Electronics®

Protecting capacitors against ripple: page 64
Optical computers come of age: page 72
Lifting the frequency ceiling for scrs: page 88

September 6, 1965
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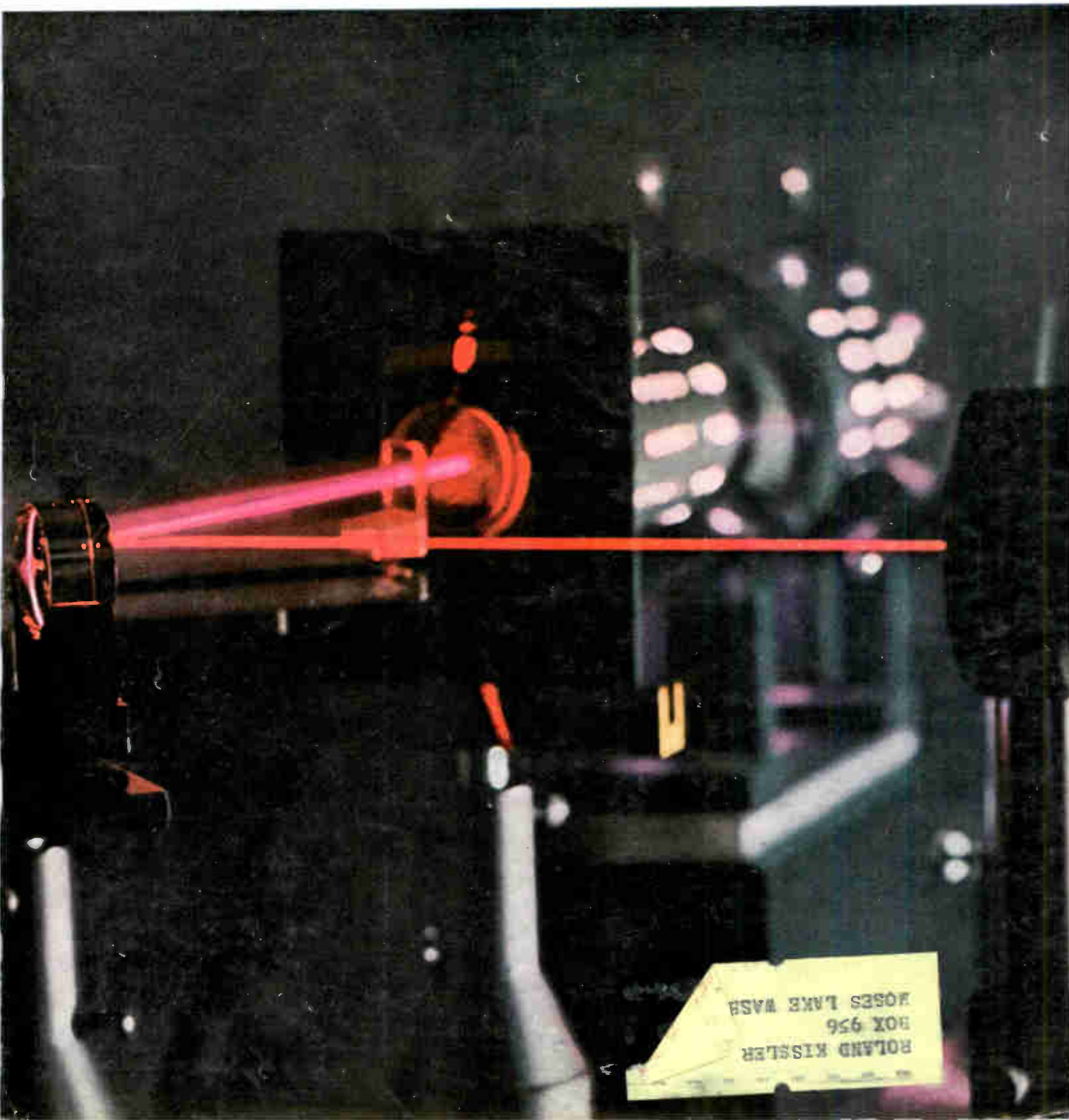
Below: Laser power supply runs optical computer: page 72



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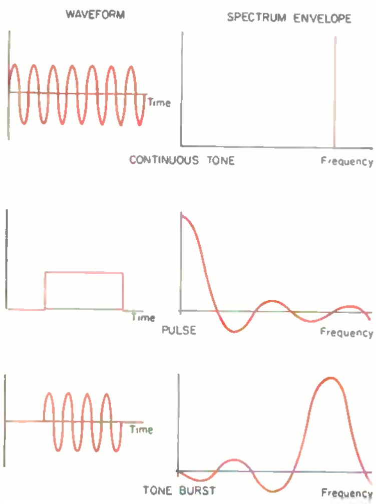
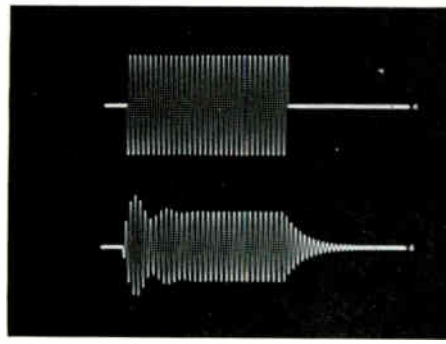
The interrupted periodic wave produced by the GR Tone-Burst Generator is a most useful signal. Its measured, repeated ac transients can do what continuous waves and pulses cannot do.

The tone-burst signal is made up of a series of equally spaced energy bursts of equal duration, created by alternate passing and blocking of an external periodic signal — sine wave or otherwise. Each burst contains a precisely selected number of cycles of the periodic wave. Moreover, since the signal within one burst is coherent (phase-stable) with that in another burst, energy distribution within the frequency spectrum is precisely defined; thus, the tone-burst signal becomes an extremely useful test signal.



The frequency spectrum of a coherent tone-burst signal clearly shows how useful a signal it is, particularly for bandpass measurements. Unlike the single-line spectrum of the plain sine wave and the spectrum of the repetitive pulse (whose energy is tied to the origin and cannot be concentrated where you want it), the symmetrical spectrum of the coherent tone-burst signal can be shaped and placed where it is needed. The tone burst's center frequency is simply that of the periodic wave from which the tone-burst signal is derived; consequently, the center frequency can be shifted easily. The tone burst's bandwidth can also be varied over an extremely wide range by adjustment of the number of cycles in the burst and the number of cycles between bursts. Thus, the test signal can be "tailored" and located in the frequency spectrum to fit your measurement needs exactly.

In a test, 31-cycle bursts of a 10-kc sine wave were used to measure the transient response of a circuit resonant above 10 kc/s. The upper trace of the oscillogram is that of the tone-burst signal; the lower trace shows the signal after it has passed through the circuit. Rise and fall times are easily measured on this trace, and overshoot and ringing are clearly visible.



The tone-burst generator is useful in many other applications including telemetry-signal simulation, sonar testing, and amplifier recovery-time measurements. For more information about this versatile instrument, write for the preprint "A Generator of AC Transients." Instrument Note IN-105, a detailed analysis of the Fourier frequency spectrum of tone-burst signals, is also available on request.

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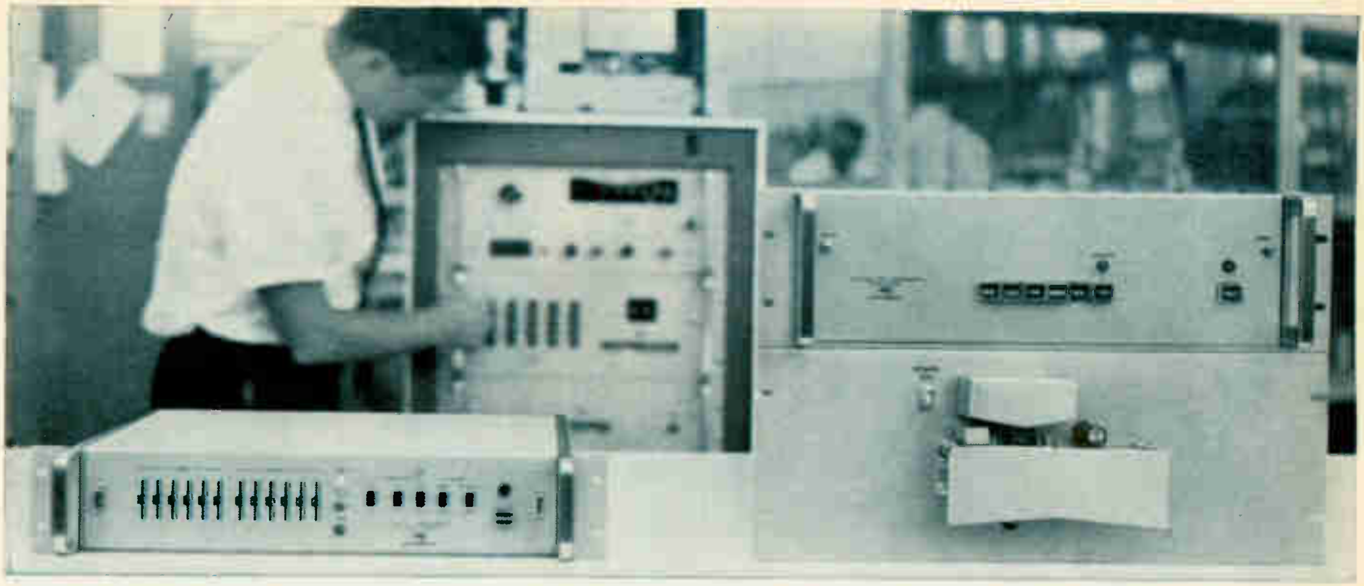

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Measurement speed (max., dc volts meas.)	5 channels per sec.	10 channels per sec.	1 channel per sec.	10 channels per sec.	5 channels per sec.	9 channels per sec.	1 channel per sec.	18 channels per sec.
Output	printed paper tape	perforated paper tape	punched card (IBM 526)	digital magnetic tape	printed paper tape	perforated paper tape	punched card (IBM 526)	digital magnetic tape
Price	$8310	$10,225	$9425	$15,825	$10,585	$12,500	$11,700	$18,100
Standard options	Time of day, ac voltage & resistance measurements, 10 mv full scale sensitivity, automatic limit comparison, cabinet.							

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197

Electronics

September 6, 1965
Volume 38, Number 18

Electronics Review

Probing the News

Electronics Abroad

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II. Application

III. Manufacturing

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Electronics: September 6, 1965, Vol. 38, No. 18

Printed at 99 North Broadway, Albany, N.Y.
Second class postage paid at Albany, N.Y.

Subscriptions are solicited only from those actively engaged in the field of the publication. Position and company connection must be indicated on orders. Subscription prices: United States and Possessions and Canada, $6.00 one year, $9.00 two years, $12.00 three years. All other countries $20.00 one year. Single copies, United States and Possessions and Canada 75¢. Single copies all other countries $1.50.

Published every other Monday by McGraw-Hill Inc. 330 West 42nd Street, New York, N.Y.10036. Founder: James H. McGraw, 1860-1948.

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Readers Comment

Hospital grants

To the Editor:

In the article "Government Spurs Medical Market" [Aug. 9, p. 107] you have made this statement: "The hospitals also have money to spend, much of it federal; the government pays up to two-thirds the cost of equipment in nonprofit hospitals."

My pathologist and I are very interested in what government funds you were referring to, because we are interested in securing additional electronic equipment but are in need of additional revenue.

W. R. Mitchell
Administrator
Passavant Memorial Area Hospital
Jacksonville, Ill.

■ Nonprofit hospitals can receive assistance in purchasing equipment through the National Institutes of Health's grants-in-aid program. Applications made to NIH are reviewed for need and intended use; if they are accepted, the hospital can receive up to two-thirds of the cost of the equipment.

Survival of the fittest

To the Editor:

May I suggest that for the answer to the problem raised in your editorial "Changing an image" [Aug. 9] you need look no further than your own editorial of July 12.

The engineering schools are working to change the education of an engineer so that he can compete in the technical areas for which the physical scientists are challenging. However, if in the process the engineering profession is wiped out, as you intimate in your July 12th editorial, it will not be the engineering school's fault—it may be the result of the engineering profession's failure to respond to the stimuli that are all around us.

We must realize that all education is in a process of continuing evolution and I intend to imply thereby all the aspects of the Darwinian form. There is competition between species of education, wit-

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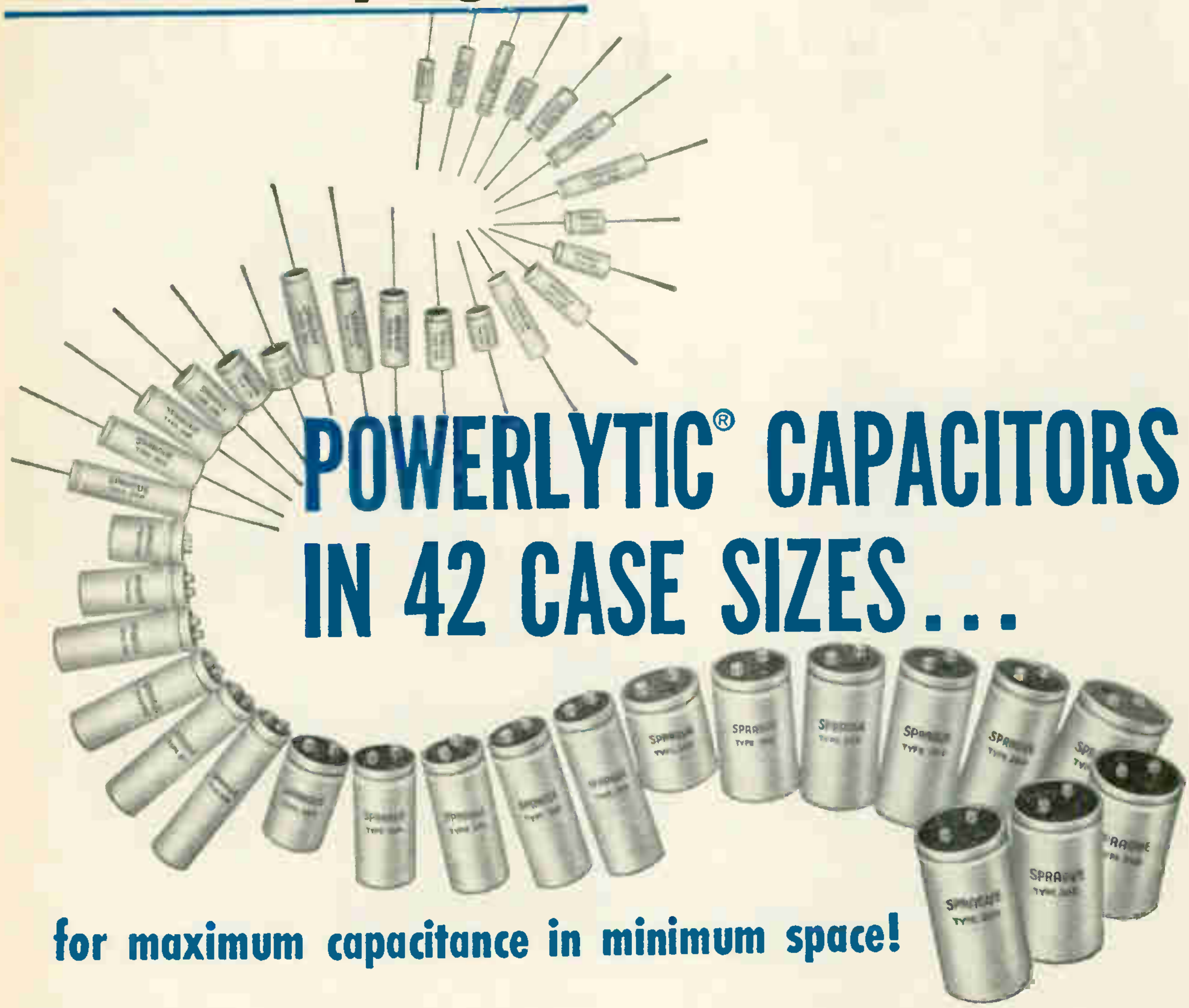

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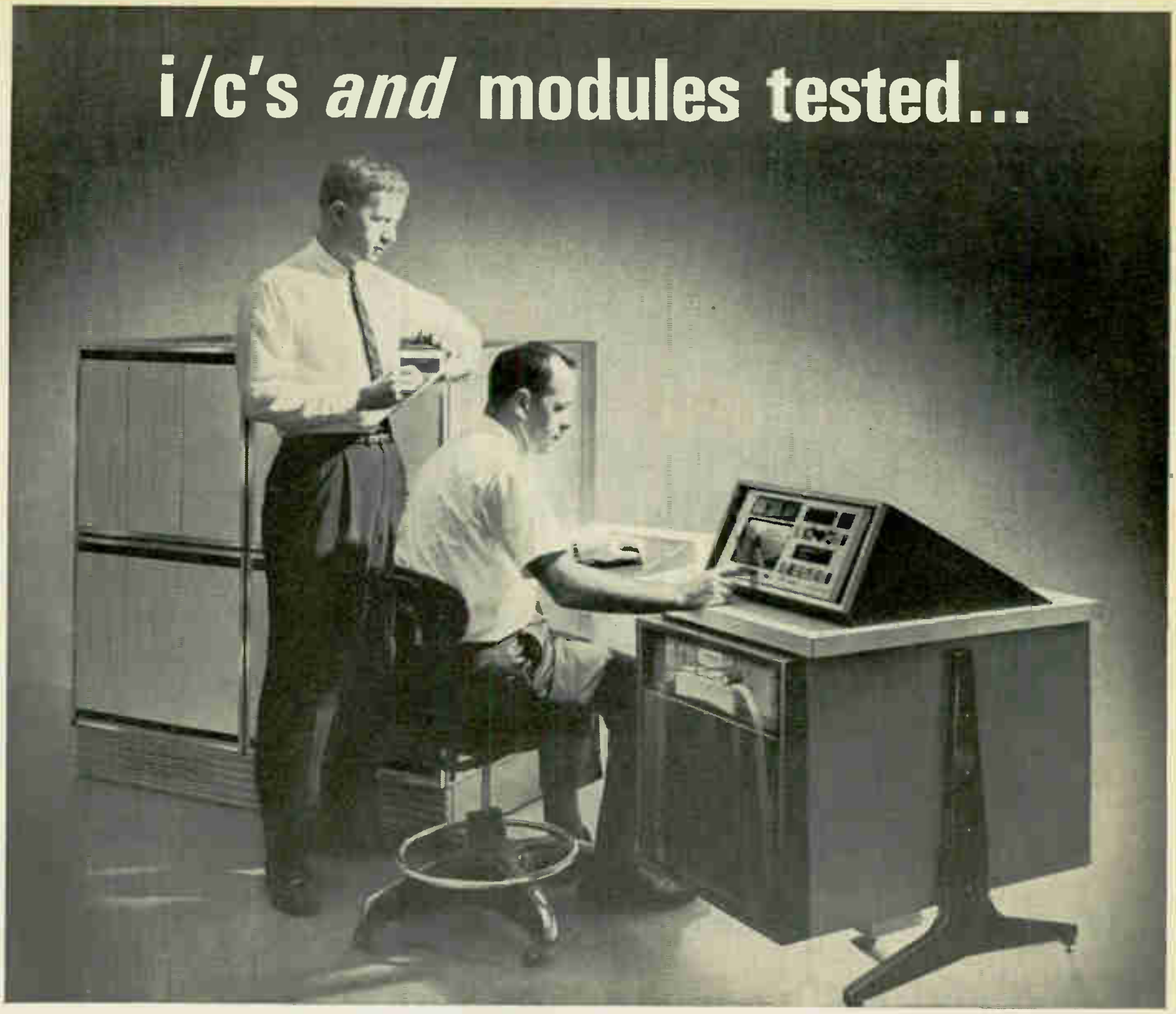

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ness your statements on Aug. 9, there will be survival of the fittest, and your editorial intimates that perhaps past engineering work has not been sufficient to justify survival. There will emerge new forms of education better suited to the conditions in the world around us. It is experiments toward these new forms which you criticize in your editorial of July 12.

Just where do you stand? Nuts and bolts, or theory for the future?

J. D. Ryder
Dean
Michigan State University
East Lansing, Mich.

▪ Probably in the middle of the road. We believe an engineer needs a grounding in fundamentals of the physical sciences as well as courses applying these physical sciences to solve engineering problems. We don't believe that turning engineers into physicists and mathematicians is the answer.

Clouds in the IC sky?

To the Editor:

After reading the integrated circuits section of your article "The changing face of the West" [August 9, p. 60], one comes away with the feeling that the business picture for the IC industry is all sunshine. This is certainly the impression conveyed by the comments of the industry spokesmen interviewed but it does not seem to be a completely objective appraisal. I believe the following observations may tend to balance the scales:

1. To state that it is now profitable for IC makers to produce IC components may be extremely misleading if not actually erroneous. The most successful IC companies are those which have the high sales volume. What about the many marginal firms that have not yet reached the big leagues? What can be said about the entire industry? And how do we define "profit?" Does it include the costs required to establish a capability before the firm has a product to sell? The ground rules must be defined.

2. Although the digital IC capability is great, the digital market is basically oriented to the industrial sector and, to a lesser extent, to military and aerospace uses. How about the linear market which is the overwhelming bulk of consumer applications and a high percentage of the potential military/aerospace and industrial functions? IC performance in this area is still limited and unit prices are very high relative to those of digital lines.

3. Is the industry running the transistor collision course all over again? The symptoms look the same; the time scale may be shortened. If all the IC manufacturers tool up for this all-consuming mass market, can they all turn a profit? Will those already firmly entrenched force out the marginal producers and leave an industry made up of a few giants? Will prices continue to decline? If so, it dampens the benefits of increased sales.

For the industry to thrive in the future, sales volume must increase tremendously, the fall of unit prices must slacken (while new markets are being enticed), and the IC linear component must attain a performance and price level generally comparable to its digital counterpart.

Herbert S. Kleiman
Arlington, Va.

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People

"We're in the middle of a revolution in the automatic control field—the shift from the use of analog to digital computers," says **Theodore J. Williams,** the new director of Purdue University's Automatic Controls Laboratory. "There's no doubt about it, digital machines can do the job (of automatic control) better and cheaper," he adds.

But there is an obstacle, Williams concedes, and it's psychological: plant managers are reluctant to relinquish control of their operations to a machine.

For the past five years, much of Williams's job has been convincing people to take the plunge: to use digital computers to operate a plant. He has been proselytizing at the Monsanto Co. with apparent success. For the Monsanto chemical plant at Luling, La., Williams and his associates, in 1960, set up their first computer control system. Two years later, at another plant, the first direct control of a chemical plant by a digital computer was achieved.

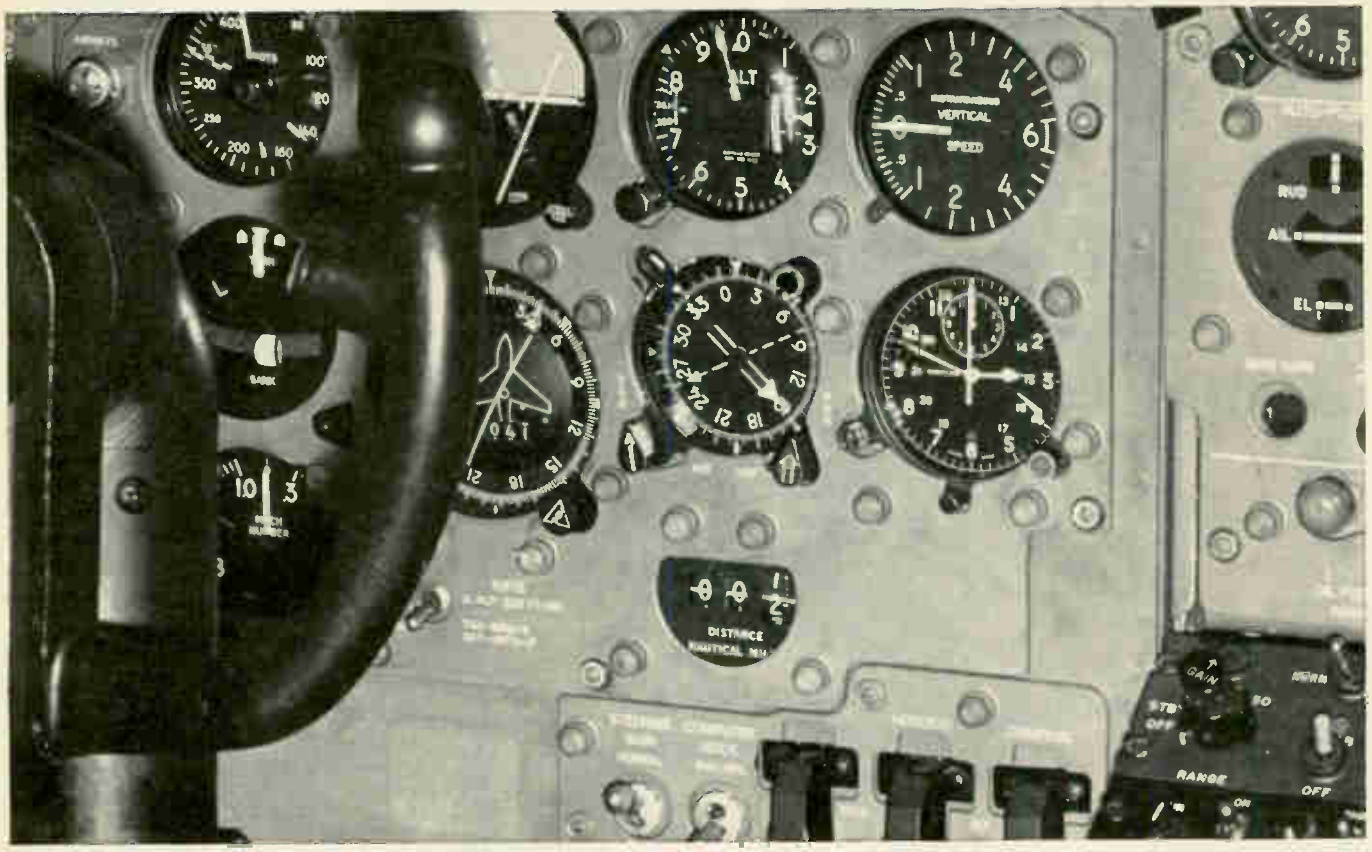
The automatic Controls Lab at Purdue has been organized in an unusual way. It's an interdisciplinary project, with the university's schools of electrical, mechanical and chemical engineering all involved.

"Purdue has one of the leading labs in the theory of automatic control," Williams explains. "We must now combine development of theory with more intensive application to industry."

Williams' background includes several specialties. He received his bachelor's degree in chemical engineering, a master's degree in chemical engineering, another master's in electrical engineering and finally a doctorate in chemical engineering.

Williams who has the title of professor of engineering at Purdue, is succeeding John E. Gibson as director of the automation lab. Gib-

On the Flight Deck Highest DME Reliability Means Machlett UHF Planar Triodes



Consistently long, reliable operation at high output power has gained Machlett UHF planar triodes preferred acceptance among all the nation's major airlines. In new DME and transponder equipment or for replacement use, they are the choice. The demonstrated superiority of these tubes is further evidence of the capabilities available to you at Machlett. Whether you require high power/high voltage triodes or tetrodes, UHF planar triodes, X-ray tubes or vidicons, or if you wish research and design development assistance, write: The Machlett Laboratories, Inc., Springdale, Conn. 06879. An affiliate of Raytheon Company.

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ELECTRON TUBE SPECIALIST

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son has been named dean of engineering at the newly formed Oakland University in Michigan.

Stephen E. Harris, a 28-year-old assistant professor of electrical engineering at Stanford University, has won the 1965 Alfred Nobel Prize for a "technical paper of exceptional merit by an author under 31 years of age." This is the second year in a row that the prize has gone to an electronics scientist for research on lasers.

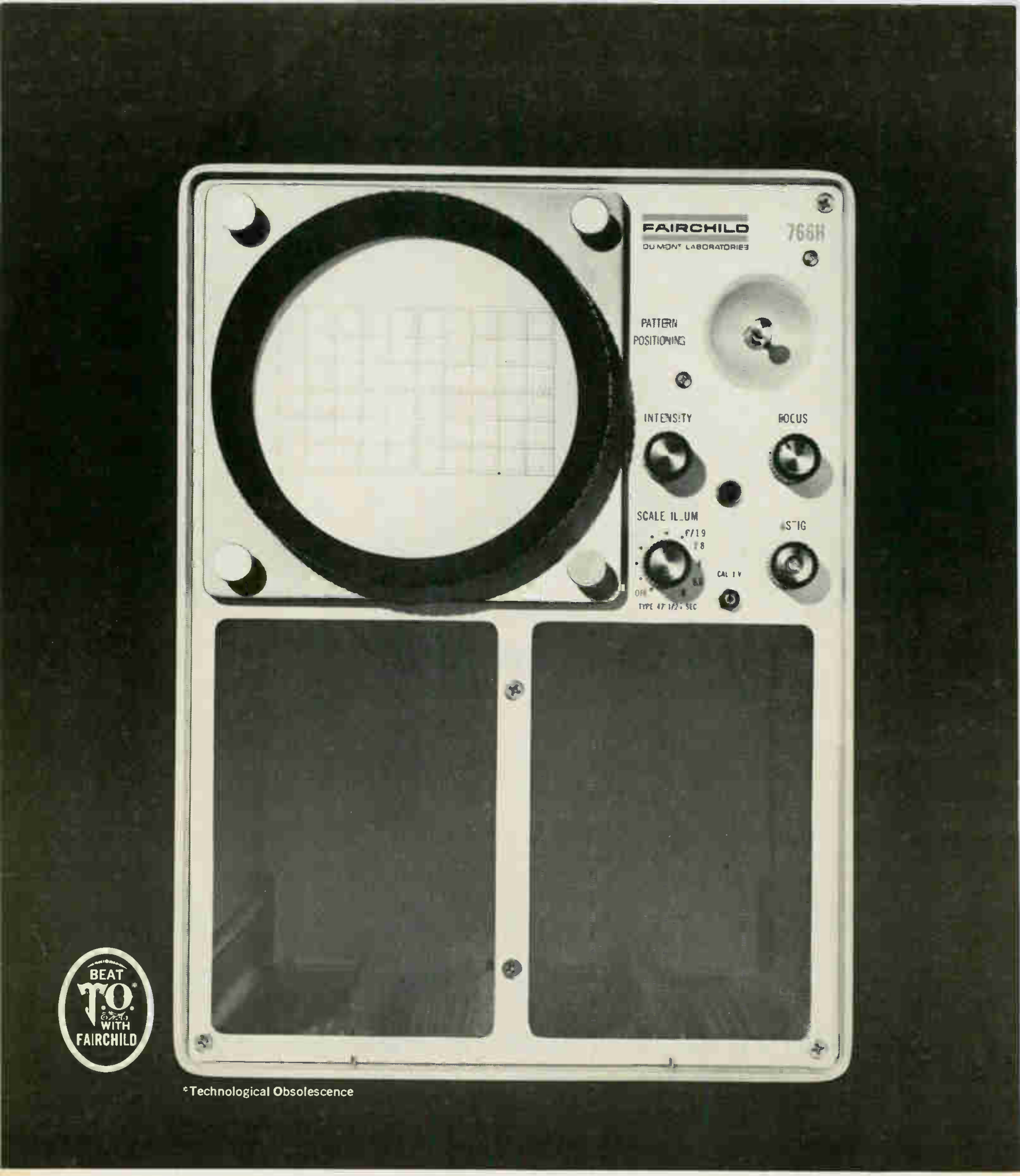
Harris worked on the demodulation of phase-modulated light using birefringent crystals. The technique has possible applications in optical and radar communications systems. With it, the random side modes of a gas laser can be transposed into controlled f-m sidebands. A further modulation eliminates sidebands altogether.

Getting the power of a multimode laser into a single frequency puts engineers "over the hump" as far as laser communications is concerned, he says. Controlling the side modes was the biggest technological stumbling block.

The next major project on his research agenda, he says, is the development of a laser system that can be used for spectroscopic examination. The resolution of such a system would reach the quantum limit of detection, and it would offer the most noiseless form of detection.

Harris's teaching duties leave him little spare time, although he also serves as a laser consultant to the optical devices laboratory of the General Telephone and Electronics Corp.'s subsidiary, the Sylvania Electric Corp. An article on the f-m and supermode lasers by Harris and three Sylvania colleagues will appear in the next issue of Electronics.

Harris has worked at Bell Telephone Laboratories, exploring traveling wave masers. But industry no longer tempts him, he says. He'd rather split his time between teaching and working as a consultant.



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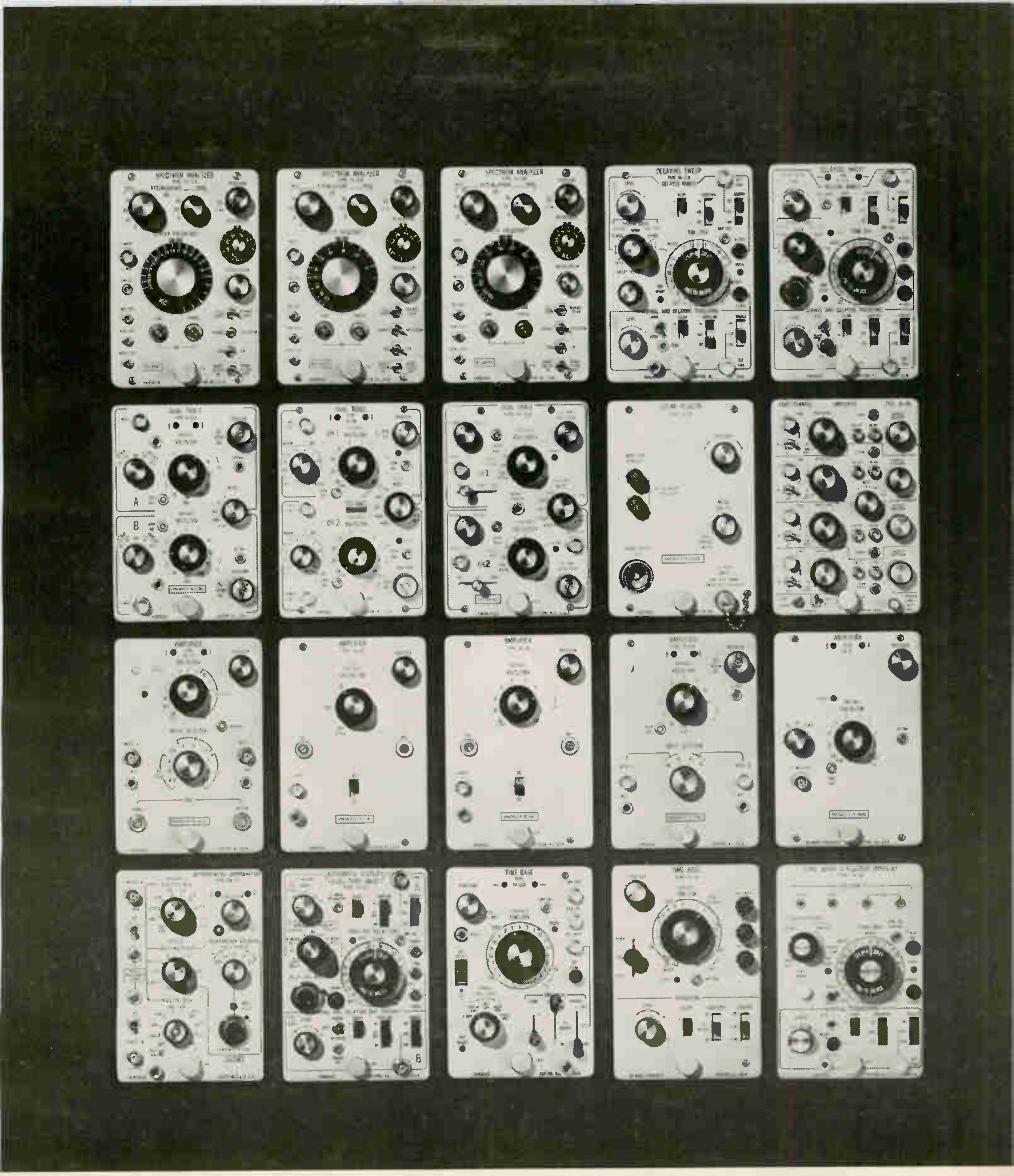

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Plasma Sheath—Plasma Electromagnetics of Hypersonic Flight Symposium, OAR; New England Life Hall and Classified section at Base Theater, Laurence G. Hanscom Field, Bedford, Mass., **Sept. 21-23.**

Systems Engineering Annual Conference, Clapp and Poliak, Inc.; McCormick Place, Chicago, **Sept. 20-23.**

Microelectronics Symposium, IEE; Univ. of Southampton, England, **Sept. 21-23.**

AE-4 Electromagnetic Compatibility Conference, SAE; Grumman Aircraft Corp., Bethpage, L.I., N.Y., **Sept. 22-23.**

Military Electronics Conference (MIL-E-CON 9), IEEE; Washington Hilton Hotel, Washington, D.C., **Sept. 22-24.***

Automation Conference, Cedar Rapids Section, IEEE; Town House Motel, Cedar Rapids, Iowa, **Sept. 24-25.**

Optics in Space Conference, Institute of Physics and Physical Society Optical Group; Univ. of Southampton, England, **Sept. 27-29.**

IEEE Broadcast Symposium, G-B/IEEE; Willard Hotel, Wash., D.C., **Sept. 23-25.**

Biennial Electric Heating Conference, IEEE; Carter Hotel, Cleveland, **Sept. 28-29.**

Symposium on Physics and Nondestructive Testing, Air Force Materials Laboratory; Sheraton-Dayton Hotel, Dayton, **Sept. 28-30.**

ERA Electronics Show, Cascade Chapter of Electronic Representatives Association; Center Display Hall, Seattle, Wash., **Sept. 29-30.**

National Symposium on Information Display, Society for Information Display; Commodore Hotel, N.Y.C., **Sept. 29-30.**

International Exhibition of Modern Electronics, Gospodarsko Razstavisce; Ljubljana, Yugoslavia, **Oct. 2-10.**

Canadian Electronics Conference, Canadian Region of IEEE; Exhibition Park, Toronto, **Oct. 4-6.**

International Scientific Radio Union (URSI), National Academy of Sciences, National Research Council; Dartmouth College, Hanover, New Hampshire, **Oct. 4-6.**

National Aeronautic and Space Engineering Meeting, SAE; Statler Hilton Hotel, Los Angeles, **Oct. 4-8.**

Aerospace Instrumentation Symposium, ISA; Ambassador Hotel, Los Angeles, **Oct. 5-7.**

Switching Circuit Theory & Logical Design Annual Symposium, G-C Univ. of Mich., IEEE; Univ. of Mich., Ann Arbor, Mich., **Oct. 6-8.**

Pan American Congress of Electrical, Electronics, and Mechanical Engineering, Mexico Group of IEEE; Mexico Section of ASME, Mexico Group of SAE; Hotel Del Prado and Auditoria Nacional, Mexico City, **Oct. 9-17.**

International Electrotechnical Commission Conference, IEC; Tokyo Prince Hotel, Tokyo, **Oct. 10-23.**

National Communications Conference (NATCOM), Mohawk Valley Section of IEEE; Utica, N.Y., **Oct. 11-13.**

Convention and Exhibit of Professional Audio Equipment, Audio Engineering Society; Barbizon-Plaza Hotel, N. Y. C., **Oct. 11-15.**

International Motion Picture Engineers Meeting, SMPTE; Fair Grounds, Milan, Italy, **Oct. 11-23.**

Call for papers

Electronic Components Conference, Electronic Industries Association; Marriott Twin Bridges Motor Hotel, Washington, D. C., May 4-6. **Oct. 8** is deadline for submission of four copies of 500-word summary to R. A. Gerhold, Chairman, Technical Program Committee, U.S. Army Electronics Command (AMSEL-KL-I), Fort Monmouth, N. J.

Scintillation and Semiconductor Counter Symposium, IEEE Nuclear Science Group; Shoreham Hotel, Washington, D. C., March 2-4. **Nov. 30** is deadline for submission of abstracts to W. A. Higinbotham, Program Chairman, Brookhaven National Laboratory, Upton, N. Y. 11973.

* Meeting preview on page 16

Model 332A Voltage Calibrator

Meeting preview

Mil-E-Con in Washington

Aerospace and electronic systems, their requirements and technology, will be examined at the ninth Military Electronics Convention (Mil-E-Con) this year. The three-day meeting in Washington, D. C. from Sept. 22 to 24, is sponsored by the Institute of Electrical and Electronics Engineers' military electronics group.

Departing from its customary concentration on military electronics alone, the meeting will discuss new designs, developments, new research and concepts in communications, navigation, instrumentation, detection, location, microelectronics, and integrated circuits across the entire spectrum of aerospace and electronic system design.

Engineers may think solid state when they discuss space electronics but vacuum tube devices are far from dead, according to John W. Coltman of Westinghouse Electric Corp.'s research and development center in Pittsburgh. He will discuss some new uses and applications for vacuum tubes.

Radar. A session on radar will include a paper by W. F. List, A. J. Demco, and J. D. Donaldson of the Westinghouse Electric Corp. in Baltimore. The paper will discuss an experiment using a silicon substrate in a doppler radar system, called CFAR for constant false alarm, to perform detection, integration, and signal processing. All this can be done by a 3/8 x 3/8 x 1/16 inch flatpack. A paper by Frank Reggia of the Harry Diamond Laboratories will describe the design and operation of high-speed amplitude and phase modulators in standard rectangular waveguide systems. Other papers will examine radar signals in tactical systems.

There will also be a special panel discussion on extraterrestrial intelligence. The group, which was organized by Stanley Winkler of the Dept. of Defense Weapons Systems Evaluation Group will be moderated by Harold Wooster of the Air Force Office of Scientific Research. The session will discuss the possibilities and probabilities of communicating with various forms of extraterrestrial life.

Who is the Best Judge When it comes to Semiconductor Requirements for Your Advanced Equipment?

When it comes to making any decisions about the equipment you're making, *you* are the *only* judge. We wouldn't question that.

But, there are a lot of requirements where a total service company like Motorola could help provide the *best* answer. For instance, questions like:

- **What is the best semiconductor device available for your particular application?**
- **How can you best provide a practical hi-rel program for your company?**
- **Where can you get assistance on a tough circuit problem?**
- **Where should your company be going with future equipment designs?**

These are all very pressing questions at times. And, a quick solution can save you time and money. As a matter of fact, we feel they are so important that we try to have the answers available *before* you have the problem. We do this with things such as:

MEG-A-LIFE II PROGRAM — a new high-reliability assurance program for semiconductors which uses military-type devices or equivalent as source types and offers three levels of reliability assurance to meet varying application requirements. It can readily be used as a nucleus of an elaborate quality program, or, for less demanding requirements, can be used substantially as is, as an in-house quality assurance procedure.

DEVICE SELECTION GUIDES —

Published cross-reference and selection guides are available from Motorola on all types of semiconductors — guides which permit you to make an intelligent device choice . . . within minutes!

APPLICATIONS ENGINEERING SERVICES — Motorola's Applications Department can evaluate your circuit and offer written suggestions on how to solve your circuit problems.

DEVICE DATA MANUAL — the newly printed 908-page Data Manual, which lists device specifications for over 2600 types, eliminates literally days of wasted time for your engineers and purchasing people by providing a single source for all data.

FIELD REPRESENTATIVES — local Motorola semiconductor representatives located in some 23 field offices all over the United States, are backed by the world's largest single semiconductor research and production facility and each is fully aware of the outlook for semiconductor innovations in the future. Your Motorola man can provide you the information you need to intelligently guide your firm and help you maintain a competitive position in equipment development.

SEMICONDUCTOR DEVICE HANDBOOKS – published texts on integrated circuits, zener diodes, power transistors, rectifiers, switching transistors, and power circuit applications available from Motorola often provide the answer to a critical circuit problem with no further searching required.

These are but a few of the standard, everyday tools provided by Motorola . . . items you'd expect from a total service supplier.

If you have any questions or would like additional information about any of the subjects discussed here, write Motorola Semiconductor Products Inc., Technical Information Center, Dept. 66, Box 955, Phoenix, Arizona 85001.

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hp standards box score

hp 740A 0.01% DC Standard, a "workhorse" with 20 ma at 1000 v output, output resolution > 1 ppm, floating and guarded, remote sensing, stability > 0.0015%/mo., regulation > 0.002% line or load ... only $2350! (The H10-740A is a 0.005% standard for just $300 more.)

hp 419A DC Nullmeter, 0.1 μv resolution with < 0.5 μv drift per day, > 80 db superimposed ac rejection, portable (30 hrs. between recharges), overload to 1200 v, low thermal emf, internal nulling supply for measuring high-impedance source voltages, $450!

hp 741A 0.02% DC Standard, an ac-dc differential voltmeter, as well, with output 0 to 1000 v to 20 ma, $1475.

DC STANDARDS

New Hewlett-Packard 735A Transfer Standard

The compact Hewlett-Packard 735A simplifies dc standards work to a point never before achieved. Ends moving standard cells and voltage dividers to remote sites or moving other instruments to standards laboratories.

Use the 735A as a 1 v reference for volt box potentiometric measurements, as a comparator for saturated and unsaturated standard cells, as a stable μv source. Four outputs: 1.00000 v reference, 1.018 v + (Δ)** and 1.019 v + (Δ)** references for saturated and unsaturated standard cell comparisons respectively, 0-1000 μv source with 1 μv resolution. In standard cell comparison, just null the output, read (Δ) directly on 3-digit readout.

The 735A, which is overload- and short-circuit-proof, has a basic stability of better than 10 ppm/month, derived from a zener diode reference supply in a temperature-controlled oven. Temperature coefficient of the output voltage is <1 ppm/°C, 0° to +50 C. The low-noise output is floating and guarded. Solid copper + and − output terminals with gold flash assure low thermal emf.

Get direct comparison readouts with your standards (just null the outputs and read the comparison on the dial) ... *and move the 735A anywhere.* 3" high, 5⅛" wide, less than a foot deep and only 5½ lbs! And it's not susceptible to temperature or mechanical shock. Price, just $375!

See what the other brief specs of the 735A can do for you—and look at the box score of other hp instruments available for your dc standards work. Then call your Hewlett-Packard field engineer or write for complete specs on what you need to make your standards work easier, faster and more economical: Hewlett-Packard, Palo Alto, Calif. 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva; Canada: 8270 Mayrand Street, Montreal.

Brief specifications, 735A*

Standard outputs:	1.00000 v; 1.018 + (Δ)**; 1.019 + (Δ)**; 0-1000 μv (Δ)**
Transfer accuracy:	better than 2 ppm between saturated or unsaturated standard cells; better than 10 ppm standard cell to 1 v; better than 10 ppm saturated to unsaturated standard cell
Stability:	<10 ppm/month
Temperature coefficient:	<1 ppm/°C
Noise:	<1 μv peak to peak, dc-1 cps
Variable output:	0-1000 μv, accuracy 0.1% ± 0.5 μv, linearity 0.1%, output impedance 146 ohms ±1%
Output:	floating and guarded; impedance 1 K ohm ±1%
Price:	$375

*See text for additional performance characteristics.
**A 3-digit direct-reading 0-1000 μv offset voltage.
Data subject to change without notice. Prices f.o.b. factory.

