information utility. It is based on the premise that a national information network can be made available to thousands of customers on a real-time on-line basis. Customers who could never afford their own national network would be able to plug into the utility. In a speech to the Columbia University Graduate School of Business, McFall casually compared his information network to the utilities of gas and electricity.

Best customer. The rapid development of the utility is in part due to Western Union's ability to borrow from the other objectives and activities of the company. McFall observes, "The backbone of the utility system had to be put in to handle our own message business —we are our own best customer."

He goes on to point out that the Telex, which is part of the integrated message system, has put 20,000 input/output devices in place for the utility network. Developing data systems for the government and other large customers has given valuable experience for the utility system.

On-line. Western Union's affiliate, PICS (Personnel Information Communications System), and Law Research Service Inc. are the first two on-line customers of the utility. Each is a relatively small operation whose ideas take on national significance by being linked to the system. Although both are in their infancy they have the potential of dramatically changing respectively the fields of personnel recruitment and legal research.

PICS is a location service, oriented to engineers and professional people. It serves over 60 industries and enlists registrants in 1,310 skills classifications. An estimated 100,000 people will pay a dollar a month to be listed by the confidential service within the next year. It will be given a certain advantage over its competitors as it will be shortly linked with Telex and the Bell System's teleprinter TWX. It's claimed that PICS will be able to supply industry with instantaneous answers to the most arcane questions—for example, is there a ferro-optics man who speaks Walloon and has a secret clearance?

Legal system. Law Research Service Inc. is a small company with a gargantuan appetite for legal references. It uses verbal "descriptors" paired with 10-digit code numbers to save lawyers many hours of arduous digging. Descriptors and numbers are listed in thesauri now available for 14 states and 17 areas of Federal law. New states are currently being added at the rate of one every two weeks and those already available are being updated every 10 days. Previously, a staff of lawyers had to sort, classify and index over 2,000,000 rulings for the state of Texas alone.

Telex gives instantaneous response, but a thesaurus holder without Telex can write a letter or call the local Western Union operator to get his printout. With thesaurus holders as far away as Israel the president and cofounder of Law Research, Ellias C. Hoppenfeld, is proud of his new concept and talks of making the system international.

"It introduces a system into the legal system" says Hoppenfeld who sees "equality of legal reference" as something that will benefit the attorney, the jurist, the client and the law itself.

Variety. McFall's colleagues point to these applications as illustrations of the rich variety of services the utility may be called on to perform. Small outfits are offered a national on-line network with real-time use no further removed than a Telex console or the ubiquitous Western Union operator. Potential users include those who now suffer the indignities of off-line batch processing or who are limited geographically by a system. Prosaic operations and services like inventories, payrolls, hotel reservations and credit ratings may be handled by the system. Applications are expected in areas like education, medicine, science, politics and crime detection. Ultimately, it's expected that the general public will be using the system too. The utility has already shown that it can perform for a customer with limited resources and new ideas.

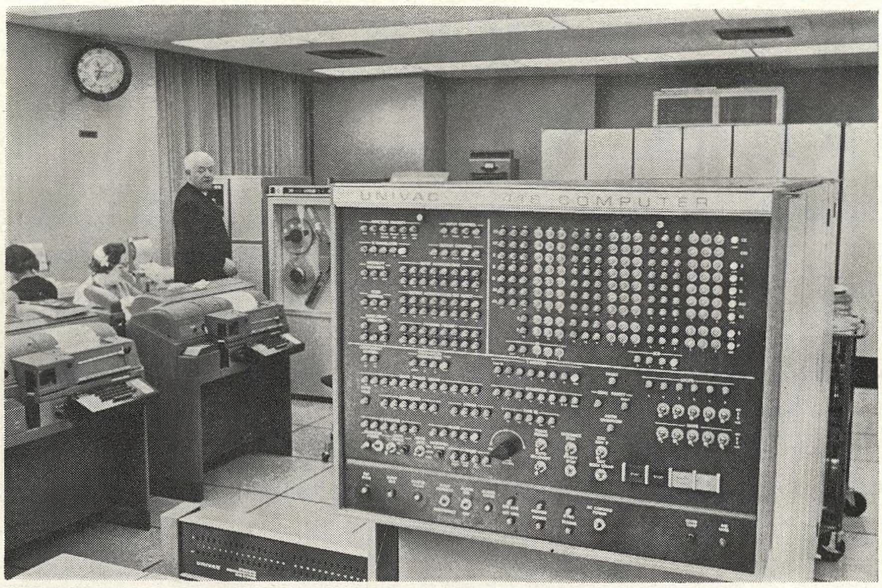
III. Data systems

"Western Union was once in AT&T's position," says McFall somewhat wistfully. Even though his company does not have this rank now, it's no midget. It ranks about 280th nationally in corporate size, currently receives about $300 million in gross income and relies on message traffic and associated business for most of its income. New leadership and spending for modernization ($500 million between 1960-65) have made the supply of data systems another area in which to watch out for Western Union.

Autodin (automatic digital network) was developed for the Department of Defense with Western Union as the prime contractor. The network is the world's most advanced digital data system and is currently being expanded to serve over 2,000 stations through nine solid state switching centers. ARS (advanced record system) is being built by Western Union for the civilian General Services Administration and will soon serve over 1,600 stations in 550 cities using broadband transmission facilities capable of accommodating teleprinter, facsimile, voice and high-speed data devices.

The system has been designed to expand as various agencies join the network—Blue Cross is being joined to ARS to facilitate Medicare record keeping.

Dedication. Other such systems —McFall calls them "dedicated systems"—as contrasted to time-sharing systems which are not dedicated to one customer—are being tested at the recently opened Computer Research Laboratory in Fairlawn, N.J. The staff at the research center will establish systems under a "single management responsibility" concept by which Western Union selects equipment, plans, programs, tests, produces operating manuals, trains the customer's personnel and delivers a fully functioning system.



One of two Univac 418 computers in Western Union's first Computer Center in New York. Centers are being opened in other major cities.

Such exacting preparation of systems by the center is expected to insure users that they won't have to go through the costly "shake downs" usually associated with new installations.

The "live testing" is conducted by over 200 specialists, five Univac 418's, two Control Data Corp. 8090's, two of Honeywell's digital data processors, a Honeywell H-200 and a Scientific Data Systems 930. Quarters have been leased in two other locations and it is currently planned to move the combined operation to a 40-acre site in 1967.

The center will test both time-sharing and dedicated systems and will play a central role in the future development of the information utility.

IV. Relay system

There are other expansion plans afoot. "We are working diligently to acquire TWX," says McFall, referring to the American Telephone and Telegraph Co. system which competes with Telex. The addition of TWX would substantially enlarge both the integrated message network and the information utility.

On the ground floor of Western Union's head office in Manhattan is the first of a group of Information Computer Centers. The New York center houses two Univac 418 computers. One is continually on-line with the second in back-up status. The center currently serves 3,000 of the 20,000 Telex subscribers as well as PICS and Law Research—compatibly serving two objectives.

Extras. The center gives three automatic extras for Telex consoles in nine eastern cities. Book messages (multiple-addressee messages) can be sent simultaneously to as many as 100 designated locations. Telex-to-Telex message service and data service (including storing a message for a busy station, then forwarding it when the console is free) is now offered, as is a Telex-to-TWX message and data system for TWX subscribers.

Increasing these services to include all Telex subscribers and the expansion of the information utility will come with more centers. Two will open soon in Chicago and San Francisco and centers in Atlanta and Dallas are scheduled for late 1967.

Melodygram. And what of the telegram itself? The old yellow form is in a diverse stable these days along with the Candygram, the Cigargram, the Dollygram, a flower service, a wake-up service and the latest, the Melodygram. The Melodygram is a telegram with a recording inside featuring a variety of selections sung by a stonecutter from Pittsfield, Mass. The titles range from "The Anniversary Waltz" to the upbeat "I Want to Communicate with You."

Large arrays are coming faster than expected . . . They pose critical questions for semiconductor firms.

1. Can semiconductor firms make a profit with arrays?
2. Will their business be invaded by systems firms?
3. Will semiconductor firms be making standardized arrays or will users want custom designs?

Fall Joint Computer Conference

Problems on a large scale

The same kind of anxiety raised when integrated circuits came on the scene is stirring in the industry now that large scale integration threatens to affect semiconductor manufacturers and systems producers

By Samuel Weber
Senior editor

With the paint hardly dry on the colorful consoles of the third generation of computers, systems manufacturers and semiconductor manufacturers are casting a wary eye on the fourth generation, not yet spawned, but already a problem child.

Large scale integration, or LSI, which promises to cut integrated circuit costs by dropping the price to a few cents per gate function, is producing uncertainty, and in some cases trepidation, about what will be the ultimate impact on the semiconductor industry and its best customers, the computer manufacturers.

At the Fall Joint Computer Conference in San Francisco earlier this month, some of the old bugaboos aroused when integrated circuits first came on the scene have been revived, and a few new ones thrown in. These include:

- With cheaper and more complex circuits on a single chip can semiconductor manufacturers make a profit?
- Will systems manufacturers accept standardized arrays or will arrays be sold only on a custom basis?
- Since the semiconductor manufacturers have integrated their product up to a subsystem level, won't systems manufacturers be tempted to move down into the semiconductor business?

Whatever the ultimate answers to these questions may be, all interested parties agree that by 1970 LSI will change radically the way computers are designed, and will profoundly affect the electronics industry in ways not yet anticipated.

I. Why LSI?

What's causing the uncertainty is the very thing that is providing the major impetus to LSI—a drive toward higher performance at lower costs. Almost everyone agrees that the potential benefits of LSI—higher speed and greater reliability—are realizable in the very near future. LSI technology is moving so fast that some industry people are already referring to conventional integrated circuits as "discrete IC's" to differentiate them from large scale arrays. Arrays can solve two of the fundamental problems that face system designers, as they try to push the switching time of computer circuits below 5 nanoseconds. According to R.L. Petritz, director of the semiconductor research and development laboratories at Texas Instruments Incorporated, a 1-inch slice of silicon could hold 40,000 gates. This kind of density considerably eases the phasing problems that occur in ordinary integrated circuits where components are relatively far apart. Furthermore, the proximity of gates obviates the need for low-impedance transmission lines to interconnect them, thereby reducing the false reflections that might occur.

Something for nothing. But although these features are attractive to system designers, the real motivation for LSI is in cost reduction. It was this cost reduction that spurred the changeover from discrete transistors to integrated circuits, according to Robert N. Noyce, group vice president of Fairchild

... the future electronics industry may be made up of four or five major suppliers ...

Camera & Instrument Corp. He believes that, assuming reasonable yields and sophisticated engineering, LSI could further slash costs per gate by a factor of 10. Noyce says, somewhat wryly, that "with LSI we are giving the systems people more and more for less and less, until eventually we will wind up giving them everything for nothing."

However, the situation appears to be clouded by the very complexity of the large scale arrays. O.R. Baker, the Signetics Corp.'s vice president for product development, says "Right now we can produce arrays with more complexity than anyone knows what to do with. It's going to take time for the systems people to learn how to make good use of them." Baker believes it will be at least three years before LSI will have any business impact.

II. Solution to software

One man who has definite opinions on LSI's future is L.C. Hobbs, owner of a consulting firm in Corona Del Mar, Calif. Hobbs suggested at the conference that the economics of LSI may provide computer makers with a way to reduce the large software costs associated with computer systems. He believes that LSI will permit cheap computer hardware to be built into the system to perform some of the functions now in the software domain. He offered three approaches to hardware/software trade offs: building special-purpose computers, designing different types of machine language and organization, and providing additional hardware facilities in conventional computers.

In addition to cutting costs, Hobbs says, the trade off would simplify the software problems that have plagued third-generation computers [Electronics, July 11, 1966, p. 129 and Aug. 22, 1966, p. 149]. With low-cost hardware, it might be feasible to design a computer whose internal machine language was Fortran, or close to it, and thus sharply reduce the duties of the compiler or even eliminate the compiler entirely.

Easier debugging. Even in conventional machines, Hobbs says, "many functions presently handled by programed subroutines can be implemented easily by special-purpose logic in a straightforward manner." He gave as examples binary-to-decimal conversions, code conversions, coordinate conversions, format control, table look-up operations, scaling and such mathematical subroutines as square root, trigonometric functions, matrix operations and the like.

Hobbs also suggests that the increased use of hardware will make debugging easier. "No one really knows whether a large operating system (the housekeeping computer software) is completely workable," he says. "There may be buried errors. But it's easy to check out hardware."

Gordon Moore, director of research for Fairchild Semiconductor, agrees that LSI arrays will completely change machine organization in computer design. "LSI will be even more revolutionary than IC's", Moore says. One of the first uses will be in memories. He suggests that arrays will be used in memories of up to 1,000 bits (scratchpads) relatively soon, and perhaps in mass memories somewhat later. He said that because selection of data in semiconductor memories can be done by logic gating, drivers and sense amplifiers are eliminated and there is much less circuit complexity around the memory. He also believes that there will be a great role for LSI arrays in terminal equipment such as display consoles, where low-cost semiconductor logic could be used to program and manipulate displays.

III. Custom vs standard

Another problem that LSI is resurrecting is the question of standardization. Fairchild's Noyce and Moore believe that in order to realize all the potential savings of large scale integration some standardization will be necessary. Noyce points out that although production costs for IC's have been greatly reduced, the start-up expense for the design and development of a custom circuit is approximately 30% of the total cost. He holds that large scale integration will be impossible if some degree of standardization doesn't take place in the industry. He suggested at the computer conference that this could be done by standardizing on the basic gate, and custom designing the rest of the integrated array to the particular requirement by various interconnections.

But Signetics' Baker scoffs at the idea. "The concept of standardizing on a basic cell design, with circuit manufacturers merely connecting them differently for their customers just doesn't seem compatible with competitive business practice in our industry," he says.

The mating game. Petritz of TI feels that standardization will probably take place on the functional, rather than the gate level. He predicts that although there will be considerable custom design work, particularly in the early stages of LSI technology, there will be an even greater acceptance of standard large scale arrays than of present day IC's.

A broad view of where LSI is taking the electronics industry is provided by Petritz. He sees the future electronics industry made up of four or five major suppliers of materials, in the form of IC's arrays and devices, to a much larger group of applications-oriented companies, which will incorporate the materials into a broad spectrum of products, much as the chemical companies service the garment industry by supplying a variety of textiles.

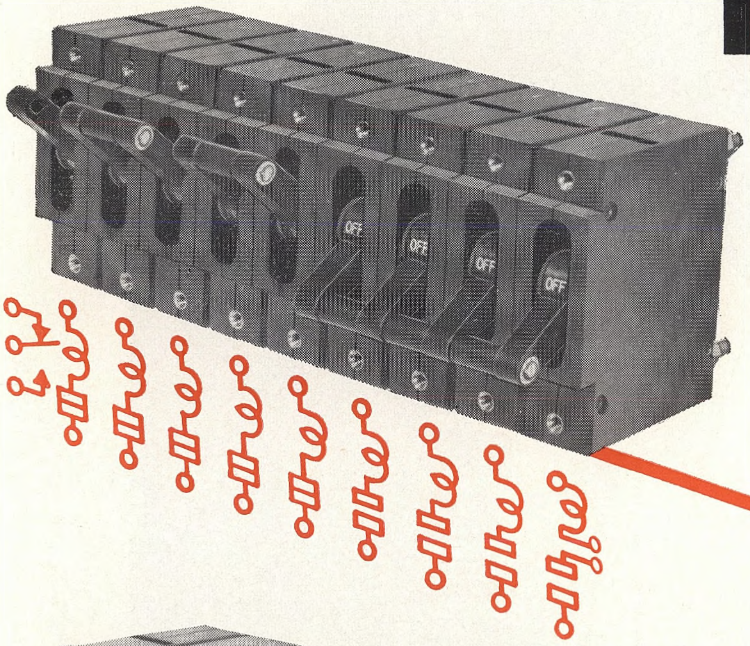
Meanwhile, Hobbs believes that it will be interesting to see what happens as the semiconductor manufacturers continue to integrate upwards, performing more of the function of the system builder "There might be a tendency," he says, "for the system builder to move down into the semiconductor business."

To this, Fairchild's Moore replies: "With complex arrays, it becomes even more economically prohibitive for the system people to build their own circuits."

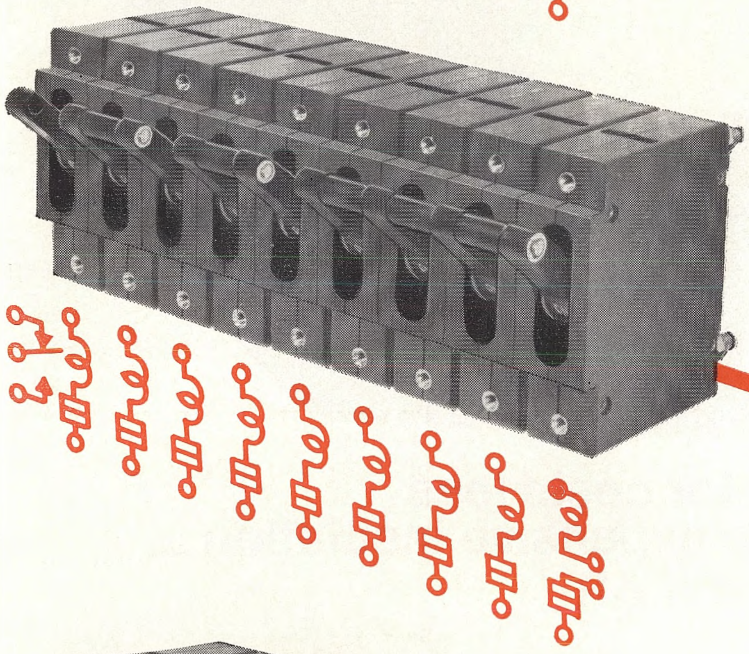
He does not feel that the reduction in cost per gate provides a threat to the semiconductor producer. "The challenge is to the systems manufacturer. Our job is to make the price of logic hardware so attractive that we stimulate him into finding new ways to use it."

NINE-IN-LINE

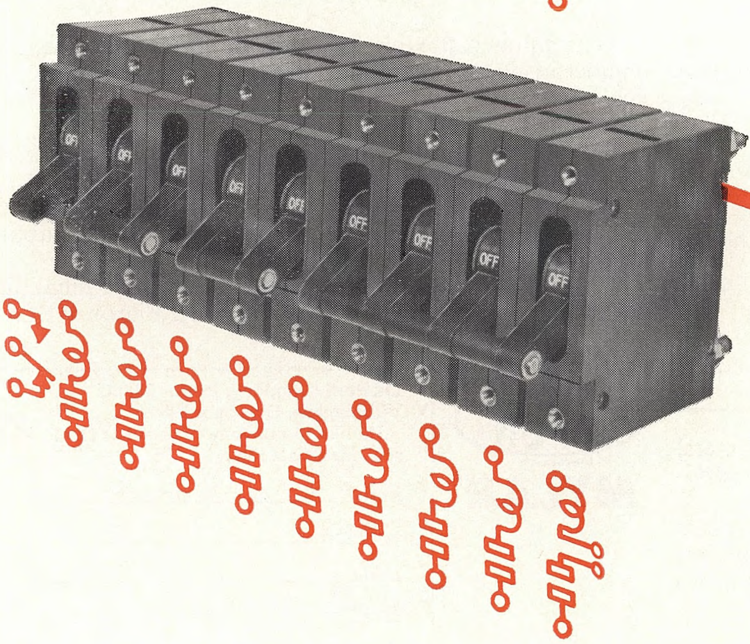
CIRCUIT PROTECTION and CIRCUIT CONTROL by AIRPAX ELECTRONICS



Step 1 is ON
Step 2 is ON
Step 3 is ON
Step 4 is waiting.



All steps are on and all functions are protected.



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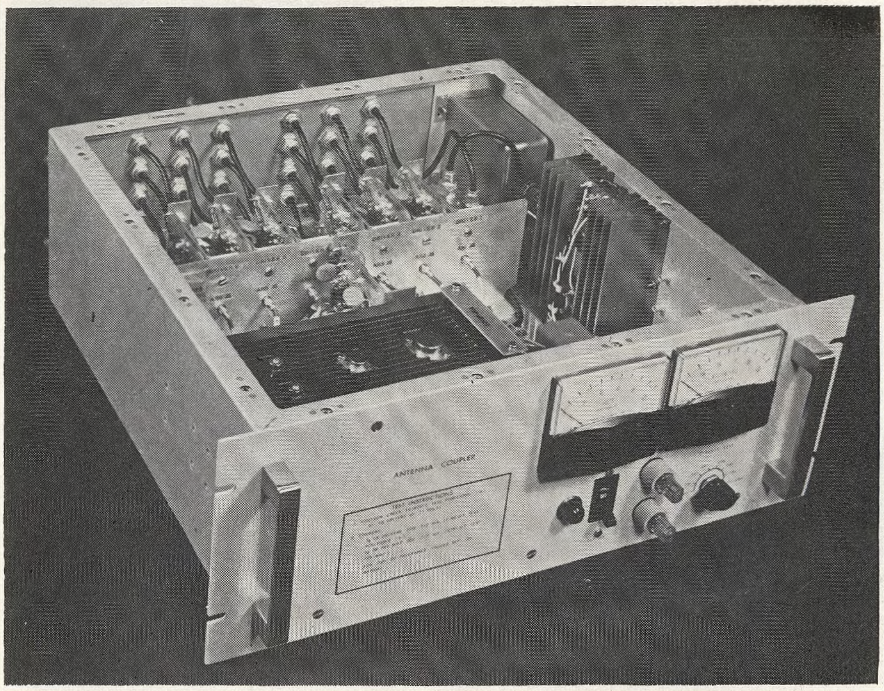
Carefully selected transistors, large amounts of feedback and solid state matching provide coupler with many firsts



A solid-state, 24-channel antenna coupler has won military approval —in fact, its developer claims it is the first such coupler qualified for military use. Designed for Air Force ground communications equipment, it is also expected to find applications aboard ship. Frequency range is 2 to 30 megahertz.