HEWLETT hp PACKARD
An extra measure of quality

422

Circle 19 on reader service card

Availability, reliability, and TI germanium transistors

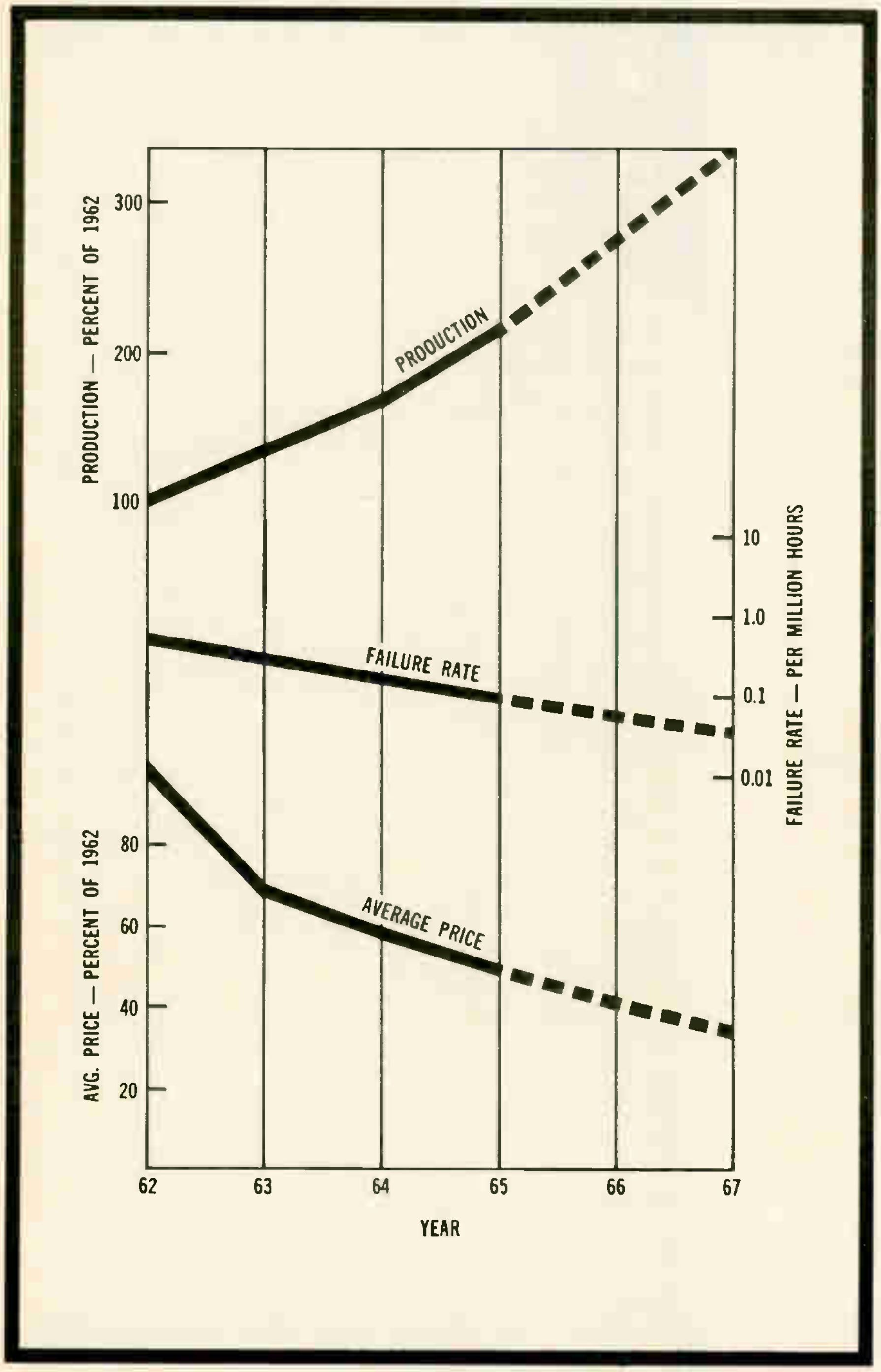

Figure 1. As production increases, reliability improves and prices go down . . . making germanium transistors even better for many applications

New products by the dozens — ranging from business machines to television sets — will employ germanium transistors from Texas Instruments for three very important reasons...availability, reliability and price! Manufacturers have found they can prevent production delays and trim costs while offering their customers top performance and trouble-free service.

Availability

When you specify TI germanium transistors, you are sure of meeting your production requirements — for spot shipments or millions per month — on schedule! The reason is simple . . . TI has made more transistors and has more production capacity than any other manufacturer.

Nearly half a billion germanium transistors have been produced by TI alone. Current production is more than fourteen million per month and capacity is still growing, as shown in the trend curve of Figure 1.

TI's current germanium production is nearly as great as the combined silicon production of all manufacturers.

Three TI plants now produce germanium transistors. In addition to the Dallas facility, plants in Bedford, England and Nice, France are in volume production. This gives further protection against costly delays.

Reliability

One billion transistor hours per failure for a failure rate of 10^{-9}! That's the order of reliability reported in actual service by large users of TI germanium transistors. No other transistors have compiled so much documented reliability.

Field service reliability is about three orders of magnitude better than results of tests at maximum ratings . . . these test results are good and getting better, as shown in the average failure rate trend curve of Figure 1. These averages were compiled from many tests involving tens of millions of transistor hours' service.

For example, only three failures per million transistor hours resulted when 2N404's were subjected to 23 million transistor hours of service at maximum ratings during the last 12 months.

price... Three reasons to use in your new designs

Another recent test resulted in a failure rate of 10^{-7}. Only one failure was recorded when 9250 TI germanium transistors were operated 1000 hours at maximum ratings.

Every transistor produced by TI is carefully tested and classified to assure uniformly reliable service in your equipment. To do the job, TI has installed high speed testers like those shown in Figure 4.

Price

Low prices are closely related to volume availability . . . that's why TI germanium transistor prices are among the lowest. TI production experts know how to reduce costs without compromising performance. They gained this knowledge while building half-a-billion transistors.

TI has invested heavily — more than any other manufacturer — to take advantage of this know-how! During the last 18 months, TI doubled germanium capacity by adding new, highly-automated machines like the one shown in Figure 2. As a result, costs are reduced, while production is increased and quality is improved.

The price trend curve of Figure 1 shows the result of this experience and investment. Germanium transistor prices are low and getting lower.

Today, germanium transistors in highly reliable hermetically sealed metal cans are comparable in price to the cheapest plastic-encapsulated silicon transistors. For cost-critical consumer and related applications, TIXM01-08 germanium transistors in plastic packages cost even less.

There you have the story . . . TI germanium transistors have no equal for availability, reliability and price. Performance exceeds requirements for the vast majority of industrial, consumer and commercial, as well as many military applications, as shown in Figure 3. No other devices—regardless of price — offer significant added benefits in most of these applications.

That is why leading manufacturers incorporate TI germanium transistors in new equipment.

Before you finalize designs for any new product that employs transistors, call your TI representative! He will help you get an edge on competition by selecting the transistor best suited to your requirements.

Figure 2. TI's mechanized alloy transistor assembly machine—an industry exclusive—insures uniformity and reliability at very high production rates

- AM-FM radios
- Communications equipment
- Computers
- Desk calculators
- Missiles
- Phased-array radar
- Satellites
- Scientific instruments
- Television receivers
- Torpedoes

Figure 3. Here are some of many types of new military, industrial and consumer equipment that will use TI germanium transistors

Figure 4. Ultra high speed automatic test machine performs accurate measurements and classifies up to 9000 units per hour

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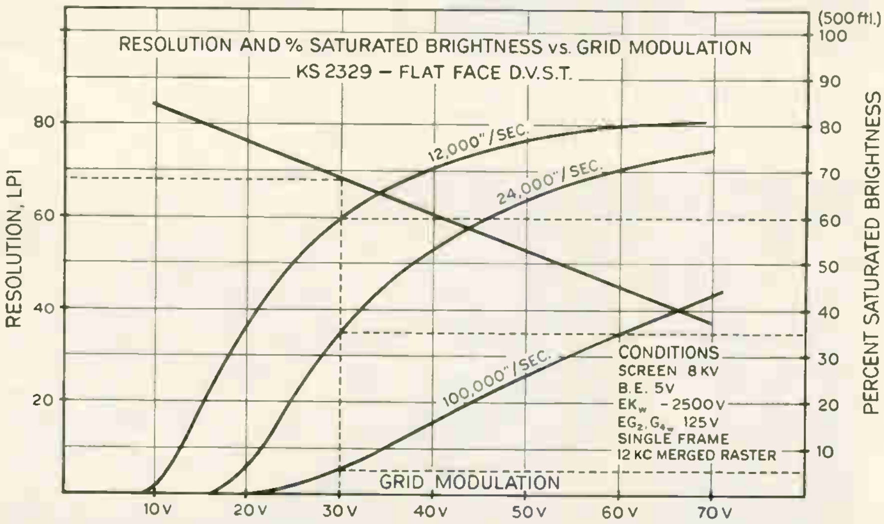
FAIRCHILD DU MONT TUBE TECHNOLOGY



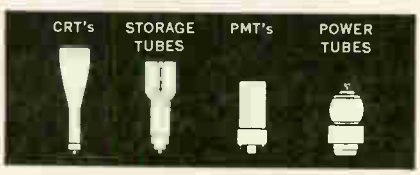
NEW STORAGE TUBE SHARPENS TRACKING SYSTEM'S VISION

The newest generation of tracking and radar systems demands a new generation of direct view storage tubes with improved dynamic display uniformity and resolution capabilities. Du Mont engineers have taken on this problem with marked success.

Case in point: the storage tube originally specified for the PPI of a certain missile tracking system (not Du Mont) lacked center-to-edge uniformity of writing, erasing and brightness. The area at the center of the screen built up a disproportionately high signal charge level. This increased background brightness to the point of obscuring nearby targets. The condition could be partially compensated by increasing storage electrode bias, but this reduced sensitivity to remote weak targets displayed in the peripheral area. Another alternative, equally unsatisfactory, was to erase the image completely every two or three minutes. This left the system blind during the interval required for a complete antenna rotation.

The problem was eliminated by the storage tube Du Mont designed and built for this application. This tube, Type KS2329, achieves substantially uniform dynamic characteristics over the entire storage surface. Resolution capability—600 TV lines in the useful diameter—is 60% greater than that of the original tube. And, with no increase in length, a 12% increase in useful diameter (to 9") was achieved.

Reliability in severe environments was another requirement. So, with its integral mu-metal shield, the Type KS2329 is potted in a resilient, fungus-resistant compound, and is fitted with multiple pin locking connectors and rugged mounting lugs.



The final result was a significant advance in storage tube technology—or, from the customer's viewpoint, a tracking system with greatly improved vision. Now both strong and weak targets are displayed with excellent resolution, persistence and brightness. Additional features include internal feedback correction electrodes for high pattern geometry accuracy and zero DP current operation to overcome deflection non-linearities resulting from unpredictable collection of writing beam current and reflected flood beam current.

COMPACT PACKAGING

Another new storage tube developed by Du Mont packs unusual performance into a small envelope—and even that is designed to provide extra space for circuitry in the area around the yoke. This tube has a screen diameter of 5", overall length of only 8". Resolution is better than 125 lines/in.; writing speed is 300,000 in./sec. Since the tube has the same excellent integration characteristics as the KS2329, it is expected to find wide application as an indicator in airborne radars, or as a radar indicator and TV display monitor.

Other Du Mont storage tube developments include an on-axis writing gun. This considerable feat, never successfully accomplished in larger tubes, hinged on locating the flood gun or guns off-axis while retaining uniform illumination. The Du Mont tube does not depend on physical alignment to do this. Instead, three off-axis guns are used with split anodes which direct the beam from each toward or away from the tube axis. Uniform illumination is achieved, the write gun is located on-axis—and the DVST can replace a CRT with no change in deflection components.

CUSTOM DESIGN OR OFF-THE-SHELF

Over the years, the solution of many individual tube problems has resulted in the availability of more than 4,000 types of Du Mont tubes. These fall into four general categories: Cathode-ray Tubes, Photomultiplier Tubes, Power Tubes and Storage Tubes. The latter includes both direct view and electrical output tubes. If you need a special purpose tube, you'll probably find it listed in the latest Du Mont tube catalog. If it isn't, we will design and build it for you. For your copy of the catalog, write (letterhead please) to Fairchild's Du Mont Electron Tube Division, 750 Bloomfield Avenue, Clifton, New Jersey.

FAIRCHILD

DU MONT ELECTRON TUBES
A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION

Editorial

Success story

The search for new devices and new ways to perform old tasks is always running into man's built-in resistance to change. It takes a success story every once in a while to convince everyone that the search is worthwhile—and such a story is being written today by the silicon controlled rectifier, the solid state switch developed nearly eight years ago. Engineers are discovering that its unique properties are useful in a variety of new products that range from battery-operated home appliances to the controls of giant steel mills.

Most experts thought that scr sales would run between $32 million and $35 million this year, a nice increase over 1964. As August ended, however, scr sales were running at an annual rate of nearly $45 million—nearly 30% ahead of the estimate. And the sales rate is still picking up.

There are a lot of reasons for this spurt in use of scr's. But the development of new varieties is one of the most important. Initially, the scr was limited to 60 cycle-per-second, low-power applications. Today's devices are rated at as high as 250 amperes at 1,000 volts. And new chip designs can handle frequencies as high as 50 kilocycles, opening up still more new applications (see story on page 88).

Another important reason is the new plastic package for the scr announced by the General Electric Co. (which developed and initially created the market for the scr) earlier this summer. GE's package dropped the price of a lot of scr's to around 50 cents. That significant price decrease opened up the home appliance market in a big way, so big that other semiconductor suppliers are rushing out a plastic package for their scr's. Motorola's Semiconductor division, for example, will announce such a device before the end of 1965.

Among the most spectacular new applications of scr's is the control of giant electrical motors with electronic circuits instead of the conventional motor-generator sets which used to generate the d-c current that regulates the drive motors. Earlier this summer, at its Warwick, Ind. plant, the Aluminum Co. of America opened up a new rolling mill in which scr's controlled the 10,000-horsepower drive motors. Actually, 35,000 hp are under electronic control at this facility. To many veterans of the semiconductor industry who sweated out the destruction of semiconductor devices by currents at the milliampere level, such performance is nearly unbelievable.

At the Warwick installation, which uses 250-amp Westinghouse devices, running at 1,000 volts, the scr's take up far less space and require much less maintenance than the motor-generator equipment. Such an installation is big business. The electrical portion of the Warwick mill—motors, controls and scr's—cost $6 million. The scr's alone (and thousands are used in the system) cost over $500,000.

Westinghouse is building an electronic control that will dwarf the one at Warwick; it will control 65,000 kilowatts at a Bethlehem Steel Co. rolling mill that will have more drive motors and more stages than Alcoa's mill.

But the greatest opportunities for the scr may lie in the appliance field, where electronic devices have not been widely used primarily because appliance makers believe they are too expensive and too unreliable. Now, however, all that is changed.

For example, an scr control could regulate the speed of a washing machine or drier without the gears now used, thus decreasing the cost and improving the reliability. An appliance manufacturer could even replace the motors now used with less expensive induction motor drives and no speed control. Speed would be changed by a change in frequency; if the motor ran at 1,800 rpm at 60 cps, it would run at 3,600 rpm if the frequency were doubled electronically.

An even greater advantage exists in battery-operated tools. The speed of most such tools is controlled by varying the resistance of the motor's field or armature with a rheostat. But that method uses a lot of power. With an scr control, there is less power drain, and batteries have longer life.

Clearly, the search for new scr's and new applications has opened up brand new vistas for the entire industry. Nobody could belittle this quest for something new.

CLIFTON steps in to the Stepper Motor field

CLIFTON STEPPER MOTORS

SIZE	8	8	10	10	11	11	8	8	8	11
LENGTH (M.F.)	0.770	0.770	0.770	0.770	1.215	1.215	1.062	1.112	0.770	1.215
WEIGHT (OZ.)	1.0	1.0	1.6	1.6	3.2	3.2	1.5	1.5	1.0	3.2
INERTIA (GM-CM²)	0.19	0.19	0.19	0.19	0.77	0.37	0.18	0.45	0.19	0.77
INDEX ANGLE	90° ±3°	90° ±3°	90° ±3°	90° ±3°	90° ±3°	15° ±1°	90° ±3°	90° ±3°	45° ±2°	45° ±2°
TYPE	PM 2	PM 2	PM 2	PM 2	PM 2	VR 3	PM [illegible]	PM 2	PM 2	PM 2
RATED D.C. VOLT.	28V	28V	28V	28V	28V	28V	28V	28V	28V	28V
RESISTANCE (OHMS/PHASE)	450	300	300	300	300	150	300	300	135 per PHASE	130 per PHASE
NO LOAD RESPONSE RATE PULSE/SEC	250	320	350	330	220	500	360	280	600	440
NO LOAD SLEW RATE PULSE/SEC	510	930	700	610	265	1600	375	650	2700	1200
HOLDING TORQUE OZ-IN ONE PHASE	0.37	0.35	0.50	0.53	1.1	0.60	0.80	0.58	0.60	1.5
DETENT, OZ-IN ZERO INPUT	0.12	0.05	0.05	0.13	0.24	—	0.17	0.10	0.05	0.12
TYPE NUMBER	MSA-8-A-1	MSA-8-A-2	MSA-10-A-1	MSA-10-A-2	MSA-11-A-1	RSA-11-A-1	MSM-8-A-1	MSL-8-A-1	MSA-8-A-3	MSA-11-A-2

EXCITATION MODE: TWO PHASES PARALLELED ALTERNATELY.

After careful testing and having already had units in end-use equipment in the field, we are now ready to announce a full line of size 8, 10 & 11 stepper motors and the controllers that go with them.

Steppers are gaining popularity rapidly in digital systems because of their quick response, high resolution, and many other distinct advantages over the conventional servo motor.

We'd like to step in to your stepper motor picture with Clifton Precision quality, reliability and application knowledge.

Clifton Precision Products, Division of Litton Industries, Clifton Heights, Pa., Colorado Springs, Colo. Area 215 622-1000; TWX 215 623-6068.

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DIVISION OF LITTON INDUSTRIES

Electronics Newsletter

September 6, 1965

Far-out methods to halt missiles

After a decade of concentrating its missile defenses over probable target areas, **the United States seems to have found a way to intercept enemy projectiles farther from its shores.** The problem has been how to reach the missile during the midcourse phase of its journey. The proposed solution is secret, but considered feasible enough to be the subject of two study contracts.

During the week in which President Johnson granted the Air Force's request for a manned orbiting laboratory, the service awarded two contracts for studies of ways to reach a missile in midcourse. **The method could involve a satellite hovering over a possible missile route.**

One contract went to the Planning Research Corp. of Los Angeles, to study "mixed defense against ballistic missile attack"; that means trying to intercept the missiles midway in their journey and again during reentry. The other award, to the Academy of Interscience Methodology in Chicago, was made for a study of "midcourse defense against ballistic missile attack."

Gemini 5 gave another indication of the Air Force's interest in early detection of missile flights. The astronauts, in two experiments for the Air Force, used infrared sensors and radiometric measuring devices to detect three missile launchings in the U. S.

A perfect flight . . . almost

Gemini 5's spectacular successes overshadowed a few technical problems that presumably are a focus of interest during the astronauts' 11 days of tests and debriefing.

One problem was the failure to obtain useful range data from the rendezvous radar system. The spacecraft sent the signals to a transponder at Cape Kennedy and received them back, but readings of the return signals on the astronauts' display panel were off scale.

Another problem was the power crisis, when oxygen pressure for the fuel cells fell to a dangerous level. Space officials say the trouble seems to have been a burned-out wire in a circuit leading to the oxygen heater.

The biggest problem, the splashdown 103 miles off target, seems to have been due not to the computer that controlled the reentry but to erroneous input.

There was no problem with reception of the astronauts' picture on television screens three minutes after it was taken with a Polaroid camera aboard the recovery ship. The photo was scanned by a storage vidicon and transmitted in digital form by Videx, a tv system that uses a bandwidth of only 3 kilocycles, reassembled on another storage vidicon in Houston, and sent to the tv networks. Videx is owned by the International Telephone and Telegraph Corp.

Superconducting tin sandwich

Researchers at the **University of Pennsylvania have observed microwaves coming from superconducting tin at the temperature of liquid helium**—−460° F. The phenomenon is a manifestation of the a-c Josephson effect—the emanation of a supercurrent from a junction formed by two layers of superconductor material whose insulating layer is very thin.

With tin oxide as the insulation, and using excitation of about 20 microvolts, Donald Langenberg, Douglas Scalapino, Barry Taylor and Robert

Electronics Newsletter

Eck achieved 10^{-11} watts output at about 9 gigacycles per second.

The researchers figure there is about one microwatt present in the junction, and much work is being done on improving the output couplings to get this power out. The frequency of the radiation can be tuned from 5Gc to 700 Gc in 5-Gc steps, at the rate of 483.6 Mc per microvolt.

The radiation is useful in the study of optical properties of solids, in measuring very small voltages, in verifying Planck's constant and the charge of the electron, and in investigating new maser materials that could emit in the far infrared. **In communications, the device could eventually replace conventional microwave generators.**

Laser trimming cermet resistors

High-value resistors of cermet thin film are being made with the help of a laser beam. The Univac division of the Sperry Rand Corp. says cermet resistors as thin as 0.005 inch can be adjusted to a resistance precision as great as 99.99%.

Cermets—mixtures of ceramic and metal—have far higher resistivity than metal alone. For years, designers have been intrigued by the prospect of using cermets to make microcircuit resistors; but it was difficult to obtain the necessary precision with the deposition process.

Univac heats the cermet momentarily with a ruby laser whose beam energy has been reduced sharply. "If we're lucky," says Sidney Rubin, research director at Univac's defense division, "we can adjust a resistor with one pulse."

Rubin says nobody is sure how the energy changes the resistor value. **The technique is being used to develop hybrid circuit amplifiers;** Univac also expects to use it to adjust resistors on silicon integrated circuits.

Computer repair with no down time

A technique for servicing time-shared computers without shutting them down has been developed by Jesse T. Quatse, manager of engineering development in the Computation Center at the Carnegie Institute of Technology. The technique is called Strobes, an acronym for shared-time repair of big electronic systems. It includes a test program to exercise the computer, and modified test gear to detect faults in the system.

In a multiprocessing system, a faulty module can be taken off-line, allowing the system to run normally.

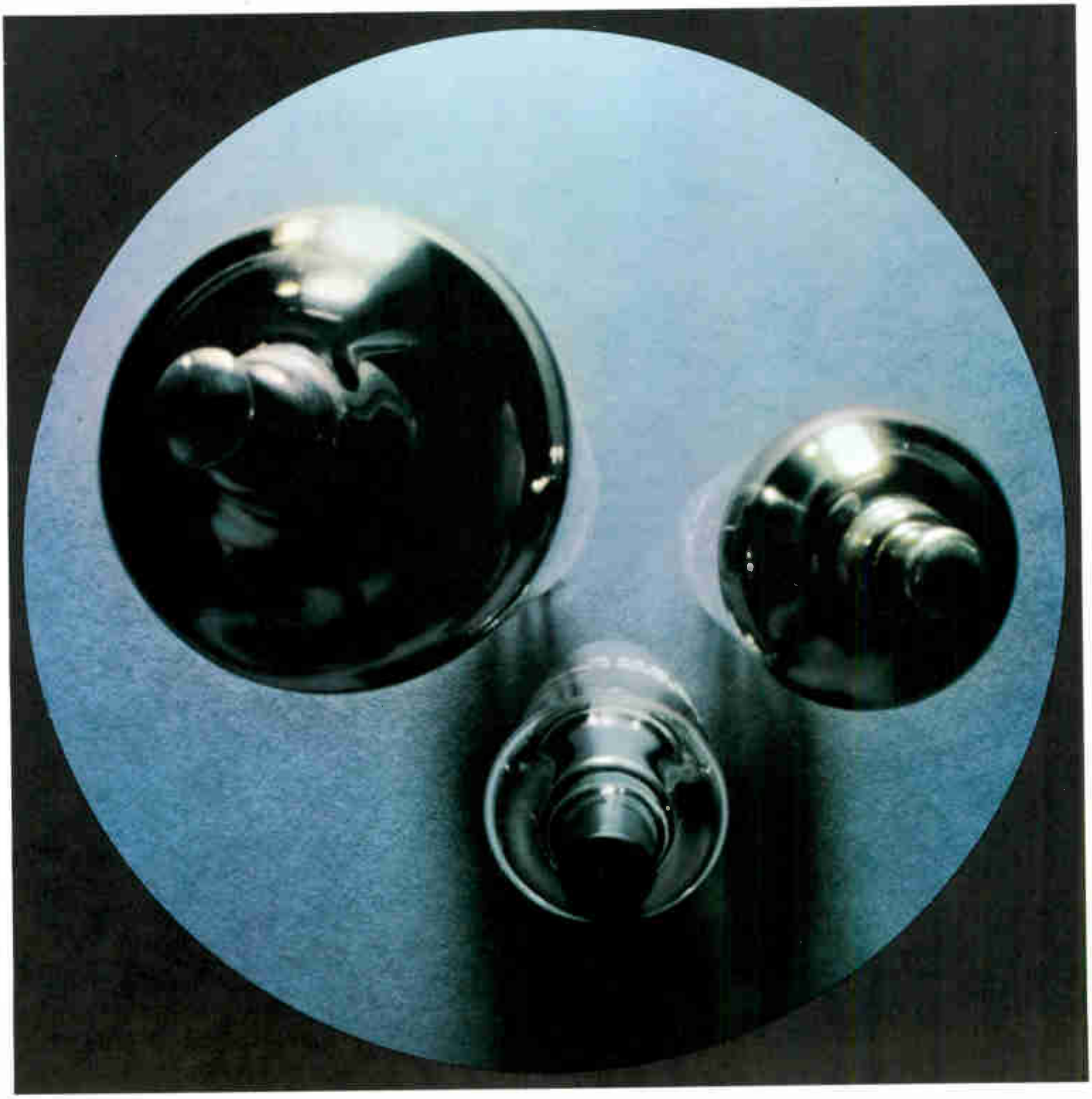
When an oscilloscope is needed, the Strobes technique requires a slight modification of standard scope circuitry, and additional external circuits that can be mounted on the scope cart. During testing, the scope beam is turned on and off by the test program; while the computer is working on the test program, the beam is on; while another program is being run, the beam is off. The switching on and off is so fast that a steady display appears on the scope.

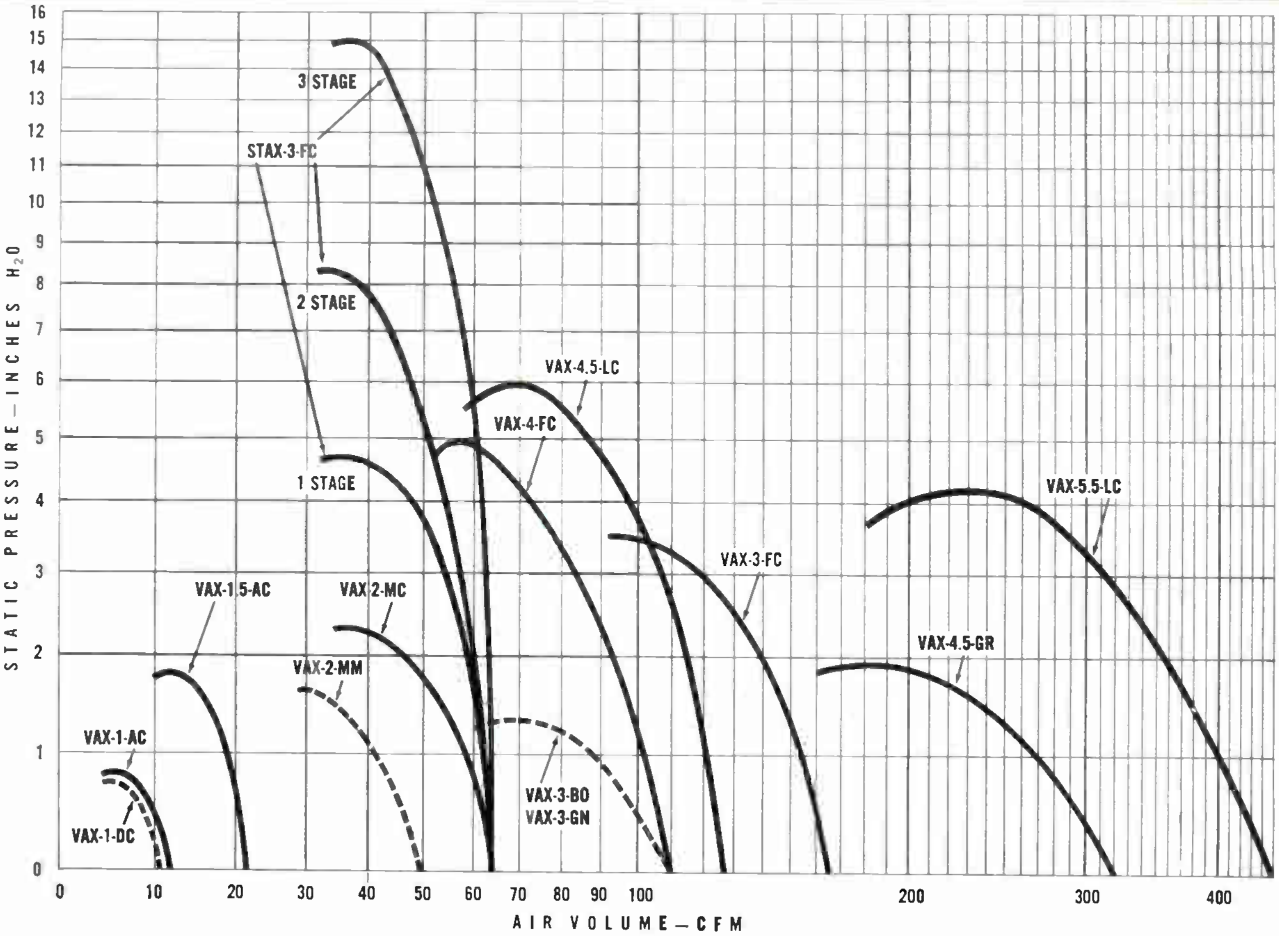
The computer executes the maintenance program in the normal time-sharing mode along with any other programs that may be running.

Addenda

The Communications Satellite Corp. has requested proposals from 29 companies for the multimillion-dollar electronics package for two ground stations to be built in Hawaii and the State of Washington. Answers must be in by Sept. 30. . . . The Keydata Corp., a subsidiary of Charles W. Adams Associates, Inc., will use a Univac 491 for its commercial computer time-sharing service, instead of the Digital Equipment Corp. PDP-6 it had planned to buy. The PDP-6 wasn't running on time.

Circle 27 on reader service card→





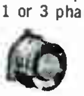
VAX-1-DC D.C. VANEAXIAL BLOWER. 1⅛" dia. 26 v.d.c. Rugged sub-miniature unit with good performance. 1.4 oz. Ideal for spot cooling. MIL specs.

VAX-1-AC A.C. VANEAXIAL BLOWER. 1⅛" dia. Operates on 26 v.a.c., 400 cycle, 1 phase. 1.5 ounces. Smallest vaneaxial blower available. MIL specs.

VAX-1.5-AC A.C. VANEAXIAL BLOWER. 1⅝" dia. Uses 115 v.a.c., 400 cycle, 1 phase. 4.0 ounces. Can be supplied variable speed for high altitude use.

VAX-2-MM D.C. VANEAXIAL BLOWER. 2" dia. Operates on 26 v.d.c., other versions available up to 50 v.d.c. Designed for MIL specs., weighs 5 oz.

VAX-2-MC A.C. VANEAXIAL BLOWER. 2" dia. Operates on 115 or 200 v.a.c., 1 or 3 phase. Weighs 5 oz. MIL specs.



STAX-3-FC A.C. MULTI-STAGE BLOWER. 3" dia. Compressor staging in a miniature unit, ideal for heat exchangers, compact "black boxes," etc., 29 oz.

VAX-3-BD D.C. VANEAXIAL BLOWER. 3" dia. Operates on 28 v.d.c., other versions may be wound to 115 v.d.c. Designed for MIL specs., 16 oz.

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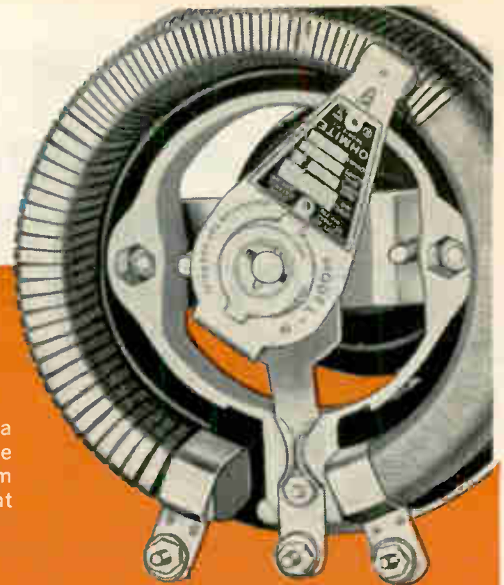
GLOBE

standard rheostat variations



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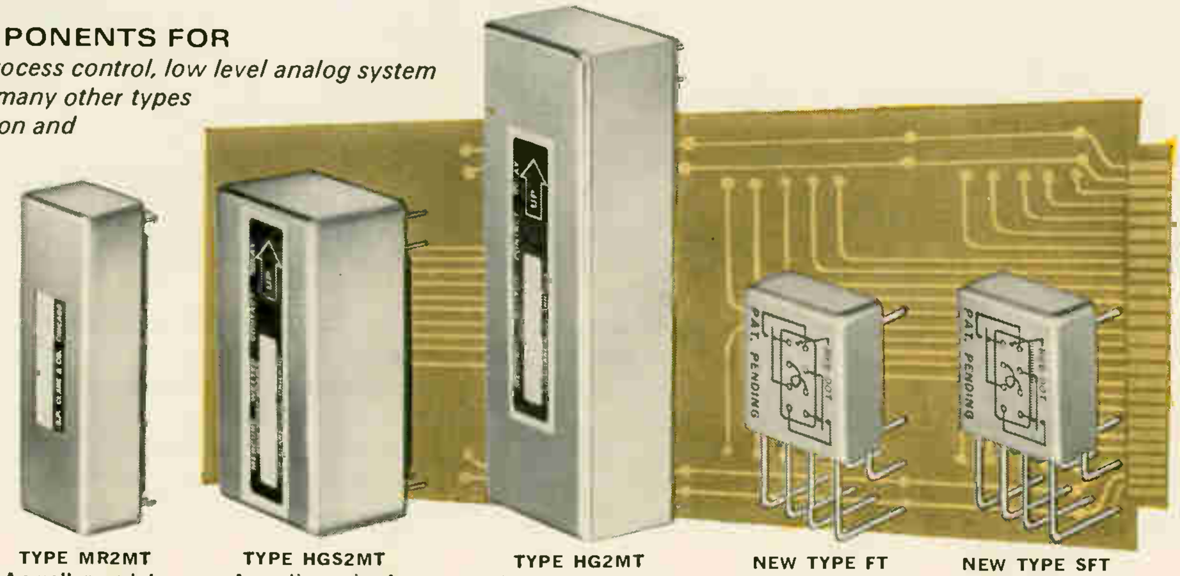

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NEW TYPE SFT
A sensitive FT design for slow speed, long duty cycle switching circuits. Dimensions identical with FT.

THERMAL VOLTAGE CHARACTERISTICS

	TYPE HGS2MT	TYPE HG2MT	TYPE MR2MT	TYPE FT

Thermal emf vs. Stabilizing Time at various coil duty cycles

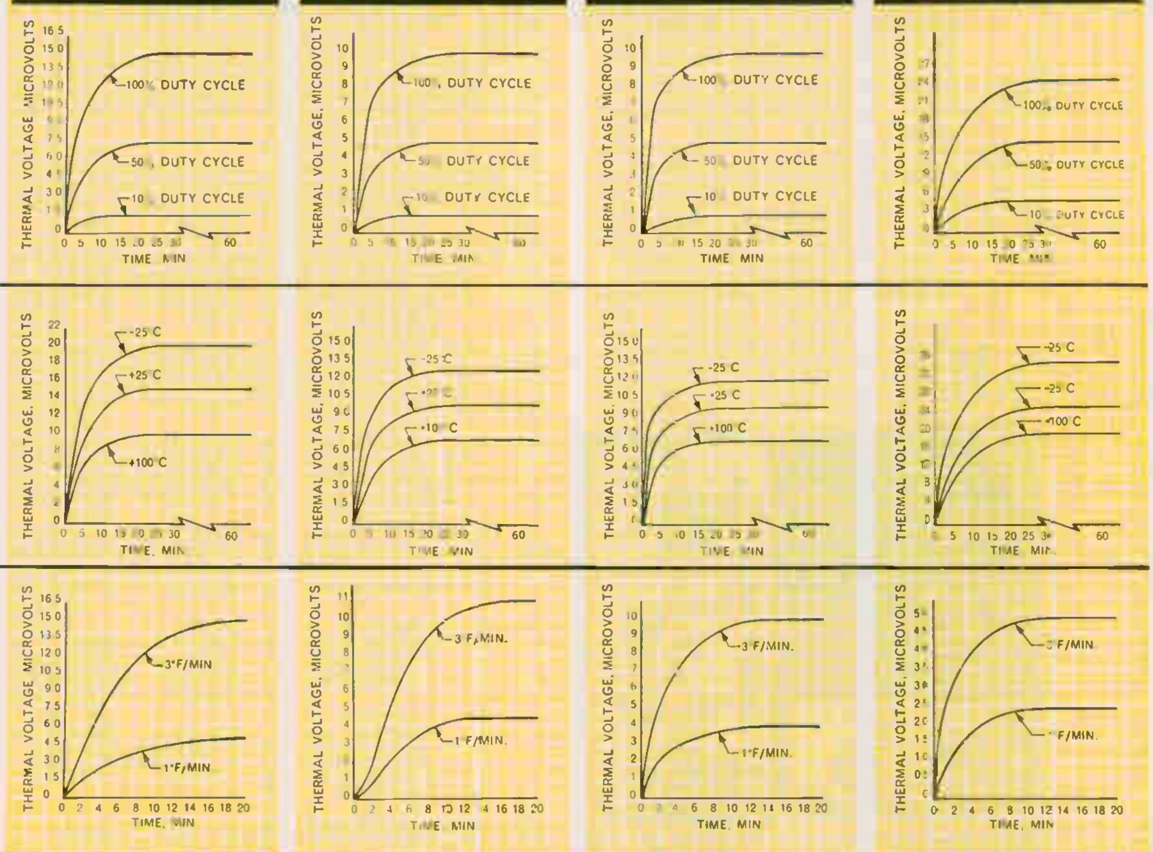
CONSTANTS
Coil drive: nominal voltage
Ambient temp: +25°C

Thermal emf vs. Stabilizing Time at various ambient temperatures

CONSTANTS
Coil drive: nominal voltage
Coil duty cycle: 100%

Thermal emf vs. Stabilizing Time at various rates of ambient temperature change

Initial ambient temperature: +77°F (+25°C)



CONTACT NOISE CHARACTERISTICS (microvolts peak-to-peak)

		TYPE HGS2MT			TYPE HG2MT			TYPE MR2MT			TYPE FT		
System Bandwidth		.06cps-100kc	.06cps-6kc	.06cps-600cps	.06cps-100kc	.06cps-6kc	.06cps-600cps	.06cps-100kc	.06cps-6kc	.06cps-600cps	.06cps-100kc	.06cps-6kc	.06cps-600cps
Time after coil energization	Closure	700μV	250μV	50μV	1500μV	200μV	30μV	3500μV	450μV	50μV	900μV	600μV	150μV
	2.0ms	500	200	40				1500	200	25			
	3.0	300	125	25				300	75	15			
	4.0	200	100	10				100	50	10			
	5.0	125*	50	5†				75*	25	5†	500	125	50
	5.5				1500	200	30						
	6.0	50	25	5†	1300	150	25	50	15	5†	150	25	10
	7.0	25	10	5†	500	75	15	30	10	5†	75	20	5†
	8.0	15	10	5†	250	50	10	25	10	5†	50	15	5†
	9.0	10†	5†	5†	75	25	5†	20	10	5†	30	10	5†
	10.0	10*†	5†	5†	50*	15	5†	20*	10	5†	25	10	5†

*Represent maximum values †Limitation of measuring equipment

...TYPE SFT The Type SFT low level relay is a sensitive version of the FT, with sensitivity of 115mw and an operating time of 10 ms. The SFT is an ideal component for slow speed and long duty cycle applications.

Thermal EMF
5 μv max.
(100% duty cycle, nominal coil voltage applied at +25°C)

Typical Noise

Band Width	Contact Noise (μv peak to peak 15 ms after coil is energized)
100KC	10μv†
6KC	5μv†
600cps	5μv†

†Limitation of measuring equipment

Sensitivity
115 mw (at nominal voltage, 24V, 5000 ohms)

Send for Data Sheet 1251A for specifications of CLARE Relays for high speed, low level switching applications. Address: Group 09N8, C. P. Clare & Co., 3101 Pratt Boulevard, Chicago, Ill. 60645

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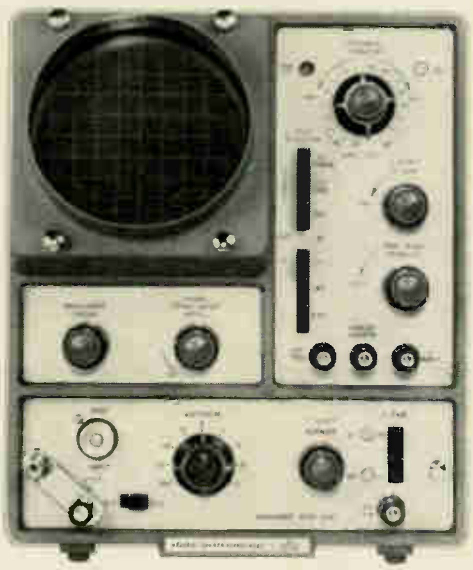

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Electronics Review

Volume 38
Number 18

Space electronics

Air Force in orbit

The decision to let the Air Force go ahead with the $1.5-billion program for a manned orbiting laboratory (MOL) means that the military has solidified its claim to a share of the man-in-space program. Just about every space expert considers the MOL project only the first of many military flights.

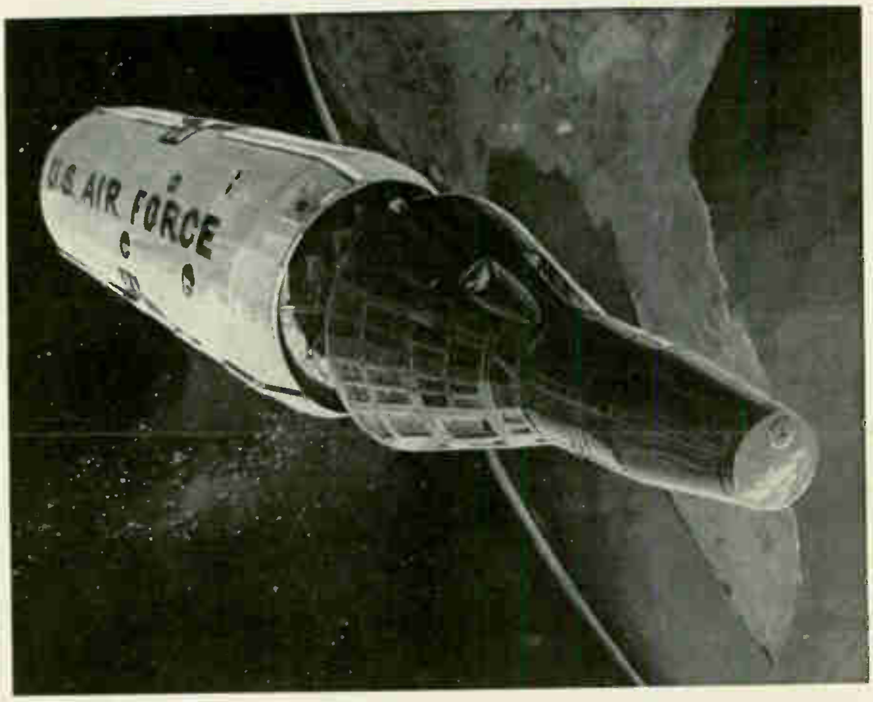
In essence, the Air Force is staking a claim to research in space near the earth. The National Aeronautics and Space Administration, which had been competing for the orbiting lab job with its Apollo Extension System. [Electronics July 12, p. 115], will concentrate on interplanetary space.

The Air Force had a built-in head start because its MOL is tied to the Gemini space capsule and the Titan rocket, and therefore could clearly be operational before NASA built its more versatile Apollo spacecraft. While the National Aeronautics Space Council was agonizing over the decision, speculation was that the Air Force would orbit the first manned space laboratory and that NASA would take over the program at a later date.

One, two . . . But with such an expensive project, whoever is first is usually second, too. The thinking is that once the military develops the hardware and the skills necessary for MOL, it will also be called on to orbit purely scientific laboratories. Apollo equipment would eventually be used—but by the Air Force.

Secretary of Defense Robert S. McNamara let the Air Force begin studies on MOL when he canceled the Dyna-Soar space glider program in December 1963. Yet he never gave a go-ahead for anything but studies.

McNamara never warmed up to the program. The decision to go ahead was in the hands of the Space Council, which is headed by Vice President Humphrey; but there is speculation that President Johnson did more than merely approve the council's recommendation—he may have made the decision himself. Gen. Bernard A. Schriever, head of the Air Systems Command, will direct MOL.



Manned orbiting laboratory will be made up of Gemini spacecraft with a cylindrical section 30 to 40 feet long added for instruments and crew space. One company has proposed a central "transtage" which would carry extra fuel and supplies.

The first stage of MOL will consist of two unmanned and five manned launches. The timing of the announcement—on Aug. 25, while Gemini 5 was still orbiting the earth—indicates that the Gemini achievements were a decisive factor in the decision. Any disappointed NASA officials might ponder that it was their own success in demonstrating that astronauts can perform well in space, and can see and report on objects on earth, that helped the Air Force carry the day.

Month in space. The first unmanned flight will come late next year or early in 1967. It will test launching, recovery and some basic elements of the system. In 1968, a fully equipped unmanned laboratory will be launched, and later that year the first of the five two-man laboratories will go into orbit. The first bloc of manned MOL flights will run into 1970. All flights are expected to last at least 30 days and possibly as long as two months.

The Douglas Aircraft Co. was selected to develop the laboratory canister, which will be 10 feet in diameter and 30 to 40 feet long. Approximately 1,000 cubic feet of the laboratory will be pressurized, so that the astronauts can live in a "shirtsleeve" environment. The balance will house supplies and logistic equipment.

The development of experiments and the integration of the laboratory with the Gemini spacecraft and the Titan 3C booster will be done by the General Electric Co.'s

Space Technology Center at Valley Forge, Pa.

Though the experiments have not yet been clearly defined, it is known that one of them will be for the astronauts to assemble a 100-foot antenna in space, to be tethered to MOL. This will be a radar sensor. Another experiment calls for attaching a large telescope to the outside of the laboratory for earth observations and photography. The reflecting telescope will have a mirror as large as 75 inches in diameter. Some of the orbiting photographic equipment would have resolutions of two or three feet.

Other experiments will consist of infrared measurements and weather reporting. The Navy wants some tests run for submarine detection and worldwide fleet movements.

Eyes over Russia. For the first time, manned space flights will be sent over the Soviet Union. Gemini 5 crossed Red China, but not Russia. Launches will be made from both Cape Kennedy and Vandenberg Air Force Base in California; the military won't say how many launches will be made at each site, however.

Adapting the Gemini capsule for MOL consists mainly of cutting a hole in the heat shield so that the astronauts can transfer from the Gemini into the laboratory.

The Titan-3C booster that will launch the 25,000-pound payload into space was developed by the Martin Co. and the United Technology Center for just this mission. Thus it does not require modification.

Neither the Pentagon nor the contractors will speculate on how the $1.5 billion will be divided; but informed sources estimate that about a third of the money will go to Douglas, and a third to General Electric, with the remaining third split between McDonald and Martin-UTC.

To date, the Pentagon has spent about $30 million on the MOL program, largely for studies. It has $150 million funded for the current fiscal year. Officially, the Pentagon says it won't seek any supplementary budget money for the project, but it does not rule out some internal transferring of funds. The big spending year for the program is generally expected to come in calendar year 1967.

Beyond Apollo. Even before the MOL announcement, it was apparent that NASA had dropped serious plans for a manned orbiting laboratory around earth. In hearings before the Senate Space Committee last week, top NASA officials, including administrator James E. Webb, made it clear that they have set their sights on interplanetary space exploration in the next 10 to 15 years. The officials talked of unmanned and manned probes to Mars, Venus and other planets as goals beyond the manned lunar landing, even though that landing is still four to five years off. Though near-earth and lunar exploration projects are being considered, it was the interplanetary area that received the emphasis.

What Gemini proved

Astronauts Charles Conrad and Gordon Cooper demonstrated what President Johnson had believed all along: man has a military role in space. Although the National Aeronautics and Space Administration has been hesitant to talk about them, the handful of military experiments that the astronauts conducted showed that, with the aid of electronics, a man in orbit could keep watch on the earth below.

Keeping watch on spacecraft

The Gemini-5 pilots were able, among other things, to spot two launchings of Minuteman ballistic missiles and a test firing of a rocket sled. In addition, they were able to take what Conrad described as "scenic shots" of Cuba during a pass over that island.

The Pentagon acknowledged that its experiments were designed to learn man's "threshold of sensitivity" in spotting targets in space and on the ground. NASA, however, said little about the experiments, except that most were successful.

Detection gear. Here's some of the electronic gear for military detection that the astronauts used in the spacecraft to test the effectiveness of a possible spy-in-the-sky role.

- To detect radiation from cold bodies in space—either spacecraft or planets—the military designers developed a supercooled interferometer spectrometer. Although the instrument was only running for 17 minutes, Air Force officials said it performed perfectly. During its short period of operation it picked up infrared radiation in the 8- to 12-micron range from a pod that was ejected earlier in the space flight. Conventional detectors can't pick up radiation in that narrow region. To operate in that range, the instrument was cooled to —397°F.
- To detect radiation from hot bodies—such as missile exhausts and cities—the military scientists designed an instrument package containing a radiometer and interferometer spectrometer. Together, they detected radiation in the 1.3- to 12-micron range.

In almost every way the flight was a huge success. It proved how effectively space officials can design around a failure. The trouble with heaters for the fuel cells, for example, caused a cancellation in the plan to rendezvous with an electronic radar pod that had been ejected into a slightly different orbit early in the flight. To make up for this loss, NASA officials put an imaginary vehicle into a hypothetical orbit, transmitted the data to the spacecraft and the astronauts were able to maneuver close to the phantom target.

Components

Charge it

The development of rechargeable nickel-cadmium batteries gave the portable tool and appliance market a big boost. One drawback, however, was the length of time it took to recharge the batteries—up to 12 hours. Now a special diode introduced at Wescon by the P. R. Mallory Co. cuts the charge time down to slightly more than one hour. The device abruptly cuts off the charging voltage when the battery reaches full charge.

Slow way. In a conventional system, the current running into a battery is kept low, a high current would damage the battery if it continued to flow after fully charging the battery. Low current into a fully charged battery is dissipated as heat and doesn't harm the battery.

Amp-gate diode. The Mallory device, called an Amp-Gate Diode, consists of two or more p-n junctions in series. The voltage-temperature curve of the diode is very similar to the voltage-temperature curve of a nickel-cadmium cell during recharging. In addition, the diode has a very sharp forward-breakdown characteristic. Thus, when the cell reaches full charge, the characteristic voltage trigger the diode, providing a low impedance path around the cell. This shunts the charging voltage through the diode and cuts off current to the cell.

Mallory's first units consist of two 0.7-volt junctions in series, making a 1.4-volt diode, equal to the voltage of most nickel-cadmium cells. The company also makes a 0.4-volt junction and any combination of 0.4- or 0.7-volt junctions may be used to match any cell voltage.

Computers

Portable accuracy

A lightweight analog computer with the dynamic range and accuracy of a large computer will be offered next January to the educational and medical research market by the Systron-Donner Corp., Concord, Calif. The computer will cost $8,000 and will be accurate to within 0.1%. It weighs about 100 pounds and measures 24 by 15 by 25 inches.

James R. Cunningham, the company's electronics division marketing manager said the full plus or minus 100-volt operating range provides increased accuracy. Other portable analog computers, he says, only offer a 10-volt range.

Fast, safe charging, say industry experts, will boost the portable equipment market past $500 million a year.

Litton's logic

Undaunted by its inability to get the Phoenix-missile computer project off the ground [Electronics, June 14, p. 41], Litton Industries, Inc., is trying its luck with a new computer for aircraft and missile command and control.

In a way, Litton is putting the Phoenix pieces back together. The new L-304 uses the same integrated circuits that Phoenix did and the construction is similar.

Vive la difference. "Our experience on the Phoenix computer project helped," says C. Gordon Murphy, Data Systems division president. "Only the logic is different." Litton says it spent $2 million of its own money over the past two years developing the difference. The L-304 engineers had greater design freedom than the Phoenix designers who had "to pursue a conservative design to meet both the specifications and a tight schedule," adds a company spokesman.

The L-304, a general-purpose prototype of a custom-designed series, will be shown Sept. 15 at an Air Force Association aerospace development briefing in Washington. The computer weighs only 27 pounds and takes up 0.3 cubic feet of space.

Fewer instructions. A key feature of the new design is the L-304's ability to handle instructions rapidly and operate on fewer instructions—40% fewer per program than other systems, Litton says. For example, a single instruction sets up a logic gate for an application such as tracking a target by means of gated comparisons. Four sets of instructions are used to check the target—in the gate, out of it, below or above it.

As a good command and control computer should, the L-304 can handle many (64) independent programs, can interrupt one program to run another of higher priority and can retain data in the memory if power should fail.

To switch from one executive program to another takes 10 microseconds, an addition 6.3 microseconds, a memory read-write cycle 1.8 microseconds.

Memory modules contain 4,096 or 8,192 words 32 bits long and an additional 254,000 words can be added.

Microcircuits. The L-304 is built with LINC (Litton integrated NOR circuits) circuits that the Fairchild Camera & Instrument Corp. custom-designed for the Phoenix computer. The Philco Corp. is also a Litton-qualified manufacturer. Litton says Texas Instruments Incorporated, Motorola, Inc., Sylvania Electric Products, Inc. and General Micro-electronics Co. are testing LINC's. They'll be made available to any computer manufacturer. Sylvania is a subsidiary of the General Telephone & Electronics Corp.

The L-304's mostly microelectronic power supply stems from one designed under a Navy contract [Electronics, March 22, p. 38] for use in avionics systems. It includes some discrete components, as do the memory circuits.

Bureaus, not books. The Phoenix's eight multilayer-circuit-board logic assemblies were packaged like leaves in a book. The L-304's three logic boards, and the other subsystems, slide in and out of a housing like drawers in a bureau. Otherwise, the packaging is similar. Nine daughterboards, each carrying 30 circuit packages, go on each side of a motherboard. The boards are multilayer types made by plating conductors on insulating layers. Heat generated by the circuits goes through solid copper pins, 0.050 inch in diameter, plated in the daughterboards, to copper plates on the motherboard and then to heat exchangers. Conduction cooling and a sealed housing, Litton points out, keeps the computer moisture-proof.

The cooling is so efficient that the computer can operate under boiling water, Litton says. As long as the external temperature is below 110°C, the silicon device temperature limit of 125°C will not be exceeded inside the computer.

Come again?

Time-sharing computers are busy machines. Questions pour in from a number of sources, and if a query is unclear or misstated, the computer has to waste time asking the questions. A smaller computer could do that job adequately and at less cost. In a project at the University of Pennsylvania, a small computer has been used between the questioner and the central processor to act as a filter, so that before a question gets through to the big computers, it is stated correctly.

John Carr, head of the computer sciences department at the university's Moore School of Electrical Engineering, maintains that such a technique has advantages far beyond its obvious economies. For example, with the central computer protected from badly stated questions, even an untrained questioner can carry on a "conversation" with a time-sharing computer system. In addition, the computer system can lead the questioner to the data he wants, much as a librarian helps a student.

Traffic cop. The university's people contrast this technique with conversational time-sharing systems, such as the Massachusetts Institute of Technology Project MAC. That system's peripheral exchange unit (an International Business Machines Corp. 7750) acts like a traffiic policeman. It directs the questions to the central computer, but it can't ask the questioner to rephrase or rethink an inquiry.

Penn's peripheral computer is a PDP-5, made by the Digital Equipment Corp. It is currently being used in a number of projects that take advantage of its "editing" function.

Dialogue. David Lefkowitz, an assistant professor of electrical engineering at the Moore School, is working on an information retrieval project called CIDS (for chemical information data system). His goal is to design a system that gives only the answers that the questioner really wants. For example, if he asks what chemical compounds have melting points above 55° centigrade, the peripheral computer may warn him that there are several hundred thousand. The questioner can then restrict the answer by saying "Limit that to inorganic compounds." Further dialogue could narrow the field still more. When the scientist and the computer agreed on the limits of the question, it would be passed on to the central computer, which would provide formulas, physical and chemical properties, and all known names—including brand names—of the chemicals.

Morris Rubinoff, a professor of electrical engineering, is developing an information retrieval system called Project Vector that would be simple enough for a high school student to use. He would ask his questions through a teleprinter at his school, and zero in on the answer in an exchange with the peripheral computer at the data center.

Noah Prywes, associate professor of electrical engineering, is working on the use of the system as an aid in heuristic problem-solving. In such an approach, the scientist attacks a problem by leaning heavily on intuition, rather than by following strict mathematical steps. A conversation-mode computer is a prerequisite for this approach.

Consumer electronics

Better image

A broker on the floor of the New York Stock Exchange can follow the ticker by glancing at one of the huge screens suspended from the ceiling. But the ticker tape is flashed onto the screens by an opaque projector—a system of mirrors and lenses—and ambient light washes out many of the images. The exchange is now experimenting with an electronically controlled display to give brokers a clearer image of the Big Board.

One 45-foot-long board, designed and built by Recognition Equipment, Inc., of Dallas, was recently installed by the exchange; and the company hopes its equipment will eventually replace the remaining five old-fashioned screens. In addition, the company hopes to install scaled-down versions of the board in the thousands of brokerage houses around the country.

Flipped disk. The board is actually an endless moving belt covered with 23,000 plastic disks, ⅞ of an inch high, that are black on one side and yellow-green on the other. Each disk covers a hole in the belt.

Stock market's ups and downs are projected brightly and clearly by new ticker-tape board.

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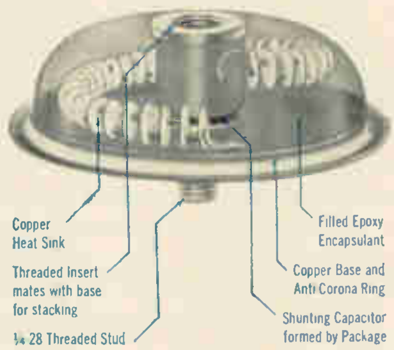

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As the belt moves from right to left at ticker tape speeds, electronically controlled air jets on the extreme right of the board flip the disks from their black side to their colored side. The disks are flipped, row by row, to form seven-inch-high letters or numbers representing stocks, selling prices and sales volume. The display is washed with ultraviolet light, causing the green-yellow disks to glow brightly. Air jets on the extreme left side flip the disks back to their black side, erasing the characters.

The electronics are all solid state components on 75 plug-in printed circuit boards in a separate cabinet. Most of the circuits are character-decoding matrixes which change the standard teletype signals sent over the ticker-tape network into pulses to operate the air jets.

The rate at which characters are formed and move across the display is servo-controlled so that the speed varies with the market activity. When information starts to come in at a faster rate, variable delay buffers store it until the speed of the belt can be adjusted. The display will form up to 900 characters a minute, matching the present high-speed ticker.

Special messages to the trading floor can also be fed to the sign with punched tape without putting the message on the ticker network.

These flash photographs were all taken at f:4. The secret is the new Honeywell electronic flash, which automatically gives more light for distant subjects, less light for close subjects. Distance of the left photo was 12 feet, of the center 4 feet, of the right 18 inches.

Quick as a flash

Automatic cameras, with photocells that adjust the lens aperture to the amount of light available, have been a boon to neophyte photographers. But the photocells won't work for flash photography; they can't adjust the aperture in the time it takes a flashbulb to pop, which is measured in thousandths of a second.

Honeywell, Inc., has come to the rescue of amateur and pro alike with a new strobe flash unit. The photographer can adjust its light output to suit the aperture, rather than the other way around.

With a conventional flash unit, a photographer must estimate the distance to his subject and divide it by a guide number to obtain the correct f stop. The guide number relates film speed, distance and aperture. With Honeywell's unit, called the Auto-Strobonar 660, he makes a single aperture setting based on film speed, and adjusts the strobe for that setting. Then he can shoot objects between 2 and 23 feet away without touching the lens except to focus.

Quick sensing. The strobe unit regulates the amount of light by varying the duration of the flash. Since there is no manual setting necessary for the distance of the subject, the strobe obviously makes some rapid adjustments itself.

It does so by measuring the amount of light reflected by the subject with a cadmium sulfide cell. This sensor has a field of view of only 12°; hence it picks up light from only the center of the subject. (Because this reflection is affected by ambient light, the cell will take the room lighting into account.) The cell is connected to an integrating circuit that amplifies the reflected light and operates a trigger to turn off the flash when the correct exposure has been reached.

The duration of the flash will vary from about 1/1,000th of a second—about standard for a strobe flash—to 1/50,000th of a second, depending on the distance from the light to the subject.

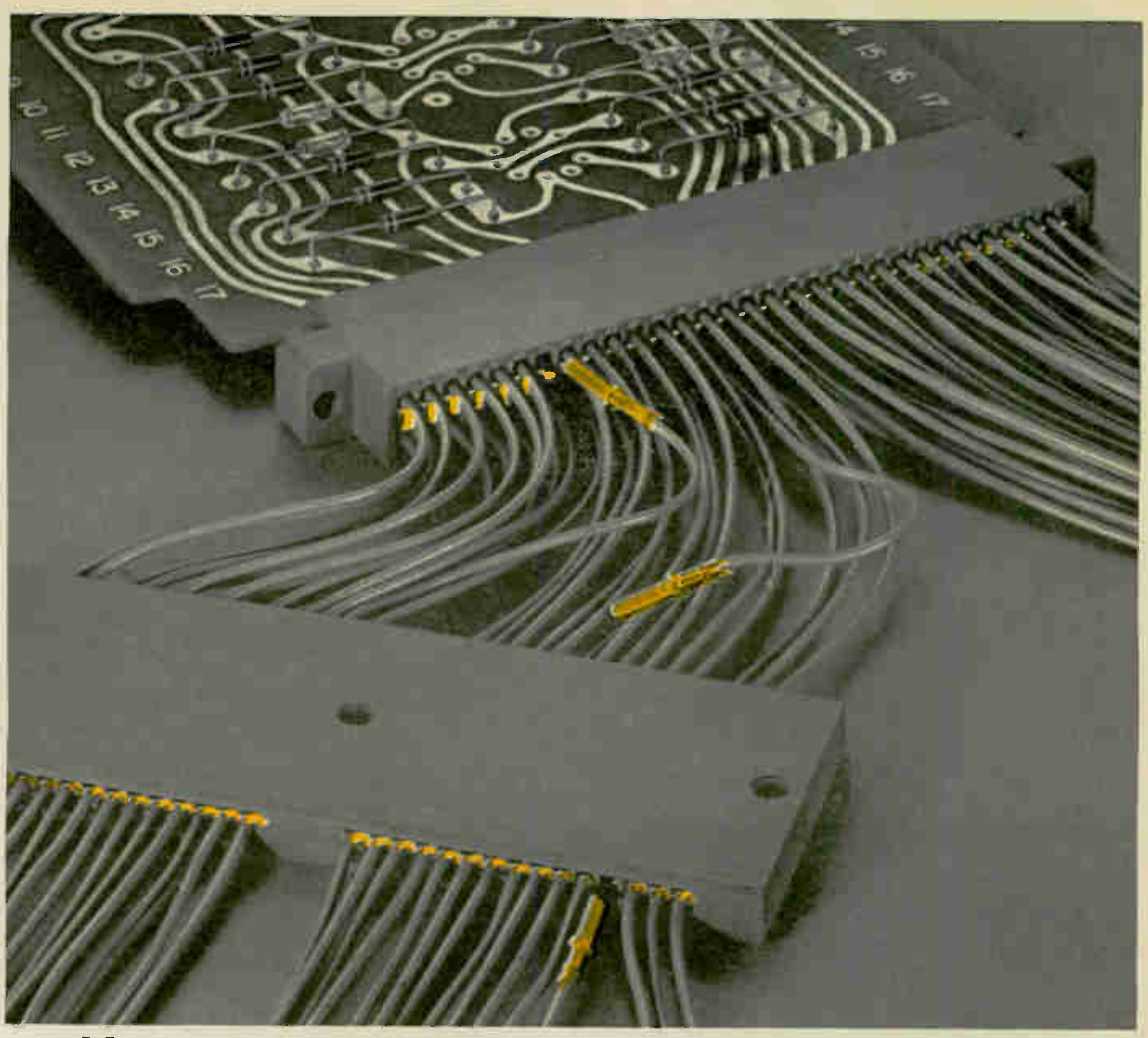
The method of turning the flash off is ingenious. Since the flash tube requires high voltage and current (500 volts, 200 amperes) Honeywell uses a condenser to build up sufficient charge from the strobe's batteries. At full operation, the unit is designed to provide enough power to operate the tube for 1/1,000 of a second. But when less light is needed, the excess charge on the condenser is shunted to another flash tube, one of low resistance, which is hidden in the strobe. Its light doesn't get out of the case.

The 660 will sell for $129.50 with a battery charger. It will automatically compensate for slave flash units and can be used for ultrahigh-speed pictures previously possible only with the most expensive industrial flash equipment.

Medical electronics

Backpacks for baboons

Not far from the slopes of Kilimanjaro in Kenya this summer a band of baboons roamed freely through the bush, eating fruit, scampering up and down trees and occasionally fighting with each other. Strapped to the backs of four of the animals were small packs crammed with telemetering equipment and batteries. Hidden in a nearby clump of trees, researchers in a truck equipped with electronic re-



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INDUSTRIAL SALES DIVISION

A-MP★ products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • Mexico • West Germany ceiving gear were observing the baboons' responses as part of a heart-research project.

Tiny transducers to gauge blood pressure and the rate of blood flow—vital measurements in the study of heart reactions—had been surgically imbedded in the animals. The scientists—from the Scripps Clinic and Research Foundation and the Regional Private Research Center of the University of Washington—selected baboons for the study because their cardiovascular responses are more like man's than those of the usual laboratory animals.

While they slept. The instrumentation for the experiment included Doppler flowmeters and pressure transducers that were attached in and around the baboons' arteries. Also implanted in the animals were tiny capsules of anesthetic that burst open when triggered by radio signals; in this way the baboons could be put to sleep after the batteries in the backpacks had run down, and the equipment recovered. Much of the gear was developed by Dean L. Franklin, chief of biomedical engineering at Scripps.

The flowmeter consisted of a plastic cuff with two piezoelectric crystals attached to the outside of a blood vessel. One crystal emitted a continuous five-megacycle signal diagonally through the blood vessel, while the other crystal placed along side the first, picked up the backscattered signal that passed through the moving blood. The speed of the blood was calculated by determining the Doppler shift of the signal. Exciting the sending crystal was a low-power oscillator, while the backscattered signal was detected by a five-megacycle tuned r-f amplifier. Both were situated in the backpack.

A baboon's blood pressure was measured by a miniature pressure gauge inserted inside an artery and attached to a wire slipped through the wall of the blood vessel. The gauge was excited by a six-volt source situated in the backpack.

The output of the pressure meter was coupled to a voltage-controlled oscillator (standard for IRIG Channel 13). The output of the flowmeter was summed with the oscillator and the resultant signal then modulated the frequency of a vhf oscillator-transmitter that operated at about 260 Mc, generating an f-m/f-m signal that was radiated to the remote receiving gear.

Tuning in. To pick up the telemetered information, the 260-Mc signal was heterodyned down to 100 Mc so that a standard commercial f-m tuner could be used as a receiver. The output of the receiver was coupled to a channel 13 bandpass filter to extract the pressure information and into a low-pass filter to extract the flow information. Outputs of both filters were coupled to appropriate discriminators to restore the original measured information.

Some of the backpacks included radio-controlled switches that could turn various transducers off and on; in this way measurements could be made at various arteries one at a time, and power could be turned off to conserve the batteries. The batteries had a life of 300 hours, so most of the baboons were under observation for about two weeks at a time.

Because of the limited number of channels, the researchers could only receive data from four baboons at a time. In all, 12 baboons were fitted with the equipment during the team's two-month stay in East Africa.

On camera. Most of the animals remained near the communications track, but when a baboon did wander off, he could be tracked down with homing gear.

In future experiments the researchers plan to train hidden television cameras on the baboons so that visual and telemetered biological data can be collected simultaneously and compared.

Manufacturing

Circuit stapler

Borrowing an idea from the razor-blade industry, the Fairchild Camera & Instrument Corp. plants to offer a low-cost tool to encourage use of the company's integrated circuits. The tool will take circuits from an injector package and plug them into printed wiring boards three times as fast as they can be inserted by hand.

The machine will be sold by Fairchild's semiconductor division for about $100. It will insert only the Fairchild type of industrial dual-in-line package, called DIP [Electronics, Aug. 23, p. 118].

Makers of circuits whose package dimensions differ from Fairchild's will have to develop their own machines, Fairchild says.

There may be competing models. Texas Instruments Incorporated says it plans to offer special tools soon, and Sylvania Electric Products, Inc., a subsidiary of the General Telephone & Electronics Corp., says the insertion of its new DIP's can be automated readily.

The Fairchild machine is being developed by the Technical Devices Co. of Culver City, Calif. It looks like a sewing machine and works like a stapler. Packages drop into an insertion head from a shipping container that holds 36 DIP's. The operator aligns the package pins with the insertion holes in the circuit board, with the help of a transparent pattern on the head. When a lever is pulled, the machine holds the board in position and inserts the DIP. It inserts more than 10 circuits a minute.

Electronics notes

▪ **Color display.** The National Aeronautics and Space Administration has awarded the Philco Corp. two contracts to develop an experimental color television display system for possible use in the mission control center of the Manned Spacecraft Center in Houston. Under separate contracts, Philco will develop a system to convert digital signals to color displays, and a color-tv monitor. Most of the tv displays in the control center are

Circle 41 on reader service card

Electronic Notes

now black-and-white. Besides displaying telemetry and other data in color, a possible application of the system might be the display of real-time motion pictures from future manned missions to the moon and other planets.

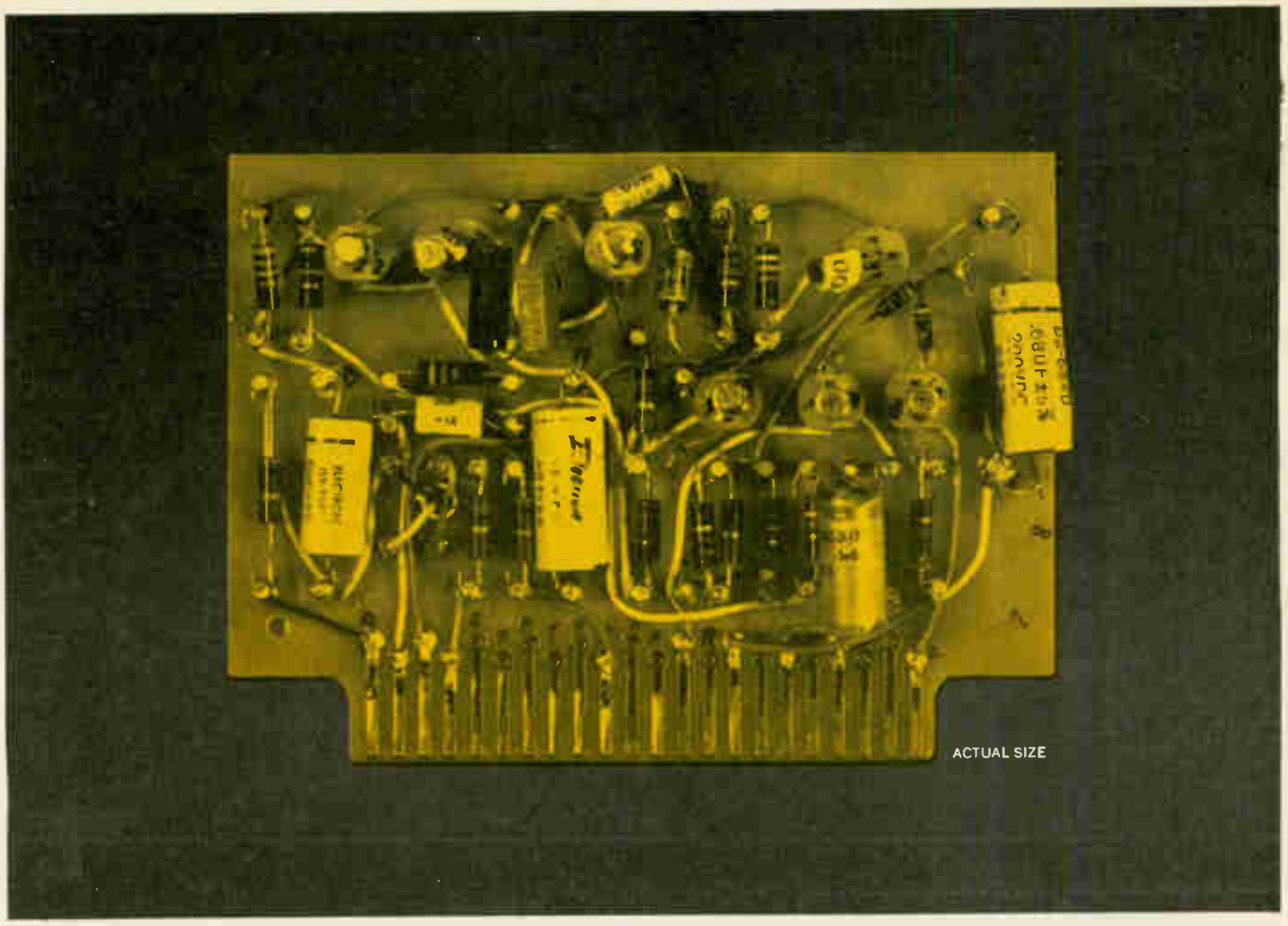
▪ **Gold anchor.** The nickel layer generally used to anchor gold plate to molybdenum can adversely affect semiconductor devices. The Bell Telephone Laboratories reports that nickel isn't needed if the molybdenum is oxidized with hydrogen peroxide. Gold plate penetrates the oxide pores. After the oxide is reduced with hydrogen at 900°C, the gold and molybdenum are locked together and the plating can be built up.

▪ **Monolithic arrays.** Two companies in addition to those previously reported [Electronics, Aug. 23, p. 40] are bidding for an Air Force contract to develop a computer made of large arrays of monolithic circuits. The General Electric Co. has submitted a proposal and the Sperry Utah Co., a division of the Sperry Rand Corp., is making a joint proposal with the Fairchild Camera & Instrument Corp.

▪ **Growing numbers.** There is now a Model 44 in the burgeoning line of System 360 computers manufactured by the International Business Machines Corp. IBM calls this the ninth in the series which currently includes the previously announced Models 20, 30, 40, 50, 65, 67, 75, and 92 in order of size.

Actually the new model is the 14th in the System 360 line; Models 60, 62, 64, 66 and 70 have already become obsolete.

The new machine is a small, fast scientific machine, equivalent in performance to IBM's older 7094, but much cheaper. It has up to 131,072 bytes (32,768 words) in its memory, which operates with a one-microsecond cycle. The machine may be purchased for $220,000 up, or rented for $5,500 a month up, depending on the type of optional equipment selected. The 7094 rented for about $70,000 a month.



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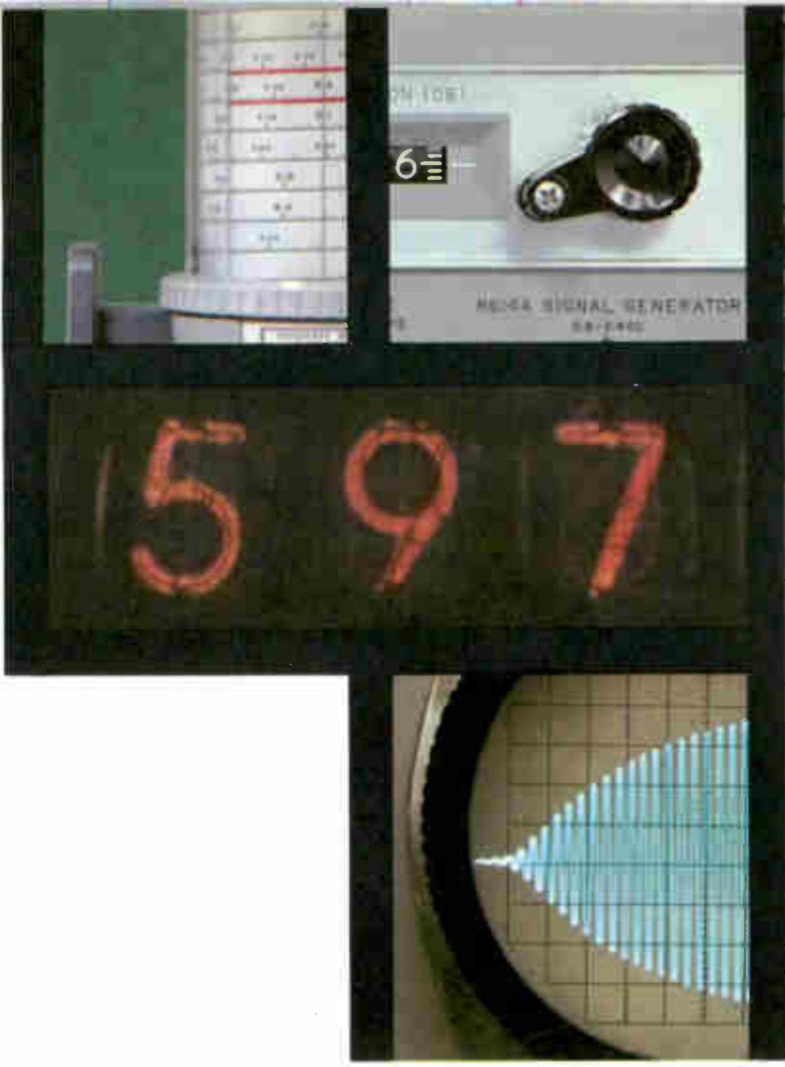

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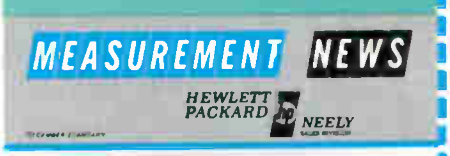


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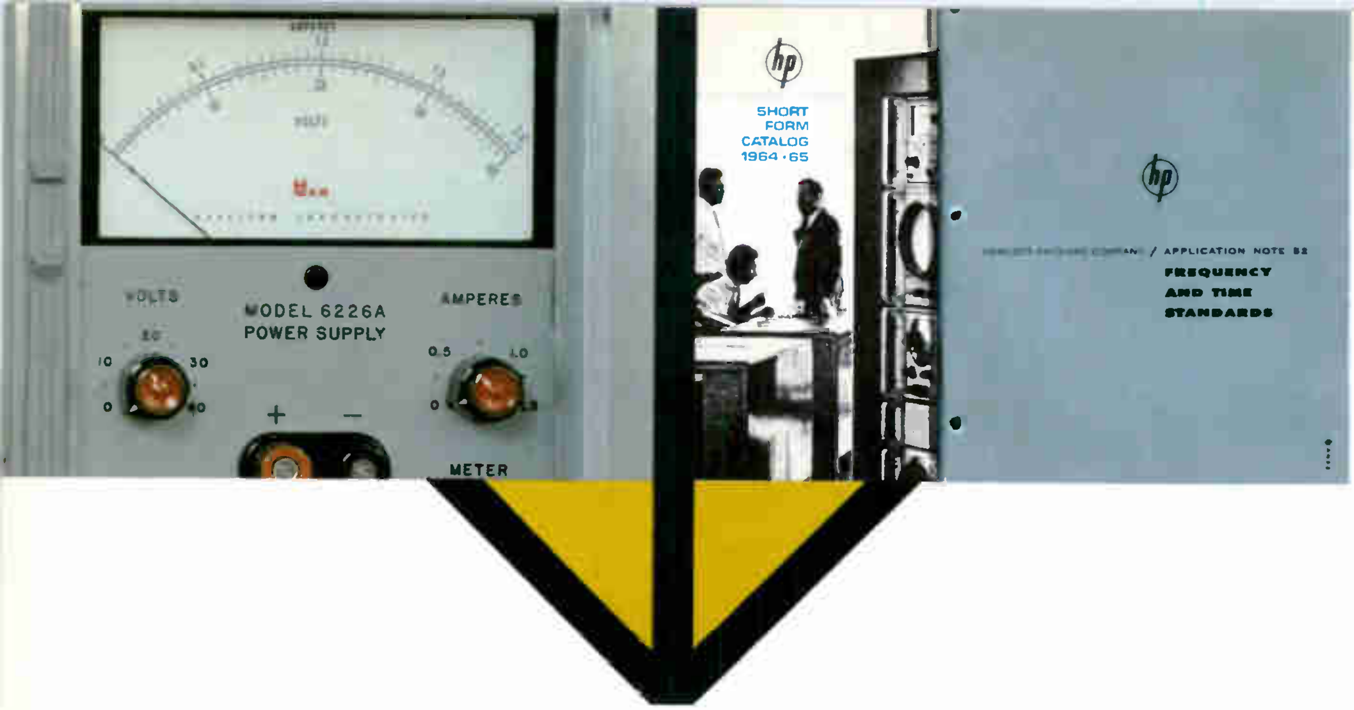

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Washington Newsletter

September 6, 1965

Congress raps Aerospace, weighs role of nonprofits

The Defense Department is under pressure from Congress to lessen its reliance on nonprofit companies that perform complex planning and management chores. Having completed an investigation of the Aerospace Corp., a special investigations subcommittee of the House Armed Services Committee is considering a broad reexamination of the need for nonprofits in the defense and space field.

The subcommittee accused Aerospace of wasting millions of dollars, and questioned whether the Air Force needs it any longer to manage missile and space programs. Nevertheless, the Air Force plans to give Aerospace the job of systems engineering and technical direction for the manned orbiting laboratory (MOL).

The subcommittee made no attempt to appraise Aerospace's achievements but Air Force Secretary Eugene M. Zuckert said these achievements have been "of incalculable value" and that Aerospace should not be judged solely on the basis of a small part of its operations. The Air Force is making its own review of the role of the nonprofits.

Both the subcommittee and the House Appropriations Committee feel that the time has come for the Pentagon to reduce its reliance on nonprofits and begin turning over their work to in-house organizations and to commercial contractors. The Defense Department has clamped annual fund ceilings on the major nonprofits to halt their growth, but it has not adopted a fixed policy of cutting their workload of phasing them out within any particular time limit. It will not, however create any new nonprofit companies or "make work" to keep existing ones in business.

The fund ceilings apply to Aerospace, the Mitre Corp., the Rand Corp., the Applied Physics Laboratory of John Hopkins University, and the Lincoln Laboratory and the Instrumentation Laboratory of the Massachusetts Institute of Technology.

Round 2: Stennis vs. McNamara

"Completely erroneous" is the way Defense Secretary Robert S. McNamara describes charges that the Army needs $6 billion worth of equipment to attain the level of combat readiness set for it by the Pentagon.

The figure is contained in an unreleased report of a Senate Preparedness subcommittee. Acting Chairman John Stennis (D., Miss.) says there are substantial shortages of helicopters, communications gear and other equipment. McNamara says the subcommittee is misinterpreting complex data furnished by the Army.

Congress probably will grant McNamara's request for an additional $1.7 billion to speed military deliveries and to offset the inventory drain caused by the fighting in Vietnam. McNamara plans to ask for more funds in January; the amount has not been disclosed, but it probably will be smaller than Stennis thinks it should be.

Military seeking Total-package bids

A buying technique, which combines military hardware development, production and lifetime provision of spare parts in one competitively awarded contract, is gaining acceptance at the Pentagon.

The Air Force developed the total-package procurement concept and is applying it to the C-5A transport plane. Now the Air Force has decided to use the technique in procuring the short-range air-to-ground missile (SRAM) and may apply it to the procurement of the Minuteman 2 intercontinental missile reentry vehicle [Electronics, May 17, p. 112].

Proposals for SRAM were due at the Aeronautical Systems division, Wright-Patterson Air Force Base, Ohio, on Aug. 30. The 12 firms invited to make submissions were the Boeing Co., Douglas Aircraft Co., General Dynamics Corp., Hughes Aircraft Co., Lockheed Aircraft Corp., Ling-Temco-Vought, Inc., Martin Co., McDonnell Aircraft Co., North American Aviation, Inc., Northrop Corp., Raytheon Co. and Sperry Rand Corp.

The Army also is contracting on a total-package basis for the avionics system of the light observation helicopter (LOH). And the Navy is looking for a project to which it can apply the technique.

Proposals for the LOH avionics package are due Sept. 13. About 100 firms received bid invitations for 1,825 units.

Patent litigation may change rules

Antitrusters in the Department of Justice want the Supreme Court to reverse a 1926 decision allowing a patent owner to fix prices for products made under his license. Government attorneys will ask the court to decide a case involving a couple of lock-bolt manufacturers, one manufacturing under the other's patent, and will argue against the price-fixing right of the patent holder. The broad question to be decided is how much control a patent holder retains over his licensee.

Waiting in the wings, if the Justice Department wins this one, is another case that will contest the practice, ruled legal 10 years ago by the Supreme Court, whereby patent holders make it a condition of licensing agreements that improvements made in their patents revert to them. The Justice Department will contend that such agreements are an unwarranted extension of the "limited monopoly" which patents convey.

Pentagon to get bids from Britain

Great Britain will be allowed to compete with United States producers of electronics equipment and of noncombatant ships for limited sales to the Defense Department. The Senate has refused to bar the purchase of foreign-built naval vessels after Defense Secretary Robert S. McNamara warned that such a ban would result in cancellation of a billion-dollar British order of F-4 fighter planes, made by the McDonnell Aircraft Corp., and of C-130 transport planes made by the Lockheed Aircraft Corp. The British are expected to bid for contracts to manufacture small ships, also electronic equipment for ships and planes.

Rules on using federal computers will exempt firms

Contractors will probably be exempted from any tightening of regulations on the use of government computers. The Budget Bureau has recommended stringent rules as to when a computer may be rented rather than purchased, and when it must be shared with another company or another government agency. But the agency is expected to accept the exemption of contractors from the regulations.

The House Committee on Government Operations, convinced by the electronics and aerospace industries' arguments, has decided to exclude contractors from the restrictions being written into law. But a committee member declares: "Our vote was less an endorsement of any industry position than it was a vote to postpone the inclusion of private contractors until the points of difference can be resolved . . ."

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QRC20-15	0-20	0-15	± .005% or ± 1 mv	1 mv	0-15	± .05% or ± 8 ma	4 ma	5¼	525.00
QRC40-8	0-40	0-8	± .005% or ± 1 mv	1 mv	0-8	± .05% or ± 4 ma	2 ma	3½	450.00
QRC20-30	0-20	0-30	± .005% or ± 1 mv	1 mv	0-30	± .05% or ± 16 ma	8 ma	7	700.00
QRC40-15	0-40	0-15	± .005% or ± 1 mv	1 mv	0-15	± .05% or ± 8 ma	4 ma	5¼	575.00
QRC40-30	0-40	0-30	± .005% or ± 1 mv	1 mv	0-30	± .05% or ± 16 ma	8 ma	7	775.00

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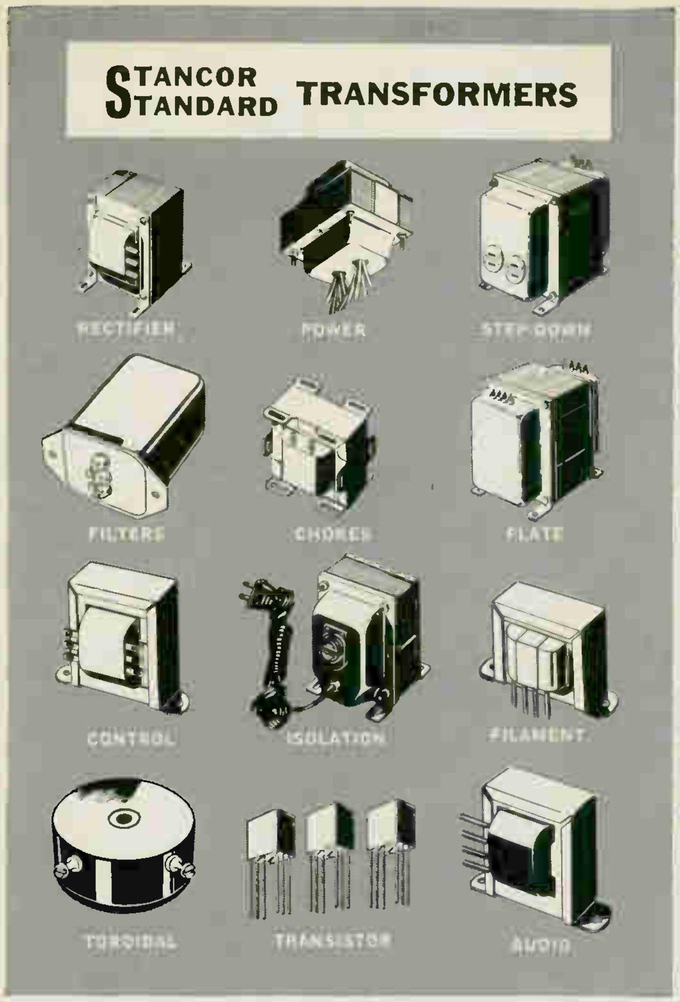

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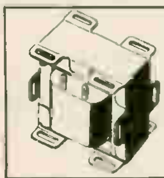

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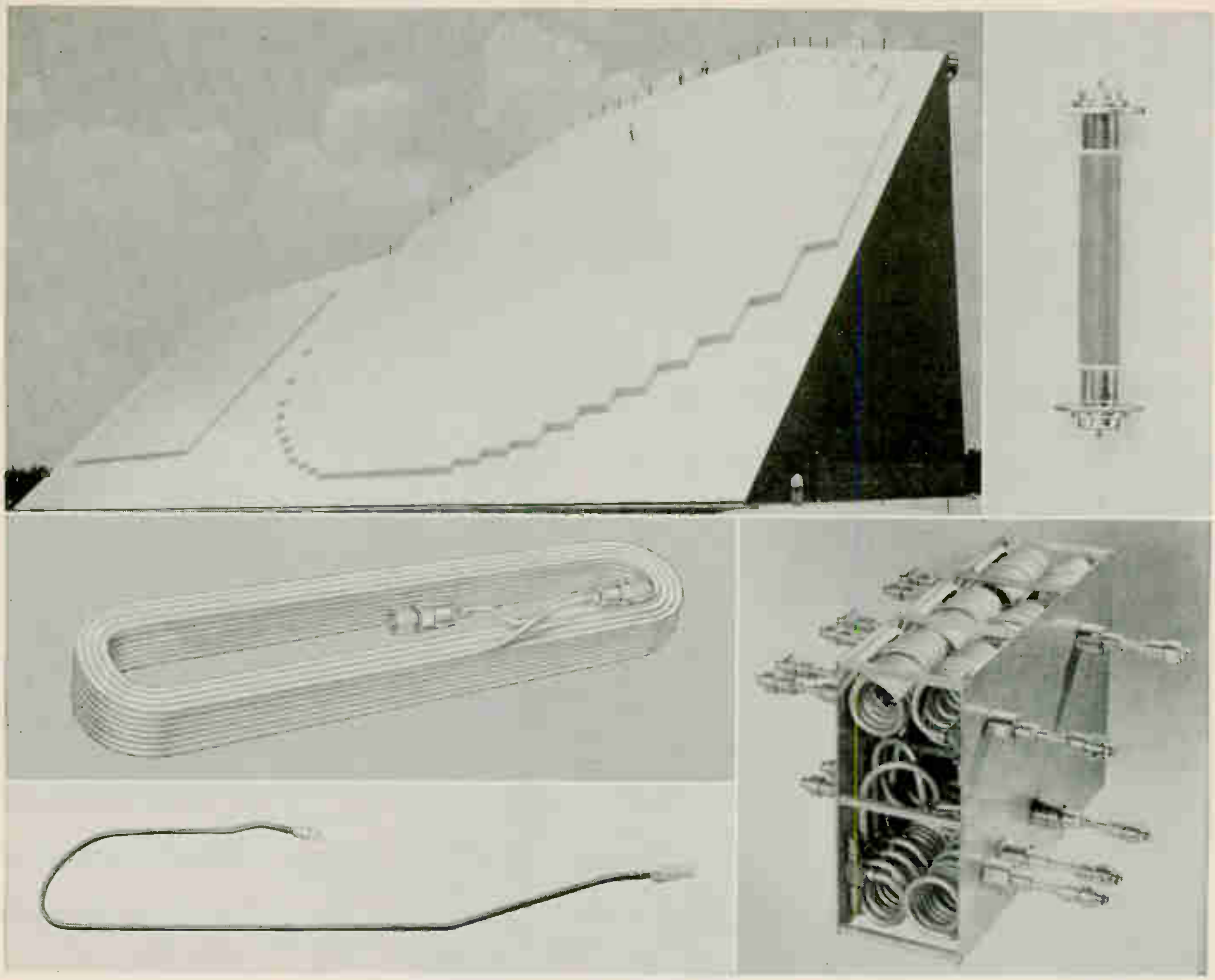

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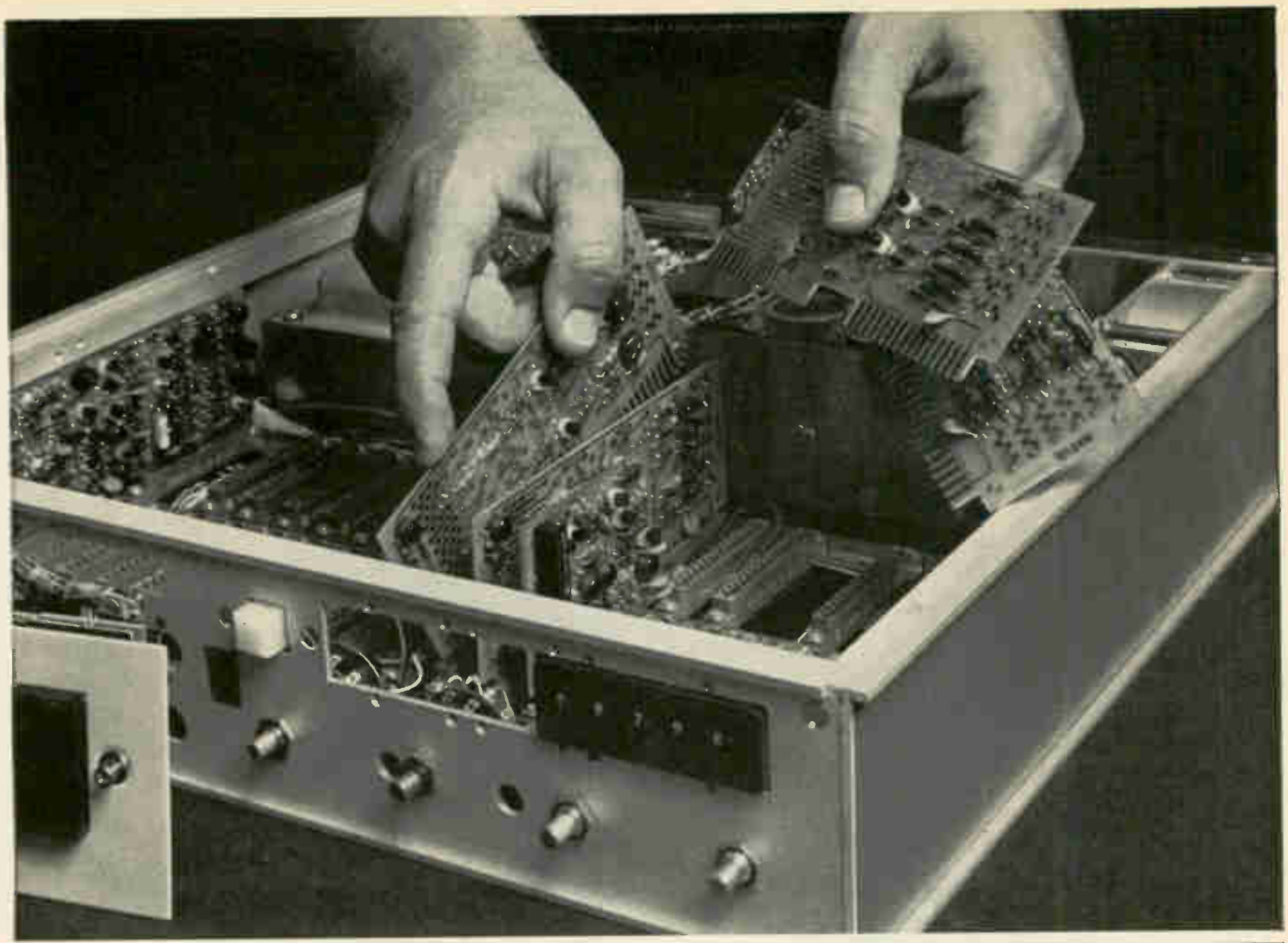