Other impressive firsts claimed for the unit by the MRC division of the Conductron Corp., Ann Arbor, Mich., are:

- All of the stages are driven by a single two-transistor preamplifier, eliminating interstage matching problems of the conventional multi-preamp designs.
- It is the first such unit that reduces interfering intermodulation products to at least 60 decibels below the signal.
- It does not use transformers for coupling to the receivers. Therefore, it is less susceptible to radio frequency interference and also provides excellent phase and amplitude tracking between channels. Each of the 24 outputs will be within 0.5 db in amplitude and ±2° in phase.

In high-frequency communications, distances between a transmitter and a receiving station can vary from a few miles to 1,000 miles or more. The coupler must therefore have high power handling capability for nearby stations while maintaining sensitivity for distant transmitters. When used aboard a master communications ship in a fleet, for instance, the same antenna must receive signals simultaneously from many transmitters.

The multicoupler's single preamp can handle more power because the transistors are medium power units rated at about 7 watts. Yet the noise figure is only about 7.5 db. Furthermore, the preamplifier with an over-all gain of 8 decibels, has sufficient power to feed six driver stages, each of which in turn, feeds four receivers. Three feedback paths within the preamplifier stages insure amplitude linearity from 125 db below 1 milliwatt to about 10 db above 1 mw.

William Face, manager of engineering at MRC, explains that the single preamplifier replaces parallel low power units needed in conventional multicouplers. With multicoupler preamps, very exact matching procedures are required to minimize phase shifts and amplitude variations when the channels are summed prior to distribution to the receivers.

Multicoupler designers do not normally consider medium power transistors because they generally result in high noise figures, but MRC discovered that selected medium power transistors could simultaneously provide low noise and high power handling capability.

Transistors are also used to match the drivers to the 50-ohm output. Conventional multicouplers generally use transformer dividers for this purpose. When many outputs are needed, the transformers are difficult to match, produce phase problems and high crosstalk levels, and have low isolation between output channels. Transistor matching avoids these problems.

Specifications

Type	C-325-24 multicoupler
Frequency range	2 to 30 Mhz
Gain	2 db ±1 db at 2 to 30 Mhz
Noise figure	6 db 2-10 Mhz 6.5 db 10-20 Mhz 7.5 db 20-30 Mhz
Intermodulation distortion for two 0.25-volt RMS signals	—56.5 db 2d order —60 db 3d order
Phase tracking	±2 degrees max.
Amplitude tracking	±0.5 db max.
Radiation (isolation back to front)	52 db min.
Output-to-output isolation	40 db min.
Gain reduction (overload)	2.5 db for 0.8 signal level
VSWR input and output	1.25:1 max.
Impedance, input and output	50 ohms (nominal value)
Operating temperatures	0°C to +52°C
Military spec	MIL-E-4158C

MRC division, Conductron Corp., 3475 Plymouth Road, Ann Arbor, Mich.
Circle **350** on Reader Service Card

New Components and Hardware

Superconductivity spells high fields

Interest in superconductive magnets has been increasing rapidly since the discovery in 1961 that niobium-tin keeps its zero resistance in high magnetic fields (its theoretical limit is 200 kilogauss). The only other way to produce extremely high magnetic fields is with copper-cooled magnets, which require vast amounts of power and coolant.

In light of this interest, the Radio Corp. of America has jumped into the marketing of high-field superconductive magnets with the announcement by its Special Electronics Components division of a line of seven standardized magnets. The magnets range in strength from 60 to 125 kilogauss, with clear bores from 1 to 3 inches in diameter. Although the magnets can be used in materials analysis, the primary application will probably be in physics research; secondary uses are in high-energy physics and plasma physics research.

Many of the magnets for high-energy and plasma applications will probably be custom built. One magnet under construction by RCA has a 150-kilogauss field with a 6-inch-diameter clear bore. The National Aeronautics and Space Administration's Lewis Research Center in Cleveland plans to use it in plasma research—to study the possibility of propelling a spacecraft with such a device.

Whether standard or custom designed, RCA's magnets use a superconductive ribbon for the coils. A thin layer of niobium-tin is vapor deposited on a stainless-steel strip which is then coated on both sides with copper or silver. An interleaving tape sandwich of Mylar-copper-Mylar provides a shunt during occasional flux surges.

Six of the company's seven standard units are solenoids with field lines along the longitudinal axis. Prices range from $8,550 for a 50-kilogauss magnet with a clear bore of 1.25 inches to $46,440 for a 100-kilogauss unit with a 3-inch bore. The seventh unit consists of two split solenoids with field lines along both the radial axis and the longitudinal axis. It is designed for magneto-optical experiments where access from two points is desirable. The unit has a rated field of 100 kilogauss, a 2-inch clear bore and a clear window gap of 1.2 inches. At $56,570, it is the most expensive in the line.

The prices quoted are for the magnets alone. Auxiliary components, such as a magnet support, a dewar and a power supply are needed, along with liquid helium. The power supply is the least costly element—a 6-volt, 100-amp battery will suffice. For turning a magnet on, RCA is offering a $225 switch.

Although specifications have been standardized, demand hasn't reached the point where units are being inventoried. Delivery time varies from 90 to 150 days.

Radio Corp. of America, Special Electronic Components division, Harrison, N.J. [351]

Proximity switch operates speedily

A miniature proximity switch with mercury-wetted contacts has been

battle of the PNP

our TO-5 PNP's have started a STIR

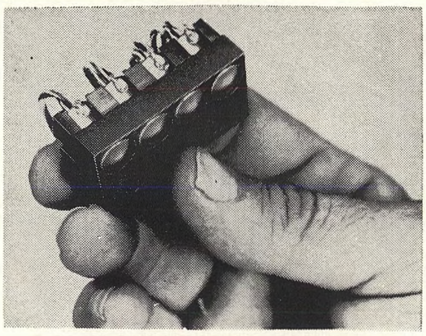
From Silicon Transistor Corporation comes PNP Power Potential that has started a revolution. For the first time a family of TO-5 transistors rated at 8.75 watts. BV_{CEO} ratings range from 40 to 100 volts, saturation voltages as low as 0.3 V at 1.0 Ampere. These types can be used as complements to Silicon Transistor Corporation's famous 2N2034 family of NPN TO-5's.

Type	T_J-°C	V_{CEO}-Volts	V_{EBO}-Volts	h_{FE} $I_C = 1.0$ A $V_{CE} = 2.0$ V	h_{FE} $I_C = .5$A $V_{CE} = 2.0$ V	V_{CE} (sat.)-Volts $I_C = 1.0$ A $I_B = 100$ Ma	V_{CE} (sat.)-Volts $I_C = .05$A $I_B = 50$ Ma	NPN COMPLEMENT
2N3202	200	40	10	20 – 60		0.3		
2N3203	200	60	10	20 – 60		0.3		2N2034
2N3204	200	80	10	20 – 60		0.3		2N2858
2N3208	200	40	10		20 – 60		0.4	
2N2881	200	60	10		20 – 60		0.4	2N2033
2N2882	200	100	10		20 – 60		0.4	

SILICON
TRANSISTOR
CORPORATION

EAST GATE BLVD., GARDEN CITY, NEW YORK 11532
(516) PIONEER 2-4100, TWX 510-222-8258

New Components



developed. Chief advantages of the switch, says the manufacturer, are repetitive high fidelity, bounce-free make-break circuit switching, high-speed operation, life into the billions of cycles, low operating force, multiple circuits, insensitivity to ambient conditions, and resistance to vibration and g load.

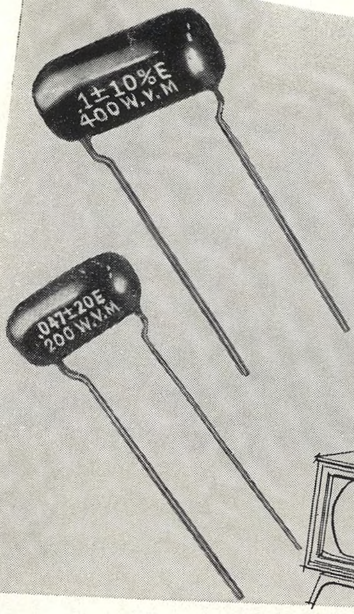
The switch is rated for a 250 volt-ampere load in a space of 0.273 cu in. per circuit. It weighs less than 0.6 oz per circuit and will operate at 3,600 cycles per minute with a response time of 0.001 sec. A switch measuring 0.0625 cu in. with a weight of less than 0.2 oz per circuit will be available soon, as will larger switches utilizing the mercury-wetted contact principle.

Any number of circuits can be built side-by-side, limited only by a $\frac{7}{32}$ in. center-to-center distance, the length of the magnet, and the space available. In a typical application of the switch, there are 64 circuits on a 14-in.-long magnet. Each switch is operable by a key of a typewriter or a series of cams for data processing work, machine programing or control, and similar functions.

General Equipment & Manufacturing Co., 3300 Fern Valley Road, Louisville, Ky., 40213. **[352]**

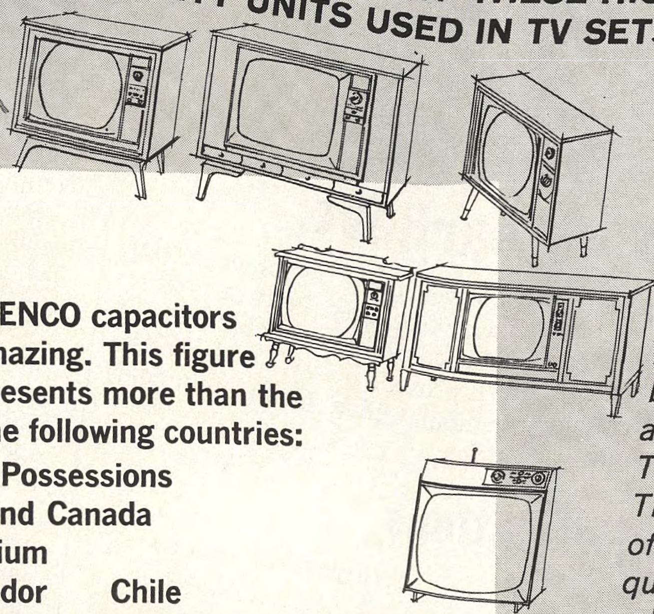
Breadboard permits higher IC densities

A breadboard for integrated circuits subsystems will hold as many as 16 14-pin dual in-line plastic packages. Little or no soldering is required, so designs can be evaluated without damaging in-



Proof Positive of High Reliability of EL-MENCO *MYLAR-PAPER DIPPED Capacitors

OVER 330,000,000 OF THESE HIGH QUALITY UNITS USED IN TV SETS SINCE 1959!



The number of EL-MENCO capacitors in TV sets is truly amazing. This figure of 330,000,000 represents more than the total population of the following countries:

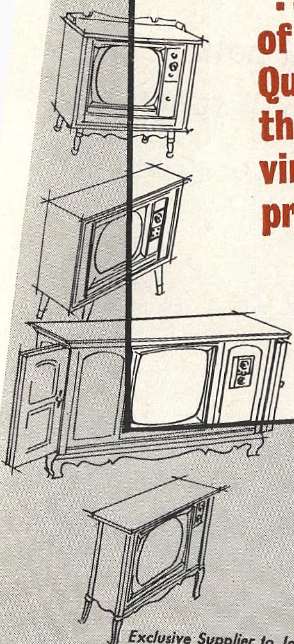
United States and Possessions
United Kingdom and Canada
Argentina Belgium
Denmark Ecuador Chile

299,813,929 people (1960 Census)

Even with this tremendous mass production the quality of EL-MENCO capacitors has not suffered. Here's a fine tribute of the high reliability of EL-MENCO capacitors from a leading TV manufacturer:

"... I am certain that you are aware of the enthusiasm our Engineering and Quality people have displayed for this unit, for to us it represents the virtual elimination of capacitor field problems in the future..."

Imagine! Over 330 million EL-MENCO Mylar Paper Dipped Capacitors have been used in black and white and in color TV sets since 1959! These capacitors of the highest quality and reliability help bring programs to millions of people who have invested in TV sets... and 330 million is just a drop in the bucket! For the demand for EL-MENCO capacitors still far exceeds the supply!*



Write dept. AE for descriptive bulletin #MPD

El-Menco Capacitors

DIPPED MICA
MOLDED MICA
SILVERED MICA FILMS
MICA TRIMMERS & PADDERS
MYLAR PAPER DIPPED*
PAPER DIPPED
MYLAR DIPPED*
TUBULAR PAPER

*Registered Trade Mark of DuPont Co.

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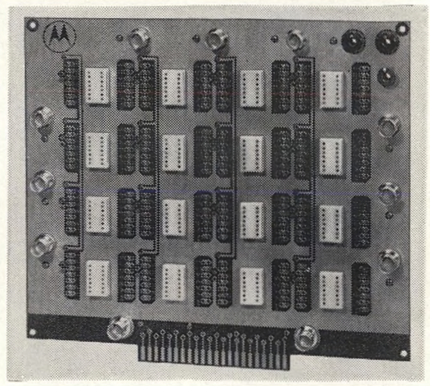
New Components



dividual IC's. The breadboards can be interconnected for more complex systems.

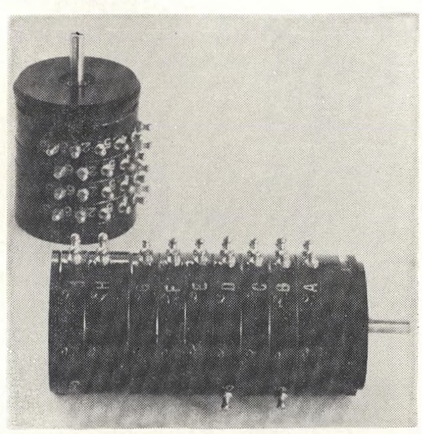
Designated XC73, it complements earlier breadboards for TO-5 packages with up to 10 leads and flatpacks with up to 14 leads.

Continuous voltage planes on each side of the gold-plated board provide even voltage distribution and reduce signal crosstalk when operating at high frequencies—up to 50 Mhz. Eleven BNC connectors and a 22-pin edge connector are provided for applying input and output signals. Interconnections between IC's are made by inserting 22-gauge wire into high-retention pin jacks.

Price is $140 each in quantities of 25.

Motorola Semiconductor Products Inc., Box 955, Phoenix, Ariz., 85001. **[353]**

Single-turn pots occupy small space

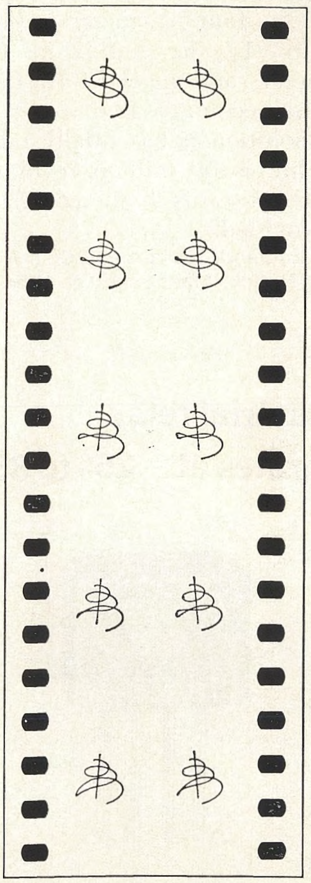


Single-turn, precision, conductive plastic potentiometers are being

Report from

BELL LABORATORIES

A 3-D Glimpse of the Hearing Process



THE MOVIE shows the basilar membrane as a "stereo pair" of spiral lines. The sequential frames shown here represent the motion of the membrane responding to the sound "oo" in the word "too" as pronounced by R. C. Lummis, one of the scientists responsible for the film.

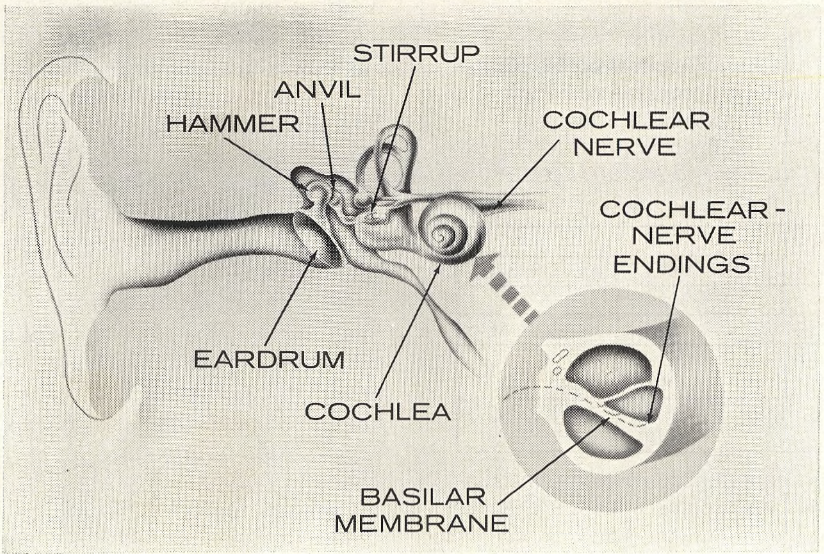
To view this illustration in 3-D, place a sheet of paper on edge between one stereo pair. Position your head so each eye sees only one image. The pictures should then seem to converge and appear three-dimensional.

For screen projection, polarized light and polarized eyeglasses are used to obtain a 3-D image.

THE BASILAR MEMBRANE is a lengthwise partition in the spiral, fluid-filled cochlea (figure). Sound, from the eardrum by way of the hammer, anvil, and stirrup, produces vibrations in this membrane. The end nearest the stirrup resonates at the highest audible tones (approximately 20,000 Hz); the end near the apex of the spiral resonates at the lowest (approximately 20 Hz).

The cochlear nerve terminates near the membrane and, by sensing the vibration at each point, converts the mechanical motion into nerve impulses which the brain perceives as a sound.

Because of its filtering and analytical functions the basilar membrane is a center of interest in hearing research. Since it is embedded in the skull, direct study is extremely difficult.



At Bell Telephone Laboratories, basic research in voice communications does not end with telephone equipment. For instance, three scientists here have made a stereoscopic motion picture showing how the ear's principal transducer—the basilar membrane—moves in response to sound.

A number of steps were involved: First, equations describing the membrane's response were converted to digital form, suitable for machine computation. Next, a program was devised so a computer could determine the precise motion of each point on the membrane as a function of any complex sound input. Finally, the resulting data were processed with another program which introduced the parallax effects inherent in binocular vision.

The output was a series of pairs of stereoscopic images. The computer drew these on the face of a cathode-ray tube where they were automatically photographed to form the frames of the movie.

In this film, the membrane's movements (actually microscopic) are greatly enlarged and slowed down for detailed examinations. Thus we have developed a promising tool for the study of hearing. For example, movies made in this way could help us evaluate theories of the basilar membrane's role in converting sound to nerve impulses. (Several complex mathematical relationships have been proposed; now we may see them in simulated action and measure their properties.)

The scientists who made this film are Robert C. Lummis, A. Michael Noll, and Man Mohan Sondhi. The membrane-response equations from which they began were originated by James L. Flanagan, also of Bell Laboratories. His work was based on anatomical measurements made by Nobel laureate Georg von Békésy of the University of Hawaii.

Bell Telephone Laboratories
Research and Development Unit of the Bell System

New Components

made for applications where a number of different pot functions must be ganged on one shaft in minimum space. Both linear and nonlinear functions are available, and switch contacts can be molded into the elements as required.

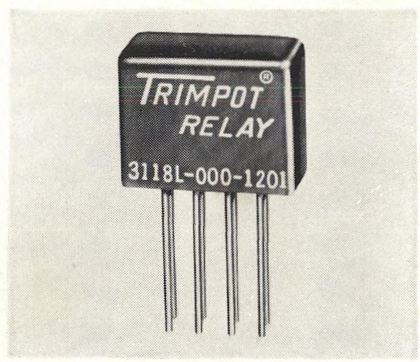
A single-cup Waferpot is only 0.680 in. deep, and each additional cup adds only 0.200 in. in depth.

Standard Waferpots are available in four diameters: ⅞ in., $1\frac{1}{16}$ in., $1\frac{7}{16}$ in., and 2 in. Other diameters and special form factors can be accommodated.

Resolution is essentially infinite, and life is 50 million revolutions. Slope ratios as high as 50:1 can be provided.

New England Instrument Co., Kendall Lane, Natick, Mass., 01760. **[354]**

Industrial relay operates at −25° to 85°C

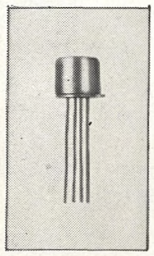


A subminiature 1 amp, dpdt relay features 0.1-in. pin spacing. Model 3118, which measures .26 x .53 x .43 in., has a pickup sensitivity of 200 mw maximum and an operating temperature range of −25° to 85°C in an unsealed, high-temperature, plastic enclosure. The range of coil resistance is 60 to 1,200 ohms.

Though an industrial unit, the relay meets the environmental conditions of MIL-R-5757D, applicable to an unsealed unit, and features a balanced armature design (50g shock, 10g vibration). It weighs .075 oz.

Contact material of gold-plated semiprecious metal, highly resistant to arcing and film formation,

No other RF transistors can offer this performance at these prices!