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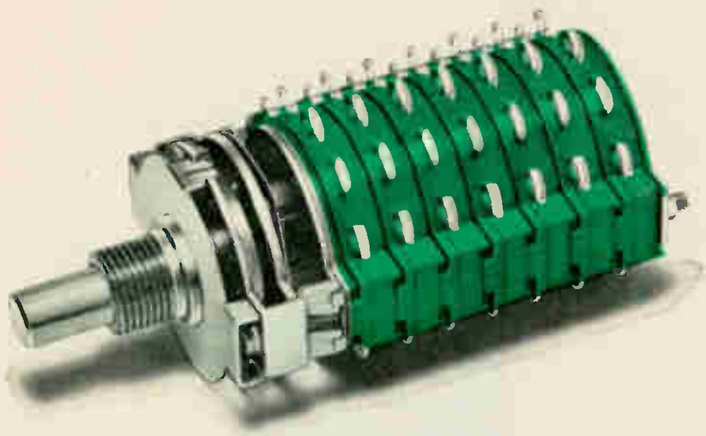

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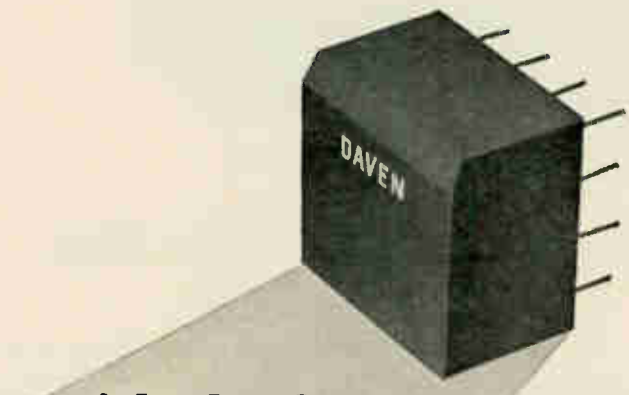

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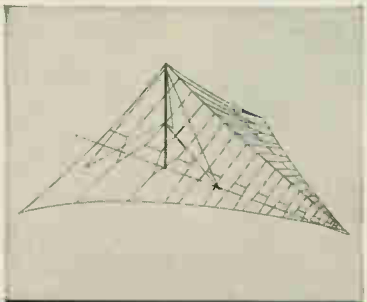

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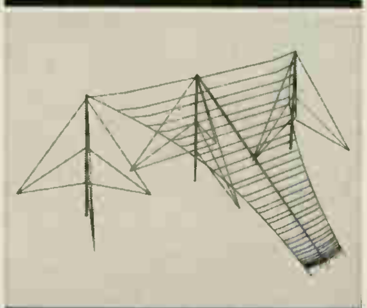

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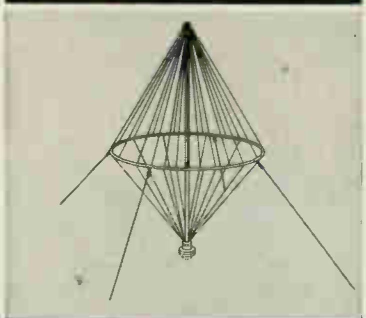

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Antenna Type	Freq. (MC)	AEL Model No.	Polarization	Azimuth B/W	Elevation Pattern: Upper 3 db Point	Elevation Pattern: Lower 3 db Point	Gain	Characteristic Impedance	VSWR	Height
HORIZONTAL										
Fixed	2.5 to 30	APH-A 2.5/30	H	65°	60°	20°	10 db	300Ω Bal.	2:1	150′
Fixed	4 to 30	APH-A 4/30	H	60°	30°	10°	11 db	300Ω Bal.	2:1	250′
Fixed	6 to 30	APH-A 6/30	H	60°	22°	6°	13 db	300Ω Bal.	2:1	220′
2-Bay	6 to 30	APH-B 6/30	H	60°	21°	6°	15 db	150/300Ω Bal.	2:1	300′
Transportable	4 to 30	APH 4/30	H	60°	70°	25°	9 db	300Ω Bal.	2:1	50′
VERTICAL										
Log Monopole	2 to 30	APV-A 2/30	V	110°	30°	5°	10 db	300Ω Bal.	2:1	180′
Dipole	3 to 30	APV 3/30	V	80°	20°	abt. 5°	12 db	300Ω Bal.	2:1	220′
CONICAL										
Monopole	2.5 to 30	ACM 2.5/30	V	Omni	—	—	4 db	50Ω Unbal.	2:1	83′
Monopole	5 to 30	ACM 5/30	V	Omni	—	—	4 db	50Ω Unbal.	2:1	43′
Monopole	10 to 30	ACM 10/30	V	Omni	—	—	4 db	50Ω Unbal.	2:1	23′
DISCONE	2.5 to 30	ADC 2.5/30	V	Omni	—	—	4 db	50Ω Unbal.	2:1	80′
Monopole	3 to 30	ADM 3/30	V	Omni	—	—	4 db	50Ω Unbal.	2:1	70′

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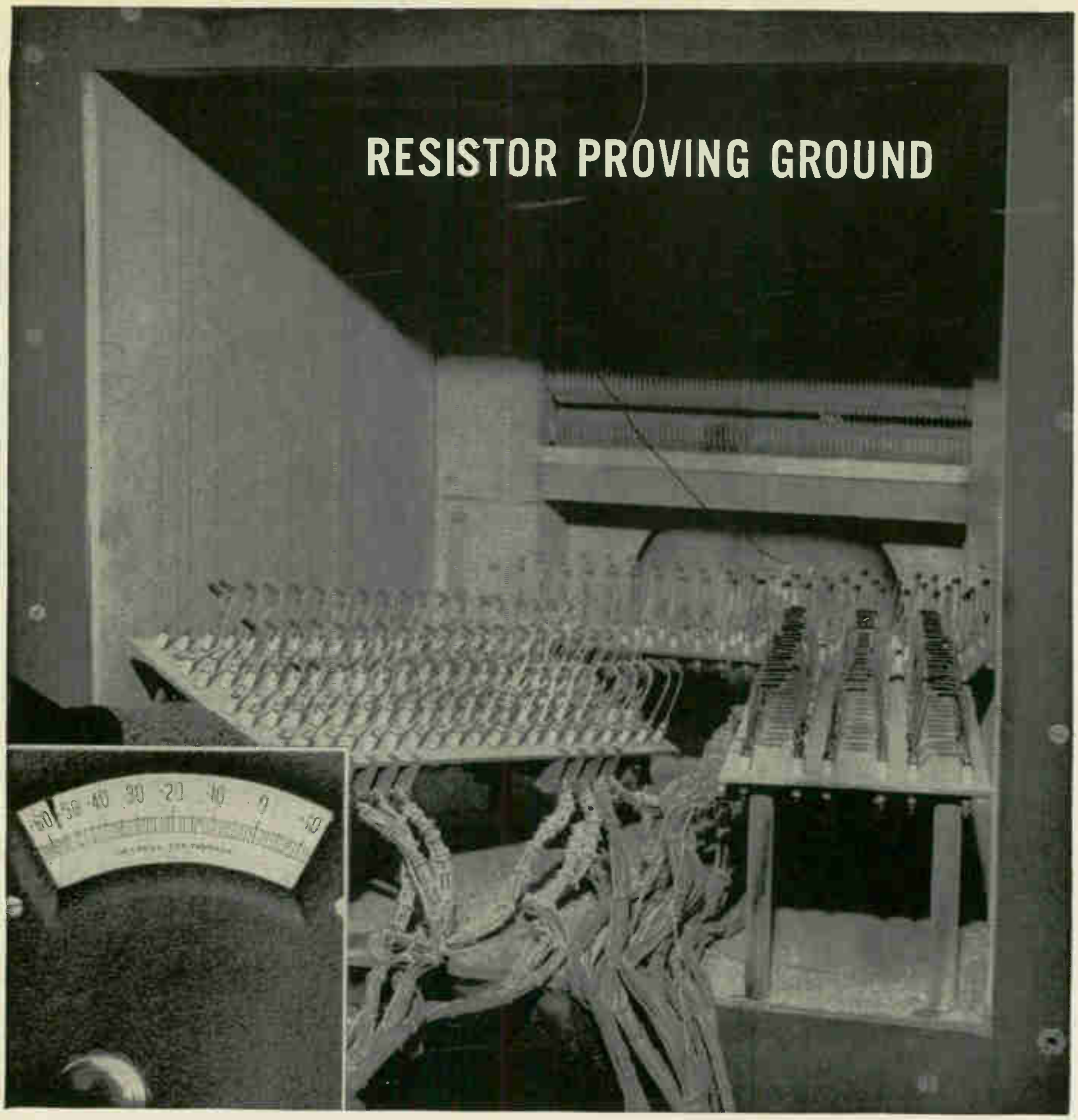

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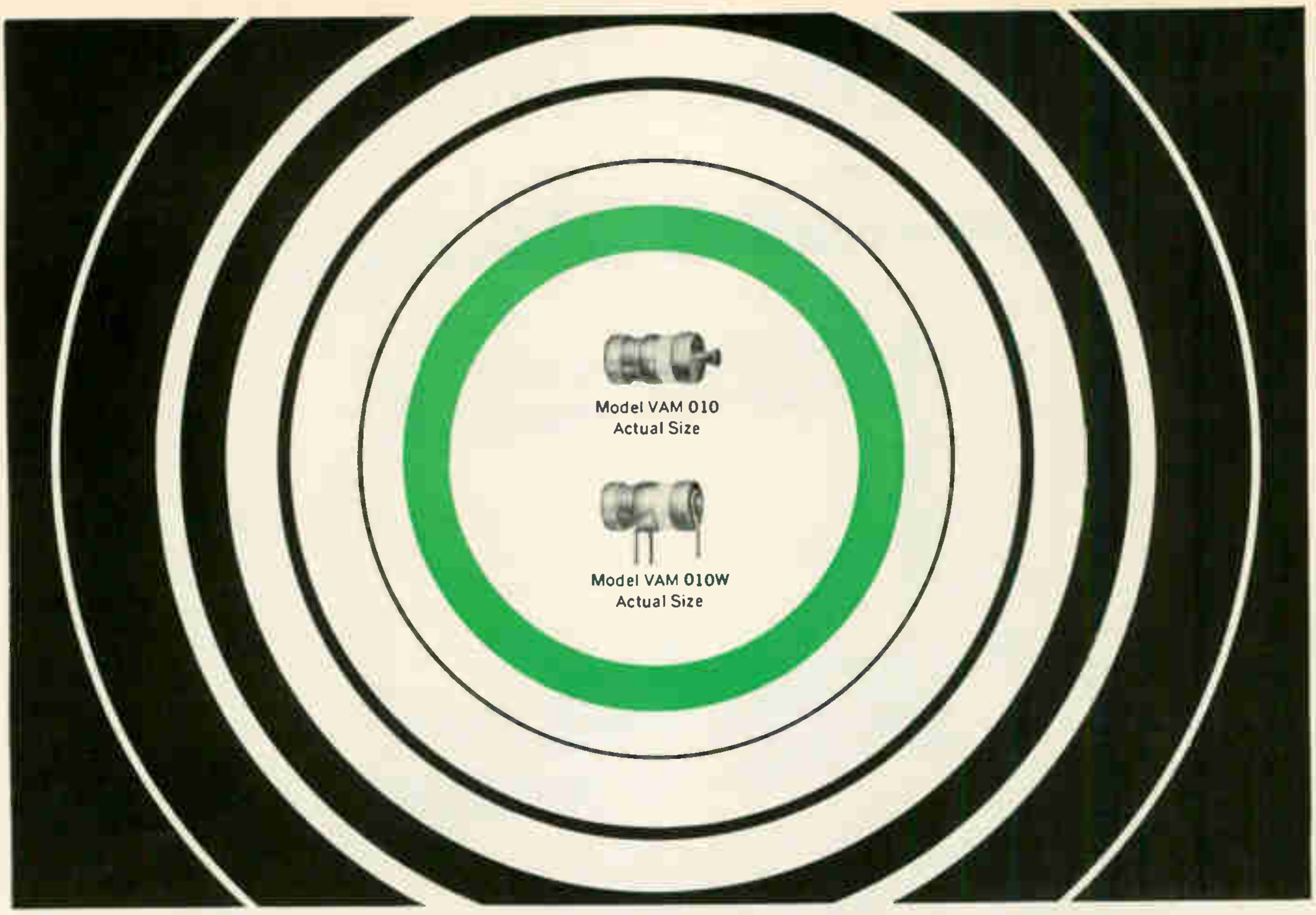

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Technical Articles

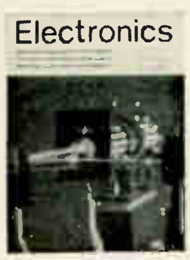
Nomograph pinpoints allowable ripple voltage for capacitors: page 64

The a-c ripple voltage across a capacitor determines its reliability whether the device is used in a missile or a radio. A nomograph and chart printed in this article give an engineer a simple and quick method to determine what is allowable. These aids include consideration of two factors often ignored by designers.

Simple diodes keep voltages constant: page 68

Though zener diodes are recognized as the best component for voltage regulation in most cases, the cheaper simple diode can do an even better job in some applications.

Computing at the speed of light: page 72



The development of the laser as a source of power has led to a whole new class of optical analog computers operating with coherent light. They are used for spectrum analysis and antenna modeling. On this issue's cover, photographer Vincent Pollizotto captured the laser beam of an optical computer's power supply as it made its way between lenses.

Scr's break the frequency barrier: page 88

The silicon controlled rectifier has already won a place for itself in industrial applications, but primarily in 60-cycle-per-second and 400-cps equipment. Now new devices and data enable engineers to use the scr at frequencies up to 50 kilocycles in applications that range from induction heating to very-low-frequency radio transmitters.

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- **Designing null detectors with FET's**
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Nomograph and chart pinpoint source of ripple voltage limitation

Here is a simple, quick method of determining the allowable ripple voltage for polar and nonpolar capacitors

By William H. Fritz,
Linde Division, Union Carbide Corp., Cleveland

Whether it's in a simple transistor radio or a complex missile guidance system, a capacitor will be affected, with respect to reliability, by the a-c ripple voltage across it. Since the allowable ripple voltage may be limited either by the d-c voltage superimposed on the capacitor and its rated working voltage or by the heat dissipated in the capacitor, it is necessary to learn which case applies. That determination can be made through the use of the nomograph and chart presented here.

Usually, engineers determine that a capacitor is properly applied by adding the impressed d-c voltage and the peak value of the a-c ripple voltage to see if the sum is within the capacitor's rated working voltage. But many engineers neglect two factors that could cause a capacitor to operate unreliably. They may forget that an a-c voltage, especially at high frequencies, can cause significant heat dissipation in the capacitor's equivalent series resistance, thus making the capacitor extremely unreliable. And many engineers are unaware that for polar capacitors with an a-c voltage there is a lower limit for the superimposed d-c voltage. Maintaining this lower limit keeps the voltage from reversing direction across the capacitor and destroying it.

The author

During World War II, William H. Fritz served with the Columbia University National Defense Research Committee on the design and application of sonar equipment. He was awarded the President's Medal for Merit for this work.

Fritz holds several patents in the field of photographic light sources and has published papers covering these developments.

A-c and d-c voltage

With good quality capacitors, the heating effect caused by the d-c voltage can be neglected, because the d-c leakage current through the capacitor is quite small; it is usually measured in microamperes. But the heating effect resulting from the a-c power dissipation in the capacitor's equivalent series resistance is appreciable and the a-c, or ripple, voltage impressed across the capacitor must be limited. A nomograph that relates pertinent variables to the maximum a-c voltage that can be impressed across a solid tantalum capacitor is shown on page 67.

Allowable ripple voltage is also limited by the rated working voltage of the capacitor and the superimposed d-c voltage. It is good practice, in designing circuits, to keep the peak instantaneous voltage across a polar capacitor unidirectional and within the limits of its rated working voltage. With nonpolar tantalum capacitors, the positive or negative peak values of the a-c voltage should be less than the rated working voltage. A chart relating rated working voltage to the composite a-c and d-c voltage across a capacitor is on page 66.

The nomograph was developed for hermetically sealed, metal-encased solid tantalum capacitors, while the chart is applicable to all capacitors. The nomograph gives the allowable power dissipation for four sizes of polar and nonpolar capacitors. Ripple voltage is assumed to be sinusoidal for both the nomograph and chart.

Heat dissipation

The heat dissipated in a capacitor depends on the ripple voltage, capacitance, frequency and dissipation factor. These factors are related in an equation from which the allowable ripple voltage can be calculated. The nomograph is based on the same equation.

When the dissipation factor for a capacitor is low, indicating that the capacitive reactance is much larger than the equivalent series resistance, the current through the capacitor is a function of only the capacitive reactance.

An exact expression for the impedance of a capacitor is:

$$Z = X_C \sqrt{D^2 + 1}$$

where X_C is the capacitive reactance in ohms and D is the dissipation factor expressed as a decimal. But even when D is as large as 0.3, the error that results from neglecting it in the above equation is less than 5%. Therefore, the current through a capacitor is given by:

$$I = \frac{E_R}{X_C}$$

where E_R is the impressed rms a-c voltage.

The power dissipated in the capacitor's equivalent series resistance R_S is:

$$P = I^2 R_S$$

By substituting for I from the previous equations, and since dissipation factor D is the ratio R_S/X_C, an expression for P in terms of voltage, frequency, capacitance, and dissipation factor can be obtained.

$$P = E^2_R \, (2\pi fCD)$$

Expressing P in milliwatts, f in cycles per second, C in microfarads and D in percent, the equation above can be solved for E_R.

$$E_R = 100\sqrt{\frac{1.59P}{fCD}}$$

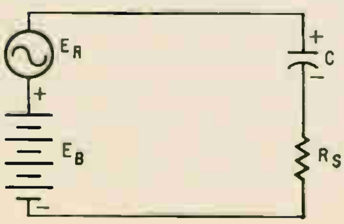
This expression can be applied to polar and nonpolar capacitors, since it yields an rms voltage that will result in maximum capacitor heat dissipation independent of any d-c voltage. For this expression, an ambient temperature of 25°C was assumed. At higher temperatures, the following derating factors should be used:

At 85°C, multiply allowable ripple by 0.9.

At 125°C, multiply allowable ripple by 0.4.

Ripple voltage nomograph

To avoid computation, the ripple voltage that is limited by heat dissipation can be determined easily from the nomograph. Because the allowable ripple voltage is a function of four independent variables, the nomograph was simplified by using the product of the capacitance and dissipation factor as a single variable. Frequency and power dissipation are kept as individual variables.



Simplified circuit of capacitor includes equivalent series resistance R_S to determine power dissipation due to E_R, the impressed a-c voltage. E_B is d-c voltage.

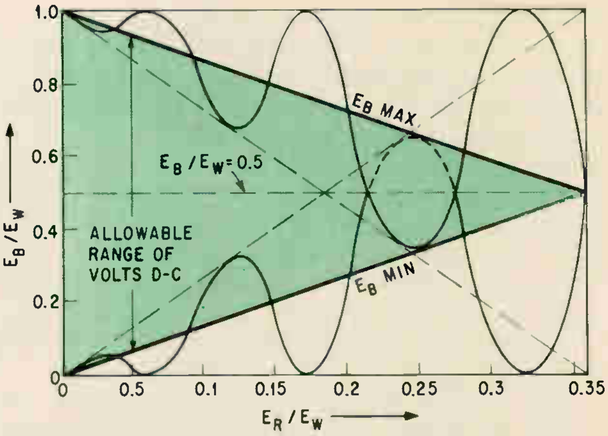


Chart relating d-c voltage E_B, a-c voltage E_R and rated working voltage E_W for polarized capacitors. For a specific capacitor and ripple voltage, chart gives the maximum d-c voltage, which limits the total instantaneous voltage within rated working voltage. Also given is a minimum d-c voltage, which limits the total instantaneous voltage to a value that will not apply a reverse voltage across a polarized capacitor.

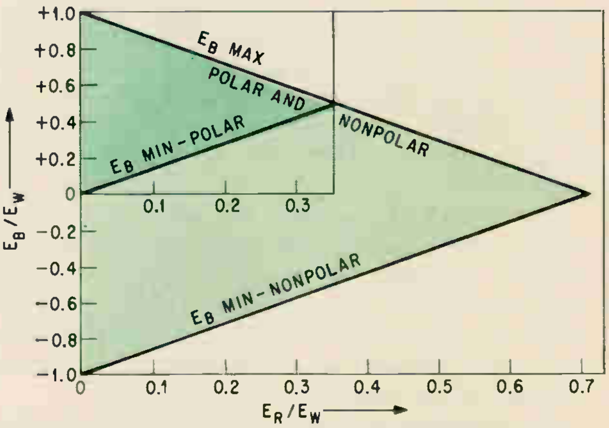


Chart relating E_B, E_R and E_W for polar (heavy-shaded triangle) and nonpolar capacitors (entire large triangle).

It is reasonable and convenient to use the product of C and D as a single variable because both capacitance and dissipation factor are measured on a common capacitance bridge. Since the capacitance and dissipation factor vary with frequency in solid tantalum capacitors, it is recommended that these values be measured at the operating frequency to get an accurate solution to a specific application problem.

How to use the nomograph

First, calculate the CD product. Locate this point on the CD scale on the nomograph. Draw a line to the operating frequency on the f scale. From the point where this line intersects the A scale, draw another line to the appropriate capacitor case size on the P scale. The point where the second line intersects the E_R scale is the allowable rms ripple voltage.

Two examples are illustrated by dashed lines in the nomograph. Lines 1a and 2a apply to a 47-microfarad, 35-volt polar capacitor operated at

800 cycles per second. This capacitor is contained in a D-size case. Assuming a dissipation factor of 12%, the CD product (for C in units of microfarads) is 564. The nomograph gives an allowable ripple voltage of 2.5 volts rms.

Lines 1b and 2b apply to a 5-microfarad, 75-volt nonpolar capacitor operated at 120 cycles per second. This capacitor is contained in a CC-size case. Assuming a dissipation factor of 6%, the CD product is 30. For this capacitor the nomograph gives an allowable ripple of 37 volts rms.

The power dissipated due to ripple can be read next to the applicable case size on the P scale.

The relation between capacitor case size and power dissipation was determined experimentally by attaching thermocouples to the capacitor case and measuring the power dissipation that caused a safe temperature rise. In using the nomograph, there are eight discrete points of interest on the power scale—one for each capacitor case size.

Limiting d-c voltage

Although a d-c voltage doesn't contribute to a capacitor's power dissipation, it affects the application of solid tantalum capacitors because it limits the maximum instantaneous voltage that can be applied across the capacitor. The applied d-c and rated working voltage limitations are independent of ripple voltage values derived from the nomograph.

The top chart on page 65, gives a graphical method of determining the range of allowable d-c voltages as a function of ripple voltage for polar capacitors. Or, for a particular d-c voltage, the chart yields the maximum allowable rms ripple. Both d-c and ripple voltages are expressed in the chart as fractions of the rated working voltage.

The following assumptions were used in developing the chart: capacitor is polar type; ripple voltage E_R is sinusoidal; the sum of the peak ripple voltage E_P plus the d-c voltage E_B never exceeds the rated capacitor working voltage E_W; the difference between the d-c voltage E_B and the peak ripple voltage E_P is never less than zero; that is, the voltage across the capacitor is always unidirectional.

In the chart, the dashed horizontal line $E_B/E_W = 0.5$, relates the d-c voltage to the maximum allowable rms ripple voltage. For $E_B/E_W = 0.5$, the maximum allowable ripple voltage ratio is $E_R/E_W = 0.354$. The allowable d-c voltage limits are bounded by two straight lines, E_B-maximum and E_B-minimum. For a particular ripple voltage ratio, these lines give upper and lower limits that establish the allowable d-c voltage range.

Another way of graphically relating E_W, E_R and E_B is given by the second chart on page 65, which includes nonpolar capacitors. To determine the allowable d-c voltage range from this chart, draw a vertical line from the appropriate E_R/E_W point. The points where this line intersects the boundaries of the permissible d-c voltage boundaries are E_B/E_W maximum and E_B/E_W minimum. Conversely, if the d-c voltage range is known, a horizontal line drawn from the appropriate E_B/E_W value to either of the E_B maximum or E_B minimum voltage boundary lines will intersect it at a point directly above the allowable E_R/E_W value.

Using the ripple voltage chart

A 47-microfarad, 35-v polar capacitor was used to illustrate an application of the nomograph; it showed that the permissible ripple is 2.5 volts rms. The E_R/E_W ratio for this ripple is 2.5/35 or 0.071. This ratio in the ripple chart shows that the allowable E_B/E_W ratio extends from +0.1 to +0.9. Applying these ratios to the 35-volt capacitor rating indicates that the d-c voltage may be any value between +3.5 and +31.5 volts, for a 2.5 volts rms ripple voltage.

The values obtained from this chart can be used for temperatures up to 85°C. At an operating temperature of 125°C, the working voltage E_W should be derated by 0.67.

Tabulating results

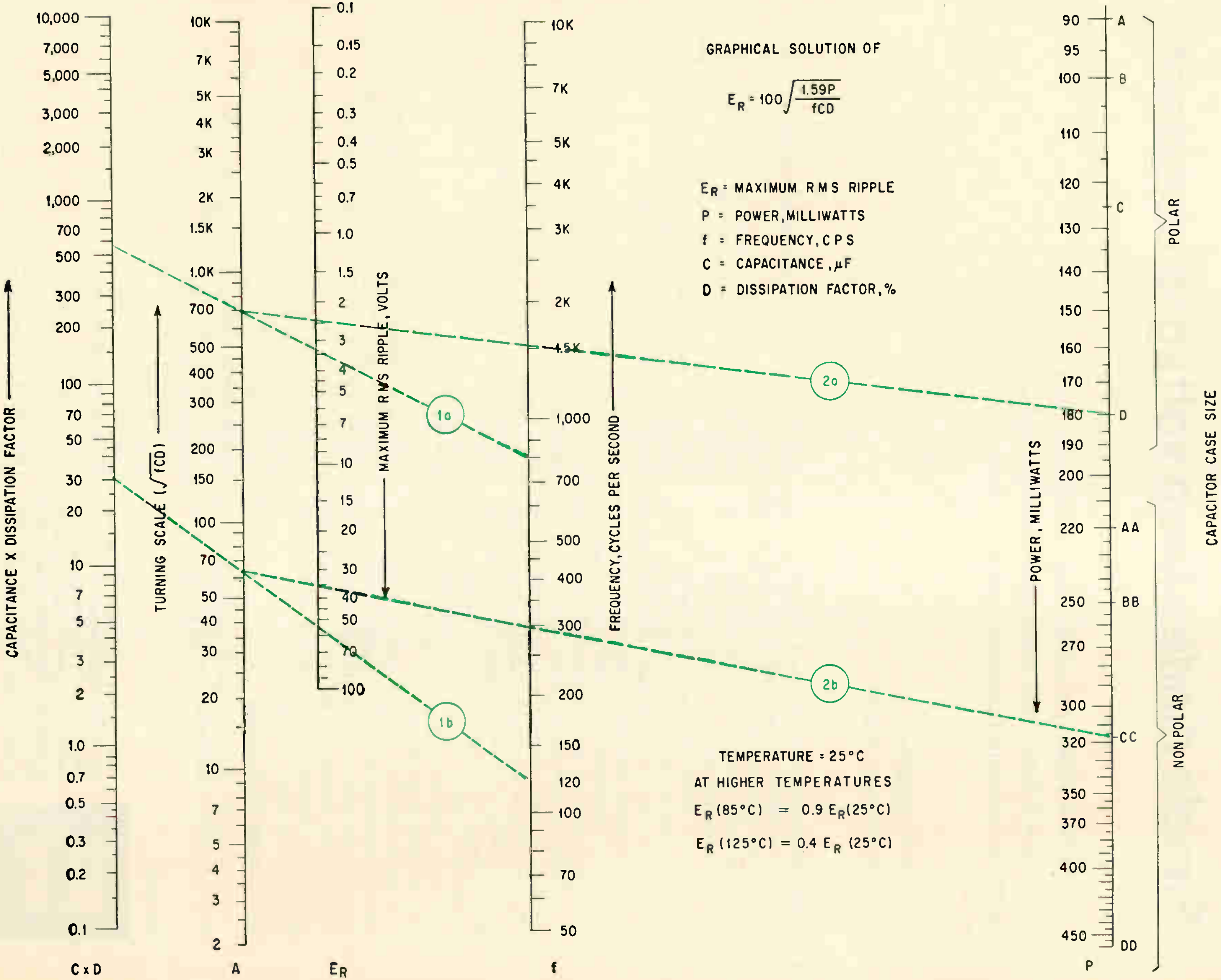
To further illustrate the usefulness of the nomograph and the ripple voltage chart, the parameters of a typical polar and nonpolar capacitor were measured at various frequencies. Allowable ripple voltages, limited by the capacitor's heating effect, were obtained from the nomograph and allowable ripple voltages, limited by d-c voltage and rated working voltage, were obtained from the chart. These values are tabulated at the left.

The E_R values in color indicate whether the heating effect or the d-c and rated working voltage dictated the allowable ripple voltage. These values indicate that the heating effect becomes increasingly important as the frequency increases. The capacitance of the two units is relatively stable over the frequency range tested. The increase in dissipation factor with frequency is typical for solid tantalum capacitors.

Determining E_R for a polar and nonpolar capacitor

f cps	C μF	D %	E_R from nomograph: E_R V rms	E_R from ripple voltage chart: E_R V rms
4.7-microfarad, 50-volt polar capacitor, size B case				
120	4.70	1.80	40	17.7
400	4.67	4.00	14.5	14.5
800	4.65	7.15	7.5	7.5
1000	4.64	8.60	6.1	6.1
5000	4.44	36.00	1.4	1.4
6-microfarad, 20-volt nonpolar capacitor, size BB case				
120	5.89	1.65	58	14.1
400	5.86	4.10	20	14.1
800	5.86	7.61	11	11
1000	5.83	9.45	8.5	8.5
5000	5.18	43.20	1.9	1.9

Nomograph for maximum a-c voltag e across solid tantalum capacitors



Simple diodes keep voltages constant

Zeners are the preferred components for regulator circuits, but for low voltages, their inexpensive cousins provide better accuracy and can compensate for temperature changes

By Allan K. Scidmore
University of Wisconsin, Madison

Zener diodes are widely accepted as the best components for use in voltage regulator circuits, and there is no question that in most cases they are best. But there are times when the cheaper simple diode or transistor junction can do a better job.

The zener diode has some well-known disadvantages. For one thing, its voltage changes with temperature, so that a voltage reference circuit using zeners may require thermistors or other temperature compensation. For another, below about 2 volts true zeners are not available. Zeners have very nonuniform characteristics when operated at low voltages. At such voltages the forward volt-ampere characteristics of the junction diode not only provide excellent reference voltages, but do so with low dynamic resistance and small variation with temperature. Zener diodes and thermistors may also have economic disadvantages [Electronics, Oct. 19, 1964, page 55].

A number of conventional signal or rectifier diodes, forward-biased reference diodes or stabistors, as well as the base-emitter and base-collector junctions of most transistors, may be substituted. The volt-current characteristics of a few of them are shown in the graph on page 69.

Analyzing the diode junction

To discuss the use of the diode in circuits, it is first necessary to analyze the circuit parameters to show the relationships of voltage, current and temperature.

Operating parameters, shown in the diode equivalent circuit on page 69, provide a model of the diode at some voltage-current point, V_o, I_o. The diode resistance, r, and offset voltage, E_o are obtained from the characteristics of the diode at a reference temperature, T_o, as shown in the graph on page 69.

A voltage, V_T, which gives a linear approximation for the temperature dependence, may be obtained from the characteristics

$$V_T = k_T \Delta T = k_T (T - T_o) \qquad (1)$$

where k_T is the temperature coefficient and is calculated from

$$k_T = \left.\frac{dV}{dT}\right|_{\text{at } I = I_o} \qquad (2)$$

The characteristic curves for most diodes are essentially exponential over a considerable range, as predicted by the theoretical diode equation:

$$I = I_s\left(\epsilon^{\frac{eV}{kT}} - 1\right) \qquad (3)$$

where I_s is the diode's reverse saturation current, e is the charge on the electron, k is Boltzmann's constant, and ϵ is the natural logarithm base.

The dynamic forward resistance, r_f, at current I_o predicted by equation 3 is

$$r_f = \frac{kT}{eI_o}$$

At room temperature,

$$r_f = \frac{0.026}{I_o} \text{ ohms.}$$

Although the dynamic resistance, r, of an actual diode is somewhat larger than r_f, it may be used in the equation at low and medium current levels.

The author

Allan K. Scidmore, associate professor of electrical engineering at the University of Wisconsin, teaches courses and directs graduate study in electronic digital computers, electronics and communications. He worked on the development of the Wisconsin integrally synchronized computer.

The value of r_f may be used as a minimum value for r, while the dependence of r on I_o may be used to predict circuit performance. The temperature coefficient, k_T, is a measure of voltage change; it is negative and generally between 0.001 and 0.003 per degree centrigrade. The value of k_T, is dependent upon current I_o, in general decreasing as I_o increases as shown in the plot on page 71, top. At a specified current, k_T is constant over a wide range.

Measuring the variables

Variations in reference voltage with supply voltage, and temperature can show how well the diode can maintain constant voltage at specified voltage inputs, and how it can compete with the zener. In the diode reference circuit below, the voltage transfer ratio, $\Delta V/\Delta E$, is a measure of the variation of reference voltage with supply voltage, and is expressed as,

$$\Delta V/\Delta E = \frac{r}{r + R} \quad (4)$$

where r is the resistance of the diode and R is the resistor in the circuit. The variation of diode voltage with temperature, V(T), is

$$V\,(T) = \frac{k_T R}{r + R}\,\Delta\,T \quad (5)$$

while the dynamic output resistance, r_{out}, is:

$$r_{out} = r || R \quad (6)$$

The performance of a forward-biased diode and a zener diode are compared in this circuit by first using the forward-biased 1N456, and then using the 1N702, a 2-volt 250-milliwatt silicon zener. Both have an input voltage of 4 to 5 volts. A comparison of the parameters and performance for both devices are shown in the table on page 70. The zener is handicapped in this range by its higher dynamic resistance and voltage drop.

If the supply voltage is fixed, $\Delta V/\Delta E$ is insensitive to changes in R. If the variation in diode resistance, r, with current is given as

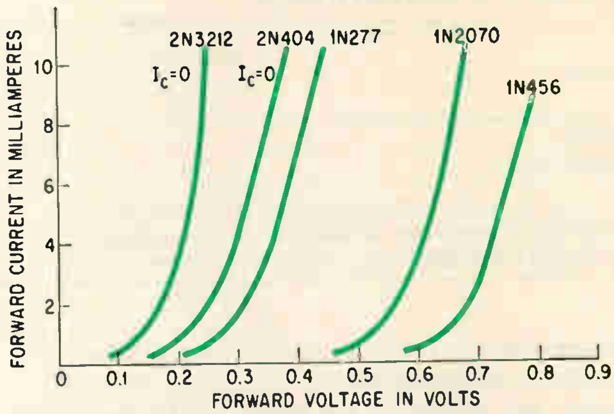
$$r = \frac{K}{I_o},$$

where K is some constant, then,

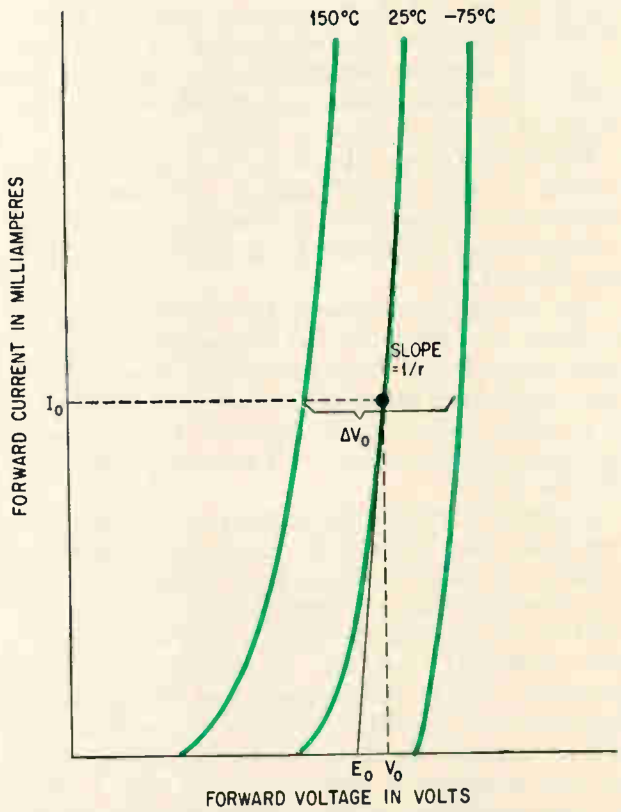
$$\frac{\Delta V}{\Delta E} = \frac{r}{r + R} = \frac{K/I_o}{K/I_o + (E - E_o)/I_o}$$

$$= \frac{K}{K + (E - E_o)} \quad (7)$$

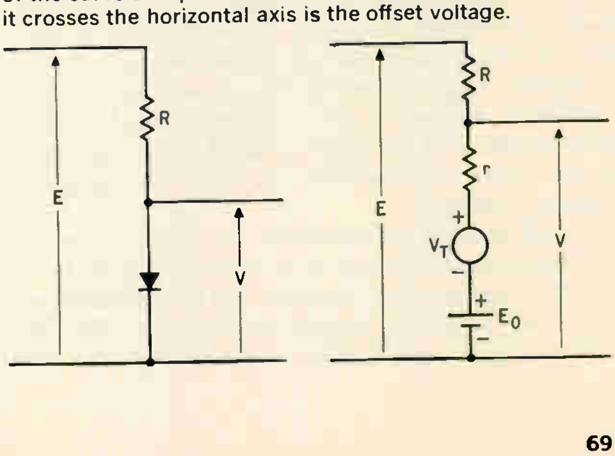
Although this equation shows that $\Delta V/\Delta E$ is independent of resistor R, there is some slight dependence due to the variation of E_o with current. The output resistance, on the other hand, has a marked



Voltage-current plots of several diodes and transistors which can be used to provide excellent references at low voltages. Above 2 milliamperes, voltage is nearly constant despite changes in current.



Curves used to obtain the resistance, r, and offset voltage, E_o, of a diode at a particular reference temperature. The solid straight line is a tangent to the curve at a particular voltage-current intersection. The reciprocal of the curve's slope is the resistance. The point where it crosses the horizontal axis is the offset voltage.



Circuit on right is electrical equivalent of diode reference circuit, left. Internal resistance, r, offset voltage, E_o, and the voltage which gives a linear approximation for the temperature dependence, V_T, are used to calculate the diode's performance as a voltage regulator at different temperatures.

Zener vs. simple diode

Diode	I_o	R	Nominal voltage	r	ΔV/ΔE	V(T)	r_{out}
IN456	2	2,000	0.68	27	1.3	−1.8	27
IN702 (zener)	5	600	2.0	60	9.1	−1.1	55

I_o is current in milliamperes, R is resistor in circuit in ohms, r is diode resistance in ohms, ΔV/ΔE is measure of variation of reference voltage with supply voltage in percent, V(T) is variation of diode voltage with temperature in millivolts per degree C, r_{out} is dynamic output resistance in ohms.

dependence on I_o and this may be the deciding factor in the choice of resistor R. As with zener references, for a fixed I_o, the larger the E, the larger the value of R, and the smaller ΔV/ΔE.

Compensating for temperature

Diodes may be used as temperature-compensating elements, and the temperature variation of one diode may be used to cancel that of the other. The two-level cascaded voltage regulator circuit at the right uses 1N456 diodes, and its behavior may be analyzed by its equivalent circuit.

Resistances were chosen so that the operating current for each diode branch is 2.8 milliamperes. Resistance r is equal to 13 ohms and the voltage—temperature coefficient k_T is equal to —0.0015 per degree C.

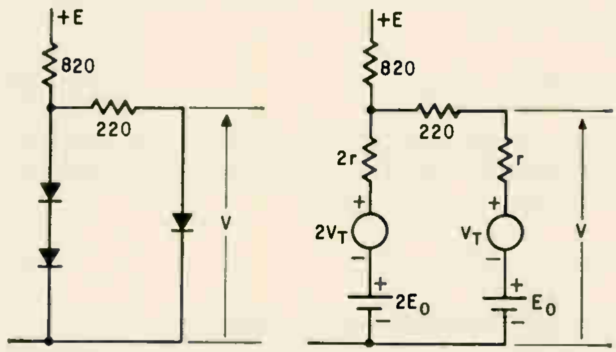
The voltage transfer ratio ΔV/ΔE for this circuit is about 8×10^{-4}, so that the output voltage is quite insensitive to the input voltage. The temperature variation of the circuit is only 1.05 times that of a single diode; but to use such a circuit as a reference voltage source still requires compensation for V(T).

A circuit in which the temperature variation of one diode may be used to cancel that of another is shown on page 71. Here, D_1 is silicon while D_2 is germanium, giving a nominal value of 0.3 to 0.4 volts for V_2. Both diodes have a negative temperature coefficient, but the temperature-dependent generators are in series opposition. Temperature dependence of V_2 will be negative for small R_e but will be positive for large R_e. Consequently, it is possible to adjust R_e and provide V_2 with a temperature coefficient which is either positive, negative, or almost zero. This circuit built from unselected diodes, obtains reference voltages constant within 2 millivolts over an 85°C range.

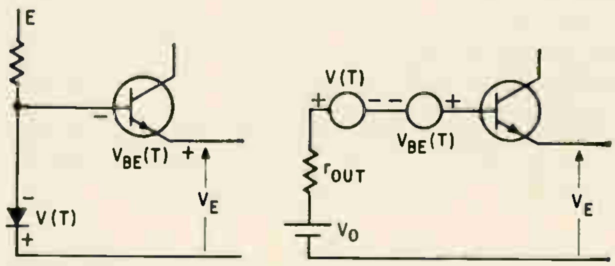
By combining this circuit with the cascaded regulator previously discussed, it is possible to produce economical low-voltage reference sources with very good temperature stability, as well as excellent regulation against supply voltage changes. Optimum results will be achieved if all diodes are kept at the same temperature, or track the ambient changes together.

An alternative arrangement to compensate for the temperature change of a reference diode is to use the base-emitter junction of a transistor, as shown in the center circuit on this page. The polarities of V(T) and $V_{BE}(T)$ for both the diodes and the transistor are indicated for an increase in temperature. Other circuit details are omitted for clarity.

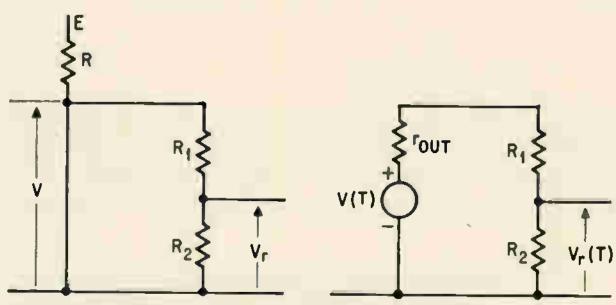
If the temperature variations of the forward drop of both devices are made equal, then the loop cur-



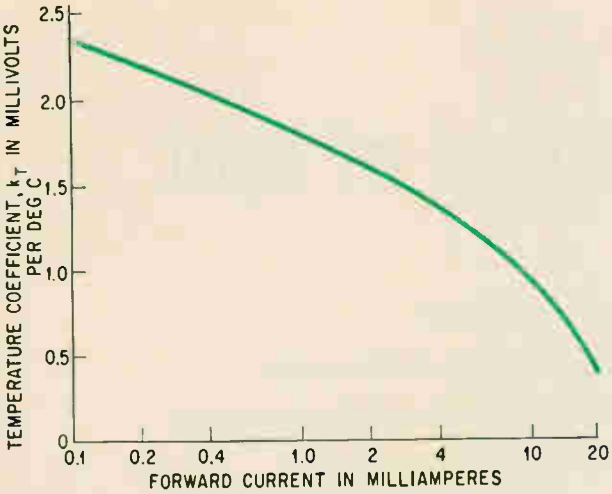
Two-level cascaded voltage regulator and its equivalent circuit. This regulator develops an output voltage independent of the input voltage. But because the temperature variation of the circuit is 1.05 times that of a single diode, it requires temperature compensation.



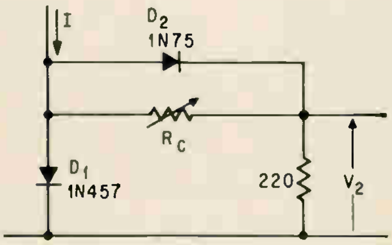
Base-emitter junction of a transistor compensates for temperature changes of reference diode. The base-emitter polarity and polarity of the temperature dependence voltage are given for rising temperatures.



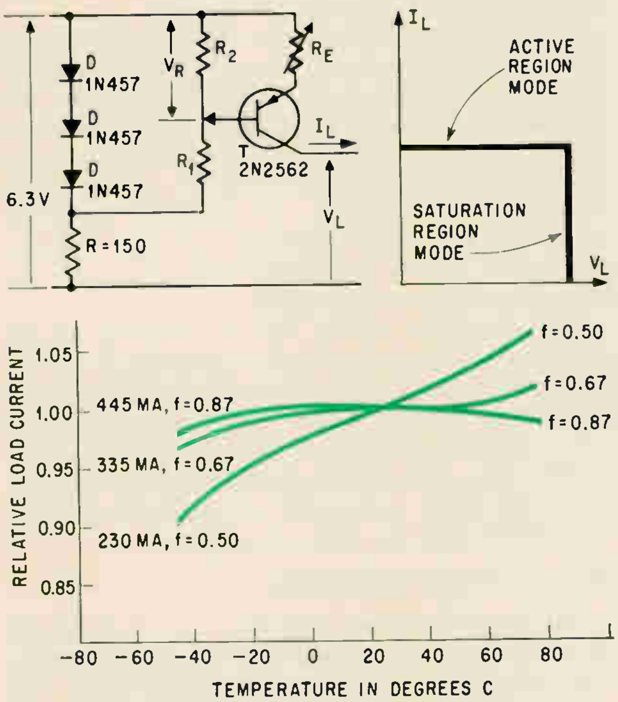
Forward-biased regulator with cascaded diodes is used to compensate for temperature changes over a wide range. R_1 and R_2 may be chosen to keep voltage variation to desired level.