ACTUAL SIZE

RCA Type	2N4259	2N3933	2N3932	2N3478
Min. Power Gain @ 450 MHz	11.5 dB	—	—	—
Max. NF @ 450 MHz	5 dB	—	—	—
Min. Power Gain @ 200 MHz	—	14 dB	11.5 dB	11.5 dB
Max. NF @ 200 MHz	—	4.0 dB	4.5 dB	4.5 dB
NF @ 60 MHz	—	3 dB max.	2.5 dB typ.	2.5 dB typ.
Max. C_{cb}	0.55 pF	0.55 pF	0.55 pF	0.70 pF
h_{FE}	60-250	60-200	40-150	25-150
Min. BV_{CEO}	30	30	20	15
P_T @ 25°C Ambient	200 mW	200 mW	200 mW	200 mW
Price*	$1.60	$1.40	$1.25	$1.15

*In quantities of 1,000 and up.

RCA covers the communications spectrum from 27 MHz to 500 MHz. Every type available for immediate delivery in production quantities. These silicon epitaxial planar transistors for *VHF* and *UHF* communications are packaged in hermetically sealed 4-lead metal cases. Check the noise figure and the power gain... then check the price! You get top performance, top value, and immediate delivery in production quantities—a unique combination that no other commercially-available RF transistor can offer! For complete information, pricing, and delivery, call your RCA Field Representative. For technical data sheet, write: RCA Commercial Engineering, Section EN11-4, Harrison, N. J. 07029.

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RCA ELECTRONIC COMPONENTS AND DEVICES

RCA ®

The Most Trusted Name in Electronics

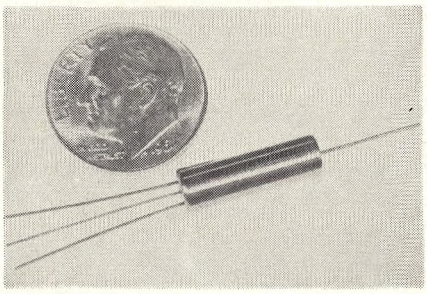
Circle 147 on reader service card

provides an operating life of 100,000 cycles. Environmental performance is monitored by the manufacturer's continuous reliability assurance test program.

Price is $6 each in quantities of 100 to 249. Delivery is stock to three weeks.

Bourns, Inc., Trimpot division, 1200 Columbia Ave., Riverside, Calif., 92507. **[355]**

Tiny reed relay operates on 15 mw



A microminiature reed relay is designed for low level switching systems that are used at ultrahigh speed. It is used to interface solid state circuits, to trigger controlled rectifiers and in computer and telemetry applications. The relay provides complete circuit isolation with zero leakage on open circuit. Ratio of switching load to operate power can approach 30 to 1.

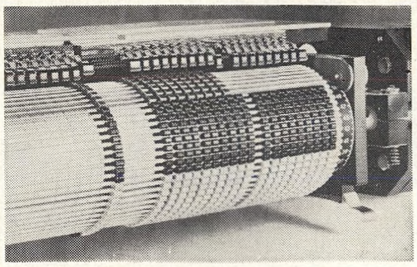
Size of the metal case is 0.210-in. diameter x 0.600-in. long. The unit is available with a 1.5, 3, or 6-volt coil and is rated for 10 ma at 28 v d-c.

Units rated up to 10 w d-c or 12 v-a output are available in a package of the same diameter but with length increased to 0.720 or 0.900 in. Coils for these larger units are standard for 6 and 12-v operation.

Winchester Instrument Co., P.O. Box 24, Winchester, Mass. **[356]**

Stepping switch offers shorting mode

An Actan stepping switch permits circuits to be maintained in an on or shorted position. To produce

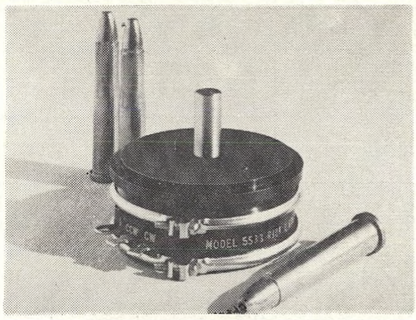


this shorting action, the program drum of the switch is studded with consecutive camming actuators for each contact. As the memory drum rotates, the contacts are maintained in the on position for the duration of the required program. The contacts will not break between positions as the drum rotates.

The shorting actuators are available in a variety of colors to simplify reading the program on the drum. The drum is completely field adjustable and requires no tools for changing the program.

Sealectro Corp., 225 Hoyt St., Mamaroneck, N.Y., 10543. **[357]**

Continuous rotation precision pots



Choice of either bushing or servo mount is offered in a line of single-turn, 1¾-in. diameter, potentiometers.

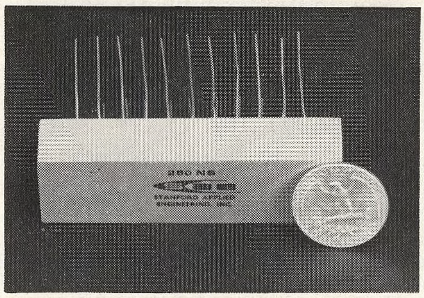
Series 5530 continuous rotation pots have wirewound resistance elements with standard resistance values from 25 ohms to 41,000 ohms. Power rating is 2.0 watts at 40°C, derating to 0 at 85°C, and total operating temperature range is −25°C to +85°C. Standard independent linearity is ±0.5% for 100 ohms and above, and ±1%

under 100 ohms. Standard resistance tolerance is ±5%.

The precision units have molded plastic housing, stainless steel shafts, and gold-plated terminals. They offer dependable and accurate performance in environmental extremes, the manufacturer reports.

Helipot division, Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif., 92634. [358]

Epoxy encapsulated tapped delay lines



Delay times of 250 nsec ±10 nsec and impedance levels of 250 ohms are available in the S series miniature (1 x ½ x 3 in.) tapped delay lines. Each line is encapsulated in an epoxy casting resin that protects all components from shock and vibration. A hermetic seal guards against moisture. Connections are brought out radially from one face so that the delay line may be plugged into a p-c board and dip-soldered into place.

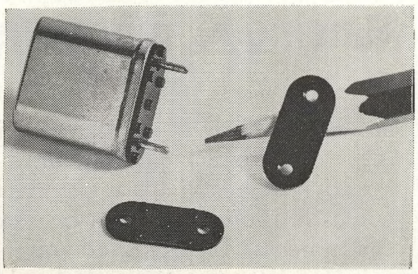
The delay lines meet the requirements of MIL-STD-202A and are available in both a high and low-impedance model.

Specifications include: rise time, 25 nsec (max); test voltage, 600 v d-c; working voltage, 300 v d-c; pulse voltage, 300 v peak; bandwidth, 16 Mhz; temperature range, —65° to 125°C; leads, No. 22 Awg tinned copper.

Stanford Applied Engineering, 340 Martin Ave., Santa Clara, Calif. [359]

Mounting pad supports frequency crystals

A specially designed Transipad permits mounting of frequency cry-



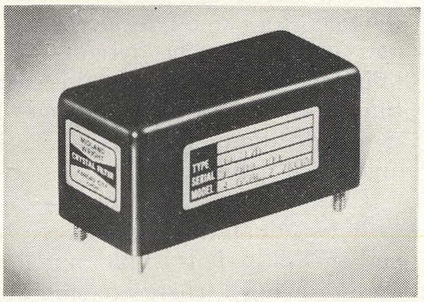
stals by soldering directly to a printed-circuit board. This support allows for thorough wash-away of solder flux after positioning on the p-c board. Seven spacer feet elevate the unit so that there is airflow between the frequency crystal and the p-c board to prevent moisture trap.

Precision molded of black diallyl phthalate, the pad (No. 10274-DAP) measures 0.312 in. in width and 0.730 in. length with two 0.070-in. diameter holes on 0.0486-in. centers.

Samples and specifications sheets are available from the manufacturer.

The Milton Ross Co., 511 Second St. Pike, Southampton, Pa., 18966. [360]

Filter suppresses unwanted sideband



A single-sideband crystal filter, for use in amplitude-modulated communications equipment, features carrier and adjacent sideband suppression to a degree not previously attainable, according to the company.

Carrier attenuation is 50 db minimum, while suppression of unwanted sideband is 65 db minimum from —200 hz to —75 khz. Carrier frequency of the unit is 1.65 Mhz. Passband at 3 db is +300 hz to +3 khz. Ripple is ±0.5 db, and nominal impedance of the filter is 12,000 ohms.

Type FC-17U filter measures $3\frac{5}{64}$ x $1\frac{7}{16}$ x 1½ in. In quantities of 100, the unit price is $75, with 6-week availability.

Midland Wright Corp., 3151 Fiberglas Road, Kansas City, Kan., 66117. [361]

IC plug-in package makes assembly easy

Designed for low-cost assembly on two-sided p-c boards, a dual in-line, 14-lead plug-in package is hermetically sealed and tested to a 10^{-8} cc/sec leak rate. The alumina-filled glass package provides low thermal resistance and features a Kovar base plate with Kovar leads formed into a 0.020-in. diameter for both strength and reliable soldering.

The 100-mil pin centers permit both loose drill tolerances and wide printed-circuit lines while the leads provide a 0.035-in. standoff to prevent solder bridging. Another feature is an index notch midway in one of the short sides, which identifies lead A to facilitate manual or automatic installation.

Sylvania Electric Products Inc., Electronic Components Group, Seneca Falls, N.Y. 13148. [362]

Metal film resistors in 10-ohm values

Metal film resistors are now available in standard values as low as 10 ohms. Previously, units were limited to 30.1 ohms, with carbon film filling in where lower resistance values were required, according to the company.

The resistors are being marketed as types MF and MFC; MFC designates units that have conformal coating. Both offer standard temperature coefficient of resistance of ±100 ppm/°C, resistance tolerance of ± 1%, superior life stability and resistance to environmental degradation.

Available on special order are units with temperature coefficient of resistance as low as ±50 or ±25 ppm/°C.

Electra Manufacturing Co., 800 North 21st St., Independence, Kans., 67301. [363]

←Circle 154 on reader service card

New Semiconductors

Raising IC functions cuts cost

A telltale sign that the drive by integrated circuits manufacturers to improve device yields is paying off comes in the introduction by Texas Instruments Incorporated of five new complex-function IC's—a dual adder, a quadruple adder, a divide-by-12 counter, a 4-bit binary counter and a binary-coded decimal-(BCD)-to-decimal decoder-driver [Electronics, Nov. 14, p. 60].

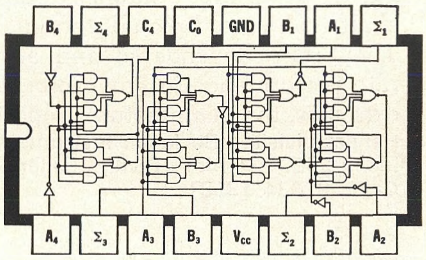
The payoff in putting more functions into a single IC is price. TI reports it can sell the units for considerably less—as much as 20% to 40%—than the cost for several, simpler IC's.

The bipolar IC's are part of Texas Instruments' series 74 family of transistor-transistor-logic (TTL) circuits and are designed for application in digital computers, data-handlers and control systems.

The dual adder adds two 2-bit binary numbers. Sum outputs are provided for each bit, with the resultant carry obtained from the second bit. The monolithic unit is designed for high-speed, multiple-bit applications for parallel-add and serial-carry. With each bit, a single-inversion serial-carry circuit in a Darlington configuration minimizes the need for extensive "look-ahead" and carry-cascading circuits. The unit's speed is 15 nanoseconds carry time through two stages and 35 nsec add time. It costs $5.75 in quantities of 100 to 999.

The quadruple full adder—basically two dual adders packaged together—adds four 2-bit numbers (see drawing). There are sum outputs for each bit and the resultant carry is from the fourth bit. Carry time is 30 nsec through 4 bits. Add time is 35 nsec. Price is $9.15 in the 100 to 999 quantity range, a savings, Texas Instruments says, of 41% compared with four single-IC adders.

The divide-by-12 counter divides by 12, 6, 3 or 2. Operating frequency is 15 megahertz. The monolithic unit consists of four master-slave flip-flops that are internally interconnected to provide a divide-



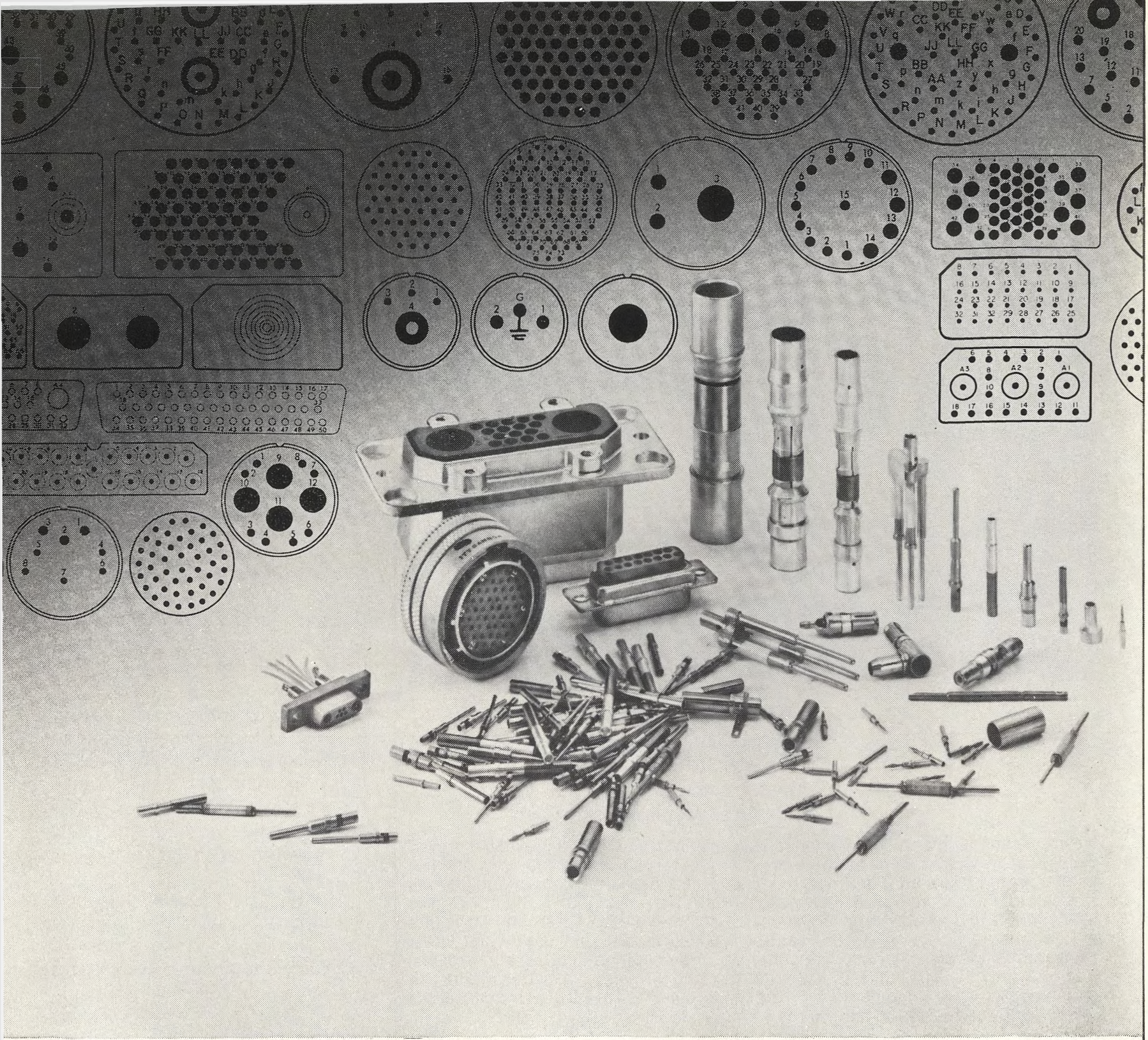
by-6 counter and a divide-by-2 counter. The two sections can be operated independently and simultaneously. Typical power dissipation is less than 40 millivolts per flip-flop. Price is $8.30 in units of 100 to 999; this is 19% less than the four IC flip-flops with gating normally required, the company says.

The 4-bit binary ripple-through counter is a high-speed monolithic unit consisting of four master-slave flip-flops interconnected as a divide-by-8 counter and a divide-by-2 counter. The two independent counter sections can be operated simultaneously. When externally connected, the sections provide a ripple-through operation by dividing the output of each flip-flop by 2, achieving division of the input frequency by 2, 4, 8 and 16. Operating frequency is 15 Mhz. Typical power dissipation is 40 mv per flip-flop. The price is $8.30 for 100 to 999 units.

The monolithic BCD-to-decimal decoder is used to drive gas-filled readout tubes. The decoder has TTL gate circuits that select one of the 10 decimal output drivers. BCD inputs are provided for TI's decade counter and the unit has high-performance output transistors to drive the indicator tubes. The decoder sells for $10.50 each, 23% below the cost of separate decoding IC's

Specifications

Types	
dual adder	SN7482N
quadruple full adder	SN7483N
divide-by-12 counter	SN7492N
4-bit binary counter	SN7493N
BCD-to-decimal decoder	SN7441N
Supply voltage	4.75 to 5.25 v
D-c noise margin	1 v typical
Operating temperature range	0° to 70°C



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and driver transistors.

All five devices are available in TI's standard 750-mil-long molded dual in-line package with 14 pins. The quadruple adder and the BCD-to-decimal decoder also come in a 16-pin package that is 100 mils longer than the 14-pin package.

Texas Instruments Incorporated, Semiconductor division, Box 5012, Dallas, Texas [364]

Audio transistors in a tiny package

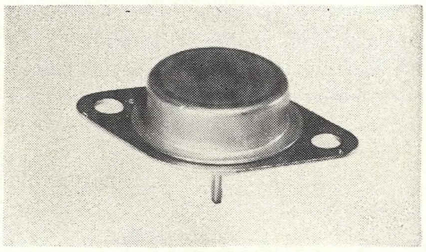
Silicon planar epitaxial audio transistors have been designed for compact applications such as hearing aids, tape heads or phone pickups. Package size is 0.078 x 0.071 in.

The devices feature a noise figure of 1.5 db over a wide band and low leakage of 10 nanoamps maximum. Current gain characteristics for the types A151, A152 and A153 are maintained over a wide range of collector currents from 20 μa to 2,000 μa.

Mounted on a ceramic substrate, the units have been designed with extra rigid leads. This permits simplified insertion in microminiature p-c boards and ease of production handling.

Amperex Electronic Corp., Slatersville, R.I. 02876. [365]

Silicon transistor has high power



A 400-v npn silicon power transistor has been added to the company's product line. It is expected to find wide usage in both the commercial and military fields.

Its applications include high-

SCIENCE/SCOPE

Five years of useful orbit life is close to maximum for a satellite powered by a hydrogen-peroxide reaction system. Now Hughes is developing a propulsion system that promises to have a 20-year lifetime. New system uses the power available to the satellite to electrolyze water into hydrogen and oxygen, which are burned in a rocket to maintain proper station position.

Hughes 10,000-channel high-frequency single sideband Manpack radio, which the U.S. Army is employing successfully in Viet Nam, is now being tested by the U.S. Air Force and U.S. Marines. The two services are conducting operational suitability tests here and abroad on this man-portable, lightweight set that will communicate reliably in jungle-type terrain.

A 16-month-long test of Japan's BADGE system was successfully completed recently by Hughes. BADGE (Base Air Defense Ground Environment) is the first of the Tactical Air Weapons Controls Systems Hughes is developing for many Free World nations. Equipment delivery to Japan is scheduled for completion this month. When it goes operational, Japan and the surrounding Pacific area will be covered with an electronic network that will automatically detect, track, and identify supersonic airborne targets.

Two laser units for commercial use were introduced recently by Hughes. They're suitable for spectroscopy, stress analysis, holography, optical pumping and instrumentation. The completely packaged pulsed lasers use singly-ionized argon gas, can produce six wavelengths simultaneously in the blue-green portion of the visible spectrum. Both are air-cooled, use normal 115-volt, 60-cycle power. Laser heads are self-contained, include discharge tube, mirrors, pulse forming network, trigger transformer, cooling fan. Power supply contains cathode heater supply, internal trigger oscillator, controls and indicators.

When England's EMI Electronics acquired a 49 percent interest in Hughes International (UK) Ltd. recently, the Hughes subsidiary changed its name to Emihus Microcomponents Ltd. New partnership will expand product areas across the entire components field, and will exploit the marriage of complementary technologies so vital for advanced microelectronics products.

The TV-guided Condor missile's data-link system is being developed by Hughes under a multi-million-dollar contract with North American Aviation's Columbus Division. Hughes is building the complete electronic systems and antennae for both the missile and the Navy aircraft that will launch it. The Condor is expected to give carrier-based aircraft a standoff capability and greatly increased bombing accuracy.

A millimeter-wave amplifier tube with an average CW power output in excess of five kilowatts has been developed by Hughes Research Laboratories. Previous upper limit was a one-kilowatt Hughes tube. New tube, developed under contract to Union Carbide Corporation for the U.S. Atomic Energy Commission, will be used at Oak Ridge for heating magnetically-confined plasma in experiments directed toward controlled thermonuclear fusion.

HUGHES INTERNATIONAL
HUGHES AIRCRAFT COMPANY

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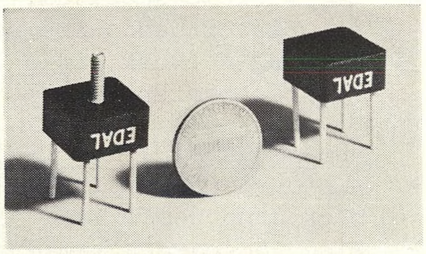
New Semiconductors

voltage, wideband amplifiers and other critical industrial and military uses. The npn can also be used for switching and series regulators, relay drivers, waveform amplifiers, converters, inverters, video amplifiers and monitors, color-difference amplifiers and operational and differential amplifiers in analog computers.