Temperature coefficient, a factor in calculating the temperature dependence voltage V_T, plotted against forward current for the diode 1N456, shows linearity over currents from 0.1 to 2 milliamperes with a gradual drop as the current is increased.



Voltage reference circuit uses temperature variations of a silicon diode, D_1, to cancel those of a germanium diode, D_2.



Constant current circuit has a string of diodes and a transistor to provide both reference voltage and temperature compensation. Curves below show deviation of load current with temperature when load current is varied by three different voltage division factors, f. At f equals 0.87, the output current was maintained within 1% over temperatures between −30° and 70°C.

rent, I_B, contains no temperature-dependent part.

Two additional factors must be considered, however. First, this circuit does not compensate for the change in transistor leakage current, I_{CO}, with temperature, although it can be used to offset changes in the forward current-transfer ratio (beta) with temperature. Second, as noted, the polarities of V(T) and V_{BE}(T) not only must match, but must also be made equal in magnitude. Fortunately, the temperature coefficient for both junctions may be varied somewhat by varying their quiescent current as indicated in the circuit on page 69.

The bottom circuit, page 70, shows another method which is used to obtain a variable V(T) from a reference diode string. The voltage variation in temperature, V_r(T), may be obtained from the circuit by inspection:

$V_r(T) = fV(T)$ where the voltage division ratio is

$$f = \frac{R_2}{R_1 + Q_o + r_{out}} \qquad (8)$$

Although the desired value of V_r(T) can be obtained by variation of R_1 or R_2, the reference voltage also is varied by the same ratio, f.

Double-duty diodes

Another method of using diodes for both reference and compensation is to string diodes together and use a transistor as shown in the simple constant-current circuit at the left. The transistor may be considered as an emitter-follower where the load current is given by

$$I_L = \frac{V_r - V_{BE}}{R_E} \qquad (9)$$

If the load current is varied by varying R_E with a fixed reference voltage V_r, the inverse relationship given by equation 9 will result. But if R_E is fixed and the current is varied by changing V_r, an approximately linear relationship between V_r and I_L exists. However, as pointed out previously, varying the constant portion of V_r in this manner also results in varying V_r(T).

Since temperature dependence of the base-emitter junction on voltage, V_{BE}(T), is not so strongly affected by current, it is not possible to provide exact temperature compensation except by adjusting both R_E and V_r.

This is feasible in applications where the emitter or collector current is to be essentially constant, but not in applications where the current is to be variable over a wide range.

The output current-temperature characteristics of the constant current circuit at the left illustrate this point. The emitter resistance, R_E, is 3 ohms; a 100 ohm potentiometer is used for R_1 and R_2. At a voltage division ratio, f of 0.87, the output current was maintained within 1% over the temperature interval from −30°C. to +70°C.

However, as the value of f was decreased, the compensation provided became inadequate, as evidenced by the larger deviation of load current at the extremes of temperature.

Computing at the speed of light

Optical analog devices transpose variable inputs into spatial dimensions and operate on them simultaneously. With a laster as a light source, the computers are useful for antenna modeling and spectrum analysis

By Kendall Preston, Jr.
Perkin-Elmer Corp., Norwalk, Conn.

Optical analog computers have been in use for several years, but they have really come of age with the laser. An optical computer powered by a laser can multiply a 10,000-element vector by a 10,000 x 10,000 matrix in one millisecond. And the coherence of the laser beam has made possible such applications as antenna pattern analysis, matched filtering, and signal spectrum analysis.

The optical computer is so fast because it uses two spatial dimensions to represent two independent variables, and thus can operate on both simultaneously. At a given instant, an electronic computer is one-dimensional, in that its input signal, no matter how complex, is just that—a signal. It takes a finite length of time for that signal to be processed by the computer circuits. The input to an optical computer is prerecorded, and processed instantaneously by a beam of light. The most common recording material is photographic film; the film can be considered a transducer in that an electrical signal acts upon it, through an appropriate optical device such as a light bulb-lens combination, so as to produce patterns of light and dark that will modulate the light beam in a specific manner. Other types of input transducers may be used; one is the photoelastic material pictured on page 80, which can operate without any delay for film processing.

The typical optical computer is shown in the drawing on the facing page. It consists of a source of light which is modulated by the input signals, via the input transducer, so that when it has passed through the lens system and energized an output transducer, the output signal will bear the prescribed mathematical relationship to the input.

The actual mathematical function is performed instantaneously, but the speed of the computer is limited by the speed of the transducers. Obviously, it takes time to process film; other methods are faster but do not have film's versatility.

Since light amplitude is the signal for the optical computer, the ratio of maximum to minimum signal levels, or dynamic range, is limited only by the amount of optical noise—or unwanted light—that can be tolerated. Proper lens design can produce a system with wide dynamic range as well as a high time-bandwidth product, an important factor in frequency resolution. Noncoherent light systems have even higher time-bandwidth products, but their dynamic range is smaller.

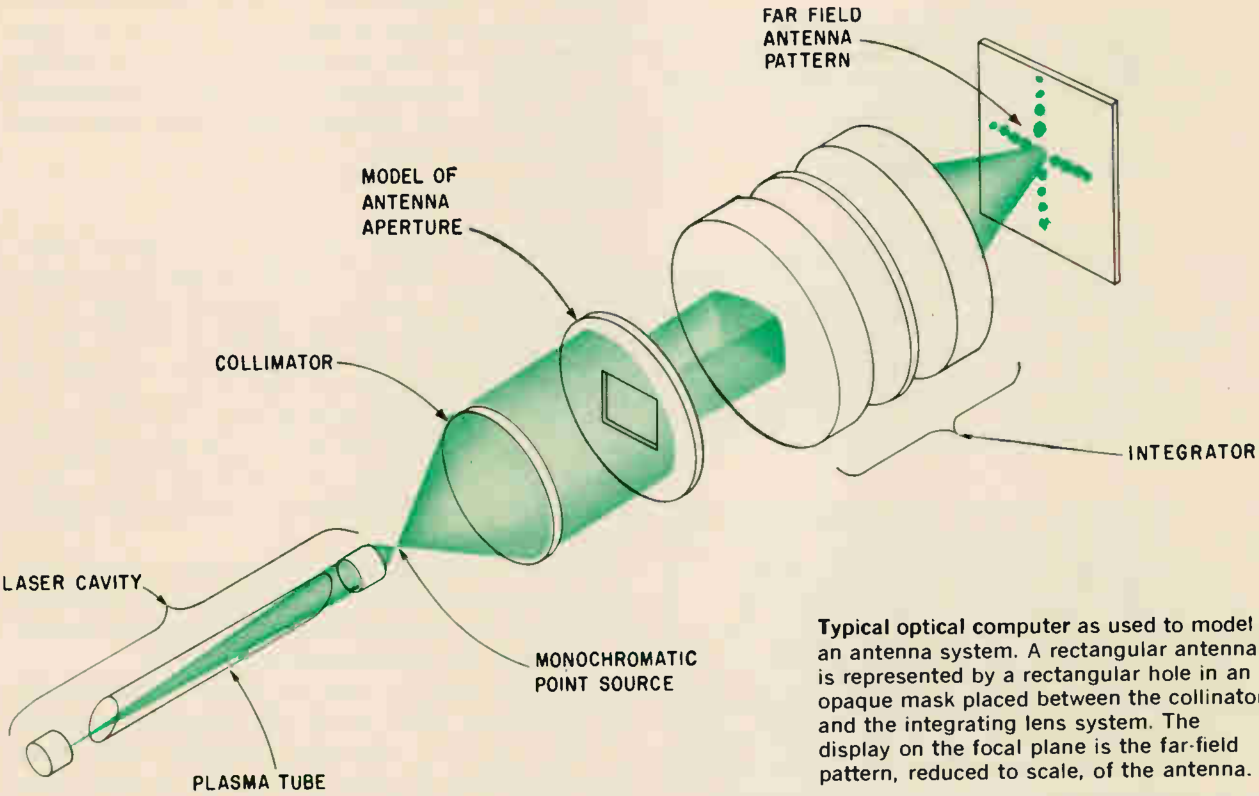
The attraction of the optical computer is not sheer speed. Since the device operates in all frequencies at once, it is extremely useful in spread spectrum communications systems and in radar and sonar signal processing.[1] Research at the University of Michigan and at Columbia University indicates that applications are possible in speech recognition, vibrational analysis, and seismology.

The lens models the antenna

An optical computer can serve as a scale model of a radar system because a lens acts on light waves just as the radar antenna acts on microwaves. The diagrams on page 74 illustrate the analogy. The scale is the ratio of light wavelengths to microwave lengths, which is about 10^{-5} to one; a one-inch lens can thus model an 8,000-foot L-band antenna. Like the antenna, the lens is highly directional. It has a radiation pattern with a calculable side-lobe struc-

The author

Kendall Preston Jr. a member of the senior research staff at Perkin-Elmer, joined the electro-optical division of the company in 1960 after seven years with the Special Systems division of Bell Telephone Laboratories, Inc. Programs now under his direction include research in hypersonic and other types of spatial light modulators for optical analog computers. He holds an A.B., and an M.S. degree in engineering and applied physics, from Harvard.

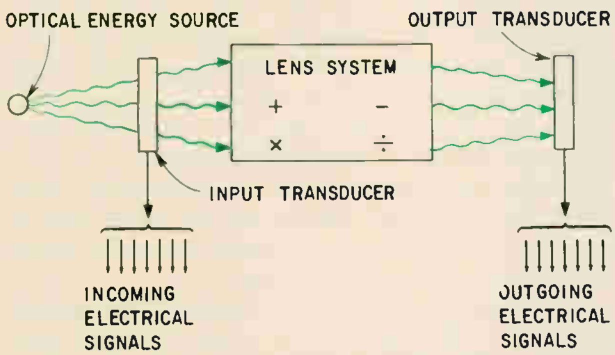


Typical optical computer as used to model an antenna system. A rectangular antenna is represented by a rectangular hole in an opaque mask placed between the collinator and the integrating lens system. The display on the focal plane is the far-field pattern, reduced to scale, of the antenna.

ture; the angle, θ, at which radiated power is one-half its maximum on the axis is given by $\theta = \lambda/D$, where λ is the wavelength of light and D is the diameter of the lens, or its aperture.

A radar antenna is energized by an oscillator at a well-controlled frequency. If it is to be modeled by an optical system, the power source must be equally well-controlled—that is, it must be a laser. The photons in ordinary light are out of phase with one another and generally of different energies. A laser is a source of monochromatic light whose photons are all of the same energy.

The system shown in the drawing above is a simple optical model of an antenna, whose far-field intensity distribution corresponds to the light intensity distribution in the output focal plane.



Optical analog computer in schematic form. The input transducer transforms electrical signals that vary in time and frequency into light signals that vary in the spatial coordinates x and y. The output transducer converts these signals, after they have been processed in the lens system, into electrical signals that can be recorded or used on other equipment.

Mathematically, that light intensity is the square of the absolute value of the Fourier transform of the input light amplitude distribution,[6] or

$$I\,(x', y') = |FA\,(x,y)|^2$$

The Fourier transform, F, is a mathematical expression that, in this case, relates a multidimensional signal to its frequency spectrum. It is defined as

$$FA\,(x,y) = \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} A\,(x,y)e^{j(\omega_x x+\omega_y y)}\,dx\,dy$$

where ω_x and ω_y are frequency coordinates.

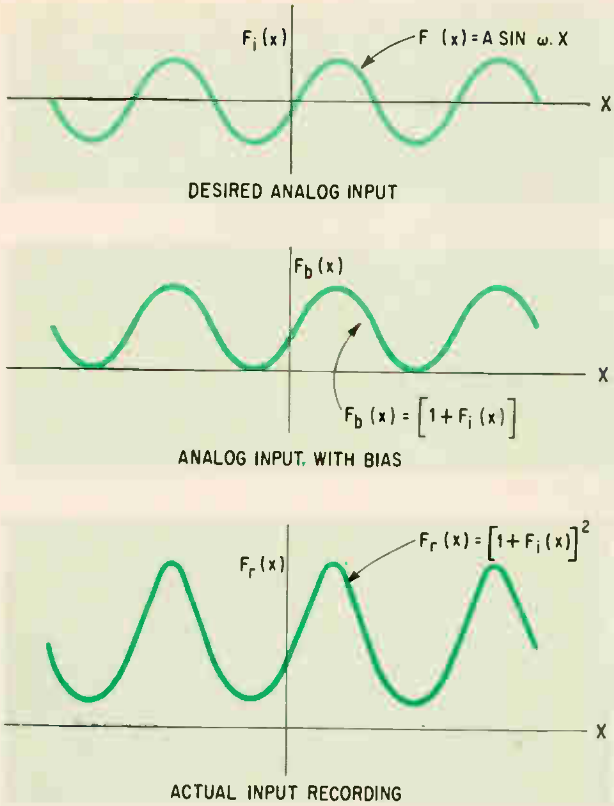
The Fourier transform of a simple amplitude distribution function is shown in the photo at the bottom of page 76.

The output pattern indicated in the sketch above is shown in the top photo on page 75. This figure corresponds to the far-field pattern of a uniformly illuminated rectangular antenna with an aspect ratio (ratio of length to width) of 3.5:1. Mathematically, this pattern is described by the expression

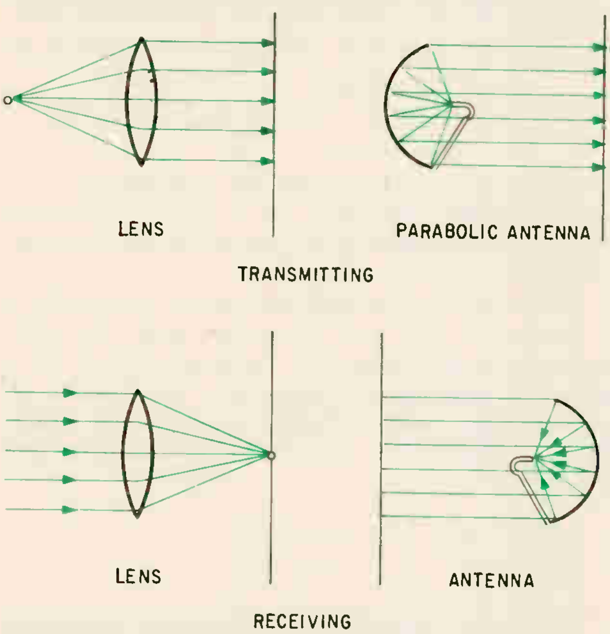
$$I = \left\{\left[\frac{\sin\,(ax)}{ax}\right]\cdot\left[\frac{\sin\,(by)}{by}\right]\right\}^2$$

The output intensity distribution is sometimes referred to as the Wiener spectrum of the input amplitude distribution.

A more complex antenna pattern is illustrated in the lower photo on page 75, which shows the far-field intensity distribution of an antenna array 1.5 miles in diameter, consisting of a circle of 96 subantennas, each 45 feet in diameter. This far-field pattern is achieved 2,000 miles from the earth's



Three representations of a simple signal for input to an optical computer. The top diagram is a simple sinusoid, the desired input. The middle diagram shows how this signal must be biased for recording on film, because of the impossibility of recording negative light. The bottom diagram shows how the signal, as recorded, shows up when checked by a photocell, whose output is proportional to the square of the signal.



Antenna design and optical design are closely related. The diagrams at the top show that the optical wave emerging from a lens fed by a monochromatic point source in its focal plane is identical, except for frequency, to the wave emitted by a parabolic antenna fed by a feed horn at its focus. The bottom pair shows the analogy between a lens bringing a monochromatic plane wave to a point focus and a receiving antenna doing the same thing for microwaves.

surface. The model used to obtain the photograph was similar to that shown in the sketch on page 73, except that the rectangular hole representing the antenna was replaced by a mask containing a ring of 96 round pinholes. The entire model was only a few feet long.

Spectrum analysis

The bidimensional nature of the optical computer makes it especially useful in spectrum analysis. In electronic analyzers, a complex voltage wave is fed to the input and the device is slowly tuned over a range of frequencies; a meter indicates a peak at each frequency present in the signal. The film recording for the optical device throws a pattern of bright spots on the output focal plane to identify all frequencies present in the input, thus operating in two dimensions of frequency simultaneously.

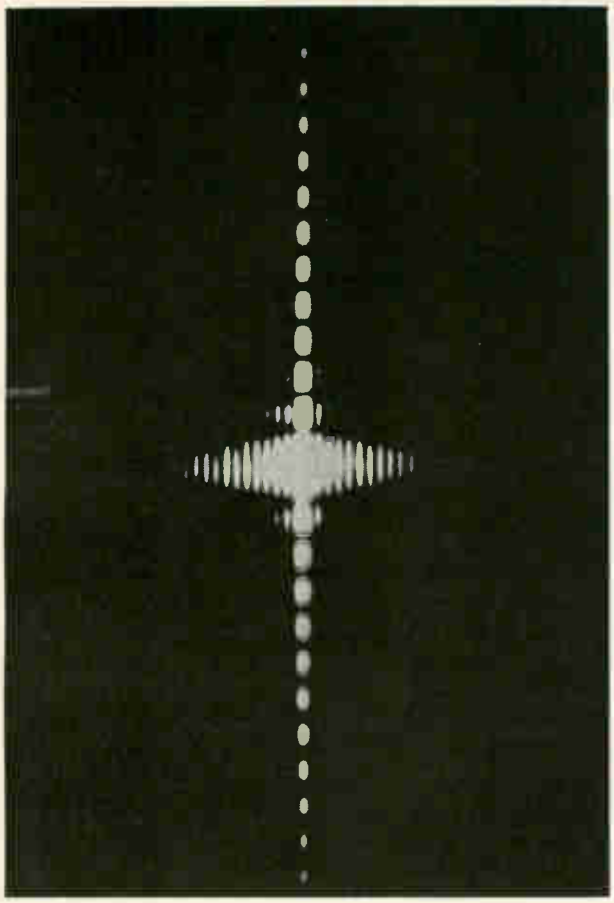
The most elementary input to the optical analyzer is a simple sinusoid. This input is shown at the top of the diagram at the left, and the output is shown in the photograph on page 76.

Such an input is easy to visualize but harder to implement. First of all, the negative portions of the sine wave represent "negative light" and as such cannot be recorded on film. A bias term has to be included so that the lower peaks lie above the zero axis, as shown in the middle diagram above left.

Another difficulty is that the amplitude of the input signal represents "optical voltage," and this is what the computer accepts as its input. But no optical voltmeter has ever been invented; all light-measuring devices indicate intensity, or power, and the input thus has to be measured indirectly. A photocell which scans a film will produce an output proportional to the squared sum of the bias plus signal. The square root of this output is what the computer sees; therefore, if the square root, when plotted, is sinusoidal with bias, the recording on the film is producing the correct input. The photocell signal is indicated in the lower part of the diagram.

The photograph on page 76 gives the output of the computer from this sinusoid input. The bright spot at the center is produced by the bias term in the input signal. The upper and lower bright spots represent the frequency of the input signal (in "cycles per millimeter" since the input was expressed as a sinusoid distribution in space). The side lobes fading off in four directions from the bright spots are caused by the finite size of the input recording; to eliminate them, the input would have to be infinitely large.

Since frequency has been transposed into spatial dimensions, the input focal plane displays both positive and negative frequencies; that is, there is no "folding" of the spectrum about the zero frequency axis as with electronic spectrum analyzers. In the latter, the upper and lower sidebands of an amplitude-modulated signal, when heterodyned to get rid of the carrier frequency, become



Far-field antenna pattern obtained with the optical model in the drawing on page 73. The antenna is rectangular, 3.5 times as wide as it is high. The bright center represents the main lobe or maximum radiated power; the diminishing blobs of light represent the weaker side of lobes of antenna power

Antenna pattern produced by an array of 96 round antennas set in a ring 1.5 miles in diameter. This pattern, found 2,000 miles out in space, was reproduced in the output focal plane of an optical model a few feet long.

positive and negative sidebands. There is no such thing as a negative frequency, so the energy in the lower sideband appears at the higher frequency of the upper sideband and the spectrum is therefore "folded" about zero.

Analyzer performance

To compare the quality of an optical computer used as a spectrum analyzer to its electronic counterpart, it is important to determine its figure of merit, which improves as the time bandwidth product (TW) increases. The TW of a lens system can be calculated from the maximum number of individual cycles of the highest frequency at which it can operate.

The diagram on page 76 shows a sinusoidal input recording placed in the front focal plane of a lens system, and the corresponding output spectrum. The output spectrum in the photograph consists of a number of bright spots; the number of spots and the distance between them depend on the spacing of the peaks in the sinusoid input. This spacing, in millimeters, is proportional to the spatial frequency in cycles per millimeter; and this spatial frequency represents a time frequency recorded on film over some increment of time.

The top tall peak, which represents the bright spot in the output spectrum above the center spot, is caused by the focusing of rays which are bent upward when they pass through the input recording. The rays are bent at an angle which depends on the frequency of the input signal.

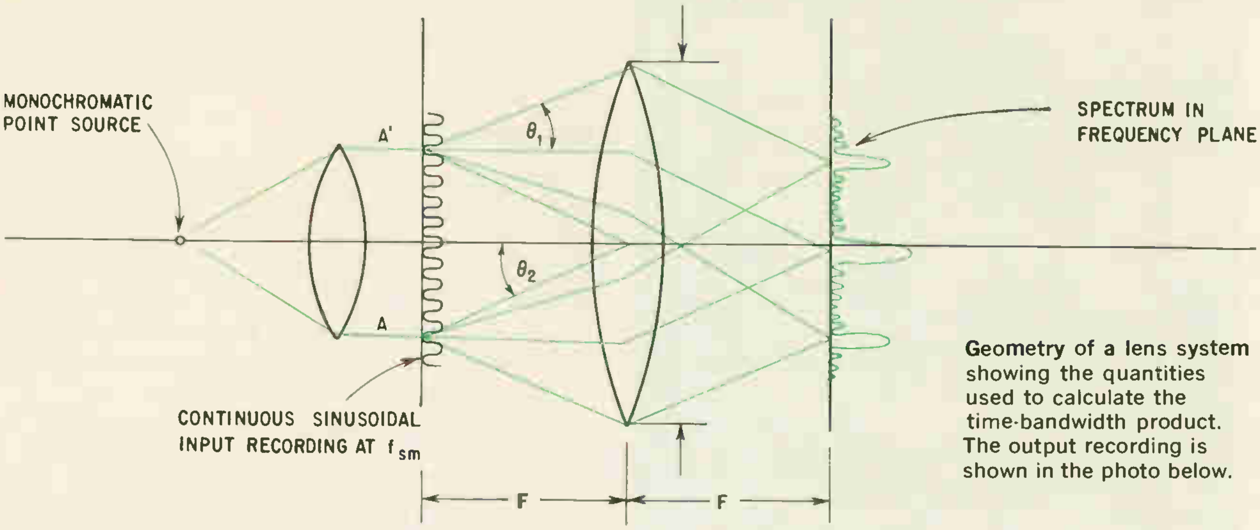
Spots far from the center are caused by focusing of rays from only the lower part of the input signal, bent upward to pass through the lens; rays from the upper part bent upward by the same amount miss the lens and are not focused. Therefore, these spots are fainter than spots nearer the center.

If the input signal is of high frequency, then there will be many peaks in the input recording, and a large angle of bending of the rays at the recording. The recording must be small, or made over a short time interval, to keep the rays from missing the lens. The large angle represents a high bandwidth; the bandwidth multiplied by the short time interval gives a time-bandwidth product which is near zero, in the extreme case.

On the other hand, if the input signal is of low frequency, then there will be only a few peaks in the input, and a small angle of bending of the rays. The recording can be nearly as large as the lens, representing a long time interval. The long time multiplied by the small bandwidth (small angle) again gives a time-bandwidth product near zero.

Maximum product

At some intermediate frequency, the time-bandwidth product will be a maximum. At this frequency, f_{sm}, the angle between rays passing straight through the top of the input recording and rays bent upward just enough to clip the edge of the



Geometry of a lens system showing the quantities used to calculate the time-bandwidth product. The output recording is shown in the photo below.

lens is θ_1, as in the diagram; the angle $2\theta_1$ is called the field angle of the lens.

The field angle can be shown, using diffraction theory, to be given by

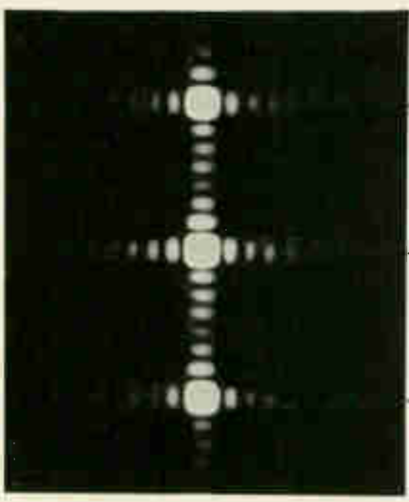
$2 \text{ arc sin } \lambda f_{sm}$

where λ is the wavelength of light used to illuminate the computer. The angle θ_2, which is half of the total angle subtended by the usable portion of the input, is given by

$\text{arc tan } (\overline{AA'}/2F)$

where $\overline{AA'}$ is the aperture of the input and F is the focal length of the lens; or by

$\text{arc tan } 1/(2f_{no})$



Focal plane display produced by an optical computer with a sinusoidal input. The bright spot in the center would be there in the absence of any input signal (a clear sheet of film in the input plane). The upper and lower bright spots correspond to the frequency of the input, they are analogous to the sidebands in an amplitude-modulated signal. The fainter spots surrounding the three bright spots are produced by the size of the input recording; to remove them would require a recording of infinite size.

where f_{no} is the f number, or ratio of focal length to aperture of the lens. Now the TW of the lens is the number of cycles of the maximum frequency over which the lens will coherently integrate or

$f_{sm} \overline{AA'}$

This is shown by trigonometry to be equal to

$2 F \sin \theta_1 \tan \theta_2/\lambda = F \sin \theta_1/\lambda f_{no}$

When θ_1 is a small angle, the TW of the lens is given by

$TW = F\theta_1/\lambda f_{no}$

where θ_1 is expressed in radians. Values of TW as high as 100,000 have been achieved in high-precision optical lens systems. The TW of even an ordinary 35 mm camera lens can be as high as 1,000. (But the coherent f number of such a lens is 10 to 100 times the f number usable for taking pictures; it is calculated with a very small aperture.)

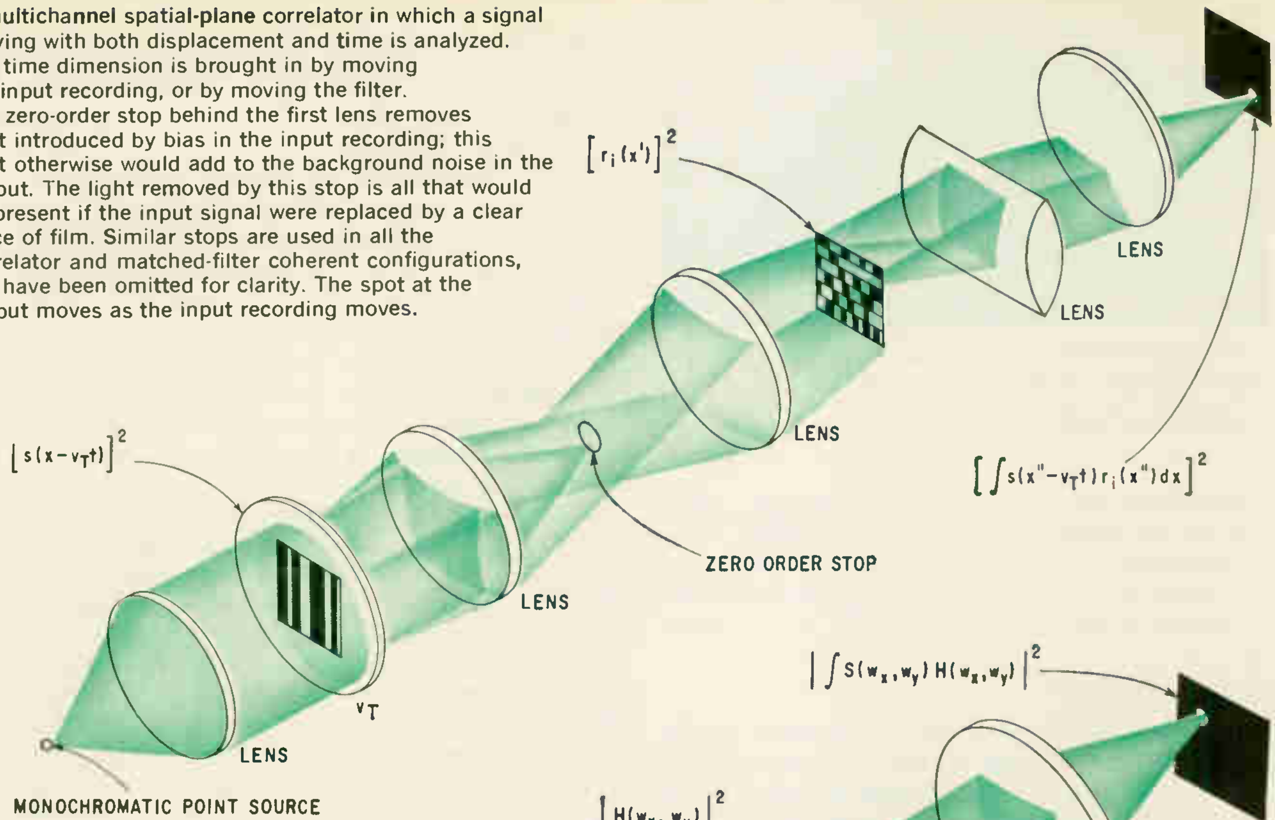
Matched filters to suppress noise

Electronic matched filters are commonly used to pick a very weak signal out of a very noisy background. These filters may be complex networks or they may be programs of large digital computers. A recent spectacular example of the latter was the retrieval of the Mariner spacecraft signals representing pictures of Mars, after the signals had been corrupted by 150 million miles of space noise.

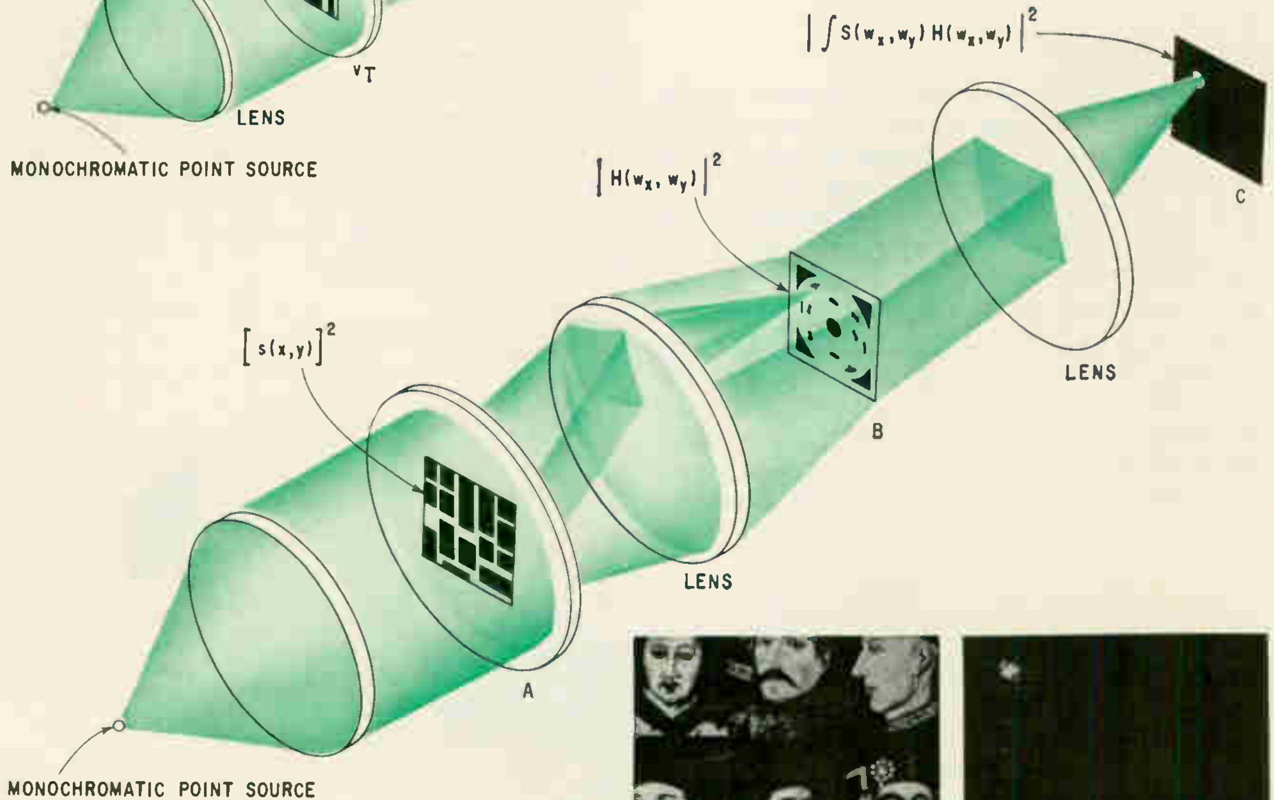
But the Mars pictures took a long time for transmission (over 8 hours for each picture) because the signals were enormously complex, and the computer had to process them sequentially.

An optical computer may be used as a two-dimensional time-frequency matched filter by placing an optical filter in the spatial frequency plane of an optical spectrum analyzer, and taking a second Fourier transform by adding another complete lens system.

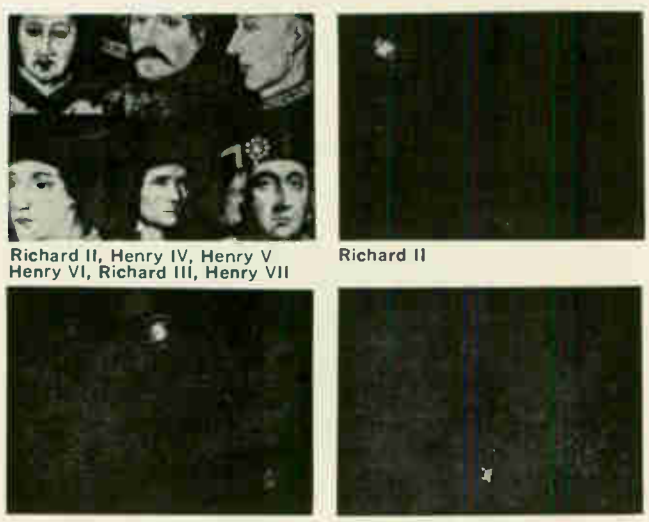
The computer compares signals much as one



A multichannel spatial-plane correlator in which a signal varying with both displacement and time is analyzed. The time dimension is brought in by moving the input recording, or by moving the filter. The zero-order stop behind the first lens removes light introduced by bias in the input recording; this light otherwise would add to the background noise in the output. The light removed by this stop is all that would be present if the input signal were replaced by a clear piece of film. Similar stops are used in all the correlator and matched-filter coherent configurations, but have been omitted for clarity. The spot at the output moves as the input recording moves.



Lens and filter configuration for two-dimensional matched filtering. The random pattern in the input focal plane is the signal. Light passing through this signal is focused by the first lens system as a pattern of spots on the filter; one such spot is shown above, with its pencil of rays in color. The filter is another pattern, which is symmetrical about its center point. Light passing through the filter at some specific angle is focused by the second lens system onto one bright spot on the output plane.



Richard II, Henry IV, Henry V Henry VI, Richard III, Henry VII

Richard II

Henry IV

Richard III

Six English kings identified by optical matched filtering. A filter corresponding to each face identifies that face in the presence of noise (other faces), and produces a bright spot on the output plane.

A highly polished lens surface, magnified to show the microscopic irregularities. The scale is indicated in the lower right corner. A micron is about 1/25,000th of an inch.

would compare two copies of the same transparency by placing one on top of the other.

According to the theory of matched filters, if the input is $s(x) + n(x)$, where $n(x)$ is noise, the frequency plane matched filter $H(\omega_x)$ is given by

$$H(\omega_x) = S^*(\omega_x)/N(\omega_x)$$

where H, S and N are Fourier transforms of the respective functions and S^* is a complex conjugate of S. (A complex conjugate may be achieved in an optical system by rotating the recording 180°.) Also, if the noise is Gaussian, or distributed along the familiar bell-shaped curve about a given energy level, then $N(\omega_x)$ is a constant and

$$H(\omega_x) = K\, S^*(\omega_x)$$

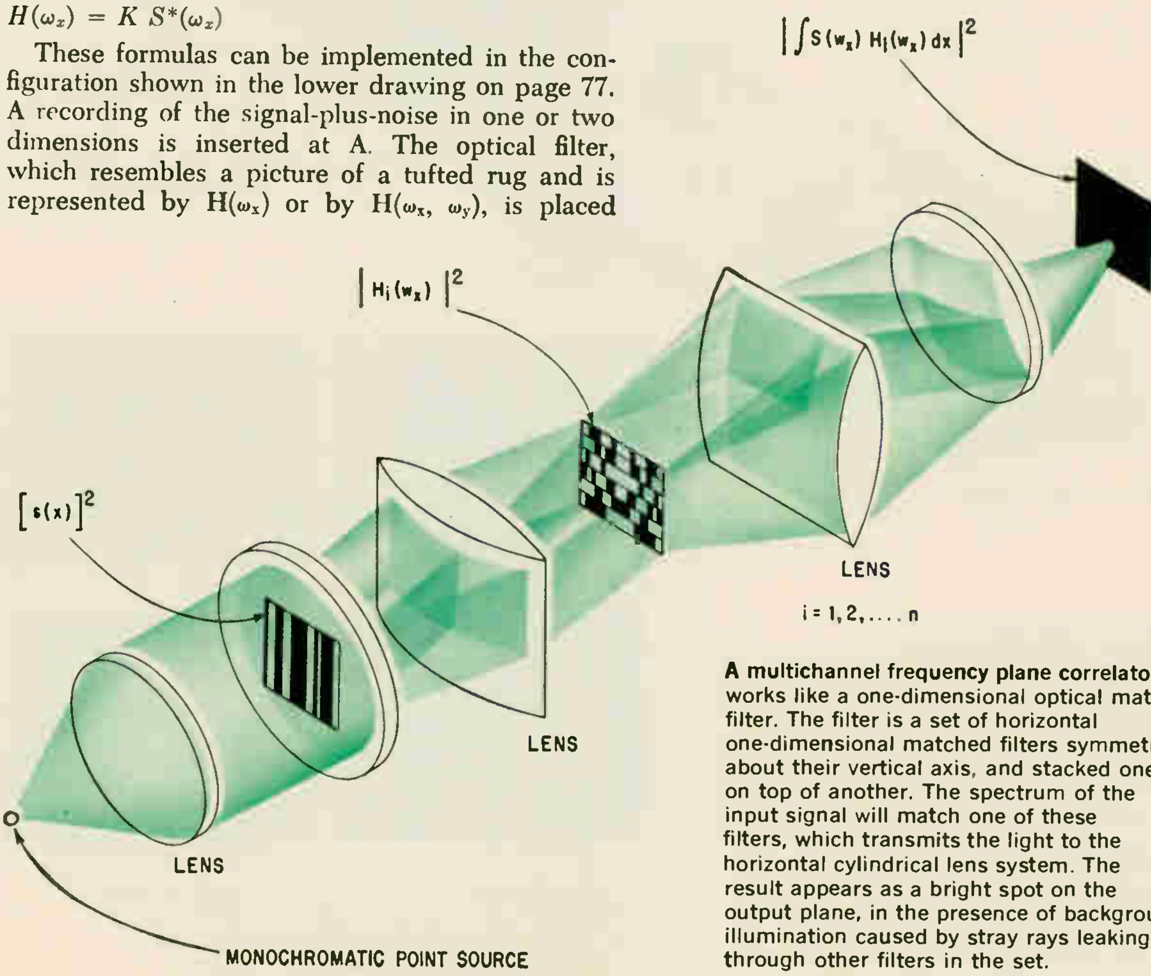
These formulas can be implemented in the configuration shown in the lower drawing on page 77. A recording of the signal-plus-noise in one or two dimensions is inserted at A. The optical filter, which resembles a picture of a tufted rug and is represented by $H(\omega_x)$ or by $H(\omega_x, \omega_y)$, is placed in the spatial frequency plane at B. Then the second lens system forms this electric field distribution in the output plane at C:

$$E(x'') = S(\omega_x)\, H(\omega_x)\, d\,\omega_x$$
$$= \int s(x)\, s^*(x-x'')\, dx + \int n(x)\, s^*(x-x'')\, dx$$

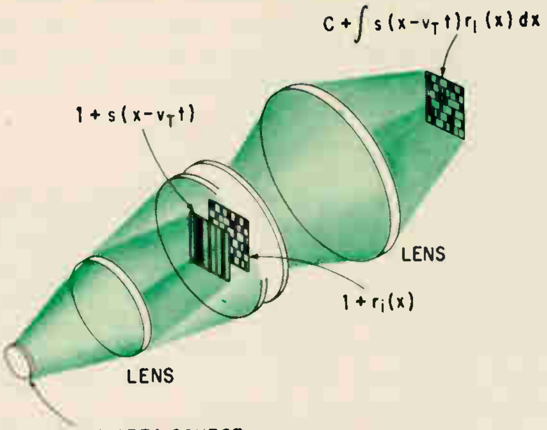
which is the correlation of the output signal with the input, plus the signal-noise cross-correlation.

A dramatic example of two-dimensional image identification performed by A. Vander Lugt at the University of Michigan is shown in the photo on page 77. The computer, using appropriate filters, has identified particular faces in a background of other faces (noise). A bright spot of light (the autocorrelation function) in the output plane indicates the presence and location of each face.

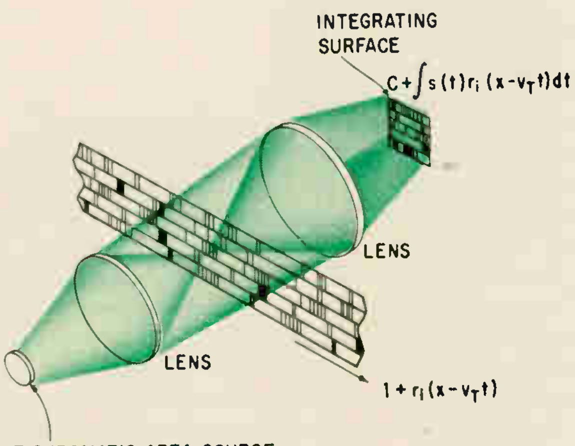
The drawing below shows another interesting example. A single one-dimensional signal $s(x)$ is recorded on the input medium; its one-dimensional spectrum appears spread across the entire y-dimension in the frequency plane. The recording is actually a set of one-dimensional matched filters—so many horizontal lines—placed in the frequency plane. The filters represent a library of 10,000 to 100,000 reference spectra, with which the spectrum of an incoming signal is compared. This feat of instantaneous parallel processing would be extremely difficult in an all-electronic system, which would have to make 100,000 simultaneous comparisons during a frequency sweep.



A multichannel frequency plane correlator that works like a one-dimensional optical matched filter. The filter is a set of horizontal one-dimensional matched filters symmetrical about their vertical axis, and stacked one on top of another. The spectrum of the input signal will match one of these filters, which transmits the light to the horizontal cylindrical lens system. The result appears as a bright spot on the output plane, in the presence of background illumination caused by stray rays leaking through other filters in the set.



A multichannel spatial plane correlator using noncoherent light. The signal and the set of filters are placed together because the bias term cannot be focused when noncoherent light is used. Note that the rays of light do not form a neat pencils, as with coherent light. Time is included in the signal function, meaning that the input signal is being moved.



Another noncoherent spatial plane correlator, in which the signal modulates the light source directly. The time dimension is brought in by moving the filter.

Space into time

It is also possible to perform both single and multichannel correlation in the spatial plane, by moving the recording and thus introducing a time dimension. The top drawing on page 77 shows a multichannel spatial-plane correlator which gives results similar to those of the computer shown in the preceding diagram, but which requires motion of either the signal s(x) or the set of references $r_i(x)$ in their respective planes. Since s(x) may be recorded on a moving medium, it inherently has a transport velocity v_T. The light amplitude distribution in the output plane on the axis becomes

$$E(x'', y_i, t) = \int s(x - v_T t)\, r_i(x)\, dx$$

Here the correlation function occurs on the optical axis as a function of time, whereas in the frequency-plane matched filtering systems, the autocorrelation function tracks the location of s(x) in the input plane. The diagram also shows a so-called "zero order stop," a black disk which blocks the bright spot corresponding to the bias term which occurs if s(x) is recorded as $1 + s(x)$ on film. As we have seen previously (page 74), the bias term causes light to appear on the optical axis. This light serves no useful purpose and increases noise due to scatter; therefore it is removed.

The reference spectra may also be recorded with a bias as $1 + r_i(x)$. In this case, the complete expression for the light amplitude distribution in the output plane is given by

$$E(x'', y_i'', t) = \int s(x - v_T t)\,[1 + r_i(x)]\, dx$$
$$= \int s(x - v_T t)\, dx + \int s(x - v_T t)\, r_i(x)\, dx$$

It can be shown that the second term in the above equation represents an image on the axis, while the first term, which is of no interest because it arises from the bias in the reference recording, is formed off axis. Thus a set of detectors placed on the axis will pick up the desired autocorrelation signals.

This is the configuration for the fast matrix multiplication referred to at the beginning of this article. The multichannel mask, represented by $[r_i(x)]^2$, itself represents a large matrix; the input signal $[s(x - v_T t)]^2$, represents a vector which multiplies the matrix.

Noncoherent optical computers

The ability to remove bias terms is inherent in coherent optical computers. When low-noise computation is desired over a large dynamic range, such coherent systems are advantageous. But they have two disadvantages: they always produce the square of the desired correlation functions, and they require a considerable number of precision optical elements. Another class of optical computers that do not depend on coherent light is useful in low-dynamic-range situations: these computers can tolerate considerably low optical specifications.

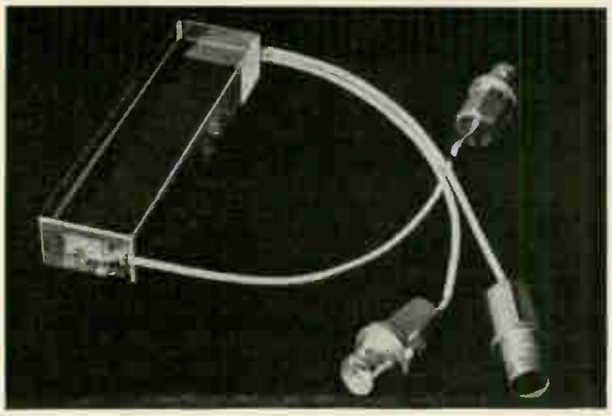
The two basic types of noncoherent optical computers are shown in the two drawings at left. In the one at the top, the signal and references are recorded directly without squaring. The signal record and the filter are adjacent because the bias term cannot be focused and removed when using noncoherent light. As the signal record is moved, the light intensity (not the electric field) passing through the two recordings is given by

$$I(x, y, t) = [1 + s(x - v_T t)]\,[1 + r_i(x)]$$

A simple lens gathers all of this light and focuses it on a square-law detector. The lens plus detector produce an output given by

$$I(t) = \int [1 + s(x - v_T t) + r_i(x) + s(x - v_T t) r_i(x)]\, dx$$

Four terms appear in the integral. The first three are unwanted; since they usually have low time-frequency components, they can be removed from the output with a low-pass electronic filter. However, shot noise—noise voltage due to random



Photoelastic input device for optical computers, made of a block of fused silica with a piezoelectric transducer. Electrical signals set up an ultrasonic wave in the block; variations in the refractive index modulate a light beam.

variations in the number of photons emitted by the light source—due to these terms remains, so that the result after low-pass filtering is:

$$I'(t) = \text{Shot Noise} + \int s(x - v_T t)\, r_i(x)\, dx$$

Shot noise should be small with respect to the desired correlation integral.