This transistor has a 400 v collector-emitter breakdown voltage (V_{CER}), and is rated at 325 v collector-emitter breakdown voltage with base open ($V_{CEO\,(sus)}$). Beta is greater than 30 at a collector current of 1 amp and a collector-emitter voltage of 5 v. The unit also has a minimum beta of 10 at a collector current of 2.5 amps and a collector-emitter voltage of 5 v.

Industro Transistor Corp., 35—10 36th Ave., Long Island City, N.Y., 11106. [366]

Single-phase bridge silicon rectifier



A medium current, single-phase bridge silicon rectifier, the series B191, sharply reduces space requirements because it can handle maximum power per unit size and is capable of withstanding high transient energy. These units make for faster assembly and simplified purchasing by eliminating the need for soldering a great many diodes. Thus fewer lead connections are required and inventory can be reduced.

The single-phase bridge units contain double diffused, passivated, controlled avalanche junctions in a cold case design for high reliability. Pure silver leads are available for straight plug-in; mounting stud is optional.

Electrical ratings of the new miniatures feature high-temperature

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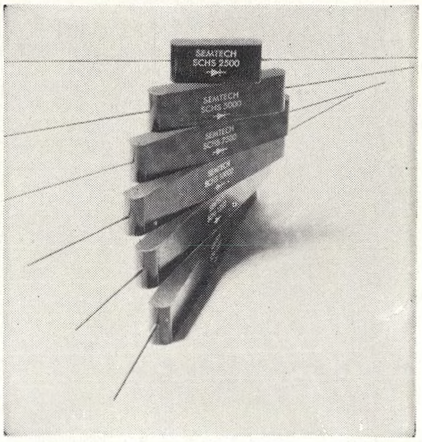
New Semiconductors

capability, low leakage current and low forward voltage drop. Single-phase bridge designs with current of 6 amps are offered in voltage ratings from 50 to 1,200 v peak inverse voltage.

Edal Industries, Inc., 4 Short Beach Road, East Haven, Conn., 06512. **[367]**

Silicon rectifiers boast high piv's



Peak inverse voltage ratings of 2,500, 5,000, 7,500, 10,000, 12,500 and 15,000 v are available from the Slimpac Sr. series of coaxial lead mounting, silicon rectifiers. The units are rated at 2 amps in free air and 4 amps in oil. Corona-free construction meets stringent life and environmental requirements.

These rectifiers feature low forward drop, low leakage (10 μa at piv, 25°C), operating and storage temperature of —55° to +175°C.

Internally, the device utilizes the manufacturer's solid double heat sink junctions welded together for mechanical strength, eliminating the use of solders. The package is 0.375 x 0.687 in. The length will vary with the piv rating from 1.50 to 6.50 in. maximum. Units have 0.051-in.-diameter axial (16-gauge tinned copper) leads for simplicity of installation.

Units are suited to all standard, single and polyphase rectifier circuits.

Semtech Corp., 652 Mitchell Road, Newbury Park, Calif., 91320. **[368]**

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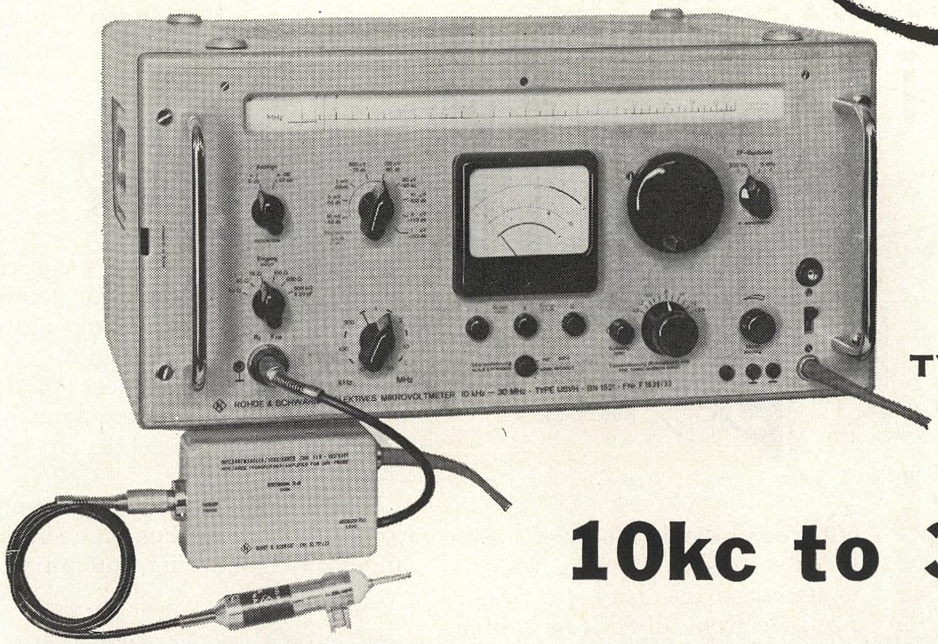
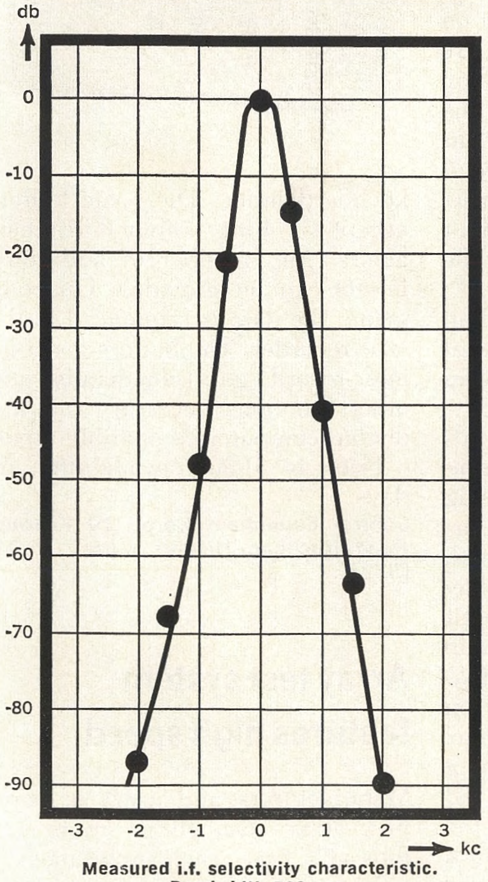


TYPE USVH

10kc to 30mc

SELECTIVE MICROVOLTMETER



Measured i.f. selectivity characteristic.
Bandwidth 500 cps.

Unique Features

- **Extremely wide frequency range: 10 kc to 30 mc.**
- **Fine frequency adjustment: ±2.5 kc.**
- **Bandwidth, selectable: 500 cps and 5 kc.**
- **Full-scale deflections, 1 μv to 1 v.**
- **Six input impedances from 50 Ω to 500 kΩ**

Here is a highly sensitive superheterodyne receiver whose output voltage is indicated by a diode voltmeter. A switch permits selection of any of the conventional input impedances. Single frequency changing is used for input frequencies from 10 to 1000 kc, double frequency changing for 1 to 30 mc, the bandwidth being 5 kc in both cases. Additional frequency conversion takes place in 500-cps narrow-band operation.

The local oscillator can be varied in frequency by ±2.5 kc and thus permit shifting of the 500 cps pass band over the 5 kc bandwidth present up to this frequency conversion.

The meter is calibrated in volts and decibels, and features an additional expanded scale with a relative calibration from 0.7 to 1. A head-phone output provides aural monitoring. A built-in calibration oscillator permits checking and adjustment. The power supply is electronically regulated for greater stability with regard to gain and frequency accuracy. A high impedance probe / amplifier is available.

Typical Measurement Applications

- Frequency response on four-terminal networks, especially at low voltage levels.
- Frequency response on amplifiers or filters within their pass bands.
- R-f distortion of long-, medium- and short-wave transmitters.
- Modulation depth.
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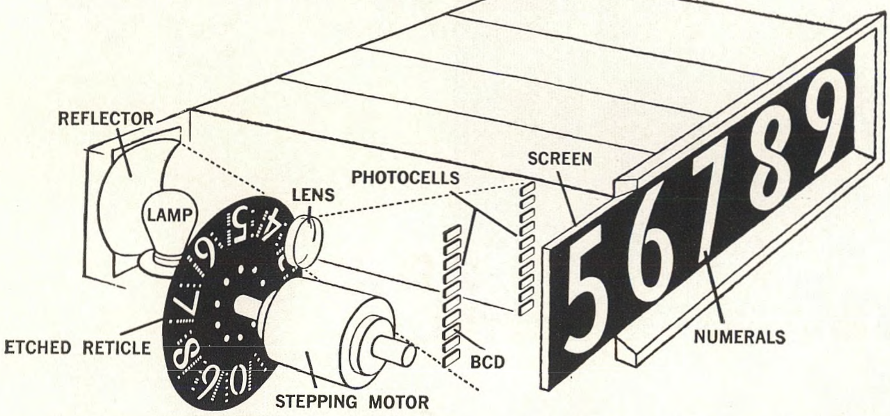
Digital readout projected clearly



A digital readout that could replace just about every readout now in use—and at comparable costs—is the claim made by the Numex Corp. for its new unit.

Also named Numex, for new mechanism, the readout has solid numerals all on the same plane that can be read from a wide viewing angle. The company's first model, series R-100, both decodes and displays signals from four-wire, binary-coded-decimal logic integrated-circuit systems. It can also be modified to accept other input codes. Future models expressly for use with counting instruments are planned. In addition to laboratory use, the company sees potential in consumer applications, such as airport displays and stock quotation boards, where the solid numerals would be an advantage.

Numex combines decoding and display in one unit, using the principles of a digital servo for decoding and the principles of a movie projector for displaying. For each decade, there is just one light bulb and one lens as opposed to most projection readouts that have a bulb and a lens for each numeral. The 10 numerals have been stamped out around the periphery of a stainless steel disk, or reticle, which is mounted on the shaft of a peanut-sized electronically driven stepping motor.

When a new digit is required, the image disk is rotated by the stepping motor. Photocells located on the back of the display panel are actuated by light beams passing through tiny coded holes in the projection disk. A 4-wire BCD input from, for example, integrated circuit logic is fed to the 8-photocell array. When disk code and BCD input match, a stop signal is sent to the stepping motor.

A detent holds the numeral in place until updating. The coded holes are not seen on the viewing panel.

Numex claims its readout affords several economies not found in competitive units. The major saving comes from the replacement of arrays of silicon decoding diodes with the coded hole arrays. The display image is bright because the unit uses a prefocused 12-watt bulb with a rugged 5-mil diameter filament. The bulb is not switched on and off, thus prolonging its lifetime.

The R-100 motor has a stepping rate of 30 pulses per second and turns in only one direction, so the longest updating time is close to a third of a second. To avoid tying up fast logic circuits, an intermediate memory, which can acquire a command in 50 nanoseconds, can be built into the device.

In quantities, a six-decade R-100 with BCD logic costs about $250, including frame and mounting hardware. BCD units are available from stock, with other logic units available in three weeks.

Numex Corp., 223 Crescent Street, Waltham, Mass. 02154 [371]

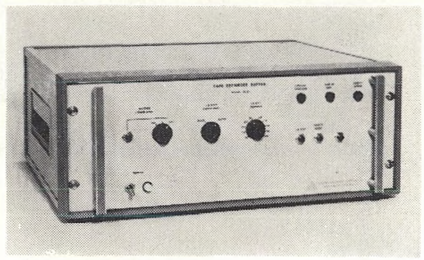
Specifications

Viewing angle	160°
Input wires	4 data, 1 hold
Speed	3 displays/second
Numeral size	1½ in. high, 1-9/16 in. centers
Over-all size per decade module	3 in. high, 1-9/16 in. wide, 6½ in deep
Power input	6.3 v
Price	About $50 a decade

Tape recorder buffers accept digital input

Series 5030 tape recorder buffers are instruments for translating, formatting and transferring digital data from analog-to-digital converters, counters, registers, digital clocks and similar devices to standard incremental magnetic tape recorders.

The buffers feature computer-compatible formatting, tape supply and parity monitoring, and optional keyboard input. The basic buffers accept six 4-bit or four 6-bit characters. Any number of additional inputs can be provided. On command, the data is sequenced to the tape recorder. The buffers generate inter-record gap commands and other functions necessary for producing computer-compatible tapes.

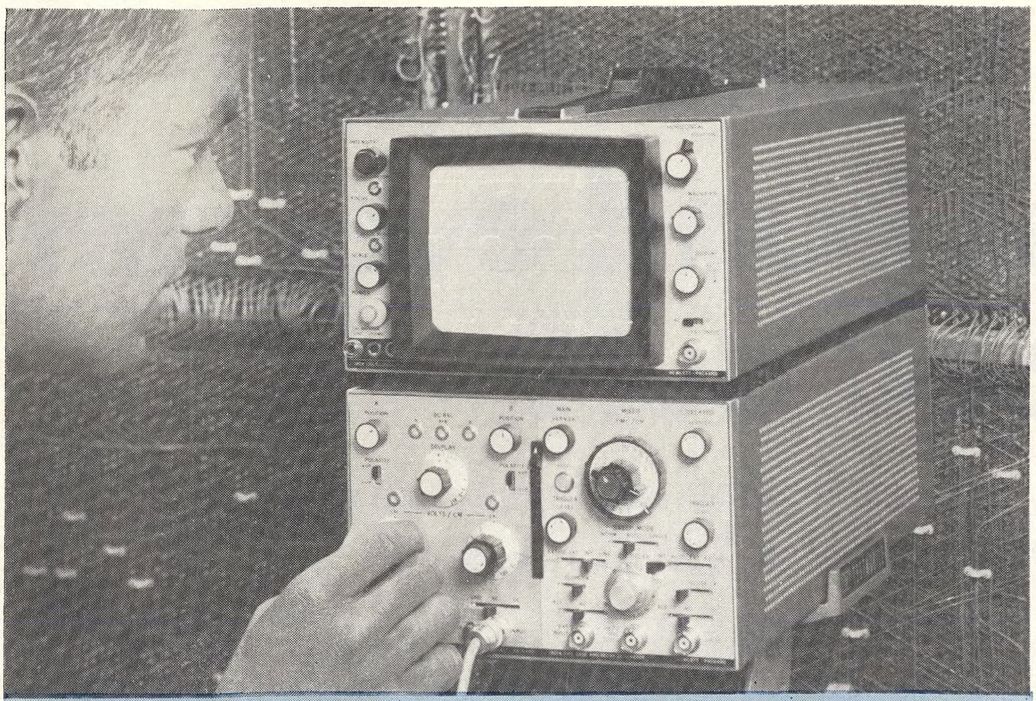


Price is $1,200; availability, 60 days.

Control Equipment Corp., 19 Kearney Road, Needham Heights, Mass., 02194. [372]

Array test system features high speed

Manufacturers and users of complex arrays can check up to 144 pins at a time, each programed as either input or output, with the series 8000 test system. Tests are run at 1,000 a second, an order of magnitude faster than any other system on the market, according to the manufacturer. The instrumen-



NEW hp 180A OSCILLOSCOPE

You can *see more, do more* with this 30-pound oscilloscope that goes anywhere—field, laboratory, or production line. Designed from the user's viewpoint in, this new dual-trace 50 MHz scope is packed with new ideas and innovations to give you big picture CRT, plug-in versatility, step-ahead all-solid-state performance, minimum weight and rugged design. These features add up to *more total performance, more usability than any other scope on the market!*

The hp 180A mainframe is the first with power supplies specifically designed for solid-state circuitry—gives you full performance benefits from solid-state devices in all present and future plug-ins. With hp's all-new big-picture 8 x 10 cm CRT, you have an extra-large display area —get bigger displays, make accurate measurements easier!

Vertical amplifiers drive the CRT vertical deflection plates directly, allowing even greater bandwidth capabilities in future plug-ins. Vertical amplifiers have low drift FET input stages for accurate DC measurements . . . plus quick 15-second warm-up. Time base plug-ins offer new easy to use delayed sweep for examining complex waveforms in detail. Tunnel diode triggering circuits lock in waveforms to 90 MHz. Exclusive hp mixed sweep feature combines display of first portion of trace at normal sweep speeds, and simultaneously expands trailing portion of trace at faster delayed sweep speed to allow magnified examination.

See the back of the actual size color photo at the right for abbreviated specifications and price. For full specifications and a demonstration of how you can *see more, do more* with this new, versatile, go-anywhere scope, call your nearest hp field representative. Or, write to Hewlett-Packard, Palo Alto, California, 94304. Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

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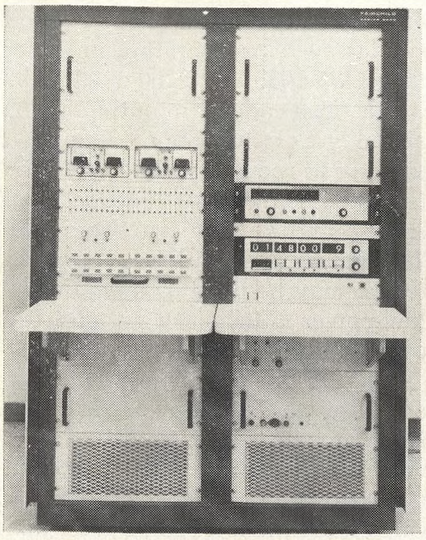


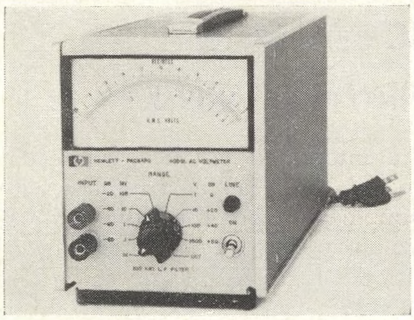
tation is programed by a magnetic disk and can be tied into virtually any computer for programing the disk or for readout and analysis of test data.

With the series 8000 functional tests can be performed on complete modules, printed circuit cards, welded modules, integrated circuits, thin-film circuits, multichip IC's, complex arrays, large scale integration and system subassemblies.

Fairchild Instrumentation, a division of Fairchild Camera and Instrument Corp., Mountain View, Calif. [373]

High-sensitivity a-c voltmeter

Model 400GL a-c voltmeter offers a linear db scale on each range. It has a 100 μv full-scale range, and 10 megohm input impedance. The maximum full-scale range is 1,000 v. A built-in amplifier produces 1 v rms a-c output for full-scale meter deflection. On the 100-μv range the amplifier has 80 db gain with a less than 5 μv noise.



Frequency range is 20 hz to 4 Mhz. Accuracy in the range from 100 hz to 1 Mhz is 0.2 db. Voltage gains up to 160 db may readily be measured over 5 decades of frequency range.

A built-in, 100-khz low-pass filter, controlled from the front panel, will eliminate the error-producing effects of high-frequency voltages when low-frequency measurements are being made.

The 400GL is said to be especially useful when measuring signals that vary within wider than usual range. With 20 db range on each scale, signals varying in voltage over a 10-to-1 range may be continuously followed, without range-changing. The unusual gain of the built-in amplifier, and the high sensitivity of the instrument, suit it for use as a calibrated high-gain preamplifier for oscilloscopes, bridge detectors and other devices. In acoustical measurements, sensitivity is so high that a calibrated microphone may be connected directly to the input terminals.

Price is $290; delivery estimates, 4 to 6 weeks.

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif., 94304. [374]

Tera-ohmmeter measures in 2 seconds

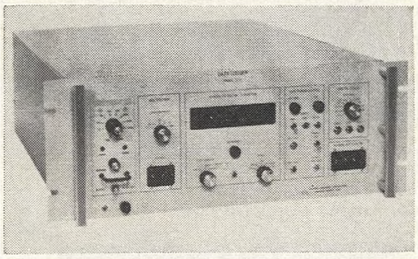
A solid-state tera-ohmmeter has been announced. Among its advantages, the TO7A features: a resistance range of 100,000 ohms to 10,000 tera-ohms, a current range of 0.1 picoamp to 10 μa, continuously variable test voltage of 0 to 1,000 v d-c, measurements in accordance with ASTM D-257 and IEC93, less than 2 seconds for measurement and accuracy of 3% of reading.

Typical applications for the TO7A include both R&D and production insulation measurements in analyzing the various factors affecting insulation resistance. Included in these measurements are humidity, temperature, impurities, voltage coefficient and so forth. Further, surface conditions are available by using the recorder output.

The TO7A is also used to measure the insulation resistance of components such as switches, potentiometers, sockets, transformers, and other devices.

Rohde & Schwarz, 111 Lexington Ave., Passaic, N.J., 07055. [375]

Data loggers record voltages digitally



The data loggers, series 7100, are instruments for automatically measuring voltages from one or more analog sources and recording them in digital form on a permanent storage medium. They are compact, combining all of the usual data acquisition system functions in one small instrument, including a multiplexer, d-c amplifier, analog-to-digital converter, output buffer, digital clock, and manual data entry.

When connected to any of five standard types of recording devices, such as tape punches, tape recorders, typewriters, card punches, or teletypewriters, the data loggers can be used for off-line data acquisition, unattended monitoring, quality control sampling, production test recording, and automatic process control.

The units have 5 to 100 input channels, scanning speeds from 0 to 30,000 channels per second, conversion rates to 25,000 hz, and an accuracy and long-term stability of $\pm0.01\%$. The standard instruments have a panel height of 7 in., mount in standard 19-in. cabinets, and operate over the temperature

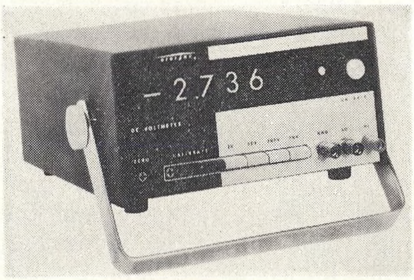
←Circle 168 on reader service card

range of 0° to +50°C.

Price is in the $5,500 range; availability, 60 days.

Control Equipment Corp., 19 Kearney Road, Needham Heights, Mass., 02194. **[376]**

D-c digital voltmeter with reading storage



An all solid state digital voltmeter features ±0.05% reading ±1 digit, reading time of 0.6 second filtered 20 msec with filter bypassed, constant input impedance of 10 megohms, automatic polarity selection and indications and BCD output.

A reading storage feature provides bidirectional tracking without blinking. The meter is of modular construction and consists of a basic unit and plug-ins specific to the measured parameter.

Models 251 and 252 with their applicable plug-ins are multirange digital voltmeters. The 251 is characterized by resolution to 1 part in 10,000 (0.01%) and three ranges—9.999, 99.99 and 999.9 v.

Resolution to 1 part in 3,000 and ranges for 2.000, 20.00, 200.0 and 1,000 v are basic to the model 252. Because of its fast reading time (20 msec), the 252 is well suited for incorporation in systems applications.

Basic model 251 lists for $525; and the 252, for $435. The plug-in units, 251-1 and 252-1, list for $150 each.

United Systems Corp., 918 Woodley Rd., Dayton, Ohio, 45403. **[377]**

Signal generators with coded f-m output

F-m receivers can now be calibrated with a self-contained, portable signal generator. Series 1041 units are crystal controlled, compact instruments for testing receivers, decoders and other components of command control, telemetry and similar systems operating in either the 1435-1535 or 2200-2300 Mhz bands. The coded f-m output of the signal generators may be applied directly to receiver/decoders to determine sensitivity, decoder response and similar characteristics. The generators, with a simple antenna, may be used as a calibrated low-power transmitter to measure over-all systems performance.

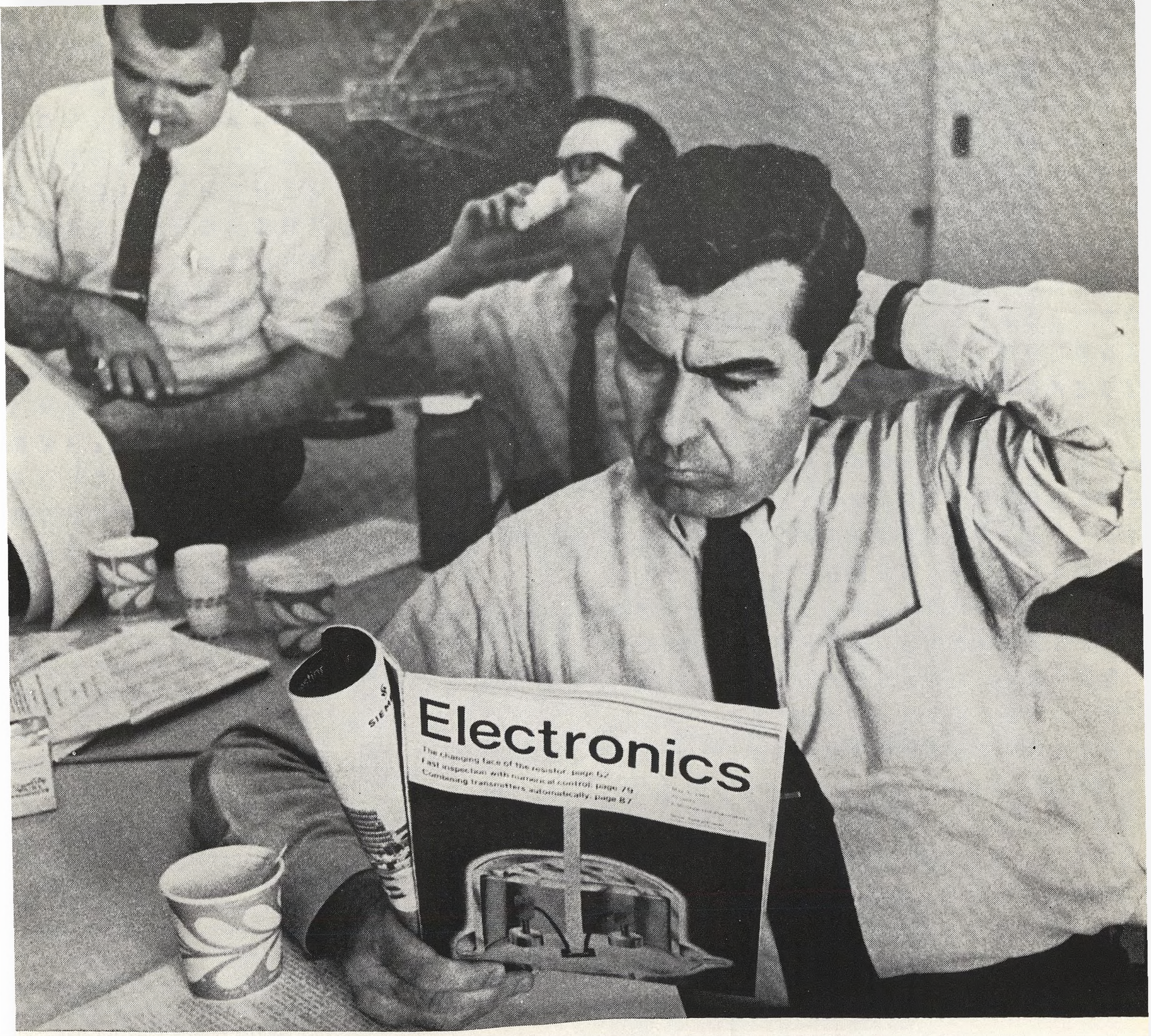
These signal generators provide an internal 10-channel coder for frequency-modulating the r-f signal. The r-f output of the signal generators is precisely calibrated in carrier frequency, amplitude and deviation to laboratory instrument accuracy. The instrument weighs 17 lbs and is contained in a rugged, watertight aluminum case that measures 8 x 14 x 9 in.

The 1041 is designed for use in the field, laboratory, or on the production test line for rapid and accurate testing. Its a-c/d-c power supply permits it to be carried from the test bench into the field for confirming flight readiness of command or telemetry equipment installations.

RS Electronics Corp., 795 Kifer Road, Sunnyvale, Calif., 94086. **[378]**

IC card tester operates rapidly

An integrated circuit card tester, model 1569, can be supplied with simple adapters that allow rapid, go-no-go, programable testing of any DTL or TTL logic card. The adapters can also be easily fabri-



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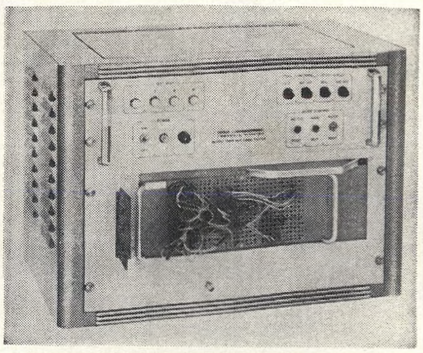


cated by the customer, if desired.

The instrument can perform as a single operation test involving as many as 16 individual, self-sequencing steps requiring less than 3 seconds total test time. The sequence is programed by insertion of patch cords into a patch panel on the unit. For high volume, repetitive testing, prepatched panels can be supplied. Stepping operation is performed by a rotary stepping switch with gold-plated contacts. The unit automatically stops at any step where the test board fails.

The test unit provides a check of logic function operation as well as voltage levels. Go-no-go indicators display whether a specific failure is one of logic function or of logic voltage level. A counter indicator on the card tester allows the operator to determine the exact malfunction in the IC board being tested. Also, a single-step test switch is provided for detailed trouble-shooting of the test board.

By utilizing boards with test sockets, the tester can be used for checking other electrical components as well as integrated circuits. Wyle Laboratories, Products division, 133 Center St., El Segundo, Calif. **[379]**

Single-band sweeper uses less than 150 w

Sweep oscillators, designated 6400 series, offer the advanced features of the 650 series in single-band units working in the 1 to 40 Ghz frequency spectrum. The new series offers performance, operational simplicity, and versatility unmatched by any other single-

SIEMENS

Siemens Polystyrene 'Styroflex" Capacitors

Mica" properties at "paper" prices

Jnique properties of Polystyrene and the nethod of manufacture developed by iemens (The polystyrene is stretched and tabilized in the stretched condition before vinding. After winding, special heat treatment shrinks the film, forming a hard, stable ody.) results in low cost STYROFLEX apacitors which offer:

Reliability: 1) against voltage breakdown assured by tests on each unit at 3.3 times ated voltage). 2) in the microvolt range (asured by positive welded contacts between oil and leads).

Stability against change in capacitance ver long periods of time is one result of the olidity and hardness of the capacitors... roduced by the special film shrinking manuacturing process.

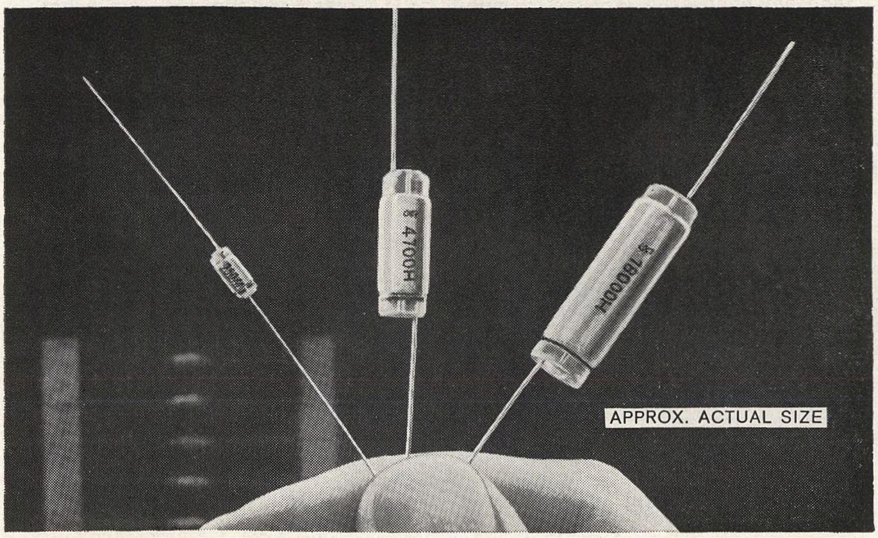
ow Self-Inductance: values as low as for xtended-foil construction.

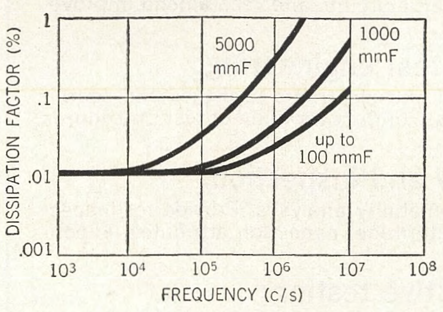
ow Dissipation Factor: usually even lower han for mica capacitors, making them espeially suitable for filter circuits.

ligh Resistance to Humidity: polystyrene as the lowest water absorption coefficient f all capacitor dielectric materials.

lighest Insulation Resistance: higher than or any other kind of dielectric.

nmediate Shipment: substantial stocks are eld in White Plains, N.Y.

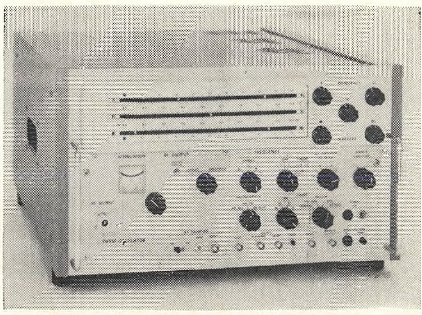




Low dissipation factor (usually even lower than for mica capacitors) is provided by Styroflex capacitors... making them specially suitable for filter circuits.

SIEMENS AMERICA INCORPORATED
Components Division
230 Ferris Avenue, White Plains, N.Y.

In Canada:
SIEMENS CANADA LIMITED
407 McGill Street, Montreal 1, P.Q.



band sweeper, according to the manufacturer. A full line of grid and p-i-n diode leveled units with either internal or external sampling is offered.

Features include 50-db continuous power control range, leveled or unleveled. These independently controlled r-f markers are available in broad-band sweep, two in narrow band.

Because 6400 series instruments use less than 150 w of power and do not need a blower, they are suited for 50/400 hz operation in airborne or remote applications. R-f output frequency and marker accuracy is better than 1%. Frequency stability is better than 0.01%. Residual f-m ranges from 0.001% to 0.003%, depending on the band.

Alfred Electronics, 3176 Porter Drive, Palo Alto, Calif. **[380]**

Pressure transducer meets aerospace needs

A solid state, strain gage pressure transducer, the TF-555, is ruggedly constructed of stainless steel for stringent aerospace applications. It weighs only 5 oz yet provides a full scale output of 5 v d-c while drawing only 5 ma current for an input voltage of 24 to 34 v d-c over the complete compensated temperature range of —65° to + 250°F.

The TF-555 is available in a pressure range of 0 to 50 through 0 to 10,000 psi gage or absolute. Size is 1.25 in. in diameter x 2.30 in. in length. Combined linearity, hysteresis and repeatability error is ± 0.25% at ambient temperature conditions.

Fairchild Controls, a division of Fairchild Camera and Instrument Corp., 225 Park Ave., Hicksville, N.Y. **[381]**

C.A.V.U.* IN SOLVENT Iowa

The profit forecast for Solvent Iowa is clear. No storm clouds of state indebtedness or inequitable taxing to slow down future growth. State revenue spending is "on the beam" — directed toward projects that will foster growth and progress. The labor picture, too, is bright and clear, with readily trainable men and women workers, many educated by an area system of vocational schools and community colleges. Space-age scientists provide technological training in state universities and private colleges. Iowa is a place where your company can really "take off and fly." Let us send you, in confidence, our report on profitable site location factors in Iowa,

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Computer family has compatible software

Family planning has been characteristic of many computers introduced in recent years. But a user moving from a smaller to a larger computer in some of these families sometimes finds that he needs a lot of software modification—despite the fact that families, by definition, are supposed to be program-compatible.

Now there's a new family of computers without this problem—says the manufacturer, the Digital Equipment Corp. At the Fall Joint Computer Conference in San Francisco earlier this month the company introduced its PDP-10 family which has five models with five levels of software. A user going from one model to the next largest needs only a few pieces of hardware and an additional software module.

The smallest model, the PDP-10/10, is for the customer who needs only 8,192 words of memory and can make do with relatively slow paper-tape input and output. Larger models step up the size of the memory, add magnetic tape input-output and provide for multiple users and time-sharing. The largest model, the PDP-10/50, has a minimum 32,768-word memory, a magnetic disk and the software needed to swap programs in and out of memory "on the fly" as different users require them.

Not only are the new computers compatible within the family, they can work with Digital Equipment's previous big machine, the two-year-old PDP-6. Like the PDP-6, the new series has a memory divided into modules of 8,192 words of 36 bits each. The computer has separate access to each memory module with overlapping capability; a cycle can begin in the second module before the first module's cycle is completed. The new machines are faster and less expensive than the old PDP-6: a 1-microsecond memory cycle time compared with 1.75 μsec, and prices ranging from about \$110,000 to \$1 million, versus \$250,000 to \$1 million for the PDP-6.

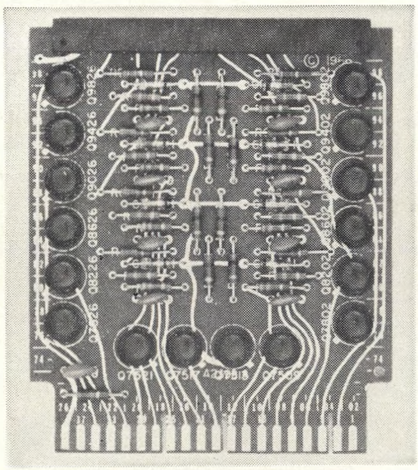
Delivery of the new computers is scheduled for next September.

Specifications

Memory capacity	From 8,192 to 262,144 words
Word length	36 bits
Cycle time	1 μsec
Add time	2.1 μsec
Priority levels	
PDP-10/10	2
PDP-10/20-50	7

Digital Equipment Corp., 146 Main St., Maynard, Mass. **[382]**

Build your own special computer



A systems approach in developing a line of digital integrated circuit modules means that engineers can build their own special-purpose computers without worrying about interface problems, including wiring and noise, normally associated with such units.

The M-series of building blocks includes more than 30 types of circuits—almost every type of module needed except a computer memory. The diode-transistor-logic circuits operate from d-c to 2 megahertz.

The circuit boards are made of epoxy and are 3 by 3.65 inches, with a 40-pin etched connector. (The photograph shows an output level converter.) Eight signal test points and a ground are built into a housing on the module's handle for easy testing.

Mounting is simplified with special block assemblies for groups of 10, 30 or 40 modules. Module connectors mount in predrilled holes, with laminated bus bars picking up the correct pin connection. The bus bars also serve as 50-ohm transmission lines for distributing clock signals within the finished computer. Connector blocks are designed for automatic wire-wrap assembly and fit into cases that hold 40, 120 or 400 modules. All cases fit standard 19-inch racks.

Computer division, Raytheon Co., 2700 S. Fairview St., Santa Ana, Calif. **[383]**

IC logic modules operate to 5 Mhz

The Interlogic is a family of general purpose, integrated circuit logic modules. The line features operation to 5 Mhz with low power consumption and high immunity to noise.

All Interlogic modules are epoxy glass p-c boards 3.5 x 5.75 x 0.062 in. and have all outputs and inputs available at the pins of a highly reliable, high-density 72-pin connector. Monolithic silicon integrated circuits are used for the basic logic functions and high quality discrete components and silicon semiconductors are used where better performance may be obtained through the use of hybrid circuits.

Use of these modules is said to result in a substantial reduction in system costs as well as permitting the designer to concentrate on system and logic requirements rather than on detailed circuit design and

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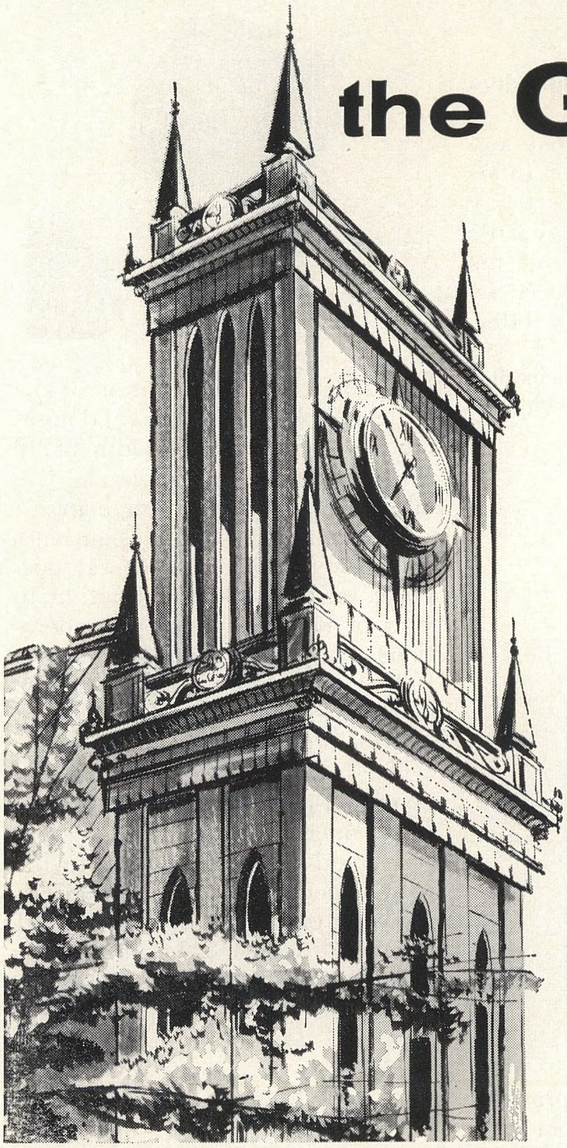

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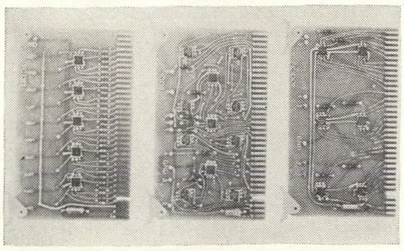
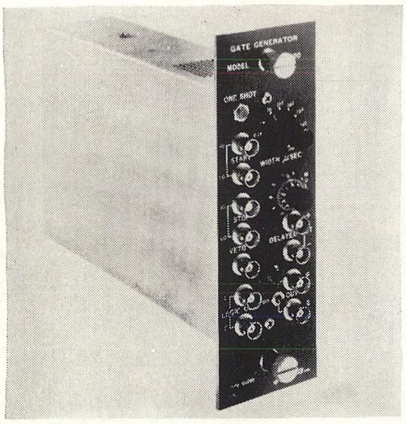


packaging; detailed Interlogic documentation is supplied.

Further reductions in cost and size are realized because of Interlogic's requirement for only +5 v d-c. A line of short-circuit +5 v d-c power supplies providing currents from 2 to 25 amps is produced by the company for use with Interlogic modules.

Information Control Corp., Abacus division, 138 Nevada St., El Segundo, Calif. **[384]**

Gate generator provides 6 outputs

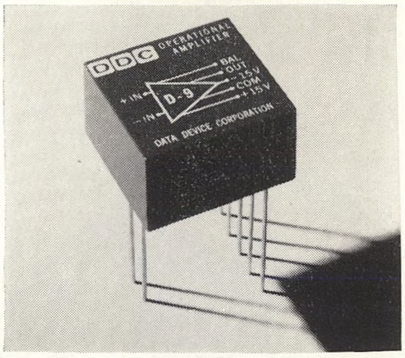


The GG200 gate generator provides six outputs, including system logic and gate signals and their complements. Delayed positive and negative trigger signals at the end of each gating cycle permit the gate generator to be used as a delay generator.