Amplitude modulation

In the lower drawing, the signal is introduced by amplitude modulation of the light source itself. The reference is moved past the light source and light transmitted through it impinges upon a mosaic or "fly's eye" detector, which produces the spatial signal distribution

$$I_o(x) = \int [1+s(t)]\,[1+r_i(x-v_T t)]\,dt$$
$$= \int [1+s(t)+r_i(x-v_T t)+s(t)r_i(x-v_T t)]\,dt$$

Note that the integration is done at the detector, not in the lens system.

The first three terms under the integral are unwanted. The first is a bias term, which accumulates with time; the second is the average value of the signal. Both are independent of x and form a spatial bias with inherent shot noise. The third term is a correlation integral, which occurs as a function of x instead of time. The optical system places no limit on the correlation interval; therefore extremely long correlation times and large time-bandwidth products can be achieved, limited only by the mechanical accuracy of the reference function motion and the tolerable values of the spatial bias caused by the first three terms.

At the end of a selected time interval, the correlation function is taken directly from the detector mosaic. Most optical computers give readouts on photographic film in the output plane or scan out information with photomultipliers, imaging tubes, mosaic detectors, rotating mirrors or other devices.

Readout from coherent light computers requires detection of a weak signal, limited by shot noise, with a dynamic range of up to 60 decibels. Sometimes, when some zero-order light is mixed with the signal, amplification is gained by homodyne detection—that is, by tuning a local frequency to match the incoming carrier signal, and then amplifying the sidebands. Readout from noncoherent computers requires a design that will not be saturated by bias shot noise, or the basic bias level itself.

Lens limitations

From the foregoing, it is clear that the electronics engineer who works with optical computers must become familiar with a whole new world of optical transfer functions, diffraction theory, photon noise problems, and the like. At the same time, he is faced with the practical problems of lens specifications and tests, optical system design, and the selection of optical materials.

For example, the dynamic range of a coherent lens system is limited by various forms of optical aberrations. The word "aberration" as used here described departures of the optical wavefront from a perfect planar or spherical distribution. These aberrations have three basic causes:

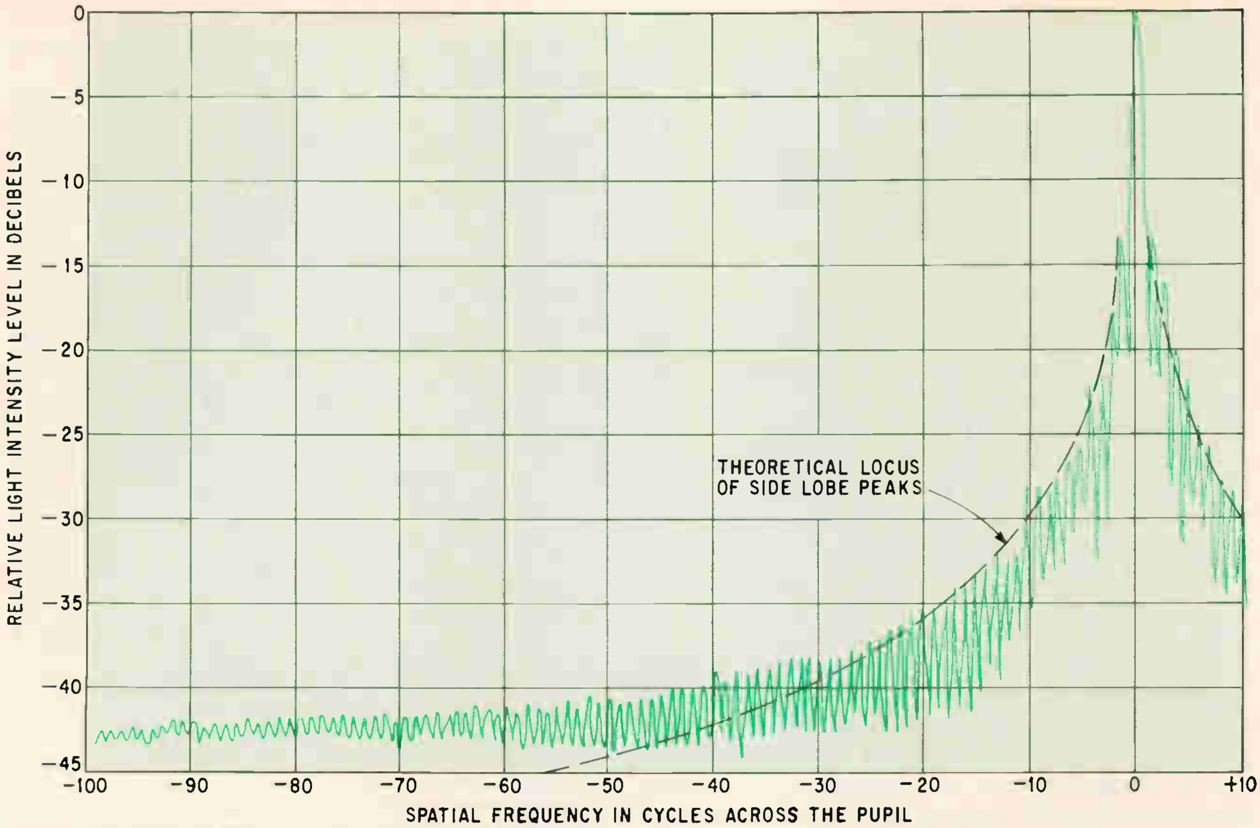
- Departure of the basic optical design from the so called "diffraction-limited" or ideal design.
- Departure of the lens system from the optical design due to systematic manufacturing errors.
- Departure of the lens system from the optical design due either to bulk irregularities in the raw material or to microscopic surface irregularities.

But lens manufacture is a highly advanced art. Modern techniques of precision optical design using adaptive computer programs, which "learn" as they operate, have evolved lens systems corrected to within one tenth of the optical wavelength rms. Errors in lens surface curvature can be held to within a small fraction of a wavelength of the actual design. Over-all surface regularity in precision optics is typically within 1/20 to 1/50 of a wavelength for lens elements of 10- to 30-inch aperture, and within 1/200 of a wavelength for elements of less than one-inch aperture.

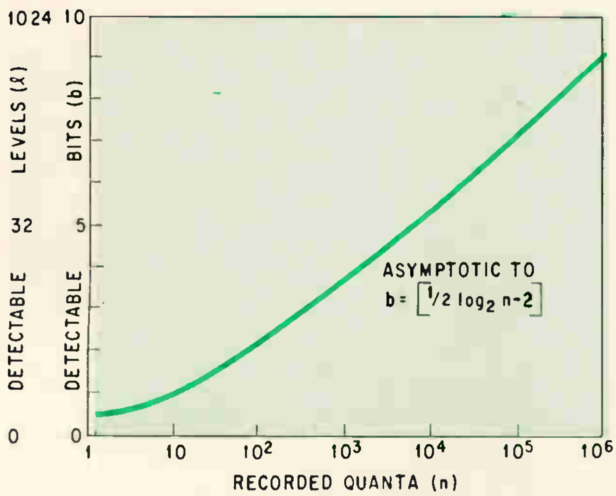
Surface flatness has been studied by electron microscopy. Its magnitude can also be inferred from scatter measurements. The photo on page 78 shows the apparently random microstructure of a polished lens surface. Assuming random surface irregularities, the ratio of the intensity of forward scatter, I_s, to the intensity of source image, I_o, for a single lense-to-air interface is:

$$I_s/I_o = \left[\frac{2\pi(n-1)}{\lambda}\, d_{cms}\right]^2$$

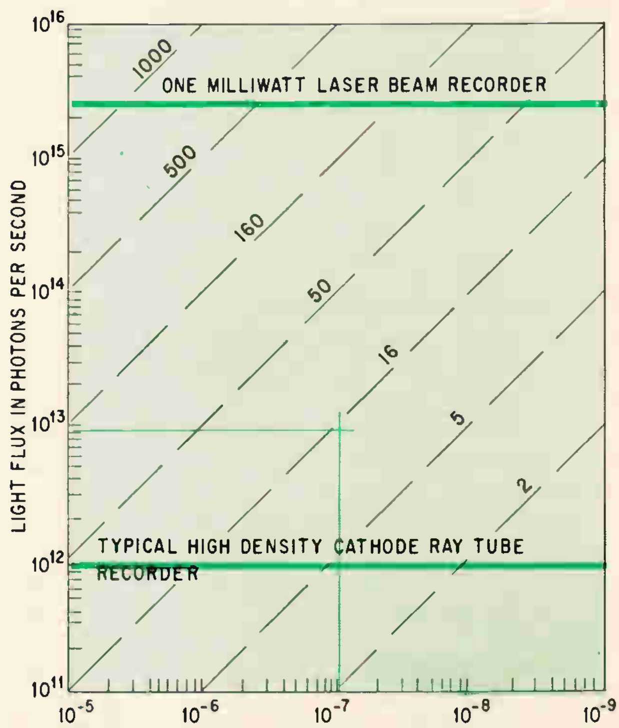
where n is the refractive index of the glass, λ is the wavelength of light, and d_{rms} is the root mean square surface irregularity. The effects of both systematic and random wavefront irregularities are inferred from plots showing the actual side-lobe structure of each computer lens system. The plot in the top graph opposite was made by mapping the light intensity distribution in the output focal plane of a lens system with coherent illumination of a rectangular aperture in the input plane. To do this, an aperture much less than $\lambda \times f_{no}$ in diameter mechanically scanned the focal plane of the lens



Light intensity distribution in the focal plane of a lens system illuminated by coherent light. Theoretically, the side-lobe peaks (fainter spots around the bright center, as in the photo on page 75) should follow the dotted line; the fainter ones are not as faint as they should be because of scattering by surface roughness of the lens.



Variation of the number of detectable levels in a photographic film, as a function of the amount of light striking the film. One level is distinguishable from another with a degree of uncertainty which depends on the number of photons required to blacken a single grain.



Detectable levels as a function of the amount of input light and the exposure time, for a quantum efficiency of 10^{-3}. The lines in color show that if light arrives at the film at the rate of 10^{13} photons per second and the exposure is one tenth of a microsecond, then $(10^{13})(10^{-7}) = 10^6$ photons strike the film and $(10^{13})(10^{-7})(10^{-3}) = 10^3$ grains are produced, giving 16 detectable levels. (This graph does not apply to relatively low density recorders using fiber optic cathode ray tubes).

and a photomultiplier measured the energy transmitted through the aperture.

The random scatter level illustrated in the plot is 43 db below the intensity of the main lobe, corresponding to an effective single surface d_{rms} of 12 angstroms per the square root of a cycle across the input format. Since the actual lens system whose test results are shown in the plot consists of 13 surfaces, the d_{rms} across the input format equals

$12/\sqrt{13}$ or about 3 angstroms. To obtain the rms surface ripple over the entire spatial bandwidth, this quantity is multiplied by the square root of the time-bandwidth product of the lens. For this particular lens, the TW was about 3,000, so that d_{rms} across the spatial bandwidth is somewhat less than 170 angstroms per surface.

Bulk scatter

This figure does not take into account bulk scatter, which occurs equally in all directions and at present may be evaluated only qualitatively. The bulk scatter seems to range from 1% to 0.01% of the input power per centimeter of glass.

Bulk scatter of another kind is caused by trapped air bubbles in the glass. Extensive data is available on bubble content in terms of size, distribution, and content per cubic centimeter from manufacturers of optical quality glass [10], but enormous variations from the mean are found from batch to batch.

A third case of background or apparently random scatter occurs as "ghost" images or reflections in the output plane. These are caused by the difference in the dielectric constants of air and glass, which brings about an electromagnetic impedance mismatch at optical frequencies. Carefully designed coatings on all lens surfaces provide a better impedance match and reduce ghost energy by one or two orders of magnitude. However, a penalty is paid when coatings are used: the bulk scatter of most coatings is significantly higher than that of glass.

Reduction of random lens system noise requires careful compromise. There are no firm rules for choise of glass, polishing methods, and coatings. Noise due to random scatter can be held down to —50 to —60 db by extremely careful manufacturing, to give the computer a dynamic range commensurate with achievable TW values.

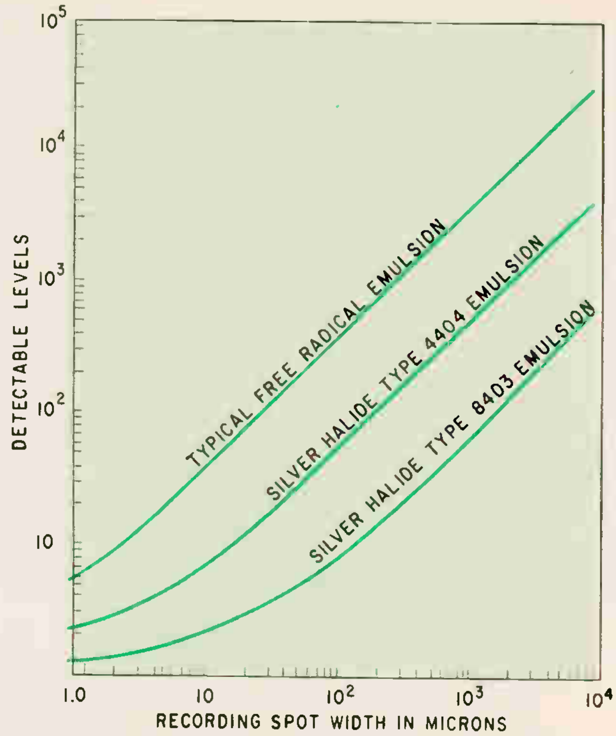
Choosing the input transducer

One of the most serious problems faced by the computer designer is that of finding an input medium with a dynamic range commensurate with that of the computer itself. Both spatial amplitude modulators and spatial phase or polarization modulators are now in use.

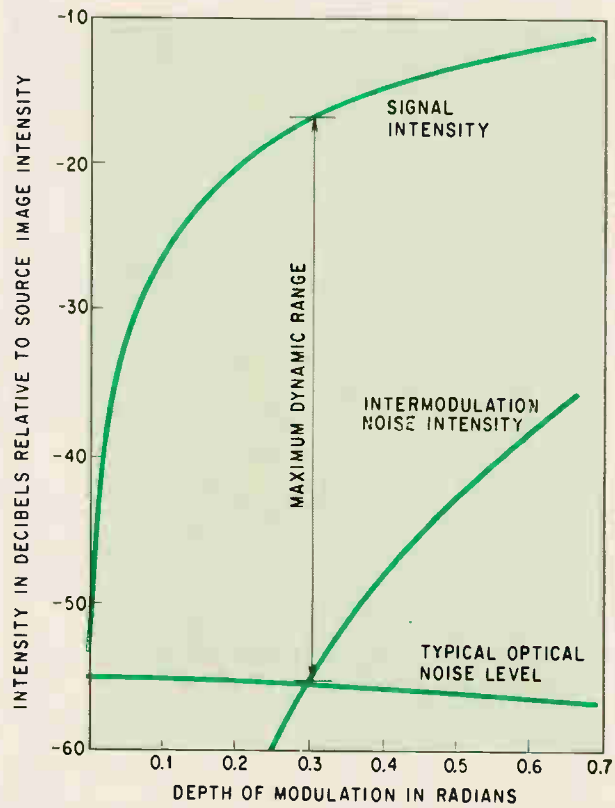
Amplitude modulators available include silver halide emulsions (photographic film), other emulsions, films with total internal reflections, electroluminescent sheets, and oil films such as CIBA Ltd.'s Eidophor.

Phase or polarization modulators include thermoplastic films, electro-optical films, magneto-optical films, photoelastic materials, and depletion layer materials.

At the moment, silver halide emulsions are used almost exclusively for recording signals from d-c up to 100 megacycles when the delay for chemical development is tolerable. The next most popular transducers are the transparent photoelastic materials, which have the advantage of instantaneous



Detectable levels versus spot size for various recording media at optimum exposure. The size of recordings may be limited by grain size.



Signal and noise as a function of depth of modulation, or modulation index. The curves are derived from Bessel functions; the optimum point is that where the "good" curve (signal) is farthest above the "bad" curves (noise).

input but also have a lower TW.

A typical photoelastic device is shown in the photo on page 80. It consists of a transparent block of fused silica with a piezoelectric transducer. The transducer creates an ultrasonic wave in the block; the pressure variations cause variations in refractive index of the medium. These variations cause spatial phase variations in the light, which passes through the medium at right angles to the ultrasonic wave.

Thermoplastic films are spatial phase modulators in the same sense as the photoelastic modulators; but like silver halide photographic materials, they must be processed before being inserted into the input plane of the optical computer.

Dynamic range limitations

All of these input devices have a somewhat restricted dynamic range, each for a different reason. The dynamic range of photographic emulsions is limited by grain noise and by nonlinearities.

Grain noise in silver halide emulsions is analogous to shot noise in quantum electronics. It arises from the fact that silver halide is a photon counter with a quantum efficiency of the order of 10^{-3}. Thus, if n_p recording photons arrive per unit area, about 10^{-3} n_p grains will be produced, with a standard deviation of the square root of the number of grains. Furthermore, if the mean grain diameter is d, the film will be completely black when the number of grains per unit area, n_g, equals $1/d^2$, assuming there is no significant overlap in photon arrivals.

If the grains are Poisson-distributed (a skewed Gaussian distribution), then the number of detectable levels of input is shown in the left-hand graph on page 81; these levels place a limit on dynamic range. The only way to increase dynamic range is to increase the number of grains per recorded sample. This can be done by using finer-grained material, or by recording over a wider area. Both methods demand more photons from the recording source. In practical circumstances, this limits the recording bandwidth of the system, especially when using present cathode ray tube recorders.

With the advent of laser beam recorders, this situation has changed radically, as shown in the graph at the lower right on page 81. This figure and the one at the top of page 82 show that with the laser, the size of recordings may be limited by grain size; silver halide material with sufficient dynamic range is not available with small enough values of d to permit recordings of reasonable size. Use of free-radical, photochromic, or diazo material may relieve this problem.

Photoelastic modulators are limited in dynamic range for entirely different reasons. Since they phase-modulate the light, intermodulation products like those of frequency modulation systems occur. For example, if two signals, $s_1(x)$ and $s_2(x)$, occur simultaneously, the effect of spatial phase modulation on the light, I_1, incident on the modulator is described by the equation:

$$E(x) = E_o\epsilon^{j\alpha[s(x)+s(x)]}$$

$$= E_o \sum_{n=o}^{\infty} \frac{j\alpha[s_1(x) + s_2(x)]^n}{n!}$$

where a is the modulation index.

Unless the instantaneous sum of both signals times the modulation index is kept significantly less than a radian, intermodulation product noise will limit dynamic range. On the other hand, the linear term in the equation must provide a signal level above the inherent lens system noise described previously. The resulting compromise is illustrated in the graph at the bottom of page 82, which indicates an achievable dynamic range of about 40 db. Similar considerations hold for other optical spatial-phase modulators, such as thermoplastic film.

Developmental input media

The dynamic range of other input media to optical computers is as yet unpublished. The quality of these devices is undergoing rapid change.

In the class of amplitude modulators, diazo, free-radical, and photochromic materials offer the potential of great dynamic range for small-area recordings at the expense of low quantum efficiency and correspondingly high recording-energy requirements. Other spatial amplitude modulators, such as films are also under evaluation[11, 12].

In the class of optical phase modulators, much work is being done on thin layers of electro-optic dielectrics whose index is modulated by either charge deposition or direct injection of electromagnetic waves, as well as on thin layers of magneto-optic material which are spatial polarization modulators when energized by spatial magnetic fields.[13]

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Acknowledgment

The photograph of the simulation of an antenna field pattern on page 75 is used courtesy of A. Ingalls of the Conductron Corp.; that of the six kings of England on page 77 courtesy of Anthony Vander Lugt, of the University of Michigan.

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.

Scr ring counter switches up or down

By John G. Peddie*

Aero Service Corp., Philadelphia

Bidirectional stepping switches are usually large, inefficient, and slow, but the circuit shown below switches in 3 milliseconds, uses low power, and when mounted on a card, measures 3 x 4 x 1 inches.

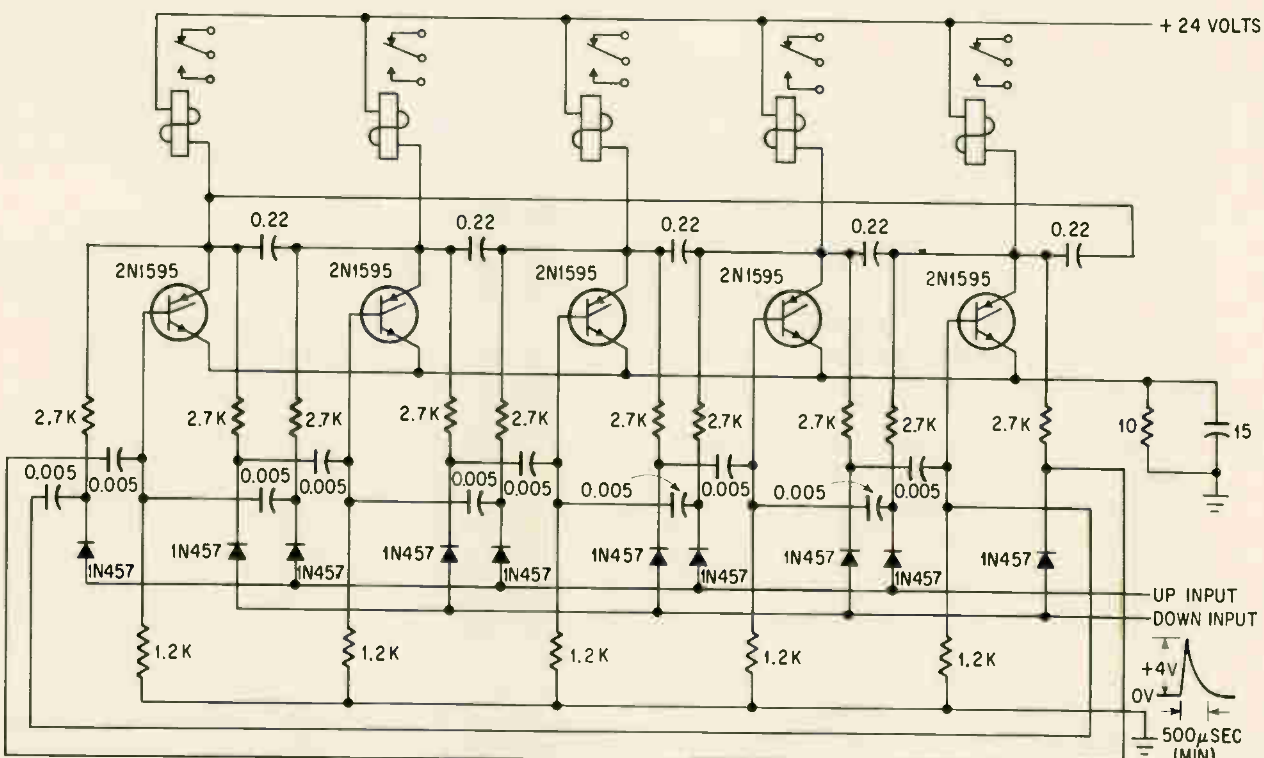
The speed requirement for a particular application was achieved with a silicon controlled rectifier ring counter and fast response relays. The counter can reverse direction without missing a count.

The bidirectional ring counter will shift the on-condition of a relay either up or down when it receives a command at either input. The counter will reverse direction, as long as an up and a down input are not received simultaneously.

When any scr is turned on, the capacitors connected to its anode bias the surrounding scr anodes negatively. This is due to the small voltage drop across an scr when it conducts. The voltage also reverse-biases the diodes that are connected to the anode through the 2.7K resistors. Only those diodes in the gate circuits of the nonconducting scr's on either side of the conducting scr can receive an applied pulse.

When a pulse is applied to either the up or the down input, the appropriate scr next to the conducting scr will start to turn on. The capacitor be-

* Presently with H. Dell Foster Co., San Antonio, Tex.



ALL CAPACITANCE VALUES ARE IN MICROFARADS
ALL RELAYS ARE C.P. CLARE TYPE RP7641G2

Scr ring counter shifts up or down, without missing a count, provided that the up and down input pulses are not applied simultaneously. The only power consumed in the counter is by the stage that is conducting.

tween the anodes of the two scr's discharges through the conducting scr, putting a reverse bias on its anode and turning it off. This shifts the on relay one position over.

The cost per stage is about $11.00 for the high-speed, miniature unit shown. However, using a slower and larger relay, and RCA 2N3228 scr's, a counter could be built for about $4.00 per stage. If the relays are replaced by Nixie tubes whose anodes are connected to 115 volts a-c, and the cathodes of the scr's are grounded, a bidirectional 10 kc counter could be built for $50.00 per decade.

Diodes protect meter from overloads

By Philip D. Blais

Erie Technological Products, Inc.

Semiconductor p-n junctions, which have extremely nonlinear forward conductance, may be used to bypass excessive currents from delicate meter movements. The error contributed by such a meter protection circuit may be controlled through the proper selection of the circuit values. The result is low-cost protection for relatively expensive meters, with a negligible loss in accuracy.

A typical protection circuit for a d-c ammeter is shown below, right. Once the maximum error that can be tolerated by the addititon of the protection circuit is chosen—for example, one percent—the maximum p-n junction current, I_j at full scale deflection voltage V_{fs} is then found from:

$$I_j = \frac{\text{error in percent} \times I_{fs}}{100}$$

Where I_{fs} is the full scale deflection current.

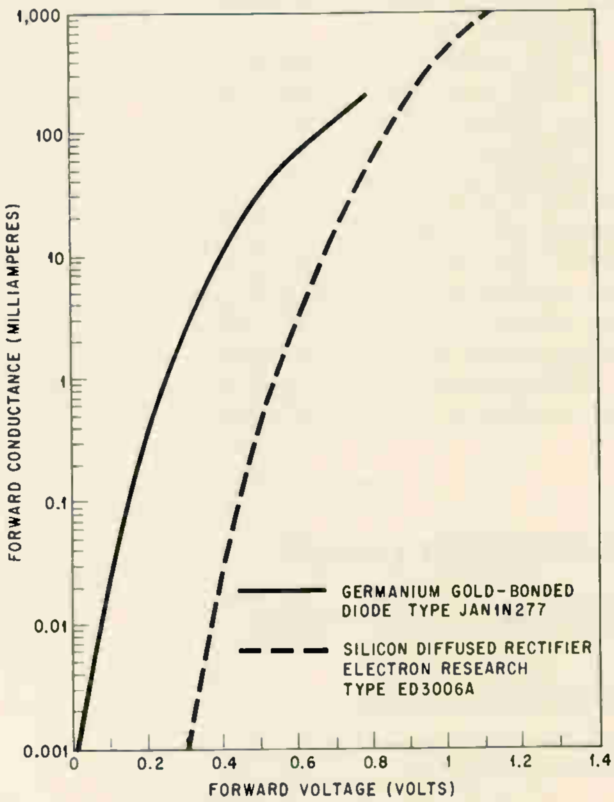
Next, the p-n junction potential, V_j, is determined by using the conductance curves at right for two common types of semiconductor diodes. Normally, the designer will work with the germanium device first, but if that does not produce satisfactory results, the silicon device is used.

Since complete protection occurs when $V_j = V_{fs}$, resistors or p-n junctions are added in series to make the voltages equal. As long as V_j is greater than V_{fs}, protection is inadequate; when V_{fs} is greater than V_j, reading error is excessive.

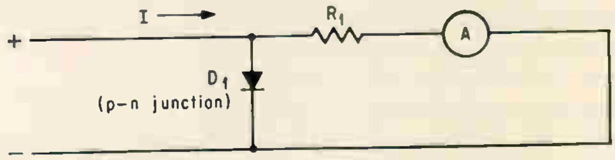
If V_j is greater than V_{fs}, the remedy is to add a resistor R_1 whose magnitude is determined by:

$$R_1 = \frac{V_j - V_{fs}}{I_{fs}}$$

If, on the other hand, V_{fs} is greater than V_j, the remedy is to replace the germanium diode with a silicon device. Then if V_{fs} is still greater,



Forward conductance characteristic for two of the more common types of diodes. Type 1N277 is typical of those devices, having high forward conductance at very low voltages and the ED3006A characteristic is applicable to most of the three-quarter ampere devices manufactured by the diffusion process. These curves should not be used for devices manufactured by the indium-bonded or alloyed-junction processes.



General circuit for protecting d-c ammeter against accidental application of excessive voltage. The value of R_1 can be adjusted for best protection.

rectifiers are added in series until NV_j (where N is the number of rectifiers) is equal to or greater than V_{fs}.

If NV_j (now considered as V_j') is greater than

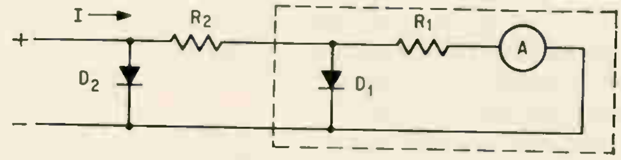
V_{fs}, a resistor is added, its size determined by the equation for R_1 in which V_j' takes the place of V_j.

After the design is completed, the overload protection for the meter is checked by estimating the maximum possible value of current that might be applied accidentally to the metering circuit.

The resulting junction potential V_j'' at overload is found from the curves on page 85. It is assumed that the protective p-n junction will pass 100% of the overload current. The overload factor, F, is equal to V_j''/V_{fs}.

Most common panel meters can be protected with the same basic circuit and minor modifications. To protect d-c voltmeters, however, the series multiplying resistor must be considered when designing the protection circuit. To protect a-c voltmeters and ammeters, two diodes, connected back-to-back in parallel, are used in place of the single diode. The peak value of the current is used in all calculations, and the total impedance, including the inductive reactance of the coil, is used in place of the simple d-c meter resistance.

Ultrasensitive meters, used in low impedance power circuits, require additional components to insure protection. One approach is to add a second stage, as shown in the diagram above.



Two-stage protection circuit is used for ultrasensitive meters which require more protection than is given the one-stage technique. The first stage is within the dotted rectangle.

The first stage of attenuation is designed as previously outlined. The second stage is designed by repeating the same procedure, using R_1 plus the meter's internal resistance, R_{int} as the new value R_{int}' for the simulated internal resistance of the meter. The value of R_2 can then be chosen to equal R_{int}'. The second stage p-n junction arrangement, D_2, should be two D_1 diodes in series.

The total instrumentation error introduced by the two-stage protection circuit is twice that of the single circuit. The total current attenuation, or overload factor, F′, is equal to the product of the individual stages' factors, or $F_1 \times F_2$.

Transistor circuit pulses 1,000 volts

By David O. Hansen

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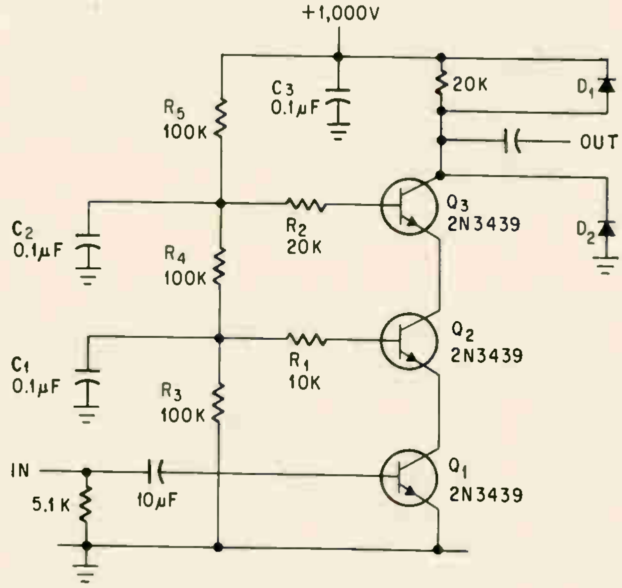
Redondo Beach, Calif.

A 1,000-volt pulse with a short rise time is provided by the solid state circuit shown at the right.

The circuit was constructed to drive a 20 kv pulse tube. With the components shown, the pulse rise and fall times are 800 nanoseconds.

The simple biasing network consisting of R_3, R_4 and R_5 assures that the collector-to-emitter voltage rating across each transistor is not exceeded.

A positive pulse of approximately 2 or 3 volts at the input switches Q_1 on. When Q_1 starts to conduct, its collector voltage falls. This turns on Q_2, because of the base current flowing into Q_2 through R_1. The same thing happens when the collector of Q_2 falls, switching on Q_3 whose base current flows through R_2. The switching times of Q_2 and Q_3 are very short, and limited only by the cutoff frequency f_α of the transistors, since they are switched by emitter drive. Therefore, the switching speed of the circuit is limited almost entirely by the switching time of Q_1, which is turned on by base drive.



Solid state high voltage pulse circuit

Diodes D_1 and D_2 are high voltage rectifier diodes with breakdown voltage ratings greater than the supply voltage. They protect the transistor string from spurious high voltage spikes that may be fed back from the load circuit.

For long pulses, increase the values of C_1, C_2, and C_3.

Sawtooth generator uses FET as constant current source

By Dwight D. Brooks and Carl F. Johnson

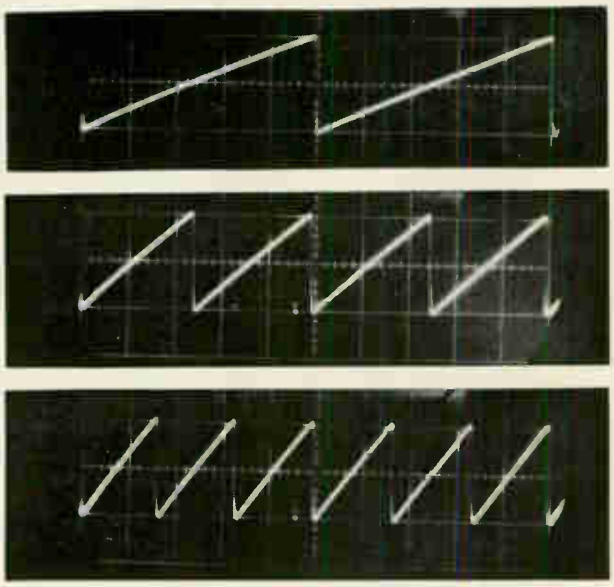
International Business Machine Corp., Lexington, Ky.

Field effect transistors in a sawtooth generator eliminate the need for complex feedback techniques to develop linear ramp function. Since an FET, used as the circuit's constant current source, has a larger dynamic swing than conventional junction transistors, the capacitor charging voltage is extremely linear and produces a linear output ramp. The output waveform, which can vary from one to three kilocycles per second, can be generated with an input modulating signal as low in frequency as 0.5 cps and only 0.4 volts peak-to-peak.

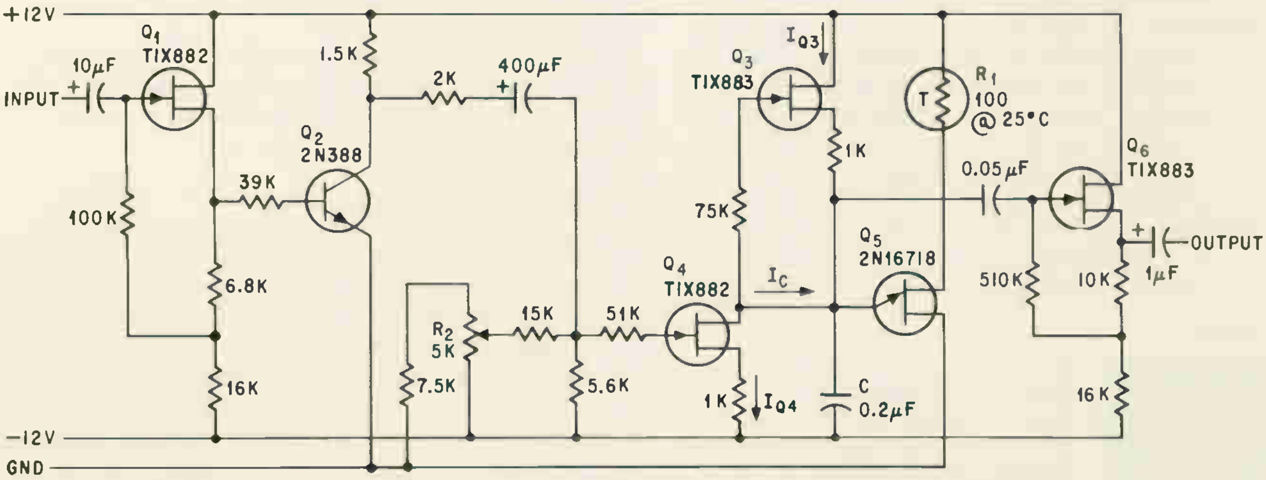
The low-frequency modulator's circuit is shown below. Transistors Q_1 and Q_2 provide both high input impedance and amplification for the modulating signal. Transistors Q_3, Q_4, and Q_5, along with capacitor C, make up the linear ramp generator. In the generator, Q_3 and Q_4 are FET current sources that drive a relaxation oscillator consisting of Q_5 and C. Driving current source Q_3 supplies a constant current, I_{Q3}. A portion of this current is conducted by Q_4 to the power supply return. The current into capacitor I_C is therefore equal to $I_{Q3} - I_{Q4}$. The value of I_{Q4}, and hence the charging rate of the capacitor, is determined by the modulating signal. The center frequency of the modulator is controlled by the value of R_2.

When the voltage on the capacitor reaches the firing potential of unijunction Q_5, the capacitor is discharged and the cycle repeated. A sawtooth ramp is thereby generated with a linear voltage to frequency relationship because I_{Q4} is a linear function of the gate to source potential of Q_4 in the actual operating range, and the current supplied by Q_3 is constant.

The peak voltage of the generated sawtooth is constant at 0.6 volt since it is determined only by the firing potential of Q_5. Q_5 is inverted from its normal operating posititon to give it a low firing point, about ¼ of the usual value. This mode of operation keeps the potential change across Q_4 small, and preserves the constant current characteristic of the FET's. The output ramp linearity is greater than 98%.



Linear output waveform is shown at three frequencies: 1, 2 and 3 kc. The vertical axis of the scope is set at 0.3 volt per centimeter while the horizontal is at 0.2 millisecond per centimeter.



Sawtooth generator uses FET's to provide output that has a linear voltage to frequency relation with a constant peak voltage. Thermistor R_1 provides temperature stability and Q_6, a source follower, reduces loading.

Scr's break the frequency barrier

New interdigital structure permits silicon controlled rectifiers to handle frequencies up to 50 kc. Combinations of them can operate in the megawatt range

By Neville Mapham
General Electric Co., Auburn, N. Y.

In recent years the silicon controlled rectifier has become the leading device for rectifying, switching and regulating current in heavy industries. At low frequencies—60 to 400 cycles per second—the scr controls tens of megawatts of power in steel mills, glass-processing plants and other production facilities.

Now the scr is moving into higher frequencies, from 5 to 50 kilocycles, which are used for induction heating, ultrasonic cleaning and welding, sonar and very-low-frequency radio transmitters.

For these applications, vacuum-tube oscillator-amplifiers are still used because the traditional scr's switching losses have been significant at these frequencies, also because the device characteristics deteriorate rapidly and hot spots form on the scr chips. But new high-frequency, high-power scr's now do the job faster and more efficiently, with low loss.

Interdigitation, recently used successfully in the manufacture of high-frequency power transistors, is now being applied to scr's. Some interdigitated scr's retain their characteristics up to 25 kilocycles. The frequency response for a 400-volt, 25-ampere device is shown in the top curve on page 89; its switching losses are negligible up to 5 kc, and the device performs usefully up to 25 kc. Its maximum turnoff time (t_{off})—the time during which the scr must be reversed-biased before it can block forward voltage—is 10 microseconds at all points below the curve.

In contrast, the first scr's were designed mainly for line frequencies of 60 and 400 cycles per second. They were thought of as thyratron replacements, and therefore tended to be limited to typical thyration frequencies. Even today, most scr's are limited to operating frequencies below 1,000 cps.

Why higher frequency

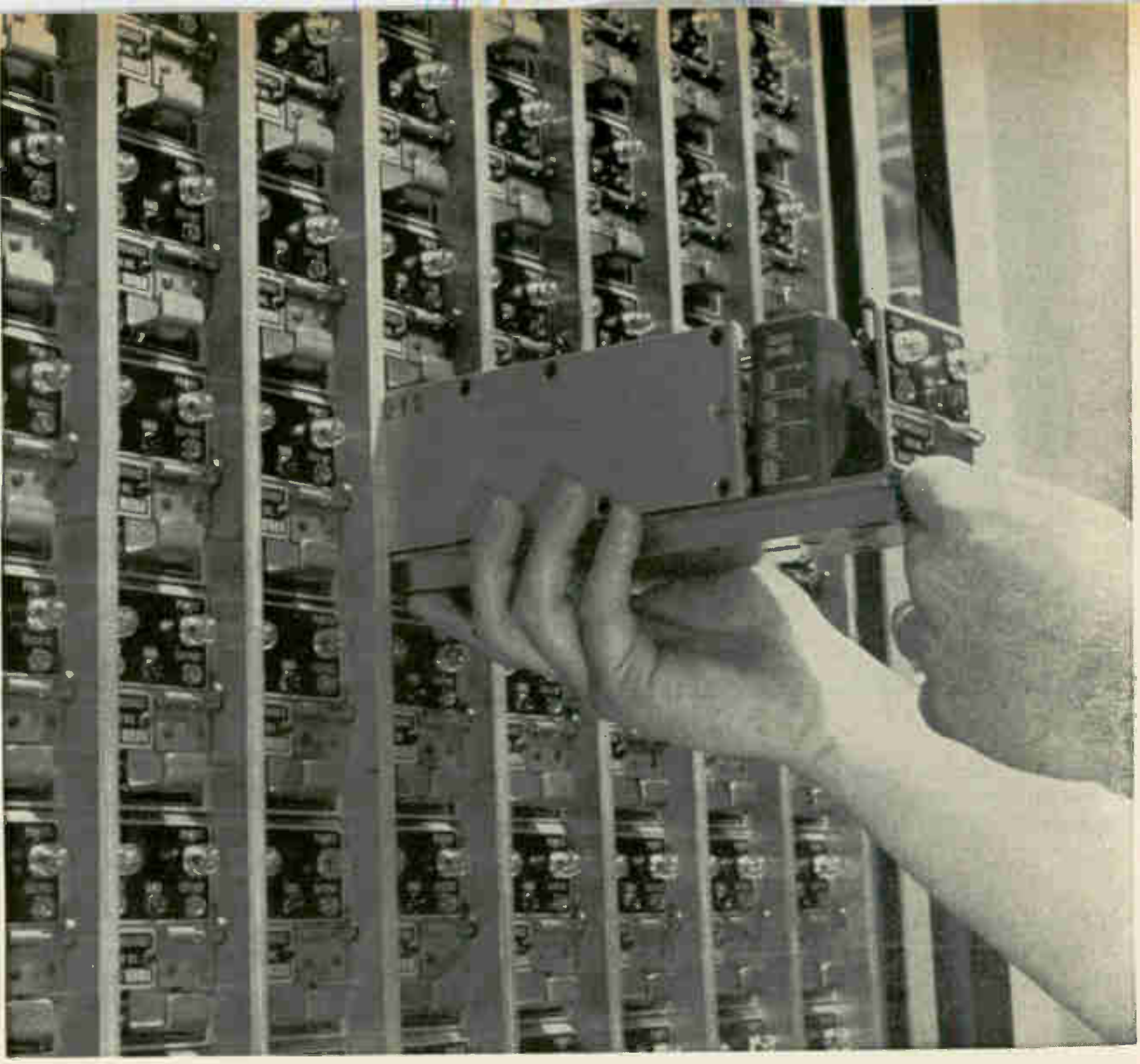
There are several advantages in using high frequencies in industrial applications:

- In this band it is less expensive to transform power between high and low voltages and between high and low frequencies; it is also less expensive to filter back to direct current.
- The higher the frequency, the faster will be the control; with scr's this is on a cycle-by-cycle basis. The control action is also smoother, because most power loads have frequency responses far lower than, say, a 5-kc scr, and the pulses are entirely smoothed out.
- Higher frequencies permit more compact circuit packaging. They operate with compact transformers, inductors and capacitors, the passive components that occupy most of the space in a power scr package.
- They permit greater efficiency. At high frequency, ultrasonic transducers can be driven directly; this eliminates losses in intermediate stages. Efficient, relatively high-tension transmission can also be employed, using scr converters to step up the voltage. Many passive devices, particularly inductors and transformers, become less expensive at higher frequencies. Some of the reduction in component cost can be traded for more efficient units.

There is only one disadvantage: a high-frequency system has to generate and control its own frequency, which may not be as reliable as that of the 60-cycle commercial power lines.

The author

Neville Mapham was born in South Africa and educated in London. Now, among his other scr investigations, he's working on very-low-frequency radio transmitters (40 kilocycles).



Five hundred scr inverter modules, each producing kilowatts of power, are combined in parallel to produce almost a megawatt of output at an ultrasonic frequency. This bank serves a military application, but with continued price reductions in components this type of scr bank will soon become common in industry too. There is no limit to the amount of power that can be produced by adding modules in parallel.

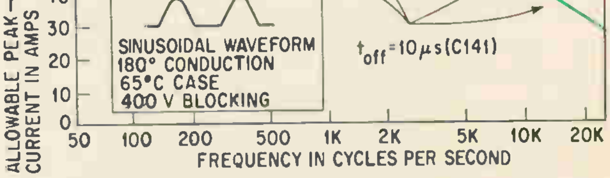
The high-frequency scr

High-frequency, high-power scr's are available; so are the circuits that can use them. But most important for the designer, the data that makes the scr's usable in these circuits is also available.

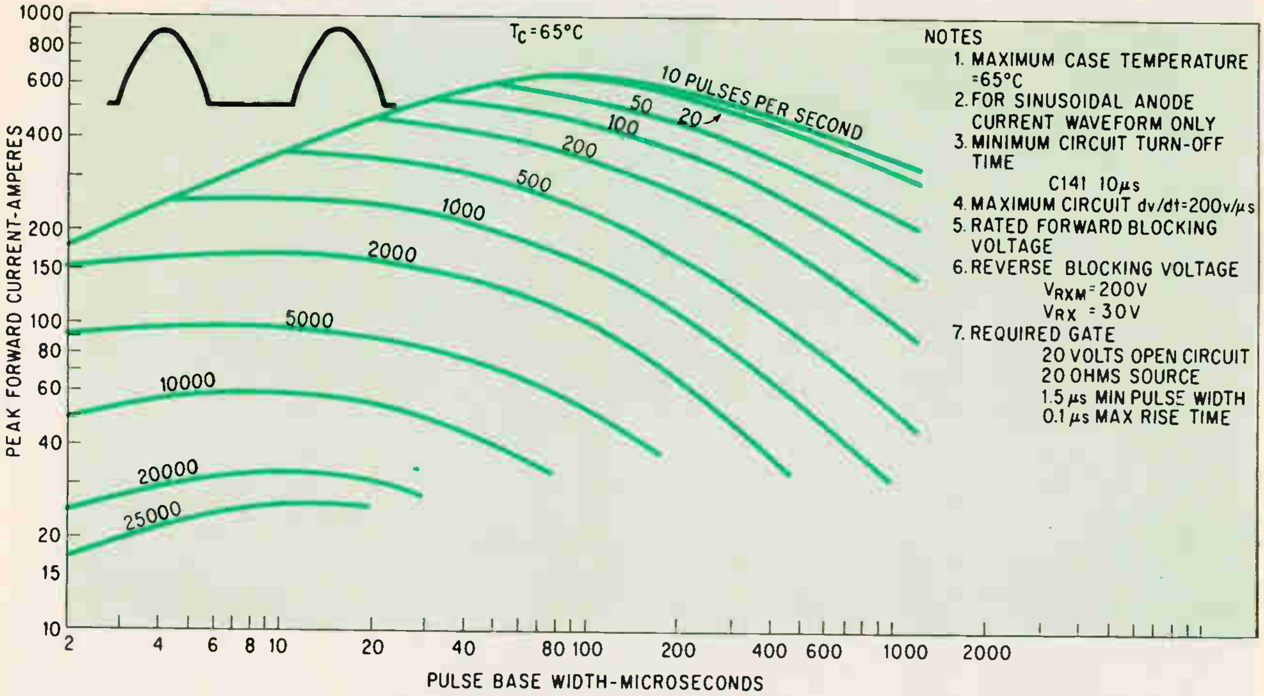
Because the high-frequency scr is often used near the limit of its ratings, it is important for the user to possess detailed application data showing the design tradeoffs for various applications. Until very recently curves were not available; data such as that given on pages 90 and 91 is necessary to a designer of high-frequency scr circuits.