Timing and rate are independent of each other. Gating time range is extended down to 100 nsec and up to 11 seconds in eight overlapping ranges. The timing cycle may be started and stopped by ±5 v to ±50 v pulses as well as logic signals, and output gate and logic signals may be vetoed by logic signals. All outputs drive 50-ohm loads and are fully protected from overload damage.

EG&G, Inc., 35 Congress St., Salem, Mass., 01971. **[385]**

Operational amplifier meets MIL-Q-9858A



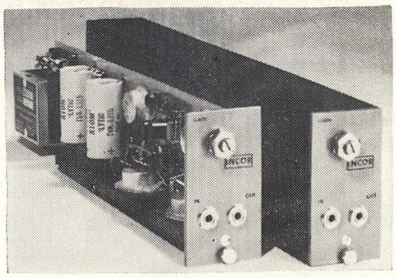
Frequency for full output of 50 khz typical (35 khz minimum) and minimum unity gain bandwidth of 10 Mhz are features of the model D-9 all-silicon operational amplifier.

The amplifier was designed to meet the need for a general purpose, medium-power output, ±10 v at 5 ma, high-frequency operational amplifier. Guaranteed performance includes gain of 86 db, offset current of 20 na, voltage drift of 20 μv/°C and noise of 5 μv rms.

The D-9 is packaged in a molded epoxy case, 1⅛ x 1⅛ x 0.625 in. high, operates from ±15 v supplies, and is manufactured to the requirements of MIL-Q-9858A. Price for quantities of 1 to 9 is $31 each; for 10 to 24, $29 each.

Data Device Corp., 240 Old Country Road, Hicksville, N.Y., 11801. **[386]**

D-c amplifier has adjustable gain

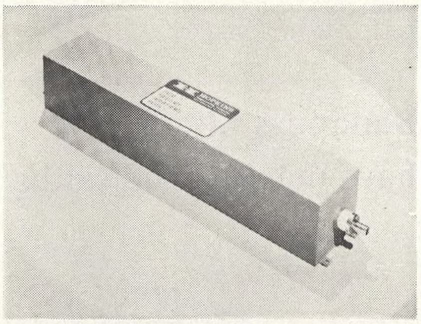


A d-c amplifier, model 102, has been added to the manufacturer's line of instrumentation amplifiers. All are single-ended, floating, solid state amplifiers, with self-contained fully regulated power supplies and guard shields. Model 102 has a continuously adjustable voltage gain of zero to unity.

Up to 10 amplifiers may be installed in a standard 19-in. rack, requiring only 3½ in. of rack space. Price of the model 102 is $95.

Other models are available with gains of 0 to 100, both switchable and continuously variable. Typical specifications include output of ±10 v at 100 ma, and frequency response of d-c to 50 khz. Prices range from $95 to $250.
Instrumentation Amplifiers & Supplies, Inc., 29 Newtown Road, Plainview, L.I., N.Y., 11803. **[387]**

Welded power filters meet Mil-F-15733E



Power filters are available with completely welded seams and terminals. The 1960-W series of radio-frequency-interference filters meets the requirements of Mil-F-15733E.

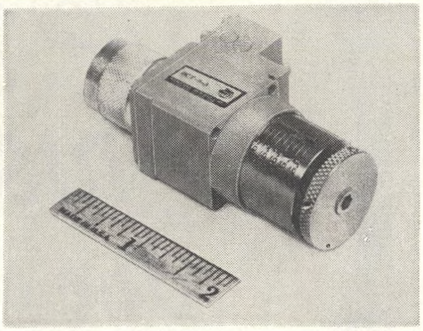
Each filter case is constructed of 14-gage minimum cold rolled steel. All seams are continuous inert-gas welded, including the terminals that are specially designed for fast, easy field servicing. The terminal assemblies are made of high temperature, high-alumina-content ceramic. The filters are available with end housings for individual mounting. For multicircuit applications, any number can be supplied in a single cabinet.

These filters provide an insertion loss of 100 db minimum over a frequency range of 14 khz to 10,000 Mhz when measured in accordance with Mil-Std-220A. They are designed to provide continuous 24-hour operation without failure.
Hopkins Engineering Co., P.O. Box 191, San Fernando, Calif., 91341. **[388]**

Circle 179 on reader service card

New Microwave

Diode oscillators feature low noise



Tunnel diode oscillators, operating from 4 to 13 Ghz, are mechanically tunable over any desired 10 to 20% band. They have low f-m noise, equal to 2 to 3 hz/khz in a frequency slot that is 70 khz from the carrier. This noise decreases as slot frequency is increased.

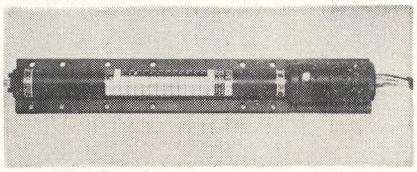
Frequency stability is 0.02% minimum over the temperature range from —30° to +60°C. The pushing figure is 0.1 Mhz per 10% change in applied voltage. Pulling figure is 0.01% when operating into a short circuit varied through all phases. Output power is 0.1 mw. A precision-tuning mechanism holds the frequency accurately despite shock, vibration or improper handling. These oscillators can operate from a 1.5-v mercury battery with 30 ma.

Prices are available from the manufacturer on request.

Delivery is 60 to 75 days after receipt of order.

International Microwave Corp., River Road, Cos Cob, Conn., 06807. **[391]**

Twt amplifier boasts low weight



A traveling-wave tube amplifier designated the L-5088 is small and light for its low noise figure. The tube weighs 1.8 lbs and is 12.5 in. long. Operating at 2 to 4 Ghz, it has a typical noise figure of 10 db and a maximum noise figure of 12 db.

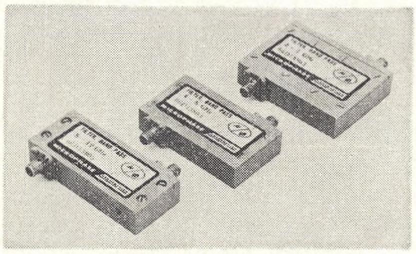
The L-5088 features periodic permanent magnet focusing and all metal-ceramic construction. Its power output is +7 dbm minimum and its small signal gain is 40 db.

Rugged construction permits reliable performance under the environmental extremes of MIL-E-5400, Class 2, for airborne equipment. The L-5088 is suited for application in missile, air and communications systems, as well as other low noise applications where small size and light weight are important.

The unit is also available with an integral power supply.

Litton Industries, Electron Tube division, 960 Industrial Rd., San Carlos, Calif., 94070. **[392]**

Bandpass filters have octave bandwidths

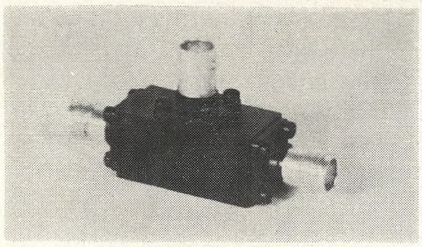


Interdigital bandpass filters, designated series MSI, cover the 1 to 12 Ghz region in octave bands. Passband insertion losses range from 0.5 db to 0.6 db maximum for the higher-frequency units, with a vswr of 1.6:1 to 1.7:1 maximum. The 60-db attenuation points are typically 1.7 times the passband. These miniature compact packages come equipped with OSM female connectors. A typical 2-to-4-Ghz filter, excluding connectors, measures 2⅜ x 1¾ x ½ in.

The MSI series bandpass filters are complemented by series SI units available from 0.5 to 8.0 Ghz, having tubular low-pass filter extensions that provide 60-db rejection to 21 Ghz. The SI series normally come with type N female connectors, and are 1 inch high. All units are ruggedly constructed to meet severe environmental conditions.

Price for the MSI series is $250; the SI series, $190 to $250. Delivery is 4 to 6 weeks.
Microphase Corp., Box 1166, Greenwich, Conn., 06831. [393]

Diode switch exhibits 50-db isolation



A coaxial, solid state diode switch boasts a minimum isolation of 50 db. Model M.T-3002 operates over the frequency range of 1,200 to 1,450 Mhz. The single-pole single-throw unit has a typical insertion loss of 0.3 db and a maximum of 0.5 db.

The units can handle a maximum peak power of 1.0 kw; maximum c-w power of 2 watts; and have a nominal switching speed of 25 nsec.

Other units are available at uhf and L-band frequencies.
Alpha Industries, Inc., 381 Elliot St., Newton Upper Falls, Mass. [394]

Interdigital diplexer meets MIL-E-5400

An interdigital diplexer has been developed that allows two sets of equipment of adjacent frequency bands to operate with one broadband antenna. It has low vswr and insertion loss for each equipment set in its operating band and also provides high isolation between each equipment set.

For band A, frequency is 650 to 890 Mhz; vswr, less than 2.5:1; insertion loss, 1.5 db. For band B, frequency is 960 to 1,220 Mhz; vswr, 2.5:1 (1025 to 1220 Mhz, 1.6:1). Isolation, band A to band B, is 65 db; band B to band A, 30 db. Type IM diplexer meets MIL-E-5400.
Transco Products, 4241 Glencoe Ave., Venice, Calif., 90291. [395]

New Production Equipment

System collects factory data

Production managers are no longer as content as they once were to rely on factory data that's weeks or even days old. At least that's what the Apparatus division of Texas Instruments Incorporated counted on when it introduced a new computer-based system for collecting production data in a wide variety of manufacturing operations.

All types of production information can be handled by the system, providing almost instantaneous readout on such parameters as materials flow, product yield and quality, inventory, labor distribution and worker attendance, according to TI.

The system is designed to eliminate the delays and errors caused by present factory routines that require such information to be first handwritten and then converted to a form suitable for data processing. A multiproduct electronics manufacturer would find the new system particularly useful, TI says.

As many as 40 remote input stations can be tied into the unit's central data-collection station where the data is accumulated and coded using format-control cards provided by TI. Then the information is sent either to conventional storage devices or fed directly into an on-line computer. Transmission over telephone lines gives the system unlimited range.

Each remote input station, designated model 956, can accept information from three sources. Fixed data comes from both a standard 80-column punch card and a punch-coded plastic personnel identification badge. Variable data is entered from a set of thumbwheel switches containing alphanumeric symbols. Stations have banks of either six or 12 switches, with stations for reading badges only also available.

To record receipt of materials on a production line, for example, a punch card accompanying the material furnishes data on type, quantity and stock number. The identification badge shows who received the material. Thumb-wheel switches dialed by the operator indicate the job for which the material is destined.

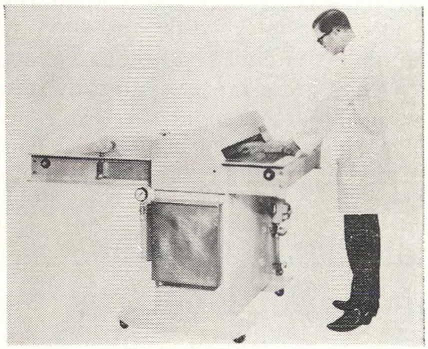
The new system overcomes many of the problems that have plagued earlier data-gathering systems, according to TI. The remote stations use an optical reader, instead of an electromechanical reader, for the cards and badges. This allows faster transmission rates for the data—100 characters or card columns per second. Three-quarters of the electronics in the system is built from integrated circuits; the logic uses IC's only.

In addition, the data is sent serially to the central data-collection station, designated model 957, over two-wire lines—instead of in parallel over multiwire cables.

Error detection at the central station is by character, transmission and power failure. Time, day and month codes, remote and central station codes, error and end of transaction codes are automatically entered. The system can also transmit inquiries from a remote location to the on-line computer through a teletypewriter. A cathode-ray tube display unit may soon be available.

Apparatus division, Texas Instruments Incorporated, 3609 Buffalo Speedway, Houston, Texas 77006 **[401]**

Roller coater meets p-c industry needs

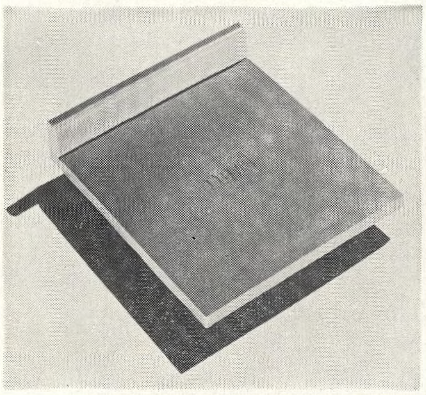


A roller coater is available for the application of photoresist and other fluid coatings to flat panels and printed circuits. Model 630 is fully conveyorized and features exclusive automatic thickness control, the company reports.

The machine will uniformly coat panels up to 24 in. wide and 1/4 in. thick in a single pass at rates adjustable from 8 to 20 lineal feet a minute. Waste of coating fluid is completely eliminated through the use of a closed recirculating fluid system design and a unique roll seal design.

Gyrex Products, Varo, Inc., 3003 Pennsylvania Ave., Santa Monica, Calif., 90404. **[402]**

Tough plastic doesn't burn



Acrylonitrile - butadiene - styrene (ABS) is an inherently tough, hard and rigid plastic—so tough that it is used for molding telephone housings. However, it will burn slowly unless it is specially coated. Recently, polyvinylchloride (PVC) has been added to make the plastic self-extinguishing, but PVC also makes the material hard to work with.

The Marbon Chemical division of the Borg-Warner Corp. is now marketing an ABS plastic that it says is both self-extinguishing and easy to process. Marbon calls Cycolac KM the "first true ABS material" that is self-extinguishing.

In addition, the company says, the KM grade is easier to mold than other ABS plastics. It flows at temperatures of 380°F to 460°F and can be molded in screw or ram machines.

At 2.36 cents a cubic inch, Marbon says Cycolac KM is 36% more expensive than PVC, but 65% less expensive than self-extinguishing polycarbonate and 52% less than self-extinguishing nylon.

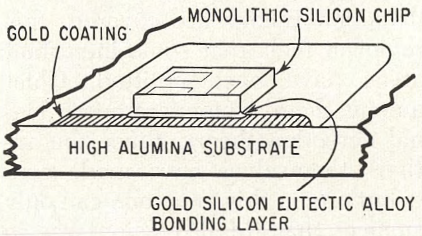
Marbon is field sampling Cycolac KM in "close to 100 applications," where high tensile strength and high impact strength are needed. The material is being used for a computer joggler tray (shown at the left), resulting in lower cost and faster production than possible with a similar plastic. It is also being used for switch housings.

Marbon Chemical division, Borg-Warner Corp., Washington, W.Va. **[406]**

Specifications

Tensile strength	5,200 psi at 73°F
Tensile modulus	300,000 psi at 73°F
Izod impact strength	
notched	2.1 ft lb/in at 73°F
unnotched	27 ft lb/in at 73°F
Heat distortion	
unannealed	½ in. at 179°F, 264 psi
annealed	½ in. at 204°F, 264 psi
Price	0.55 cents per pound

Ceramic gold coating has high conductivity



A ceramic gold coating has been developed for silicon integrated circuit applications. The 8800B coating, after application to ceramic substrate, makes possible direct attachment of goldbacked silicon semiconductor chips without the necessity of using gold or gold-alloy preforms. Attachments may be made by ultrasonic bonding or simple scrubbing of the silicon chip against the coating at about 400°C under nitrogen.

It features extremely high conductivity approaching that of ceramic silver preparations, according to the manufacturer, and may be used in flatpack and TO-5 constructions. It is suitable for silk screening and may be diluted with butyl carbitol acetate for other applications.

The paste has a peak temperature firing range from 850°C to 1050°C, and adheres readily to ceramic surfaces, including high alumina bodies, beryllia, steatite and titanates. The resistance of a 1-mil-thick film is less than 0.02 ohm/square.

The material is available from stock for $51 per troy ounce in production quantities. A sample 1-oz jar is available for $65.

Electro-Science Laboratories, Inc., 1133-35 Arch St., Philadelphia 7, Pa. **[407]**

Circle 183 on reader service card→

New Books

Picking up signals

Signal Detection Theory
John C. Hancock and Paul A. Wintz
McGraw-Hill Book Co., 247 pp., $11.75

Signal detection based on statistical theory is an established discipline and nearly every major university offers at least one graduate course on the subject. However, there are few books which cover detection theory exclusively that are suitable as texts—most are research monographs and give little consideration to applications.

Hancock and Wintz's book fills the void. They have done a creditable job of writing a coherent text that includes modern topics, applications and a collection of problems. Not only is it suitable for second-year graduate students in communications theory, but it can be recommended to teachers, researchers and practicing engineers interested in communications problems. A knowledge of multidimensional random variables (Gaussian) and some matrix theory is needed.

The authors develop sampling and matrix models of general channels, then give the basics of classical statistical decision theory. In separate chapters on sequential detection and the estimation of parameters, discrete sampled operations are assumed in developing the equations—a departure from the usual treatments using the Karhunen-Loève expansion. The results of the book's analyses, therefore, can be fed directly into a digital computer.

The latter part of the book is concerned with the timely and important topics of signal detection under conditions that are not ideal. Emphasis is put on adaptive receivers based on both decision-directed strategies and strategies that are not decision directed. Results with the two techniques are compared for a channel with unknown, or random, gain.

Optimum detectors are derived for signals transmitted through linear, randomly time-varying channels. Taking the channel sampling models developed earlier, detectors are derived for "rake" receivers (for signals transmitted through the ionosphere, thus subjected to multipath interference); multilink, or diversity, receiving systems and stochastic receivers (for determining which random signal has been received).

The volume concludes with an interesting discussion of detection techniques that involve a learning feature—where past events influence future actions. Also included are two appendixes—one on Hilbert transforms and another on waveforms.

Although most of the topics considered to be in the province of detection theory are covered, this reviewer feels that some important areas have been omitted. Chief among them is nonparametric signal detection theory. Since the authors themselves have made contributions in this area, one can only suspect that this exclusion was in the interest of brevity.

Raymond L. Pickholtz
Polytechnic Institute of Brooklyn
Brooklyn, N.Y.

Limited primer

Electronics
Roy H. Mattson
John Wiley & Sons, Inc., 620 pp., $12.95

Although the title indicates an examination of the fundamentals of electronics, the author describes only a few devices, almost exclusively semiconductors, and some of their circuits. Writing in a casual, colloquial style, he presents a number of facts, drawing upon the undergraduate's understanding of atomic physics and circuit analysis; little is derived. A familiarity with electronics would make the book more understandable, but then perhaps unnecessary.

Considerable space is given to several appropriate device models, to biasing considerations and to a cascaded transistor amplifier. A few remarks are devoted to modulated signals, the principles of feedback and switching circuits. Notable omissions include oscillators, practical modulators and demodulators, tuned amplifiers, electron ballistics and controlled power supplies.

This first edition contains a scattering of mistakes, typographical and grammatical errors and ambiguities. Answers are given for most of the almost-200 problems, some of which involve design work.

Compared to other texts now in print, this one covers only a tiny portion of the vast field of electronics, and many readers will be disappointed to see how little is said about that.

Robert C. Gebhardt
The City College
New York, N.Y.

Managing computers

Computer Control of Industrial Processes
E.S. Savas
McGraw-Hill Book Co., 400 pp., $16

Although aimed at bringing an understanding of computer control from an application and production point of view to a diverse audience including engineers, the book appears more suitable for marketing people and nontechnical managers.

Part one describes principles and part two the practice of computer control. Unfortunately the theory discussed in the first section is not illustrated in the second section. There is no discussion of design principles, and practical applications aren't adequately covered.

Julius T. Tou
Director, Information Science Research
Battelle Memorial Institute
Columbus, Ohio

Recently published

Electron Dynamics of Diode Regions, Charles K. Birdsall and William B. Bridges, Academic Press, 270 pp., $10

Construction and analysis of models for studying the motion of charged particles in time-varying fields. The models analyzed are simplified versions of parts of practical devices—primarily active microwave devices, tubes and semiconductor amplifiers. Variational time dynamics, as used by Beham, Muller and Llewellyn, is emphasized.

Nuclear Electronics: Conference Proceedings, Bombay, Nov. 1965, International Publications, Inc., 662 pp., $13.50

The second conference on nuclear electronics held by the International Atomic Energy Agency drew participants from 12 countries who discussed power and neutron-flux measurements, reactor control, safety devices and data processing to ensure optimum operation. Both papers and subsequent discussions have been edited.

Technical Abstracts

Converting telemetry receivers

Factors limiting uhf telemetry systems operation

H. Gong, R.T. Herman and P.L. Konop,
Mitre Corp.,
Bedford, Mass.

No one has ever claimed that operating in the ultrahigh frequency band is easier than operating in the very high frequency band. But a report sponsored by the Air Force shows that no technological factors prevent the design of equipment that will operate in the two new uhf bands, from 1,435 to 1,540 megahertz (L band) and from 2,200 to 2,300 Mhz (S band). The move to uhf from the 215 to 260 Mhz range (P band) now used must be done by January, 1970, to make room in the vhf band for tactical military operations.

The major problem may be transmitter frequency and stability. The changeover will increase the operating frequency by a factor of about 10 while only doubling the minimum bandwidth per channel (from 0.5 Mhz to 1.0 Mhz). To maintain equivalent drift tolerances, transmitters must be more stable than those now in use at vhf. Generally such stringent tolerances are not currently being met at uhf.