The graphs show how the peak forward current varies with pulse base width. The curves in the graph on page 90 show how much the scr must be derated as the pulse rate is increased. The designer needs this information to determine how much anode current the scr's will be able to control for the switching waveform of any application. If the designer knows the number of pulses per second and the base width of the individual pulses, he can find the allowable peak forward current.

The curves in the graph on page 91 show how much energy per pulse will be dissipated for a given operating condition. They tell the designer how much power will be lost in the scr, and therefore how much cooling will be necessary in the scr's heat-sink mount. This information is presented in a manner that helps the engineer to make tradeoffs in typical design situations. If he knows from the previous graph how much peak anode cur-



High-frequency scr retains power-handling ability at tens of kilocycles, as shown in graph. Derating is not needed until 5 kc.



Effects of duty cycle on higher-frequency scr's current-carrying ability. The three parameters of graph cover most scr load waveforms. Data is for GE's new fast turn-off C141 (2N3649-2N3658) SCR that uses gold diffusion to achieve turn-off times below 10 microsecond. It has a 200 volts per microsecond dv/dt and a 400 amps per microsecond di/dt.

rent he can use, he can use this graph and, starting with the known pulse width, find how many watt-seconds of energy are dissipated by the scr. If he cannot provide a heat sink large enough to remove this amount of energy, he has enough information from the graph to start making compromises.

Flexible high-frequency circuits

The appeal of high-frequency scr circuits lies in their flexibility. With a good high-frequency inverter and some compatible rectifier and converter circuits, the designer has building blocks that he can combine in myriad ways to transform, control and manipulate kilowatts of electrical power.

The first requirement is a good inverter, a circuit that converts a direct-current input into a high-frequency alternating current. The basic sine-wave inverter (see opposite) has proved useful in the high-power area over the past five years because the scr switching losses are low with the sine-wave. These low switching losses make the sine-wave inverter a much better starting-point circuit for a high-frequency inverter than a forced-operation square-wave inverter. Low switching losses are vital in the production of kilowatt power at kilocycle frequencies.

There are four limitations to the basic scr sine-wave inverter:

- The scr's turn-off time is too long.
- Peak voltages increase drastically with load.
- Regulation is poor.
- The load cannot be disconnected from the circuit without harming the scr's.

Each of these problems can be overcome by a circuit modification.

The sequential scr inverter

A typical turn-off time for the basic sine-wave inverter is 0.2 cycle. Even if a high-frequency scr with a 10-microsecond turn-off time were used, this would limit the frequency of the basic inverter to 20 kilocycles per second (10 μsec per 0.2 cycle = 50 μsec per cycle or 20 kc). While it is possible to produce scr's with turn-off times of less than 10 microseconds, this can be accomplished only at the cost of reduced blocking-voltage ratings.

The sequential inverter circuit gets around this limitation. It permits the output cycle to be shorter than the turn-off times of the individual scr's.

Consider a sequential circuit made up of five sine-wave inverters [diagram on p. 92]. If the scr's are triggered from a ring counter so that all the scr's on one side of the inverters [scr's 1 through 5] are fired one at a time and then those on the other side (scr's 6 through 10) are fired one by one, no scr will limit the operation's over-all speed. With the five sequentially fired inverters, each scr will have 2.2 cycles in which to turn off, instead of only 0.2 cycle.

This assembly of circuits delivers a sine-wave train to the load because as indicated by the polarity dots at the transformers, the inverter stages are connected to the load with alternating polarities. In this way, the load will see the proper alternating polarities of a continuous sinewave even though the circuit diagram indicates that the same sides of the inverters are being fired in sequence.

The number of individual inverters, the scr turn-off times and the period of the output frequency are related by the equation

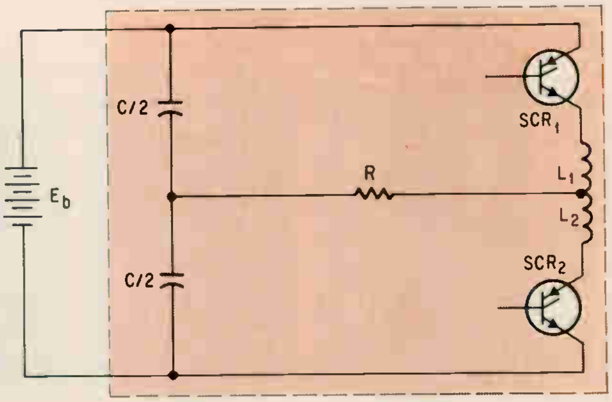
$$t_c = \left[\frac{n-1}{2} + 0.2\right]\tau\ \mu s$$

where t_c is the turn-off time allowed the scr's, n is the number of pairs of scr's and τ is the period of the output frequency in microseconds.

The greater the number of stages, the higher the output frequency can be pushed beyond the scr's turn-off time limitations. However, the output power must be derated at higher frequencies (see table under circuit diagram).

The second drawback of the basic sine-wave scr inverter—the large variation of SCR voltages with load changes—can be corrected by inversely connecting fast-recovery diodes across the scr's. This is shown in the diagram for the improved scr inverter on page 93. The diodes discharge the capacitor after each pulse and prevent successive pulses from building up high voltages under heavy loads. The diode insures that the peak voltage across the scr will never be greater than three times the supply voltage.

The third and fourth drawbacks of the basic inverter—poor load regulation and inability of the



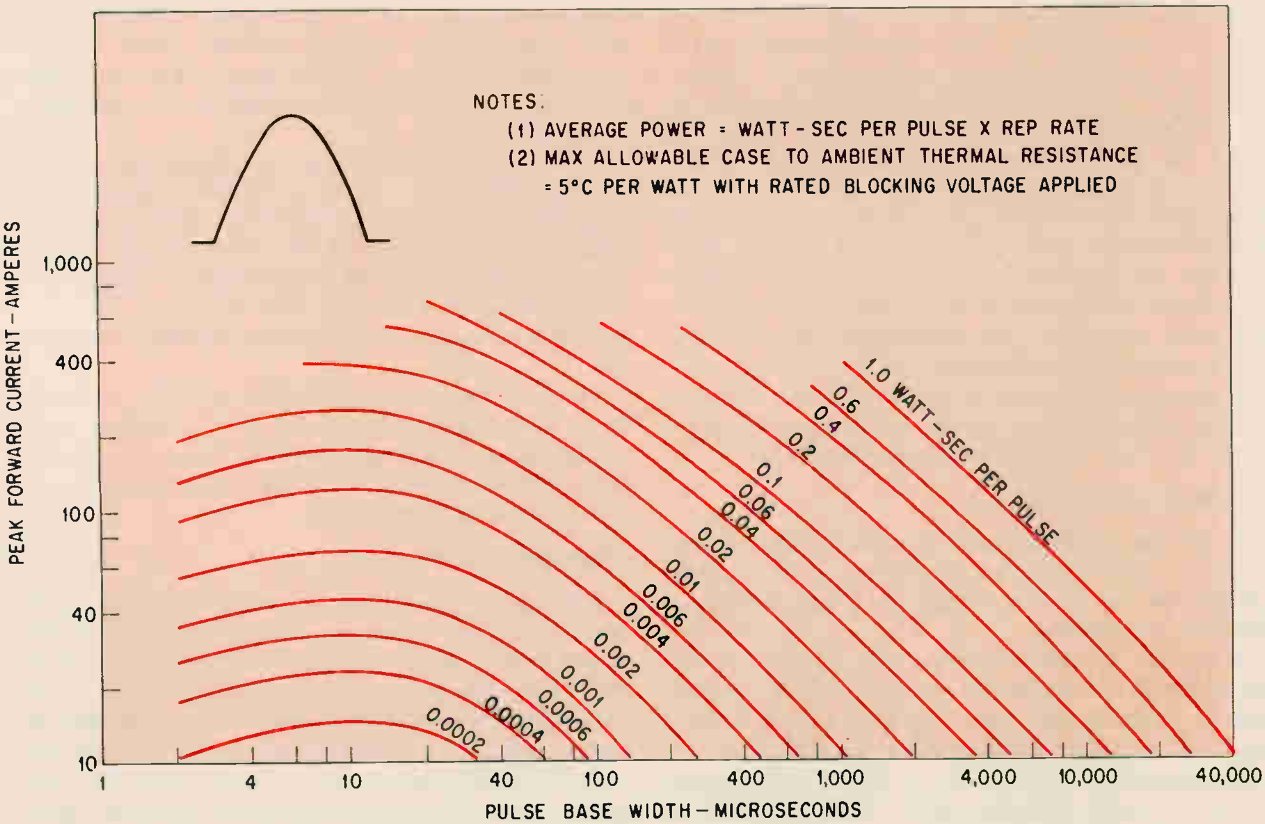
Sinewave inverter is good start for high frequencies.

inverter to operate with an open-circuited load—are both corrected by rearranging the circuit so that a single capacitor is connected in parallel with the load, rather than in series.

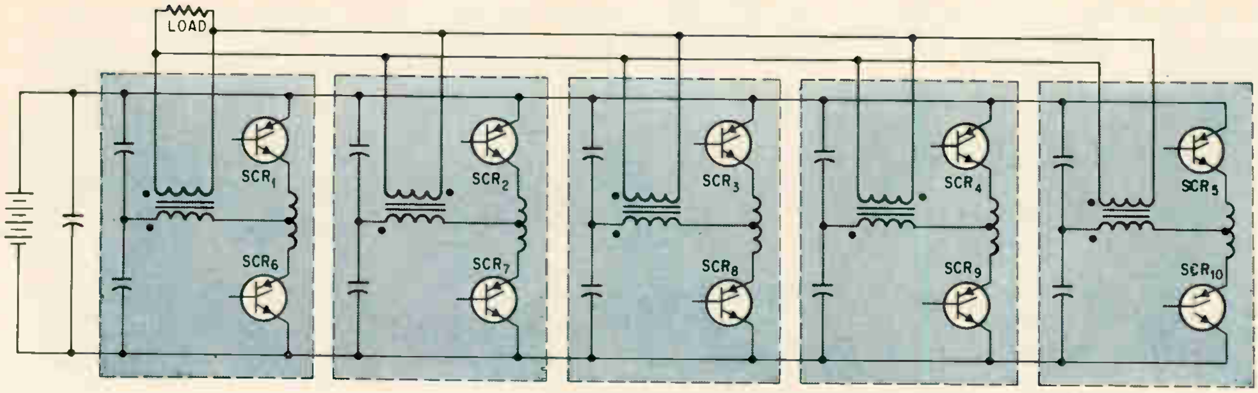
Now the load sees a constant-voltage source rather than a constant-current source; this is usually expected of a power source. A constant voltage permits better regulation because most loads' impedances are matched to operate with constant-voltage sources.

The inverter can operate with an open-circuited load without burning out the scr's. This is an important improvement, for most users expect to be able to disconnect loads from power supplies.

The improved inverter is much easier on the scr

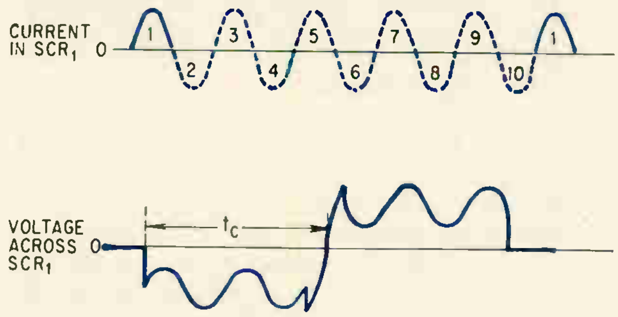


Energy dissipated by high-frequency scr in controlling various pulse shapes is shown. Watt-seconds for individual pulses must be multiplied by pulse repetition rate to give the average power that the heat sink must remove from the scr. This tells the designer how much heat sinking he needs.



Frequency in kc	Power output in kw
10	30
20	23
30	19
40	16
70	10
100	7

Supply voltage is 200 volts. Case temperature of the 10 scr's (General Electric C141303DX30's) is kept below 65° C. Over-all efficiency is 90%.



Sequential sinewave inverter is one way to get around the turn-off time limitations of most scr's. This circuit presents a longer turn-off time to the individual scr's than the operating frequency would suggest, because of the sequence in which the scr's are triggered.

devices, as shown by the waveforms with the schematic. The scr carries the positive-going current only; the diode carries the negative-going current. With no load, the diode current is nearly equal to the scr current; the scr current is still slightly larger by the amount of current needed to make up for circuit losses.

As the load increases the diode current decreases, because correspondingly more current is being drawn from the supply. Meanwhile, the sharp reverse-voltage spike at the start of the scr turn-off has disappeared. The peak reverse voltage across the scr is now no more than a volt or two. But most important, the forward blocking voltage is the same with and without a load. This protection is important because, as previously noted, the shorter turn-off times of the high-frequency scr's result in lower forward blocking voltages.

Improved diodes needed

In the improved inverter, the diodes used across the scr's must have fast recoveries if they are to protect the scr. Power diodes are being developed for this application.

When the forward current in the average power diode drops to zero and reverse voltage is applied, reverse current will flow for as long as several microseconds. The oscillogram on page 93 shows reverse-current recovery for a typical 12-ampere diode (General Electric A27). This behavior is undesirable for two reasons:

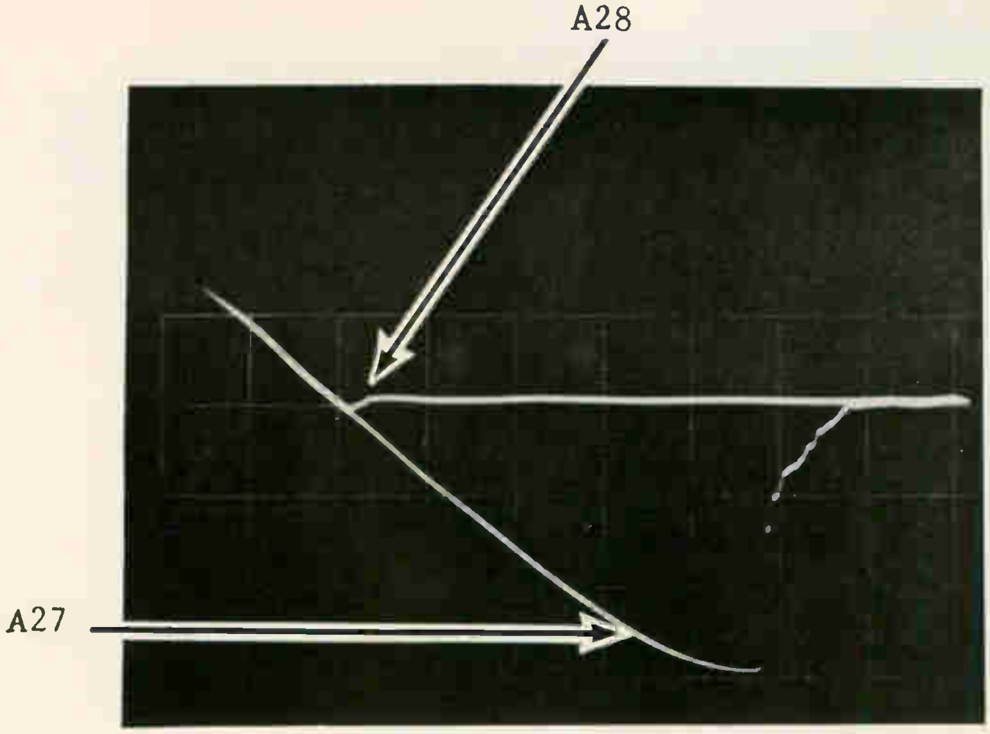
- The circuit's normal turn-off action is delayed because during this diode-recovery interval there is, in effect, a short circuit across the diode.
- The abrupt change in recovery current generates noise both in radio-frequency interference (rfi) form and in induced voltage spikes in the surrounding circuitry. Often these spikes are large enough to falsely trigger or even to destroy other semiconductors.

The new fast-recovery power diodes recover so rapidly that none of these troubles occur. The only problem is that the improved diode performance is at the expense of the diode's peak reverse voltage rating. Available fast-recovery diodes are still limited to 400 volts, but they can be connected in series to obtain increased voltage capability.

To show the inherent flexibility of these circuits, three scr applications have been singled out: powering an alternating-current load, regulating and controlling power simultaneously, and converting to different frequencies.

Alternating-current load

For loads that need alternating current, such as a fluorescent lamp, scr circuits can convert the power into a higher more efficient frequency than the 60 cycles per second available from power lines. The system shown in the diagram on page 94 could start from a 60-cps line supply, but the scr circuits would convert this to 9,600 cycles at 1,500 watts. The frequency-conversion process goes through an intermediate direct-current stage, then to the scr inverter than increases the frequency to 9,600 cycles. The d-c stage could also incor-



Fast recovery is possible with power diodes, as shown in this graph of Newer diode A28 recovers in a fraction of the time taken by A27 plotted against a vertical scale of amperes per centimeter. New A28 diode, represented by top curve, recovers in a fraction of the time required by the A27 represented by bottom curve. Horizontal units are 0.5 milliseconds per centimeter; vertical are 8 amps per centimeter.

porate regulation with a modification to the scr circuit.

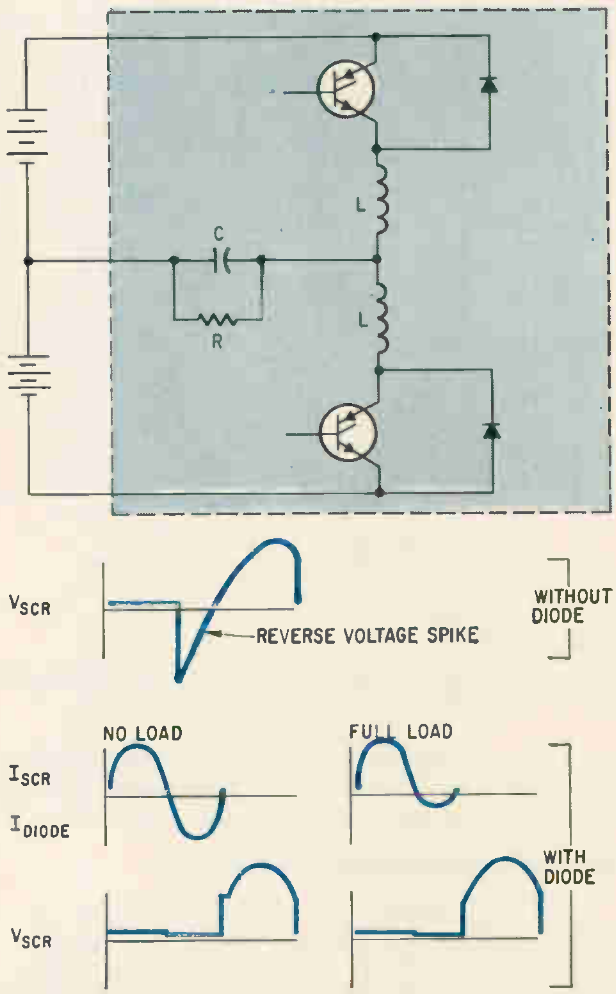
It is important for the inverter to be able to operate without a load in this case because fluorescent lamps do not ionize immediately when the voltage is applied, but for a short time behave as if they were very high impedances.

The reactors are connected in series with the lamps because fluorescent tubes operate on negative resistance slopes at ordinary voltages. Their operating characteristics are similar to those of a neon lamp, which also has a negative-resistance segment in its current-voltage characteristic curve. The reactors used in series with the lamps have power factors that alternately lead and lag so that a unity power-factor load is presented to the inverter. This permits economies in the wiring and transformer ratings.

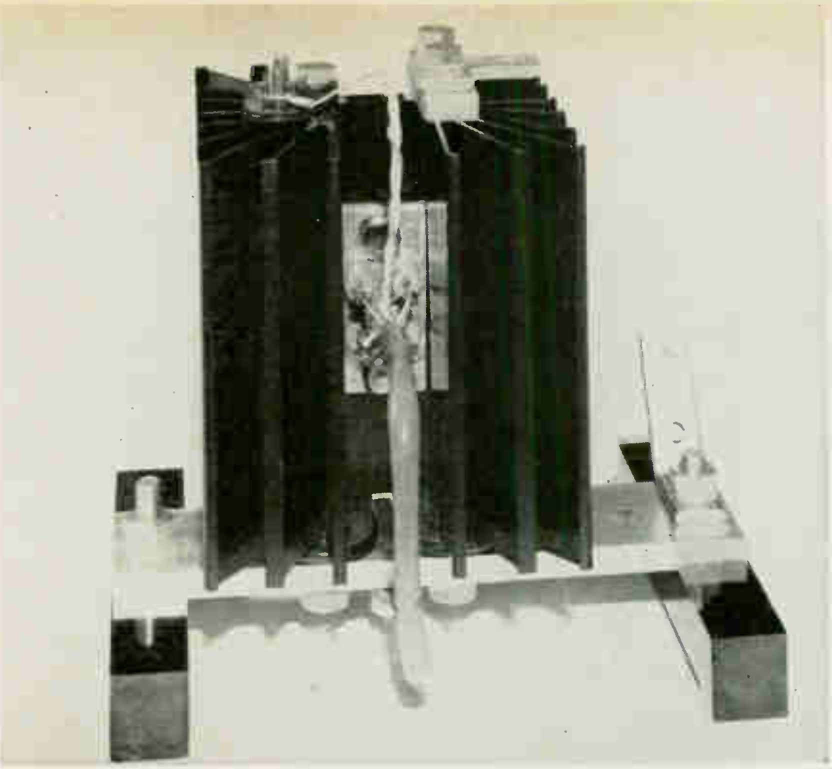
The over-all efficiency of this power supply is greater than 90%.

This high efficiency is possible because more efficient inductors and transformers are available for higher frequencies. The inductors and transformers do not become much more efficient at higher frequencies, but it costs less to build a high-efficiency inductor or transformer for high-frequency operation; this is because the higher the frequency, the less the amount of core and winding material that must be used.

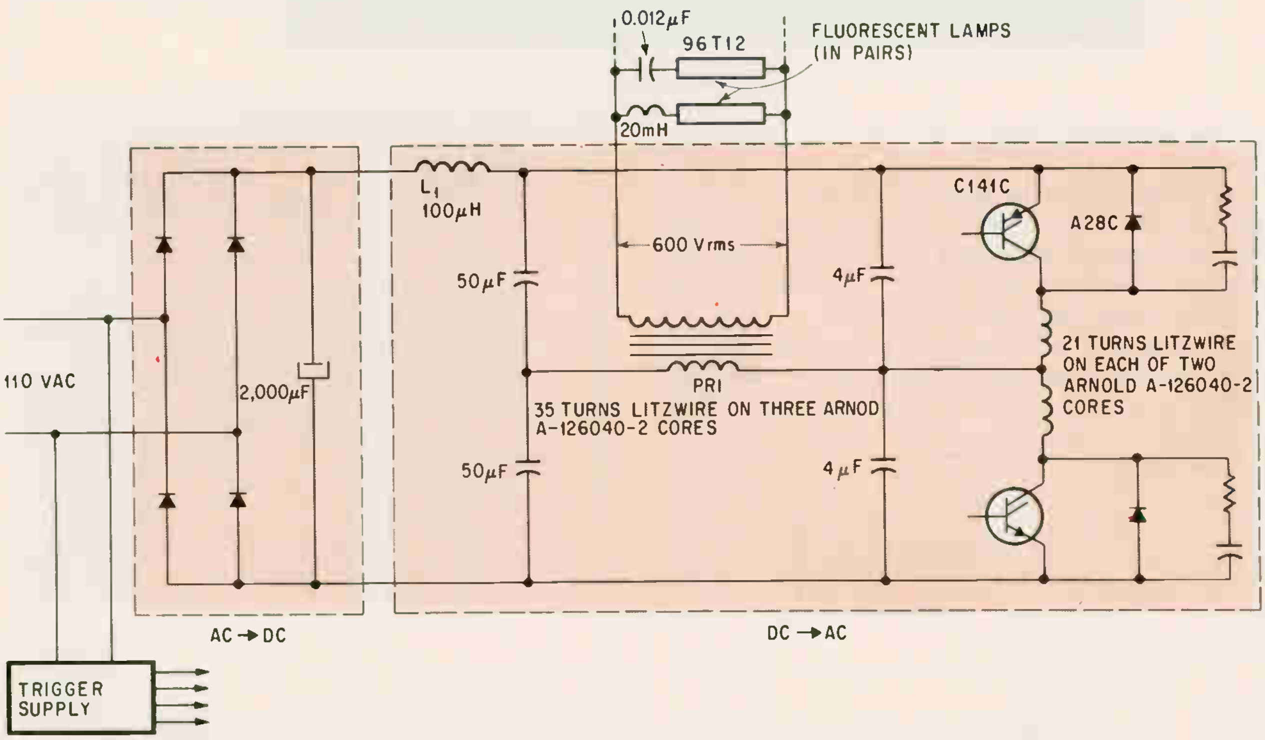
The higher-efficiency components also have side benefits. Because they generate less heat, they present less burden for a building's air-conditioning system. But, these more efficient high-frequency inductors introduce some circuit problems. It is necessary to introduce RC networks across each scr-diode combination to damp out ringing, which



Improved sinewave inverter. Now the voltage across the SCR's won't grow out of bounds with the high-Q condition of a heavy load. As a by-product, the reverse-voltage spikes across the SCR's is removed.



Four scr's clustered on a common heat sink. It is possible to match these scr's closely enough at their operating current levels so that each will be able to operate within 10% of its rating.



High-frequency power supply drives fluorescent lamps at 9,600 cps. The 1,500-watt output of the scr inverter can power a parallel string of lamps.

occurs because of the inductor's stray capacitance. This adds some complexity to the circuit, has a negligible effect on the over-all efficiency.

Regulating and controlling power

Scr inverters can do more than transform power to more usable forms and levels; they can regulate and control the power at the same time. In the d-c-to-d-c converter shown in the diagram on page 96, the improved inverter has been changed to a bridge configuration by the addition of another set of scr's and diodes. This doubles the output power.

The control or regulating feature is added by using scr's for reconverting to direct current. This type of d-c-to-d-c converter has some attractive advantages. Because of the high operating frequency—about 20 kc—the ripple frequency is also high, and the filtering components can be small, light and economical.

The control response is more rapid than conventional 60-cycle systems by a ratio of 20,000 to 60. Phase-controlled scr's can vary the output voltage from 0% to 100% during a few cycles.

The basic d-c to d-c converter can be used to

Scr: the best of the high-power switches

The four popular devices for solid state switching are the transistor, the gate turn-off switch, the four-layer diode and the silicon controlled rectifier. The scr is best for loads over one killowatt; this section shows why.

The plot of current vs. voltage compares the dynamic behavior of these four devices when switching a 10-ampere inductive load across a 400-volt line. The on and off static conditions are assumed to be the same for all four devices. The turn-on paths are also the same for all four devices, each going through a maximum dissipation of 100 watts.

The difference is in the turn-offs. The transistor and the gate turn-off swing up through large dissipations when turning off the inductive loads that are associated with power-inverter circuits. This is a severe limitation to the power-handling capability of these devices, because the large transient losses tend to concentrate in hot spots.

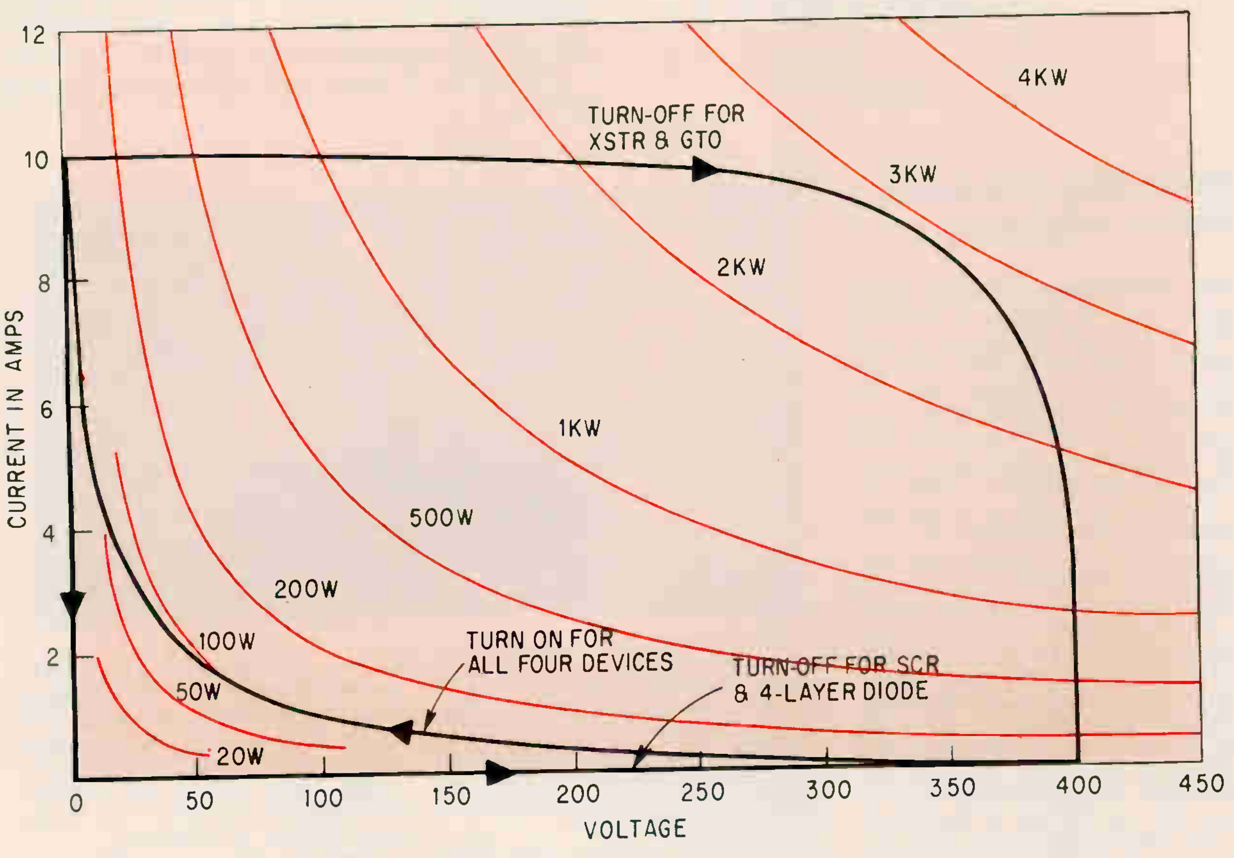
Meanwhile the scr and four-layer switch diode have practically no losses during turn-off because they are turned off by the circuit voltage dropping to zero. Thus the choice for a high-power solid state switch narrows to the scr and four-layer diode.

But the four-layer diode tends to drop out of the running at high voltages because of the difficulty of obtaining and controlling the very high-voltage spike needed for triggering.

For power handling at high frequencies the scr still wins out. The same interdigitated structure that increases a transistor's ability to spread out hot-spot heat also helps the scr.

The major high-frequency switching losses are the turn-off losses, to which the scr is immune. Interdigitation, therefore, helps to lower an scr's already-low turn-on losses which are the same order of magnitude as those of the transistor. Note that present scr's have power-handling ability one or two orders of magnitude greater than transistors have.

For the time being, scr's have no competition.

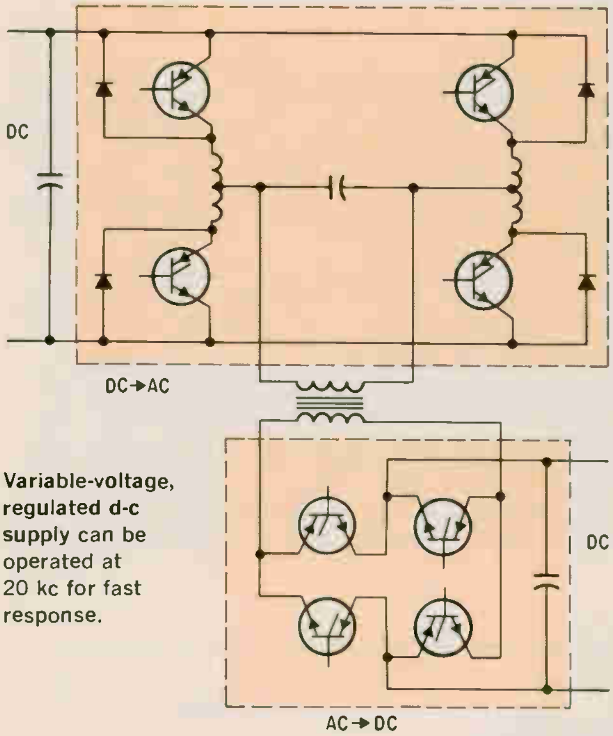


distribute power around factories or to supply power for process-control systems, computer systems and large vehicles. With such compact, efficient circuits the designer is free to convert electrical power to the forms best for distribution and use. He can, for example, use relatively high d-c voltages for distribution around the system, avoiding the expense of heavy bus bars. He can then use this type of regulated power supply to convert to whatever voltage level is needed at the various terminal points.

Converting to different frequencies

The first two examples have shown that high-frequency scr systems can deliver different levels of a-c and d-c power equally well. The final example will show that they can also be used to convert to a range of frequencies by means of a device called a cycloinverter.

The cycloinverter is produced by adding another set of inverse-parallel phase-controlled scr's to a d-c-to-d-c converter, as shown in the diagram on page 97. This addition enables the system to deliver



Variable-voltage, regulated d-c supply can be operated at 20 kc for fast response.

an output at any frequency from zero (or d-c) to one-third that of the inverter.

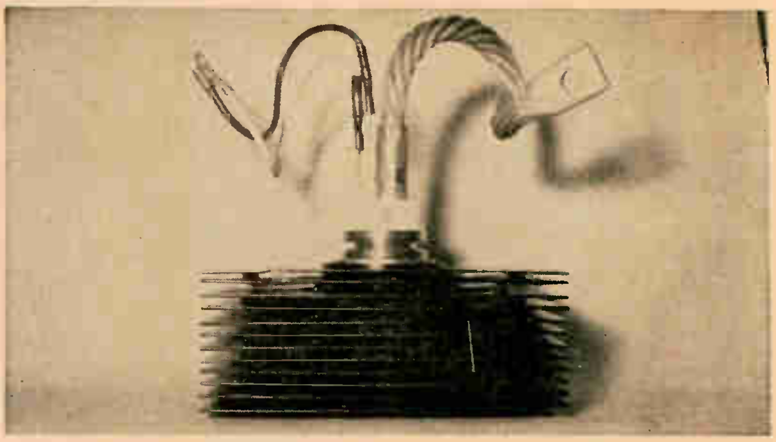
The cycloinverter is, in essence, an inverter followed by a variable converter, called a cycloconverter. In the cycloconverter schematic on page 97, the first waveform is the output of the high-frequency inverter and the second waveform depicts the action of the phase-controlled scr's. The shading shows how a low-frequency advancing and retarding of the scr's triggering point develops a sinusoidal variation in the amount of power gated by the scr. The triggering circuits that cause the scr action are not shown; they can be found in standard scr design manuals.

The sinusoidal variation in the size of the power pulses passed by the scr is then smoothed by an output filter, resulting in the final waveform.

Higher and higher frequencies

Circuits are now limited to outputs of about 10 kw using scr's. But many industrial and military applications call for power in the order of 100 kw and even one megawatt. There are three approaches to production of these high powers with existing circuits:

Packaging promotes higher frequency



The Westinghouse Electric Corp. uses a finned package to increase the power and frequency of one silicon controlled rectifier. For the type 223 scr, copper fins are brazed to the scr's protective housing, and the whole assembly can be mounted in a forced-air duct. The package permits a 20% increase in the power of a conventional scr, the 2N3530. This increase enables a small, high-frequency scr element to put out more power without forming hot spots.

A water-cooled version of this device is used in a very-low-frequency transmitter being developed by Westinghouse's Baltimore division. A frequency of about 20 to 40 kilocycles per second is obtained by operating the scr's sequentially so the turn-off time of any one scr is not a limitation.

To achieve short thermal paths between the silicon element and the cooling fins, the scr housing is constructed so the header to which the scr is attached is about in the center of the fins. Westinghouse uses several spring-loaded washers to hold the device against the header. The company explains that this arrangement gives good thermal and electrical contact and permits more latitude in construction of the chips. For example, new techniques for obtaining higher-speed devices—such as gaseous diffusion and gold doping—can be more easily employed because the wafer construction does not have to withstand hard-soldering to the housing header.

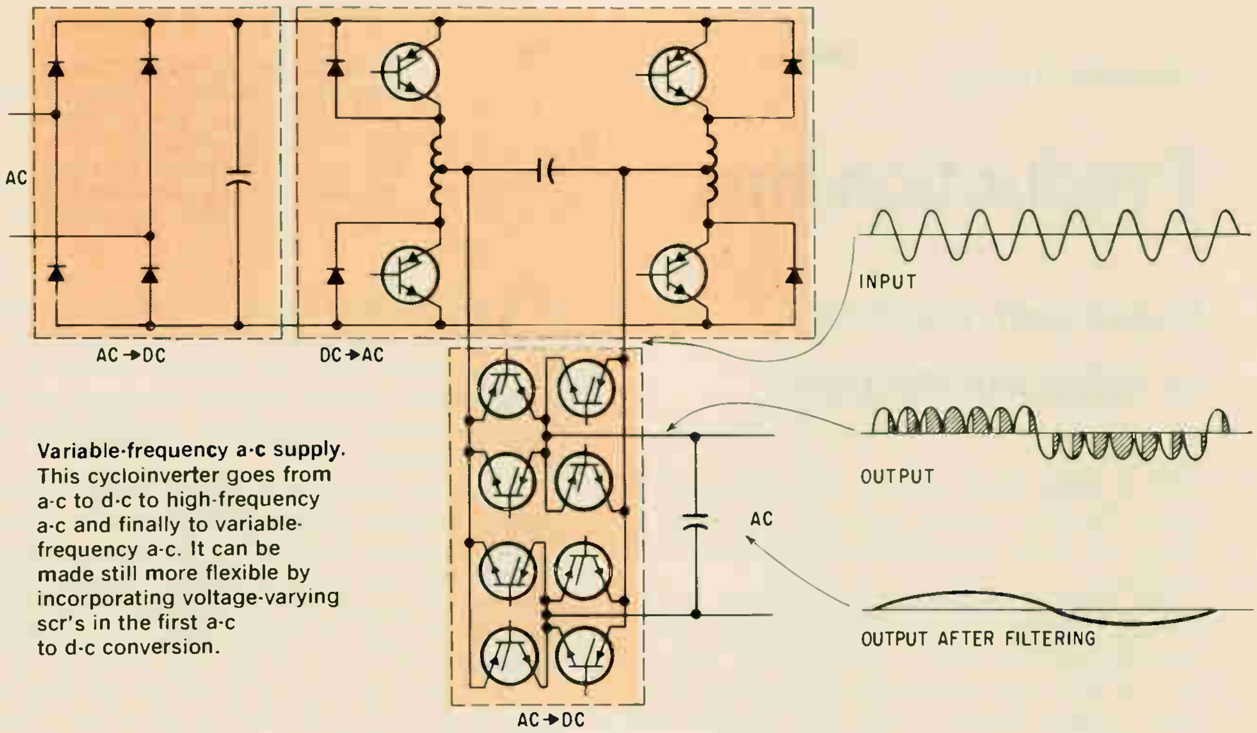
Between the closely spaced fins are small spoiler tabs, which induce turbulence in the cooling flow for better heat transfer.

The finned package, 4 by 5 by 2½ inches, occupies only one-eighth of the space needed by a similar 470-ampere (rms), 1,000-volt device mounted on an extruded aluminum heat sink.

Other companies in the United States and abroad are also looking to new packages to increase scr current and voltage ratings [see related story on p. 177]. These increased power-rating packages will eventually be applied to the higher-frequency devices. For increased current, the General Electric Co. is experimenting with a large disk-shaped ceramic package sandwiched between two finned heat sinks, much like the Siemens unit shown on page 177. This structure may lead to 5,000-ampere scr's within a few years, a GE spokesman says. Of course, at these levels water cooling is mandatory.

Motorola, Inc., is working on multiple-chip assemblies for high currents, but these seem to have problems at higher voltages. It is difficult to achieve load-sharing among many chips; if one pellet lets go, its explosion will rip open the whole package, according to another industry official.

Hitachi, Ltd., in Japan, uses a rippled porcelain package for its new 1,300-volt 250-ampere scr and its 3,000-volt, 300-ampere rectifier. For very high voltages, the scr package resembles a power-line insulator.



Variable-frequency a-c supply. This cycloinverter goes from a-c to d-c to high-frequency a-c and finally to variable-frequency a-c. It can be made still more flexible by incorporating voltage-varying scr's in the first a-c to d-c conversion.

- Higher-current scr's
- Parallel individual scr's
- Parallel circuits

There appears to be no reason why low-frequency, high-power scr's cannot be modified to perform at high frequencies. Existing devices suffer from the formation of hot spots, analogous to the secondary breakdown that plagues power transistors. But the anodes and cathodes of scr's can be made with the same interdigitated structure that provides a solution to hot spots in power transistors.

With interdigitation, it should be possible to develop high-frequency devices that carry hundreds of amperes, matching the current-carrying ability of the largest low-frequency scr's. Higher voltages are more difficult to achieve than higher current ratings, but eventually these also should become possible.

Until a wide range of high-current, high-frequency scr's is available, the designer should consider paralleling methods of obtaining higher output powers.

The clustered scr assembly represents one approach to paralleling at the device level. As shown in the photograph at the top of page 96 several high-frequency scr's are mounted on a common heat sink and operated in the circuit as a single unit. It is possible to match the scr currents at the desired high operating level closely enough so that there will be adequate current sharing among the devices in the cluster. This holds true over a range of pulse widths, and the cluster can be operated safely to within 10% of the total rating of the individual scr's.

Circuit paralleling allows several improvements in an scr circuit:

- The power output of any inverter can be increased 100 times or more.
- The assembly cost can be reduced, because it is less expensive to produce many standard small inverters than a few special large inverters—even assuming that the scr's were available to build the large inverter.
- Smaller packages cost less to transport. Standard means of crating and shipping can be used.
- It is easier to standardize product lines. A manufacturer can make up and ship many different sizes of power supplies, using standard, off-the-shelf inverter modules.
- High reliability is possible. With protective circuitry, faulty modules can be automatically isolated from the system. With the many modules that might be used for the larger power supplies, a very high level of redundancy could be achieved.

Looking to the future, high-frequency scr's used in building-block circuits may open up many new areas for electronics. These future power circuits will be far different from the simpler systems of the past. In sophistication, they will rival signal-level circuits.

References

1. John C. Hey, "The widening world of the scr," Electronics, Sept. 21, 1964, p. 78.

2. Reuben Wechsler, "Good teamwork from scr's," Electronics, Aug. 23, 1965, p. 60.

Manufacturing

Production tips

Production tips is a regular feature in Electronics. Readers are invited to submit brief descriptions of new and practical processes, assembly or test methods, and unusual solutions to electronics manufacturing and packaging problems. We'll pay $50 for each item published.

Paper path shortcut to mass trimming job

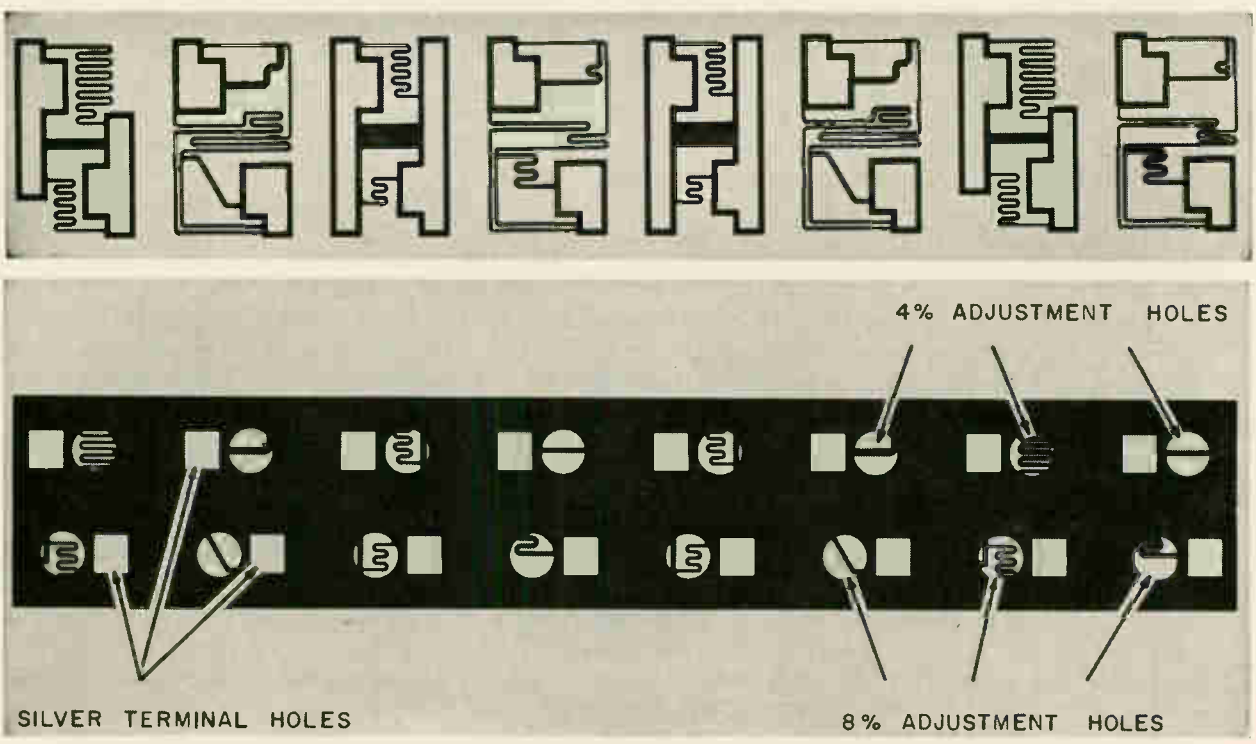
With a paper mask, Intellux, Inc., trims 480 precision thin-film resistor networks at a time. The masks are made automatically by a tape-controlled machine.

The resistors are deposited in groups, such as the eight-resistor group illustrated, that are later interconnected to form a network. As deposited, each of the eight resistors is a small network of three parallel resistors, with the resistor having the nominal value in the center. The upper and lower resistors are shorting paths. Cutting either or both of these paths changes the value of the resistor.

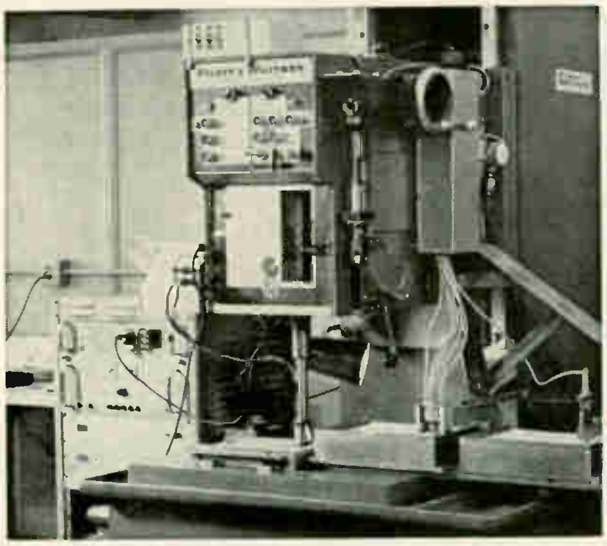
The resistor network is trimmed to the tolerance desired by cutting selected shorting paths. The black band seen in the illustration is a coating of insulation over the network, with openings over the shorting paths and the resistor terminals. The paper masks expose selected shorting paths so the paths can be removed by "sandblasting" with a jet of abrasive.