In going from vhf to uhf there are no drastic changes in propagation characteristics and only minor increases in atmospheric attenuation, but both doppler and doppler rate increase tenfold. This increase can reduce the sensitivity of tracking receivers as much as 5 decibels. The greatest doppler shift occurs when tracking orbiting vehicles, with the lower orbits causing higher shifts. The doppler rate for aircraft can be as much as or even greater than the doppler rate for orbiting vehicles. Thus, general-purpose receivers should be designed to respond to the maximum doppler rates that would be encountered in tracking orbiting vehicles.

Space attenuation (path loss) increases 16 db from P band to L band and 19 db from P band to S band. When the effective area of the receiving antenna is constant, the path loss will be exactly offset by the receiving antenna's gain. Antenna gain does not always directly compensate for the space loss, however, and both parameters should be considered separately.

Transmission through a plasma is slightly better at uhf, but there are still regions of reentry blackout. Multipath signals due to reflections from a plasma tend to reduce coverage, because of nulls in the resulting interference pattern. The increase in margin can nominally be set at —3 db.

Since uhf antennas are more easily designed with narrow beams, the minimum elevation angle at which ground multipath problems occur is reduced. However, within this angle, the problems are as severe as those at vhf. The multipath problem occurs when the antenna is tracking a satellite or aircraft at low elevation angles where it "sees" the ground through finite beamwidth and through sidelobes. With wide beam antennas, multipath effects are greater than at vhf.

In both uhf and vhf the environmental noise from the ground is greater than that from the sky, so that sidelobes and backlobes on receiving antennas should be suppressed as much as possible while retaining adequate gain.

Antenna efficiency suffers with frequency increase. To give a 60-foot antenna the same effective area at uhf as at vhf, all mechanical tolerances must be improved tenfold, electrical components such as the feed must operate efficiently and the conductivity of the dish surface must be improved.

Presented at the 1966 International Telemetering Conference, Los Angeles, Oct. 18-20

Diode with buried p-n junction

The epitaxy-over-oxide diode

W.H. Legat, L.K. Russel, A.F. Dixon, and W.C. Rosvold
Raytheon Co.,
Semiconductor Operations,
Mountain View, Calif.

An extremely efficient diode permitting voltages greater than 250 volts in the reverse bias condition, and with a leakage current of less than 10 nanoamps, can be manufactured at low cost using a new technique that allows many wafers of 1,000 diodes each to be processed at one time. The diode has a resistance of less than 3 ohms in a forward bias direction.

To produce the epitaxy-over-oxide diode, a thin, high-resistivity epitaxial layer is deposited on a low-resistivity substrate. An oxide is then grown over the epitaxy, and a small window is cut through the oxide. An epitaxial layer of low resistivity and of opposite conductivity from the first two layers follows. It insures that forward bias resistance is kept low.

When the second epitaxial layer is deposited, some of the impurities diffuse through the oxide window, forming a p-n junction in the first, high-resistivity epitaxial layer. Above the window, the second epitaxial layer grows as a single crystal, and over the oxide alone, the silicon forms into fine grain polycrystals.

After the second epitaxy is deposited, its outer portions are cut down to the oxide, forming a flat-topped mesa structure. Several layers of metal are put on the mesa, with the final metal layer having a rounded surface. The metal layers form a nonrectifying contact with the second epitaxial layer.

Burying the p-n junction in the material results in several advantages:

- Light and gaseous ambients cannot affect its performance.
- The oxide layer forms a barrier to current flow and forces current between the metal contact and the bottom of the diode to flow through the window and through the p-n junction, thus holding the amount of current leakage to a minimum.
- Stresses from automatic assembly techniques are absorbed by the thick rim of polycrystalline material, with little stress being imposed on the single crystal.

Although the experimental diodes were built for the lower frequency ranges, a switching diode could be built by diffusing gold during fabrication.

Presented at the International Electron Devices Meeting, Washington, Oct. 26-28

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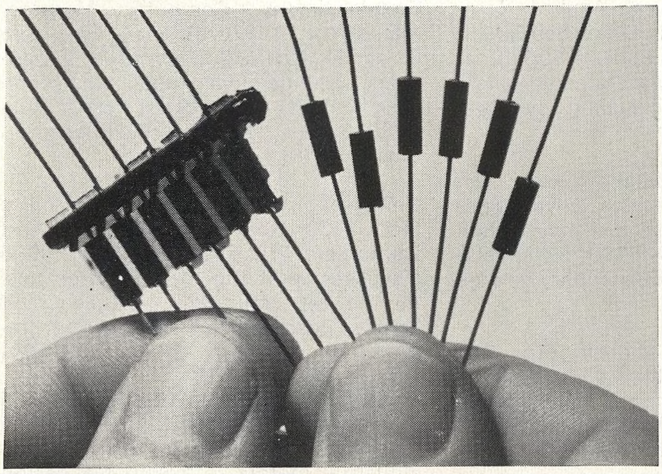

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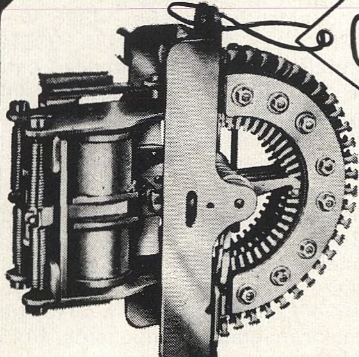

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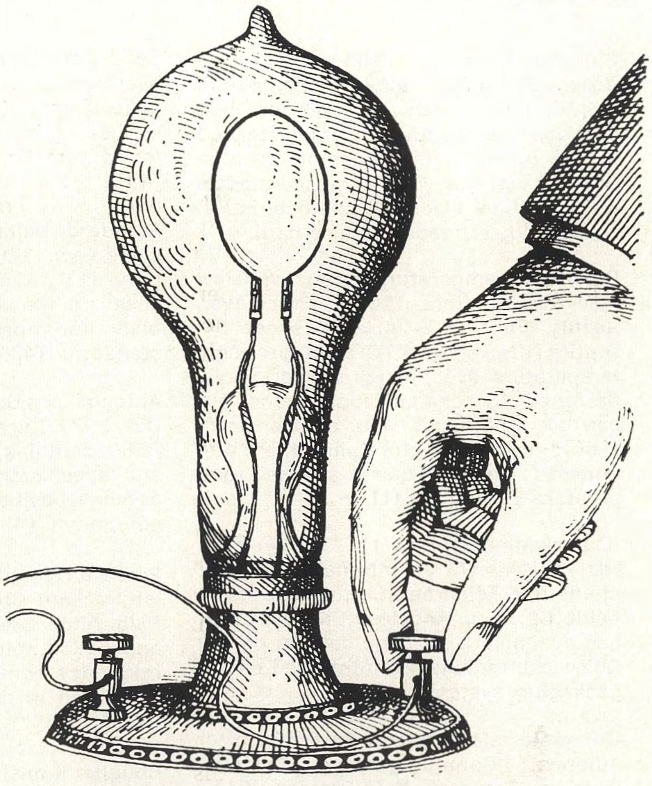

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New Literature

Digital readouts. Transistor Electronics Corp., Box 6191, Minneapolis, Minn., 55424. Data sheets No. 543 and 544 describe self-contained transistorized digital readouts that cost an average of 30% less than fully enclosed models with identical electrical characteristics. Circle **420** on reader service card.

Precision temperature oven. Winslow Tele-Tronics, Inc., 1005 First Ave., Asbury Park, N.J. A data sheet describes the model PTO-1045 precision temperature oven, which was originally designed for crystal applications but can also be used with diodes, transistors, semiconductors and other components which require precise temperature control. **[421]**

IC packaging system. ITT Cannon Electric, a division of International Telephone and Telegraph Corp., 3208 Humboldt St., Los Angeles, Calif., 90031, has available a six-page catalog on the Chico pac module, an integrated circuit packaging system. **[422]**

Uhf radio relay system. Radio Corp. of America, Communications Systems division, Camden, N.J. Catalog B-117 describes the AN/ARC-97 radio repeater set, which is said to be the only presently available self-contained, two-way, automatic uhf radio relay system. **[423]**

Traveling-wave tube. Microwave Associates, Burlington, Mass., has available a technical bulletin describing a traveling-wave tube that covers a full octave from 450 to 900 Mhz. **[424]**

Space communication. Radio Engineering Laboratories, 29-01 Borden Ave., Long Island City, N.Y., 11101, offers a brochure describing f-m subsystems in space communication. **[425]**

Detector mounts. American Electronic Laboratories, Inc., P.O. Box 552, Lansdale, Pa., has published a series of five technical bulletins covering a broad line of high-sensitivity detector mounts. **[426]**

Current driver. Computer Test Corp., 3 Computer Drive, Cherry Hill, N.J. Bulletin 65-F discusses the model 1720, a bipolar, 10-nanosecond current driver with dual outputs. **[427]**

Welded circuit modules. Radix, Inc., 1560 Orangethorpe Way, Anaheim, Calif., 92801. An eight-page brochure describes in detail the elements involved in the production of welded circuit modules. **[428]**

Memory system. Electronic Memories, 12621 Chadron Ave., Hawthorne, Calif., 90250, has issued a 10-page brochure on the Nanomemory 650, a system intended for real time or high-speed computers and check out systems. **[429]**

Solid-state controllers. Applied Engineering Corp., Foxhill Drive, South Walpole, Mass., 02071. Bulletin SC600 describes Hydralign solid-state controllers for automatic edge-guiding systems. **[430]**

Standard voltage source. Power Designs Inc., 1700 Shames Drive, Westbury, N.Y., announces a technical data sheet on the model X-336, a high-stability, low-impedance secondary voltage standard. **[431]**

Antenna positioner. Andrew Corp., P.O. Box 807, Chicago, Ill., 60642. Bulletin 8560 contains descriptive information and specifications for the type 30802 antenna positioner for microwave relay equipment. **[432]**

Precision frequency comparison. Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif., 94304. A nine-page application note describes how to make frequency comparisons with very high resolution in only a few minutes time. **[433]**

Chopper transformers. Airpax Electronics Inc., P.O. Box 8488, Fort Lauderdale, Fla., 33310. Bulletin TRS-5 describes the series TRS300 transformers that are designed for chopper applications but also serve many non-chopper uses. **[434]**

Data amplifier. Dana Laboratories, Inc., Campus Dr. at Von Karman Ave., Irvine, Calif., has published data sheet 615 on the model 2211A wideband data amplifier, a direct-coupled, differential amplifier designed for research instrumentation and data acquisition. **[435]**

Thermocouple controller/alarm. Control Data Corp., 4455 Miramar Road, La Jolla, Calif., 92037, has available a data sheet on the Magsense model 73 thermocouple controller/alarm. **[436]**

Linear scan unit. Magna Corp. 11808 South Bloomfield Ave., Santa Fe Springs, Calif., 90670. A two-page bulletin explains how the model 4510 linear scan unit may be used with potentiostats having dual potential control channels. **[437]**

Relay signature analyzer. Electro-Tec Corp., P.O. Box 667, Ormond Beach, Fla., 32074. A four-page brochure describes a signature analyzer that offers designers, manufacturers, and users of electromechanical relays simultaneous display of all poles of any relay dynamic switching characteristics. **[438]**

D-c servo motors. General Electric Co., 1635 Broadway, Fort Wayne, Ind., 46804. Bulletin GEA-8251 covers a line of Hyper-Servo motors for use in electronic data processing peripheral equipment. **[439]**

Counter-timers. Computer Measurements Co., 12970 Bradley Ave., San Fernando, Calif., 91342, offers a four-page brochure giving applications and specifications of models 604A and 605A, 2.5 megahertz all-silicon counter-timers. **[440]**

Universal circuit cards. Pico Electronics Inc., 1133 Northeast 7th Ave., Fort Lauderdale, Fla., 33304. Bulletin PC966 discusses what the manufacturer calls the newest concept in printed-circuit boards designed for engineering, research and prototype production. **[441]**

Motors. Globe Industries, Inc., 2275 Stanley Ave., Dayton, Ohio, 45404. A four-page brochure on commercial-industrial motors is a valuable design aid in choosing the proper motor for the application. **[442]**

Portable video monitor. Ampex Corp., Mail Stop 7-14, 401 Broadway, Redwood City, Calif., 94063. Features and specifications of the VM-9A portable video monitor are contained in bulletin V043. **[443]**

Synchronizing generators. Cohu Electronics, Inc., Box 623, San Diego, Calif., 92112. Diagrams, specifications and photographs illustrate a four-page technical data sheet on synchronizing generator systems. **[444]**

Drafting aids. By-Buk Co., 4326 West Pico Blvd., Los Angeles, Calif., 90019, has published a cross-referenced catalog, P-42, illustrating a complete line of printed-circuit drafting aids, featuring the Tape-Lift method for fast, accurate p-c drawing. **[445]**

Magnetic components. Transonic, Inc., 808 16th St., Bakersfield, Calif., 93301. "Magnetic Components for Commercial and Aerospace Applications" is a six-page folder covering the firm's facilities and major magnetic components. **[446]**

Low-noise preamps. Microwave Products Group, a division of Consolidated Airborne Systems, Inc., 115 Old Country Road, Carle Place, L.I., N.Y., 11514. Data sheet No. 102 describes a line of solid-state, low-noise preamps. **[447]**

Magnetic demodulators. General Magnetics, Inc., 135 Bloomfield Ave., Bloomfield, N.J., 07003. Bulletin MM108A contains technical data on solid state magnetic demodulators for converting phase reversing a-c signal voltages into phased detected polarity reversing d-c voltages. **[448]**

D-c motors. Printed Motors, Inc., Glen Cove, N.Y., has available a four-page brochure on a line of low cost, ferrite d-c printed motors for commercial and industrial applications. **[449]**

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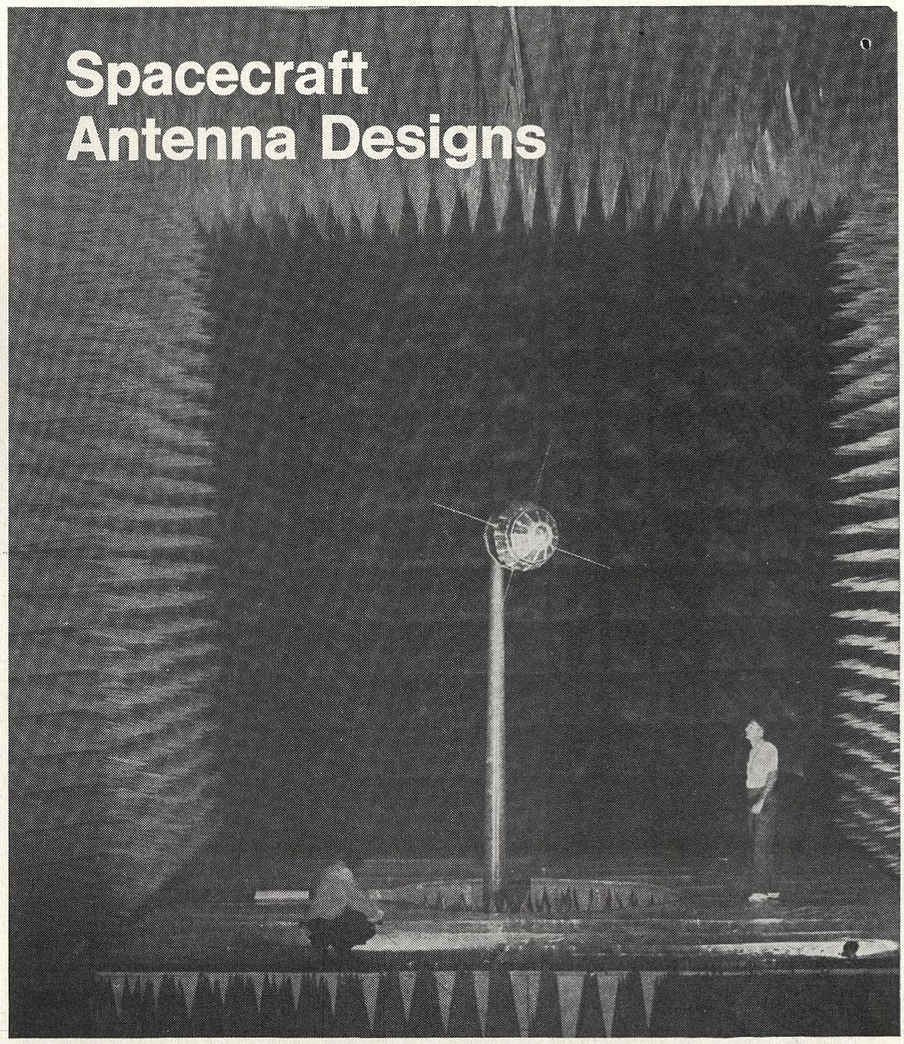

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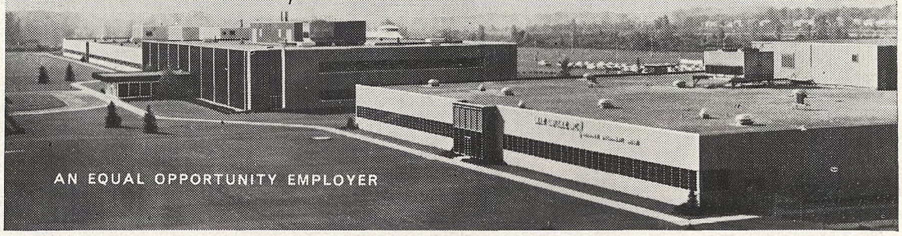

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Newsletter from Abroad

November 28, 1966

Swedish professors protest purchase of IBM computers

Professors at Lund University in southern Sweden are getting national attention in the press with their protests over the computer-buying policy of the government purchasing agency Statskontoret. The professors contend the International Business Machines Corp. gets far too much of the government's computer business and they're questioning the propriety of having a former IBM employee in a high-level post at Statskontoret.

The professors' plaint stems from a Statskontoret decision to buy an IBM 360-65 to replace a 10-year-old computer Lund scientists built themselves. University officials recommended a Control Data Corp. 3800 computer but the government buying agency overruled them. The professors maintain the CDC machine is much faster and would cost \$1,150,000 compared to \$1,300,000 for the IBM machine.

The professors who rated the CDC 3800 the best buy for Lund have openly charged Statskontoret with running a "purchasing dictatorship" favorable to IBM. One professor pointed out that 32 of the 41 computers ordered by Statskontoret for delivery through 1968 are IBM machines. The agency also recommended seven other IBM machines but these orders went to the Swedish aerospace firm SAAB after some political string pulling.

Japan firm on ban of wholly-foreign IC ventures

The Japanese government has taken an adamant stance on its ban of integrated circuit production by wholly-owned subsidiaries of foreign companies.

The policy was reaffirmed when the Ministry of International Trade and Industry (MITI), which controls foreign capital investments, turned down a bid by Texas Instruments Incorporated to set up an IC plant in Japan. Despite protests by the company and the United States government, MITI made it clear this month it was sticking by its stringent conditions for outsiders who want to produce IC's. MITI's terms: at least 51% Japanese participation in IC ventures; limited production for three years; and an agreement to license IC technology to Japanese producers at reasonable fees.

Along with its controls on plant investments, MITI also has set up machinery to restrict imports of IC's for computers. So far, though, MITI has approved all requests for IC import licenses [see p. 196].

British IC maker slashes prices

Still another indication that a shakeout among British integrated circuit producers might come as early as next year turned up this month as STC Semiconductors Ltd. whacked its IC prices by as much as 50% for some logic circuits.

The move may well touch off a wave of price cuts in the United Kingdom, where a half-dozen big British companies and the major American IC producers are hustling to stake out market shares. Although low prices should speed the coming of a mass market for IC's in Britain, they're bad news for companies that had hoped to ease into IC production. Only big producers can expect to survive the rough competition in sight. STC Semiconductors is an affiliate of the International Telephone and Telegraph Corp.

STC slashed its prices across the board for its line of MIC 930 diode-transistor-logic circuits, both for flatpacks and dual-inline packages in military and industrial versions. Typical of the new prices: $5.70 for a flatpack quadruple two-input gate in quantities from 100 to 1,000. Up to this month, the price tag on the circuit was $10.70 for quantities of 25 or more.

Computer maker sidesteps French 'Plan-Calcul'

President Charles de Gaulle's scheme to forge a strong French computer industry apparently won't work out as neatly as first thought. One of the major companies involved in the government's "Plan-Calcul" is jumping the gun to put an integrated-circuit process control computer on the market next fall. One of the main goals of Plan-Calcul is to develop an all-French third-generation medium computer for scientific and industrial use by late 1968 or early 1969 [Electronics, Oct. 17, p. 223].

The company that's sidestepping the government computer scheme is Societe Europeene pour le Traitement de l'Information (SETI), a subsidiary of the Compagnie des Compteurs. CDC owns half of the joint company set up under Plan-Calcul to build the peripheral hardware for the all-French computer. The central processor will be developed by a second joint company in which three major French computer makers—but not CDC—have a share.

SETI's third-generation process control computer will be only partially competitive with the larger Plan-Calcul computer. **However, SETI will have a head start of perhaps two years and thus pick up part of the market that the government had hoped would be the preserve of the joint companies formed under Plan-Calcul.**

Philips may slow European expansion

A downturn of radio and television set sales in Western Europe has forced Philips Gloeilampenfabrieken NV to recast its strategy for growth. **The Dutch company is shifting from an aggressive expansion policy to a cautious one, especially in Europe.** Philips also is thinking about weeding out of its worldwide empire some departments whose profits performance has turned lackluster in recent years.

The shift is intended to ease a squeeze on profits that began last year and has continued this year despite increases in sales of about 8% for both years. **Philips now expects its profits for this year on sales of $2.3 billion will run just under $100 million, down 10% from 1965.**

The company, though, has managed to cut down its worldwide work force this year from 252,000 to 246,000 and has worked down its inventory from 41% of sales to 39%. **Since sales of industrial and military equipment should continue to show strong gains next year, Philips may be able to check—but not eliminate—the erosion of profits next year.**

Electronic giants spark Paris Bourse

A bid by foreign electronics companies to take control of a major French producer of light bulbs and electron tubes has livened up the normally sluggish Paris Bourse. Late last month, word leaked out that the de Gaulle government would let control of Claude-Paz et Visseaux go to a foreign company. Since, Claude-Paz has zoomed from $38 a share to $68 and the Bourse as a whole has moved upward.

Throwing the takeover struggle onto the stock exchange marks a change in French policy. In the past, the Finance Ministry has kept negotiations secret when outsiders tried a takeover even of companies like Claude-Paz which isn't considered vital to national independence.

Electronics Abroad

Volume 39
Number 24

West Germany

Slow but sure

Time was when the development of integrated circuits was almost exclusively the preserve of American electronics companies; but now European firms have begun to stake out some strong IC claims of their own.

France's Compagnie Européenne d'Automatisme et d'Electronique, for instance, has developed a family of IC's for computer applications—called current mode complementary transistor logic [Electronics, Oct. 31, p. 151]. And West Germany's Telefunken AG has come up with a bag full of IC novelties, including a monolithic-zener-diode-transistor logic circuit (DTLZ) that many experts rate as an important European first in IC technology.

Telefunken also has developed an emitter-coupled-logic circuit (ECL) that switches in less than 0.5 nanosecond and has a propagation delay time of 400 picoseconds—among the best times known. And the German company has a new germanium planar transistor—intended for television tuners—that can be fabricated by IC techniques.

So far, however, only the DTLZ circuits are being marketed and output is still less than 100,000 circuits a month, although the company says production is climbing fast.

Immune. The main advantage of the DTLZ logic is its high immunity to noise. To be sure, the high noise threshold comes at a sacrifice of speed and it makes for relatively high power consumption. But Telefunken sees great promise for the logic in relatively slow data-processing applications like machine-tool controls, elevator controls, process controls and computer peripheral equipment where noise levels can run as high as 5 volts. Fortunately, power consumption of the logic circuitry is a minor design consideration in these applications.

Telefunken's circuits maintain a noise immunity between 5 volts and 6 volts over a temperature range from —20°C to 100°C. The pulse delay time is less than 1 microsecond, pulse rise time is a maximum of 200 nsec and fall time approximately 2 μsec. Power consumption is about 40 milliwatts per stage. Fan out is 10 and the output voltage swing nearly 12 volts, enough to drive directly a relay, a stepping switch, or the like.

Different. The basic circuit configuration of the DTLZ logic resembles quite closely that of a classic diode-transistor-logic (DTL) NAND circuit. There are, however, two significant differences. Instead of a pair of conventional diodes in the base circuit of the transistor, the DTLZ circuit uses a single zener diode; it is the key to the high noise immunity. The other main difference is in the gating diodes; to simplify fabrication of the circuit, they are located on the output side (collector) rather than on the input side of the circuit.

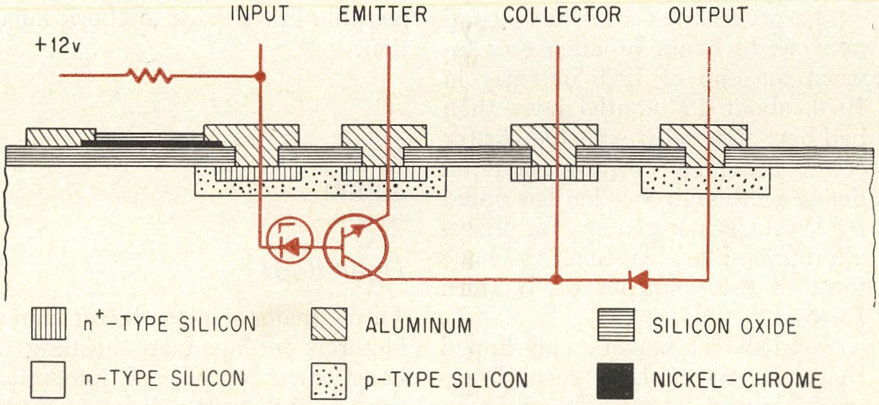
In a DTL NAND gate, the switching level—and thus the noise immunity—is roughly equal to the voltage drop across the two diodes in the base circuit—about 1.2 volts. In the DTLZ circuit, the zener diode—which is connected in the opposite direction of DTL base diodes—boosts the immunity to nearly 6 volts, some five times higher.

Telefunken now is producing a family of five types of DTLZ gate circuits and flip-flops. All are housed in TO-5 transistor cans with either eight or 12 leads. The company fabricates the circuits by conventional planar IC technology except it uses deposited nickel-chromium resistors instead of diffused resistors.

Fast checks

Like most European post office departments, West Germany's handles money as well as mail. Some four million vouchers—checks, money orders, deposit slips and the like—pour into each of the country's 13 post office banks every working day.

The post office already has made the first steps toward automating mail-sorting [Electronics, Aug. 23, 1965, p. 166]; now it is trying out automatic voucher-handling. The trial is under way at Ludwigshafen, where a system developed by Telefunken AG is handling 1,000 accounts. Girls get into the act for two key operations—coding and



Zener diode in base circuit of the transistor gives Telefunken's integrated-circuit logic high immunity to noise. Input of 6 volts or higher is needed to switch output from logic "one" condition of 12 volts to logic "zero" condition of about 0 volt.

signature checking—but apart from that, electronically controlled machines do the job.

The day's load of bank mail first passes to an envelope opener that can empty 10,000 envelopes an hour. Then the contents go to a coding station where girls type the account numbers and amounts of checks in magnetic-ink characters. A sorting machine reads the account numbers and arranges the vouchers by account number.

Then follows the signature verification. As each voucher passes through this station, the specimen signatures for the account—stored on a slide—are displayed on a screen for comparison with the one on the voucher. The verified vouchers then go through an electronic reader that transfers the data on them onto magnetic tape, the input for a bookkeeping computer. Daily statements are printed out on long rolls which feed directly into a packing machine which cuts and folds the statements and packs them into envelopes along with the associated vouchers, at rates up to 3,000 envelopes an hour.

Girl checks signature on voucher against specimen called up by punching account number into keyboard. Signature verification is one of only two manual operations in voucher-handling system under trial in West Germany. The other is encoding magnetic-ink characters that can be read electronically onto the vouchers.

Sweden

Fading color

Instead of a lift, the Swedish entertainment industry suffered a letdown when the government this month revealed its proposed timetable for starting up a second television network and color-tv programs.

The program calls for the second network to begin broadcasting toward the end of 1969 or early in 1970, about 18 months later than had been generally expected. As for color, the plan proposes nothing definite although Sweden has opted for West Germany's PAL (for phase-alternation-line) system as have most of the countries of Western Europe.

Swedish set makers had hoped that color tv—and the second network—would be introduced sometime in 1968. That timing would have been a tonic for 1967 set sales. It would have opened up the color-set market and also would have boosted black-and-white replacement sales since about 75% of the sets operating in Sweden will need an additional tuner to pick up the second network. Now, with the start-up for the new network delayed 18 months, the industry expects tv set sales next year will stay at this year's level—200,000 sets.

The government's proposal, made by a committee headed by Communications Minister Olof Palme, has to be approved by the Parliament and presumably will be. The chief reason for the postponement is financial. The government is cutting back on spending wherever possible in its drive to check inflation.

Japan

Open door

All the major semiconductor manufacturers in Japan are hustling to boost their output of integrated circuits and most will be ready to pour them out in quantity next year. Even so, a market of sorts seems to be opening up for outsiders, notably United States companies.

During the six-month period that ended with September, IC imports boomed. The Ministry of International Trade and Industry (MITI), which rides herd on the country's foreign trade, says imports for the period totaled 345,000 circuits worth $1,555,000. Most went to computer makers for their third-generation models.

MITI has been keeping a close eye on IC imports, and last spring it quietly set up the administrative machinery to restrict imports of all digital IC's and linear circuits having more than 35 elements on a single chip. Although MITI requires import licenses for these two categories, it has thus far approved all requests.

How long MITI plans to keep the door wide open is anybody's guess. The import controls were set up to shelter Japanese computer makers, most of whom plan to produce their own IC's. Japanese officials maintain the protection is justified because the country's semiconductor producers, unlike most of their U.S. counterparts, haven't had the support of military contracts to get them into IC production.

MITI set up the IC import controls largely because it wanted to make sure Japanese companies wouldn't be discouraged by a flood of low-price U.S. circuits coming into the market. Right now, demand for IC's is running well ahead of Japanese production capacity so there's no talk of invoking a ban. And even as Japanese IC capacity catches up, MITI most likely will leave the door at least partly open; the outright restriction of computer-circuit imports would tend to make the country's computer industry noncompetitive in world markets.

Mexico

Double play

Mexico may well become the Hong Kong of North America if the twin-plant concept takes hold in the electronics industry.

The two plants—one in Mexico and the other in the United States—operate under a single management. The Mexican facility handles labor intensive operations and the U.S. plant carries out the technological operations plus finishing touches.

This tactic is possible because Mexico allows companies duty-free import of raw materials and plant equipment if they export the product manufactured in Mexico back to the U.S. American customs levy a duty only on the added value—an amount that is very low.

There are signs that the idea is already catching on. The semiconductor division of the Fairchild Camera & Instrument Corp., for example, set up a plant in Tijuana last July to turn out transistors. The Transitron Electronic Corp. built a transistor plant in Nuevo Laredo that is scheduled to start production before the year is out. Transitron already has a plant just across the border at Laredo, Texas. Several other large electronics companies in the U.S., aware of the possibilities, are also considering plants in the border areas of Mexico.

Big border. Although the U.S.-Mexican border stretches for 2,000 miles, the two-plant scheme works best when the Mexican labor is close to manufacturing areas in the U.S. This is especially true for the electronics industry in Southern California which can draw on a cheap labor force of 120,000 from the Mexican towns of Tijuana, Tecate and Ensenada. The concept has worked well for the past two years in El Paso, Texas, where manufacturers of plywood doors, wrought-iron garden furniture and garments erected plants across the border in Juarez.

Unskilled labor in Tijuana costs 60 to 75 cents an hour including all fringe benefits. By comparison, wages in Los Angeles, 125 miles to the north, are about $2.25 to $2.40 an hour including all fringe benefits, or $65 a week higher.

The 1965 manufacturing payroll in Southern California was estimated at about $7 billion. The potential for production of semimanufactured goods in the Tijuana area is placed conservatively at $100 million to $200 million a year. If the entire U.S. frontier is included, the figure becomes two or three times greater.

Opportunity. The twin-plant idea gives Mexico a good chance to increase exports of manufactured goods—both finished and semimanufactured—into the U.S. market. Over $1 billion worth of labor-intensive finished goods, mainly from Japan and Europe, were imported by the U.S. in 1965. Electronics goods accounted for $296 million of this total—the single largest item. Some marketing experts think the twin-plant scheme will help Mexico boost its share of the U.S. import market for labor-intensive products from next-to-nothing to as much as $100 million.

The Netherlands

Cut to size

Electronics companies have to think big today to keep abreast of rapid changes in technology and the trend toward larger markets. But Philips Gloeilampenfabrieken NV, the Dutch electronics giant, is purposely thinking small in a pilot project designed to help developing countries establish their own electronics industries.

The project, under way in Utrecht, the Netherlands, simulates the economic conditions that face plants in less-developed areas of Asia, Africa and Latin America. The Utrecht plant evolved in much the same way a facility in Africa might, starting with the simple assembly of radio and television sets and passing by stages to the manufacture of some complex components.

Do it yourself. The idea was conceived and put in motion by 44-year-old John van den Brink, an 18-year veteran of the company. As a starter, Philips hired about 50 unskilled or semiskilled workers from the Utrecht district and trained them to assemble radio and tv sets.

Van den Brink recalls: "In 1961 we moved into the ground floor of a simple three-story apartment building in one of Utrecht's residential quarters, 50 miles from the main works at Eindhoven. We did not put any signboard or nameplate on the building. We knew that there would be no expansion possibilities beyond the original 1,000 square meters. We just aimed at imitating conditions of a plant in a developing country, and so we restricted our contacts with Eindhoven to communications by letter, not by phone, and an occasional visit. We wanted to remain isolated and small." So far investments in the pilot operation have remained below $280,000.

Easy does it. The theme of the Utrecht project is simplicity. Philips revised large-scale mass production methods and adapted them for countries lacking a manufacturing tradition. Tools, equipment, administration, documentation, stores, inventory control and assembly lines were all scaled down.

Notes Van den Brink: "We are constantly on the lookout for simpler production methods, and as far as possible, we make our own tools and repair them." For example, Philips uses a household iron, obtainable in every developing country, as a hot plate in certain coil and other assembly processes.

Philips further perfected the pilot method by capitalizing on its errors. In 1962 the plant in Utrecht started with a series of simple radio sets, turning out 6,000 that year. Production was cut to 1,500 in 1963 and to 500 in 1964. But this proved too small an output to keep the plant functioning smoothly, so production was expanded to the current 4,000 sets a year. Over the years, improvements in assembly methods have cut the number of man-hours needed to turn out a radio set from 3½ to 1½. Philips expects to get the figure down to about 1 man-hour per set next year.

Tv set production was started in 1963 and today the plant turns out between 2,000 and 4,000 sets yearly.

Step-by-step. The entire program embraces three stages. In the first, workers training at Utrecht simply assemble a radio or tv set using "imported" components. In the second stage, they manufacture some components; for example, a variable condenser is made with plates manufactured elsewhere. A coil or a loudspeaker may be fashioned in the same manner. Finally, in stage three, the workers manufacture some components from raw materials.

Philips now is looking at the possibility of using the Utrecht approach for telecommunications equipment and data processing equipment. Substantial markets for both seem certain as the developing countries shift from agricultural to industrial economies.

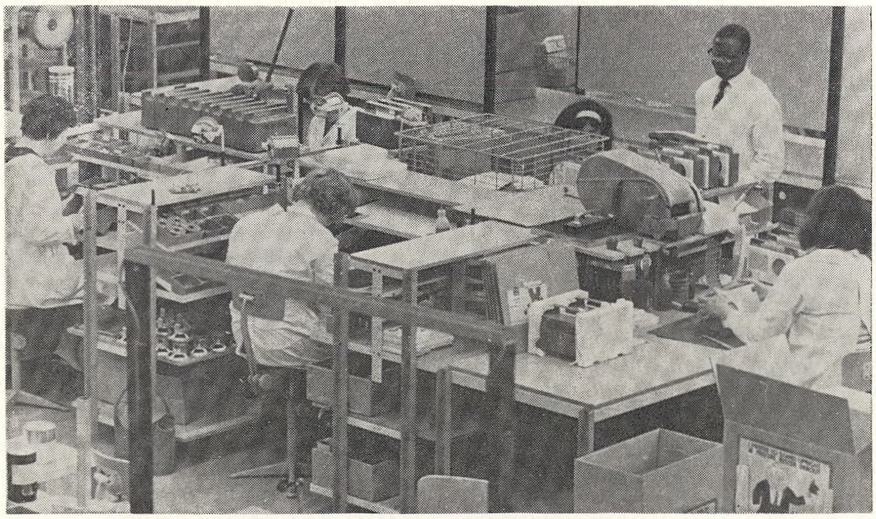
Philips is now offering the experience gained at Utrecht to developing countries. Trainees from small nations spend three months to six months working at Utrecht and then take the technical know-how back home with them. The United Nations has expressed interest in the plant and some personnel are being trained on the spot overseas.

Utrecht "packages" are sold not only to Philip's small plants abroad but also to purely national factories. The packages include complete radio or tv assembly lines plus certain components—all packed in one large wooden crate. They also contain instructions in English along with illustrations. Philips will not say how much the package costs.

So far, reports Van den Brink, the packages have been sold in over 25 different countries, including Indonesia, India, Pakistan, Ceylon, Nigeria, Congo, Ghana, Ethiopia, Costa Rica, Peru, Uruguay, Greece and Turkey.

Returns. The Philips plan to give emerging nations an industrial push appears to be a sound financial move. The company is putting $140 million a year or about 5% of its worldwide capital investment in the developing countries. The Dutch corporation hopes for a healthy return over the years to come.

Industry projections add weight to Philips' expectations. By 1980 the developing countries will just about double their demands for consumer goods. Philips, with a small home market, needs all the overseas outlets it can get to keep growing.



On their own. The better to simulate conditions in developing countries, Philips deliberately isolated its small-plant pilot project at Utrecht from its big plants at Eindhoven.

Great Britain

Fast number

Prospects are bright for the integrated circuit market in Britain over the next few years. From an estimated $2.8 million this year, the IC market is expected to more than double in 1967 to $7.4 million. And that's just the beginning. By 1970, the market should zoom to as high as $35 million or $40 million a year.

Trouble is, the market is too attractive. A half-dozen big British companies want in on the action and so do the American producers of IC's. A shakeout, perhaps as early as late next year, seems inevitable and the scramble is on to stake out market shares now.

Mullard Ltd. is counting on speed to win enough customers to survive the rough competition. This month, the company announced it would have in full-scale production early next year perhaps the fastest logic circuit on the market, an emitter-coupled-logic IC with propagation delay of 2 nanoseconds for use in central processors of high-speed computers.

Mullard's basic circuit is a four-input dual NAND/NOR gate that consumes 60 milliwatts per stage. It is designed to operate with logic-routing transmission lines of 75-ohm impedance. Mullard claims the circuit performance is affected only "minimally" by temperature variations and says one application for it could be airborne computers.

By the end of 1967, Mullard expects to be producing the circuits at a rate of several hundred thousand annually at its Southampton plant. The full line will include at least six types of gate circuits, two types of flip-flop circuits and an interface circuit to link the fast central-processor logic to other units of the computer.

To speed its fast ECL logic into commercial production, Mullard turned to the Westinghouse Electric Corp. for IC production technology. Mullard also is backstopped in technology by its parent company, Philips Gloeilampenfabrieken NV of the Netherlands.

Philips, in fact may one day be a major outlet for the Mullard circuits. The Dutch company plans to have a line of general-purpose computers on the market by 1968 or 1969. By then, though, Mullard apparently will have even faster circuits in production. Mullard like many other IC producers, has in development logic circuits with propagation delays less than 1 nanosecond.

Well grounded

Three of Britain's major electronics companies have joined forces in the hope of picking up a big piece of the fast-developing world market for communications satellite ground stations.

Over the next seven or eight years, as many as 80 ground stations very likely will be built around the world, a potential market of some $300 million. Already, 13 ground stations are operating or under construction around the globe; another 25 are in the advanced planning stage.

To tap that market, The Plessey Co., Associated Electrical Industries Ltd. and the General Electric Co. (a British company not affiliated with its American namesake) have formed World Satellite Terminals Ltd. (WST). The new company plans to offer stations on turnkey contracts for about $2.8 million a copy with delivery in 18 months.

WST already has bids in for two stations. One is for Hong Kong, where the British communications company Cables and Wireless Ltd. plans a station. The other is for Goonhilly Downs, where the British post office will build a second satellite communications facility. Edward Fennessy, WST's chairman, also expects that the new firm can pick up business in traditional British export markets like Africa, the Middle East, and South America.

Big dish. The ground station package WST offers uses an 85-foot fully steerable dish antenna. Although it is designed primarily to work with upcoming International Telecommunications Satellite Consortium's synchronous global satellite systems, the station also can handle medium-altitude satellites with 6-hour orbits. It is built for around-the-clock operations and has a backup system that switches in automatically within 150 milliseconds after a component failure.

Although WST will handle sales, supervise construction and generally manage the ground-station business for its three parent companies, it will not produce hardware for the stations. The antenna dishes, steering gear and servo controls will come from Associated Electrical Industries. British General Electric will handle the transmitters, receivers, amplifiers and communications monitoring equipment. Plessey's contribution involves the waveguide complex, auto-tracking equipment and the control display.

Tunisia

Tourist lure

As part of a campaign to bolster its economy through tourism, Tunisia is turning to television.

More than the bustling souks of Tunis, what lures tourists to Tunisia are unspoiled Mediterranean beaches and low prices. Some 160,000 Europeans flocked into the country this year, compared to a mere 7,000 only three years ago. The tourist industry, almost nonexistent five years ago, brought in an estimated $23 million of foreign exchange this year, a substantial chunk of Tunisia's nonagricultural income.

Many of the holiday-makers who sprawl on the hot sand all day are lower-income Italians. After the sun goes down, they want more action. Despite Moslem reservations on drinking and dancing, Tunisian tourist authorities insist that entertainment—notably television—is a must for resort hotels and bars.

For that reason, the government-owned Radiodiffusion-Television Tunisienne plans to link its tv system with Italy's next year. The tie-in will come through a 120-mile microwave connection between Ain-Draham, on high ground 90 miles west of Tunis, and Sicily. The Italian company Società Generale di Telefonia ed Elettronica S.p.A. has the contract to build the link. SGTE is a subsidiary of the General Telephone & Electronics Corp.

The growing Tunisian tourist industry also should promote some new business for producers of air-traffic-control equipment. Plane traffic at the country's major airport, near Tunis, has doubled over the last five years, and the growth in sight points to the need for additional equipment. Along with the electronics fallout from tourism, a market for communications equipment, industrial controls and teaching machines should develop as Tunisia tries to escape from the straitjacket of a largely agricultural economy.

Despite a lingering bias for French technology (France ruled the North African country for 75 years) the upcoming markets most likely will be open to all comers. Sweden's Allmanna Svenska Elektriska AB (ASEA), for example, picked up the order for the control equipment for Tunisia's first integrated steel plant.

Around the world

Great Britain. The three major associations of British real estate agents may band together to set up a nationwide property register on a computer that local agents could query through an on-line system. The British affiliate of The National Cash Register Co. is consultant to the associations for the $1.4 million scheme.

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November 28, 1966

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