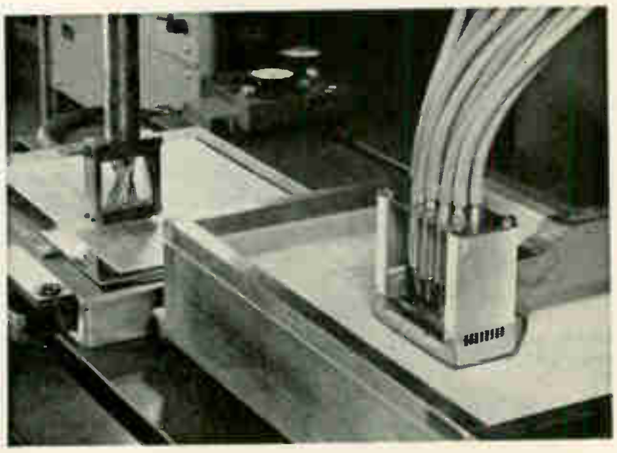
The masks are made by a numerically controlled milling machine (Pratt & Whitney Co. Tape-O-Matic), modified by Intellux. The large substrates carrying the resistors and a sheet of paper for the mask are mounted side by side on the bed of the machine. Instead of milling tools, the machine is equipped with special heads that work in concert.

One, called the reading head, has 16 probe contacts used to measure the as-deposited value of the resistors in the network. The machine is programed to lower this head on each network in turn. As each measurement is made, a simple, specially designed computer determines which shorting paths should be trimmed out and relays the information to a second head. The second head is



Typical group of network resistors (top). The black overlay (bottom) shows where a coating of insulation is deposited over the resistors, exposing shorting paths for tolerance adjustment and terminal locations. Holes in the trimming mask coincide with shorting paths that are to be cut to adjust the resistance value of the network.





Masks are punched by a modified milling machine (left). The photo above is a closeup of the punch that makes the trimming mask (right). At left is the reading head.

an air-actuated punch that perforates the trimming mask at locations corresponding to the selected trimming paths on all the networks.

The third head on the machine, seen at the right in the photo of the mask-making machine, punches another sheet of paper to indicate the locations of networks that cannot be trimmed to tolerance, so they can be identified as rejects.

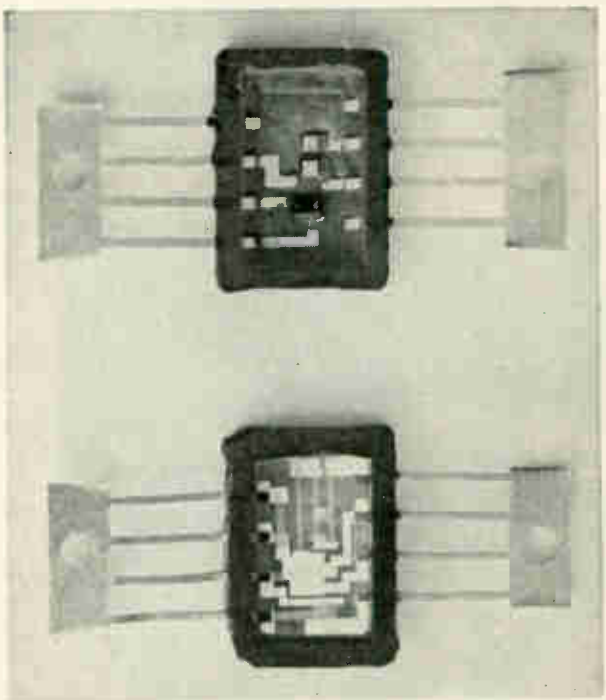
Two-step method simplifies hybrid-circuit assembly

A Japanese company has worked out a simpler method of assembling hybrid microcircuits. It does the assembly and packaging in just two combined steps.

In the United States, when a manufacturer makes a hybrid circuit of semiconductor-device chips and a thin-film network of passive components, usually the chips are bonded to the network as one assembly step, the connection points on the network are bonded to the package leads as another step, and the package is sealed.

When Fujitsu, Ltd., makes a hybrid circuit, it bonds the semiconductor chips to the package leads and then in one operation bonds the network to the leads and seals the package.

The method is not restricted to bonding of discrete semiconductor devices, says Seiichi Tabuchi, manager of Fujitsu's semiconductor department. Integrated circuits can also be used. The company is developing monolithic circuits, which it plans to use next year in computers.



Semiconductor chips are bonded to the leads (top). The passive network is dropped into place, then soldered at the time the package is sealed.

The lead frames are stamped from Kovar sheet. The lead ends are longer than usual and are bent down so they lie flat in the bottom of the glass body of the package. The semiconductor components are mounted on the lead ends and connected to other lead extensions by bonded wire leads. Normal transistor bonding methods are used to make these subassemblies, since the chips are not bonded to a thin film.

The passive network part of the hybrid circuit is bonded to the leads by placing it on the leads and heating solder coating on the connection points. The leads enter the package near the top of the sidewalls and extend a short distance from the walls before they bend down to the bottom of the package. This forms a mounting rim for the thin-film circuit's substrate.

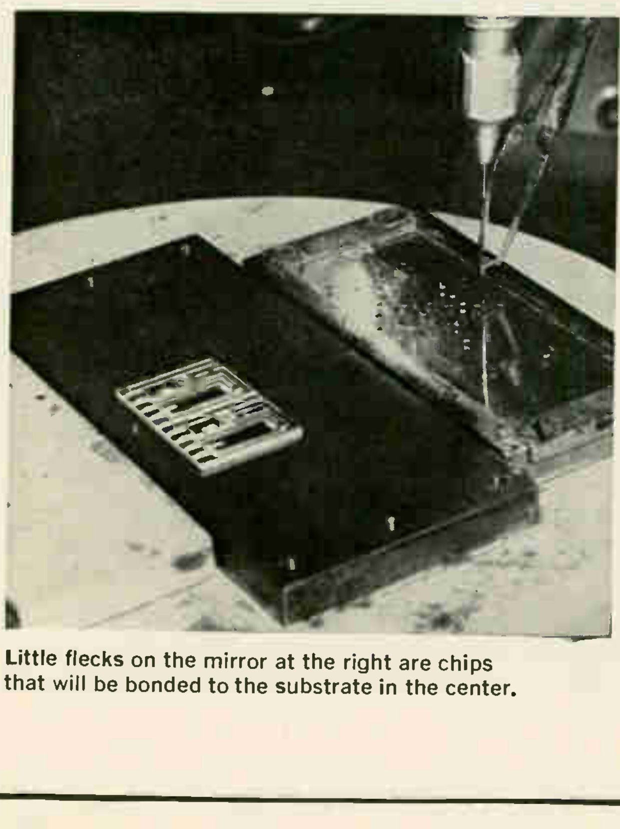
Bonding of the leads to the network and sealing of the package are done in a furnace in an inert atmosphere. The package cover is fastened to the package body by glass frit.

Through the looking glass to bond semiconductor chips

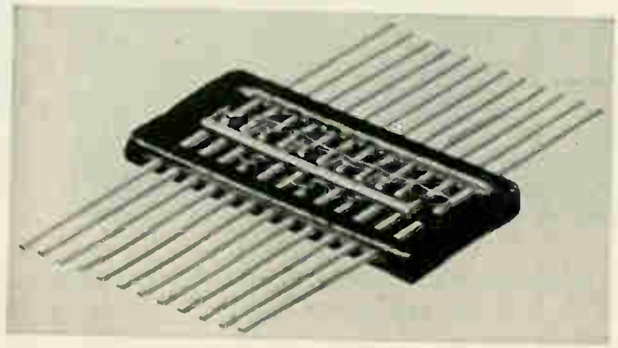
Automation isn't needed to make hybrid microcircuits with face-bonded semiconductor chips [Electronics, June 28, 1965, pp. 66 and 68].

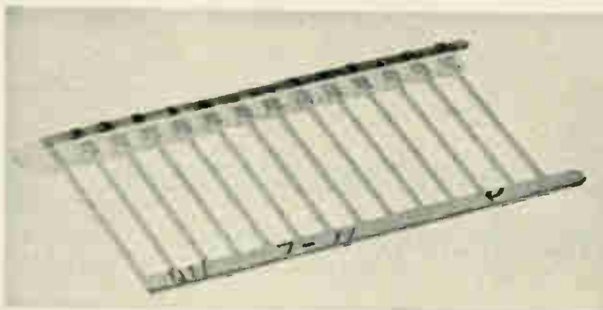
One chip-orientation and bonding method employed by the Burroughs Corp. requires just a looking glass and a heated vacuum needle, plus an operator peering through a microscope.

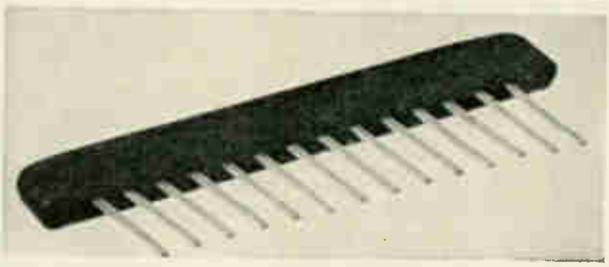
The chips are scattered face down on a mirror. The operator picks up a chip with the needle, rotates the needle on its axis while watching the chip face in the mirror. When the contacts are properly oriented, the chip is placed on the circuit substrate. The substrate has solder-coated conductors and is on a hotplate. The combined heat of the chip and the substrate causes the solder to melt and bond to the chip contacts, after which the chip is released from the needle. This procedure is illustrated in the photo at left.



Little flecks on the mirror at the right are chips that will be bonded to the substrate in the center.

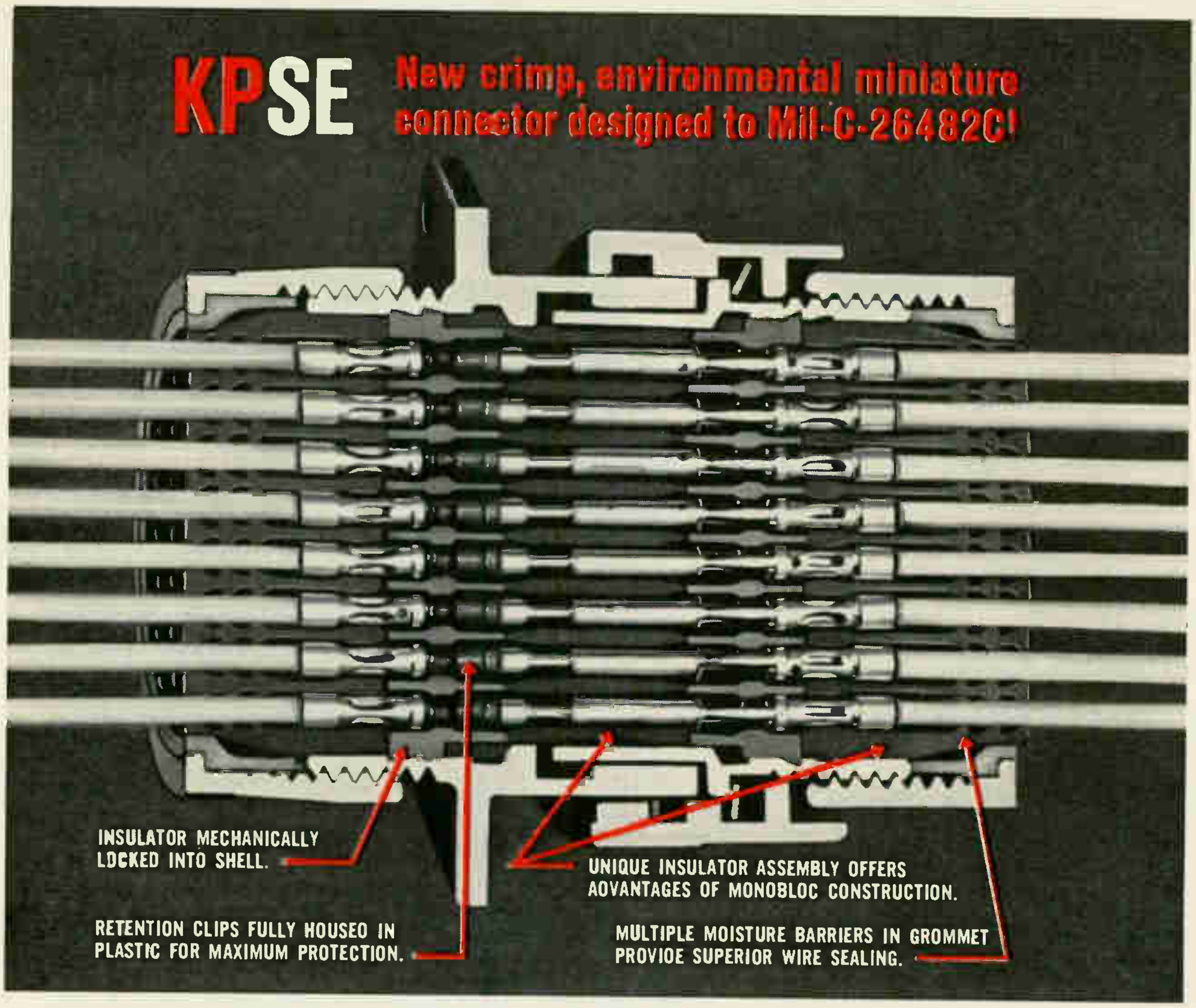






Transistor strings, top, and diode strings, center, are made by bonding chips to package leads. Below is an encapsulated diode string.

The other photos show a couple of tricks Burroughs uses to package diode and transistor assemblies. The dice are bonded on the gold-plated package leads and connected to other leads or to each other by wire that is thermocompression stitch bonded. In the smaller package, for diode sticks, the rib used as a common lead is mechanically held to the individual leads by a support film of glass. The rib running down the center of the larger package, for a diode-transistor decoder, is a common-emitter lead.



ITT Cannon's new environmental KPSE miniature circular connectors include advanced design features which meet or surpass all requirements of MIL-C-26482C.
The unitized construction of the elastomers and plastic wafer, which comprise the KPSE insulator assembly, eliminates separate bonding operations . . . no voids or contamination to cause electrical failures. The insulator is held in the shell by a mechanical plastic-to-metal lock which prevents axial movement under pressure. Contact retention clips are completely surrounded by plastic instead of rubber to provide maximum clip protection against possible damage from front release tool.

KPSE connectors with crimp, snap in contacts use standard MIL-C-26482 hardware, thus intermating with any solder or crimp 26482 connector. They are available in eight shell sizes, six service types and accommodate up to 61 contacts. There's one for your use in aircraft and missile applications, electronic subsystems and ground support systems.
These new environmental connectors are available from ITT Cannon Authorized Distributors.
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These new units are available in three contact ratings, all meeting the latest revised requirements in the aircraft and aerospace industries. The 9324, is the smallest, lightest, 3-phase, 20 amp AC contactor on the market. The 9123 (MS 27997) is a 25 amp AC or DC unit. The 9124 (MS 27222) will carry a 50 amp AC or DC load. And most important, special mountings are included to make them interchangeable with larger MS "top hat" contactors.

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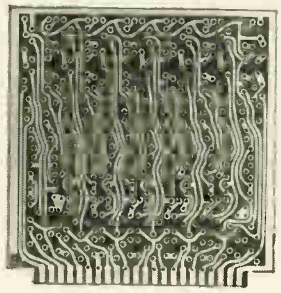

Here are the solutions to some typical problems we have recently received.

SMALL-QUANTITY CUSTOM WORK

PROBLEM: Our power supplies and amplifiers are made to customer specifications. Last-minute changes often make it necessary for us to have redesigned circuit boards in 48 hours. Since the quantities involved are very small, we're having trouble finding a supplier who will shorten his normal delivery cycle for us. We'd like to have the quality of Photocircuits' products, but we feel sure a large firm such as Photocircuits can't give us the special service we have to have. Can you recommend anyone?

SOLUTION: Our PROTOcircuits Division, almost ten years old, was set up specifically to solve this problem for prototype and small-quantity customers. PROTOcircuits is a small internal facility, working independently of our regular operation. Paperwork is cut to the minimum — most quotes, delivery promises and other information are often handled by phone. Like an express checkout at the supermarket, our PROTOcircuits group won't even look at you if you need more than a handful of parts!

NO LOCAL SUPPLIERS

PROBLEM: Our R&D Laboratory is not located near any large manufacturing areas. When purchasing components such as transistors, resistors and capacitors, our engineers select from manufacturers' or distributors' catalogs and order by mail or telephone. Since printed circuits are not available "off the shelf", we have trouble getting the parts we need when we need them. Have you done anything to help those of us far from the metropolitan mainstream?

SOLUTION: More than half the customers of our Standard Circuit Division had the same problem you do. They found they could order printed circuits by mail and telephone as easily as other components because of the unique Standard Circuit concept. By using only a limited number of standardized design, manufacturing and procurement techniques, all completely described in a 70-page catalog, the paperwork and communication problems of buying a custom-made component are drastically reduced. Additional benefits of the Standard Circuit concept include fast deliveries, low prices and the elimination of tool and set-up charges.

INTEGRATED CIRCUITS

PROBLEM: Our product-engineering group is designing equipment utilizing integrated circuits. The increased packaging density offered by interconnecting them with multilayer printed circuits is not absolutely necessary. Are there any other advantages to consider?

SOLUTION: Many multilayer customers consider two other factors as equally important. First, heat removal from small, flat-pack integrated circuits can often be a problem. With multilayers, all interconnecting circuitry can be placed on internal layers. Wide strips of copper are then plated on the surface of the board under the area where the flat packs will be mounted. By running these strips to the edge of the board to connecting hardware, excellent heat sinks are created for the integrated circuits. Second, another troublesome area is "cross-talk" between critical circuits on the board, or isolating circuits from external interference. This problem is easily solved with multilayer printed circuits, by incorporating copper shielding planes, where necessary, on internal layers.

MAKE OR BUY PRINTED CIRCUITS

PROBLEM: At a rather large capital expense, we're considering updating our internal facility for making printed circuits. In announcing your new "CC-4 Process", you stated that it allows substantial cost reductions in printed-circuit manufacturing. Are these reductions large enough to influence our decision?

SOLUTION: If you consider savings in the cost of printed circuit assemblies of 10-20% important — Yes. Large volume printed circuit users with internal facilities have compared the cost of completed assemblies using their own etched foil product against the same assemblies incorporating CC-4 boards made by Photocircuits. The low cost of these boards combined with the production economies resulting from the superior solderability of CC-4 copper revealed that "making" was more expensive than "buying".

(If you have a problem in printed circuitry, let us hear from you.)

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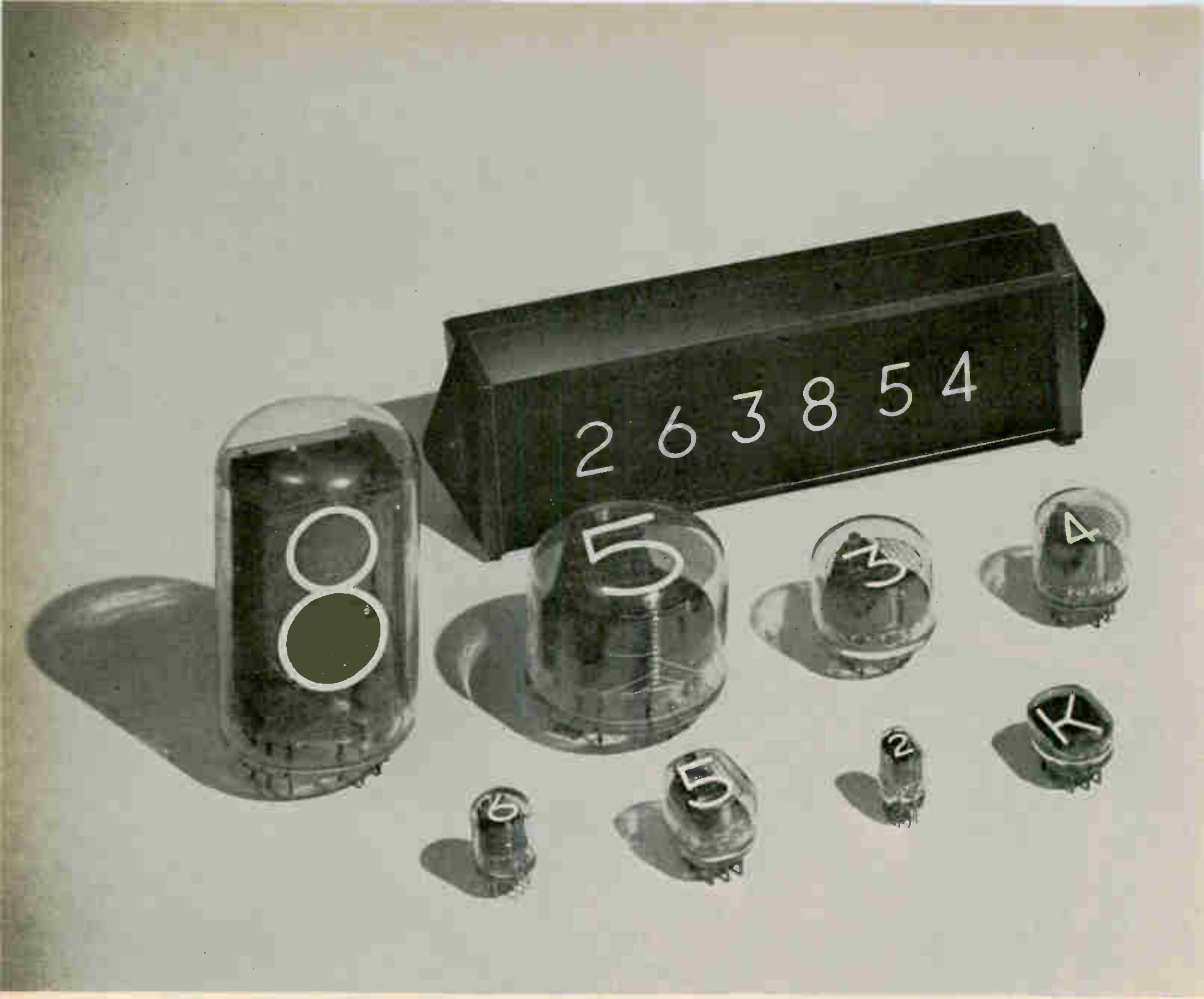

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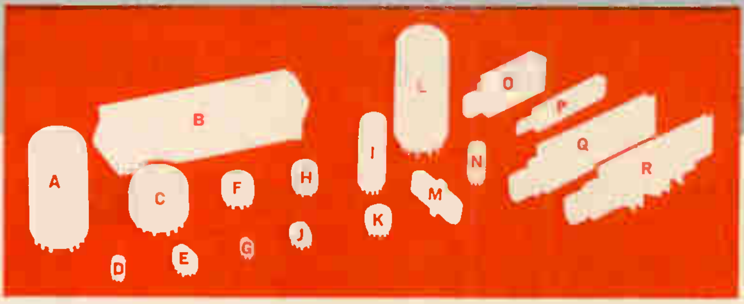
So let's hear from you. Your application, specification, budget, equipment are important to us. We're in business to meet your display requirements. Remember—you get much more than a readout when you buy a NIXIE tube display.



A. B7037—Side-viewing Jumbo Tube • Character size—2" Viewing distance—100'

B. Readout Assembly—6-digit bezel assembly containing 8422 NIXIE tubes

C. B8091—Large Tube • Character size—1.4" Viewing distance—65'

D. 7977—Miniature Tube • Character size—0.3" Viewing distance—14'

E. 8422/B5991—Standard Rectangular Tube • Character size—0.6" Viewing distance—30'

F. 8423/B6091—Super Tube • Character size—0.8" Viewing distance—38'

G. B4998—Miniature Rectangular Tube • Character size—0.3" Viewing distance—14'

H. 8421/B5092—Standard Tube • Character size—0.6" Viewing distance—30'

I. B-8971—Large Alphanumeric Tube • Character size—1.5" Viewing distance—65'

J. B5971—Standard Alphanumeric Tube • Character size—0.6" Viewing distance—30'

K. B9012—PIXIE® Position Indicator Tube • Character size—0.125" Viewing distance—8'

L. B7971—Jumbo Alphanumeric Tube • Character size—2.5" Viewing distance—100'

M. BIP-8200 Series—Binary-coded-decimal to decimal decoders; drives 8422 standard rectangular and B5992 plus-minus rectangular NIXIE tubes.

N. B5030; B5025—Long Life Biquinary Tube; Non-Mercury Biquinary Tube • Character size—0.6" Viewing distance—30'

O. BIP-9451; BIP-9501; BIP-9502—Decoder/Driver Modules with memory to operate 8422 standard rectangular tube from BCD or decimal inputs or B5971 alphanumeric tube from 13-line input.

P. BIP-9402—Miniature Decoder Module with memory to operate B4998 miniature rectangular tube.

Q. BIP-8055—150KC decade counter; decimal output is available for preset/reset operation and carry output is provided for cascaded multi-decade applications. Preset/reset module available to reset up to six decades.

R. BIP-8054—110KC bi-directional decade counter; decimal output is available for preset/reset operation, and carry output is provided for cascaded multi-decade applications. Building-block support modules are also available to provide accumulator function.

Only Burroughs manufactures NIXIE Tubes.

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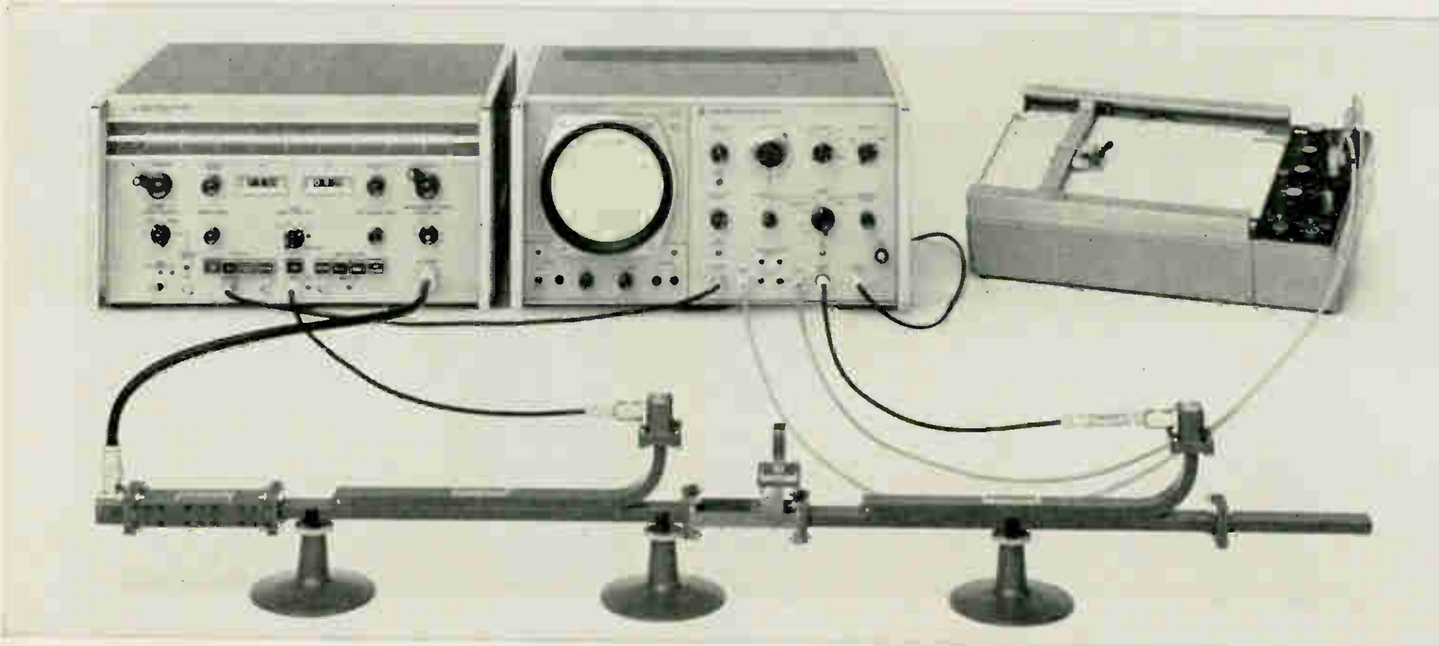

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Display

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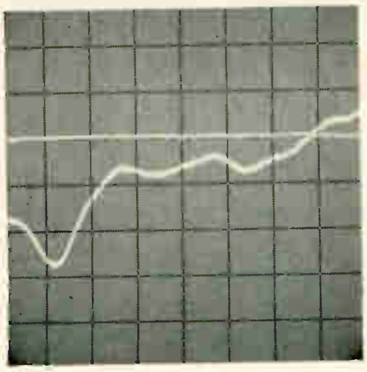
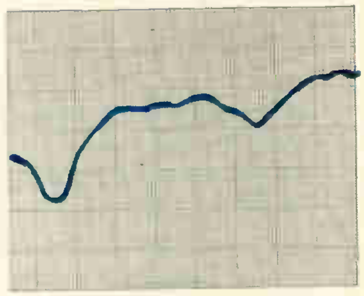
The chopper-stabilized logarithmic amplifier in the 1416A utilizes the full 30 db dynamic range of the square-law detector, providing accurate readings of either attenuation or return loss directly in db. The continuously variable, calibrated db offset permits high resolution (to 0.5 db/cm) over the full db range.

The 1416A also provides front-panel x-y outputs for direct x-y recording of measurements in db vs. frequency on standard graph paper. Or use the outputs to digitize measurements with a digital voltmeter.

1416A Swept-Frequency Indicator, $675, plugged into the 140A Oscilloscope, $575



The level trace shown in the oscillogram is a "zero" representation which shows the overall system flatness before insertion of the device to be tested. It provides assurance that the characteristics displayed in the second trace are a valid depiction of the device's attenuation vs. frequency. Vertical sensitivity in each case is 1 db/cm. The 1416A's calibrated offset (control also shown here) allows the attenuation plot to be displayed on screen, even though the attenuation may be as much as 30 db below the "zero" reference!



Simultaneously, using the 1416A front-panel x-y output, the attenuation plot is made directly on standard graph paper. The 1416A recorder output sensitivities are adjusted to conform with the major lines of the graph paper, which can be done quickly and easily at a single frequency, because the overall system flatness eliminates the need for pre-insertion of calibration grids.

Ask your Hewlett-Packard field engineer for complete information on the 690 Sweepers, 423A, 424A Series Detectors, 752 and 770 Series Couplers and related instrumentation. Or write Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva; Canada: 8270 Mayrand Street, Montreal.

For complete technical description of state-of-the-art microwave measuring techniques, ask your Hewlett-Packard field engineer for a copy of Application Note 65, "Swept-Frequency Techniques." Yours for the asking.

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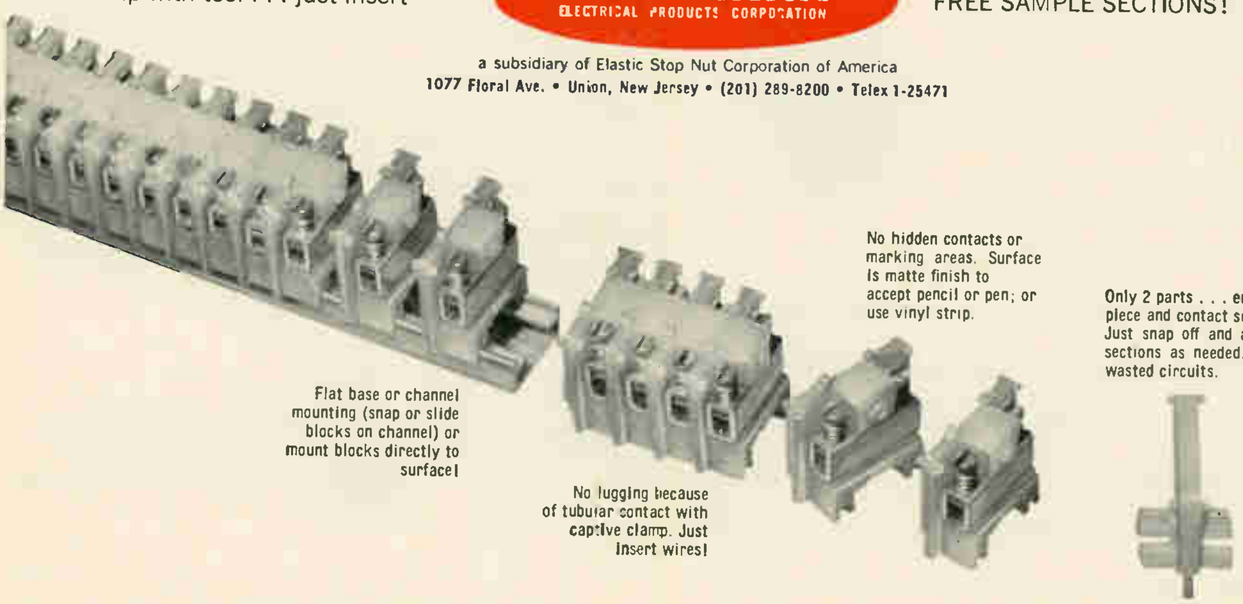

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Probing the News

Space electronics

Agena may outperform Gemini 6

If manned capsule is even slightly out of position for next month's rendezvous attempt, its astronauts may turn over control of the maneuver to the instrumented, unmanned target vehicle

By Lloyd Mallan
Consultant in the aerospace sciences

On the third day of the Gemini 5 flight, astronauts Gordon Cooper and Charles Conrad successfully maneuvered their craft to effect a rendezvous with a hypothetically orbiting Agena rocket. But there'll be no make-believe when Walter Schirra and Tom Stafford go up in Gemini 6, late in October. They will try to rendezvous and dock with a real Agena target vehicle that precedes them into space. If the difference in the orbits of the manned Gemini and the unmanned Agena is small, the astronauts will be able to handle the job. If there's a big difference between the two orbiting paths, Agena's electronic system will handle the initial portion of the rendezvous operation.

I. Different orbits

Basically, the Gemini 6 plan calls for Agena to be launched first and established in orbit. Once that is done, the manned capsule will be sent aloft into its own orbit. Next comes the ticklish job of bringing the two vehicles together.

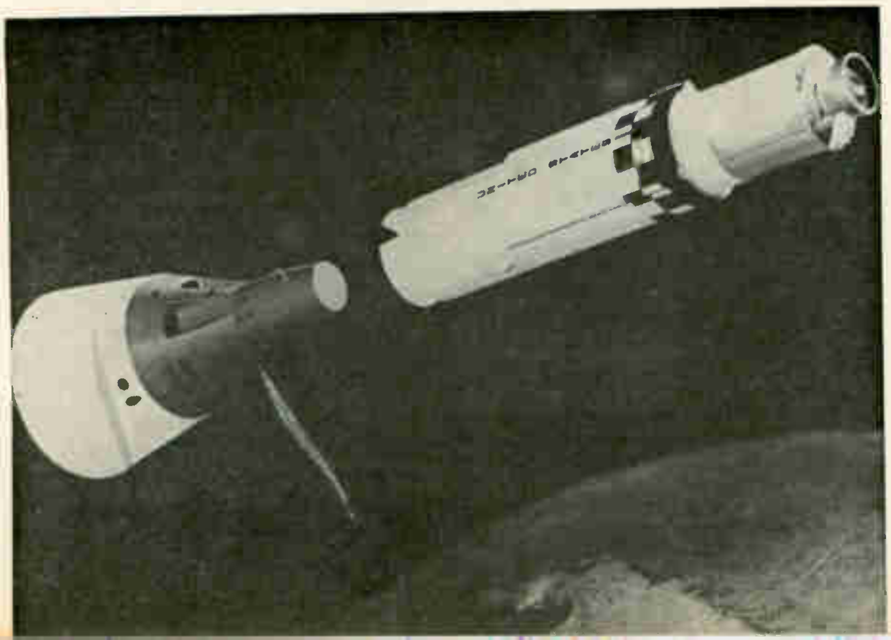
Agena will be in a circular parking orbit at an altitude of 161 nautical miles. After it has completed at least one full orbit—and possibly several—the Gemini capsule will be launched into an elliptical orbit, with an apogee (highest point) of 146 nautical miles and a perigee of 87 nautical miles. Before rendezvous, the orbit will be changed to a circular, 146-mile orbit.

Ideally, Gemini will blast off at the precise moment calculated for its orbit to be closely in phase with that of the Agena—that is, so that the angle between the planes of the two orbits and the angular distance between the two vehicles will both be small.

If it works out that way, the astronauts will apply thrust so their orbit intersects that of the target. They'll overtake Agena, which will be a short distance ahead. Gemini's lower orbit gives it a higher velocity than Agena, orbiting farther away, relative to the earth. At an orbit of 146 nautical miles, the Gemini capsule will gain on its target, orbiting at 161 miles, at the rate of 5.64° per orbit.

A limit of 70° has been set on the permissible phase difference between the two orbits; a difference that gives the astronauts 12.4 orbits, or 18.4 hours, to catch up. If the difference is less than 70°, the Gemini capsule will perform the rendezvous maneuvers. If the difference is greater than 70°, Agena,

The $2.9-million Agena vehicle, right, equipped to home in on Gemini, will be one of the most sophisticated vehicles ever placed in space.



unencumbered with life-support gear, will do the maneuvering.

There's a strong possibility that the electronic systems in Agena, not the astronauts, will handle the rendezvous task until Gemini is close enough to take over. That's because even a brief hold of Gemini's launch could mean too great a phase difference between the orbit of the target and the tracking capsule for the astronauts to overcome.

II. Obedient Agena

The unmanned Agena can be commanded to compensate for the widest possible errors. Either the astronauts or the controllers at the Houston Manned Spacecraft Center can order it to go into an elongated ellipse or a larger circle, either of which would slow it down considerably and let the command capsule reach it more quickly. After the catch-up, the astronauts could complete their phase of the rendezvous and docking operation.

Easy as parking. "The Agena target vehicle is amazingly versatile," says Major Robert A. Krahn, program control officer at the Gemini-Agena Target division of the Air Force Space Systems division, El Segundo, Calif. "It can be commanded to fly nose-forward or tail-forward. You can tell it to fly at a 90° angle to its orbit. It can be told to change its orbit and to match the plane of another orbit. In effect, you can maneuver it into a selected position almost as easily as you back up your car alongside a curb."

Gemini's ability to change orbit is very limited because its load-carrying potential has to be used for life-support systems.

The Agena target vehicle was modified from a standard off-the-shelf Agena-D, the same hardware that maneuvered the Ranger spacecraft on their highly successful picture-taking expeditions to the moon. But the "D" model is primitive by comparison with the Gemini-Agena Target vehicle.

'Most reliable ever.' A standard Agena-D costs $1.2 million. The Lockheed Missiles and Space Co. is the contractor for the Gemini-Agena and modifications of the target vehicle more than doubled the cost, to $2.9 million. What did the National Aeronautics and Space Administration get from the Air Force for the extra money? It got one of the most reliable and most sophisticated vehicles that has ever been placed in space," according to Lt. Col. Mark Rivers, chief of the Gemini-Agena Target division.

III. Electronic controls

An extra-sensitive ultrahigh-frequency receiver feeds signals from the ground or the manned capsule to the programer, a computer-like device, which then feeds into a controller. The controller is an arrangement of a large series of relays, which operate pneumatic and hydraulic attitude and velocity controls. The programer can instruct the controller in real time or by stored commands, which are retained in a magnetic memory bank.

The system is digitized and responds only to the correct digital signal from earth or from the Gemini spacecraft. As the digitized signals are received aboard the target vehicle, they are superimposed on a time-synchronization signal. The combination is conditioned and amplified by the receiver, then passed on to the programer for decoding. The programer continually samples the signals, looking for evidence of transmission errors. If there is the slightest anomaly, the programer rejects the signal.

Delayed execution. The time that a command is carried out is governed by an electronic clock, a counter that transmits a sequence of signals at regular intervals of time. The clock is called the Emergency Reset Timer (ERT) and is accurate to one microsecond. The specified execution time for each command is represented by a number. As the programer samples the more than 260 rows of the memory bank, it compares the number on the clock at that moment with the numbers tagged to each command in the bank. When any two numbers coincide, it withdraws that command from the bank and sends it to the controller for action.

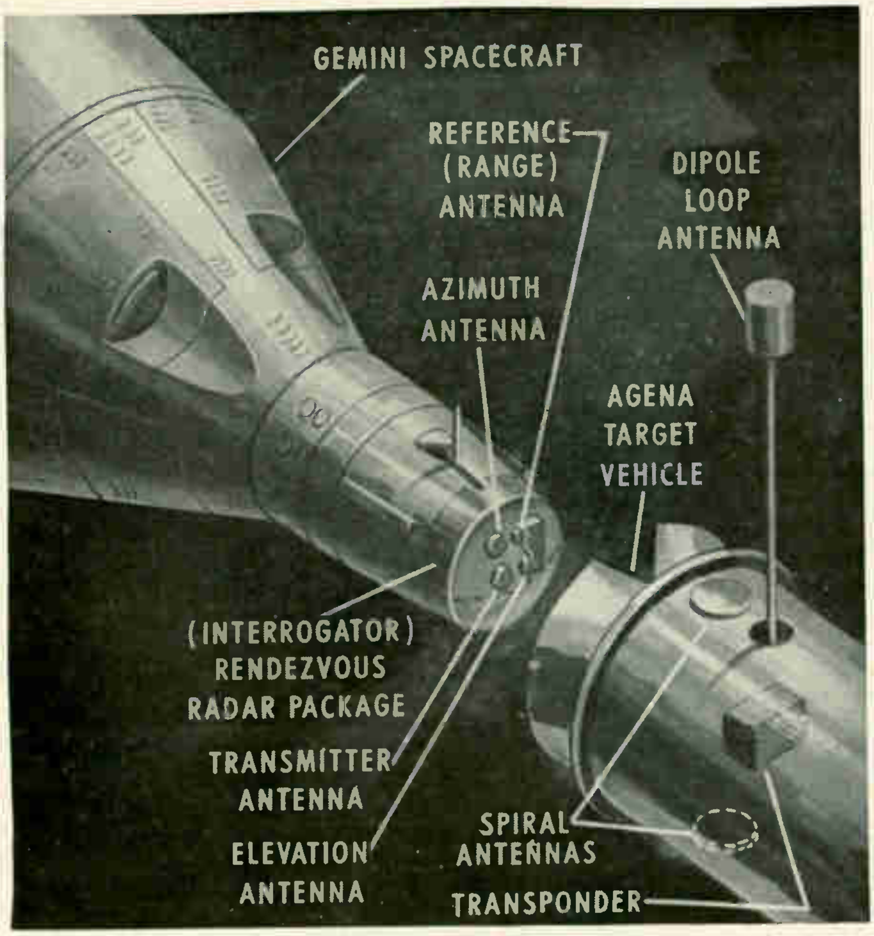
The ERT has another important function. Normally, the telemetry transmitters and radar beacons are turned off to conserve power until the target bird is within acquisition range of a ground-control station or the spacecraft. But in emergencies—for instance, a malfunction that causes tracking stations to lose the bird—the ERT turns on everything aboard the target that can transmit a signal.

Telemetry. There are two telemetry transmitters aboard the Agena, which can be commanded to transmit separately or simultaneously. One transmitter gives real-time telemetry readings; the other transmits stored readings on command. Sensors sample and encode several hundred functions for telemetry transmission or storage, at rates ranging from eight to several hundred samples per second. The storage unit here is a magnetic tape-recorder that plays back into one of the transmitters.

Some of the devices whose functions are telemetered are the gyros that determine attitude, relays that may be closed or open, the receiver, the programer, the controller as a whole, the ERT, and numerous pressure- and temperature-sensing devices. The telemetry data is received by the ground-control stations and sent via cable or radio links to the Manned Spacecraft Center at Houston. Here a high-speed computer system analyzes the data and displays the information in the control room. This information is the basis for commands to Agena and also indicates malfunctions aboard the craft; these can possibly be corrected from the ground.

One boss at a time. Three radar beacons aboard the unmanned target provide command links between the ground stations and the Agena, and the manned capsule and the Agena. They also provide ranging information. The ground links are C-band and S-band beacons; the link between the astronauts and their target operates in the L band. When the astronauts want to command Agena, all ground control is automatically locked out. As soon as the L-band beacon on the target is interrogated, a signal is sent to the uhf receiver, cutting it off. This is a safety procedure to prevent somebody on the ground from telling Agena to change direction when the astronauts are set to intercept their target.

An additional safety factor is the



Radar pulses from Gemini trigger a transponder in Agena during rendezvous. Gemini is equipped with four antennas, Agena with three.

multiple system of L-band antennas on Agena. The astronauts can remotely switch from one beacon antenna to another, either to find a signal or to select the strongest one.

From the ground. The telemetry transmitters aboard Agena continue to send data back to earth, even though the ground is locked out from command and control of the bird. The data is analyzed at the Manned Spacecraft Center and the controllers in Houston can tell the astronauts what corrective action is necessary for rendezvous and docking. Both orbiting vehicles are also watched constantly by ground-based radar to give the controllers a better picture of the maneuvers. Until the manned spacecraft is very close to its target, probably about a mile away, the whole operation can be managed safely from the ground. At a mile vehicle-separation distance, however, the ground radars become less accurate than the astronauts' eyes. At this point, the astronauts really take over the mission.

IV. Rendezvous

The rendezvous takes place this way: Gemini's spiral transmitting antenna, rotating to pick up Agena anywhere within a 70° beam, will contact the target vehicle at a range of 250 to 300 miles. The antenna will send a radar pulse to Agena's omnidirectional dipole array antenna, or, if the dipole should fail, to Agena's two 70° beam spiral antennas.

The radar pulse goes to a transponder in Agena which transmits a reply signal that is both delayed in time and shifted in frequency. This transponder reply is returned to three 70° beam receiving antennas in Gemini.

Equipment in the spacecraft next provides range information in two forms, digital and analog. The analog data goes to a range and range-rate indicator facing the astronauts, who may then make manual corrections in velocity. Digital outputs from the time measurement method go to a computer for automatic velocity corrections.

Using these procedures, plus an interferometer technique for measuring range rate by comparing the radar pulse's arrival time at two antennas, Gemini 6 will approach to within 20 feet of Agena. The close docking maneuvers will be performed manually by the astronauts who will rely mainly on visual sightings.

V. Docking

The astronauts will control their target by positioning it for the docking approach. To see more clearly, the astronauts will order Agena to turn on high-intensity lights. A control panel in Agena's docking collar will give them readings on the target's attitude and velocity.

Finally, the Gemini spacecraft will move into the cone of the docking collar. Both the spacecraft and the collar were designed by the McDonnell Aircraft Corp. At this point, three metal claws in the target will clamp into position around the nose of the Gemini capsule and make a rigid combination of the two vehicles.

Up to the moment of actual docking, the collar-cone is flexible to allow for errors of alignment as the spacecraft maneuvers forward and backward (or commands the target to do so) until the two vehicles are engaged. At this point, the L-band radar drops out of the circuit and the spacecraft is directly linked by wire to the electronic systems of the Agena.

Agena in control. The astronauts can ride with Agena through all its various orbital maneuvers but they cannot control it; the Agena guidance system will take over.

The major purpose of the Gemini-Agena rendezvous and docking experiments is to develop systems and methods for the safe return of future Apollo astronauts from the surface of the moon to their lunar-orbiting mother ship. But there also could be valuable spinoffs for national defense in terms of intercepting, inspecting and, if necessary, destroying potentially hostile satellites.

U.S. improves air defense

From Cape Cod to the Ryukyus, systems are being expanded for defense against bombers and sub-launched missiles

By Thomas Maguire
Boston Regional Editor

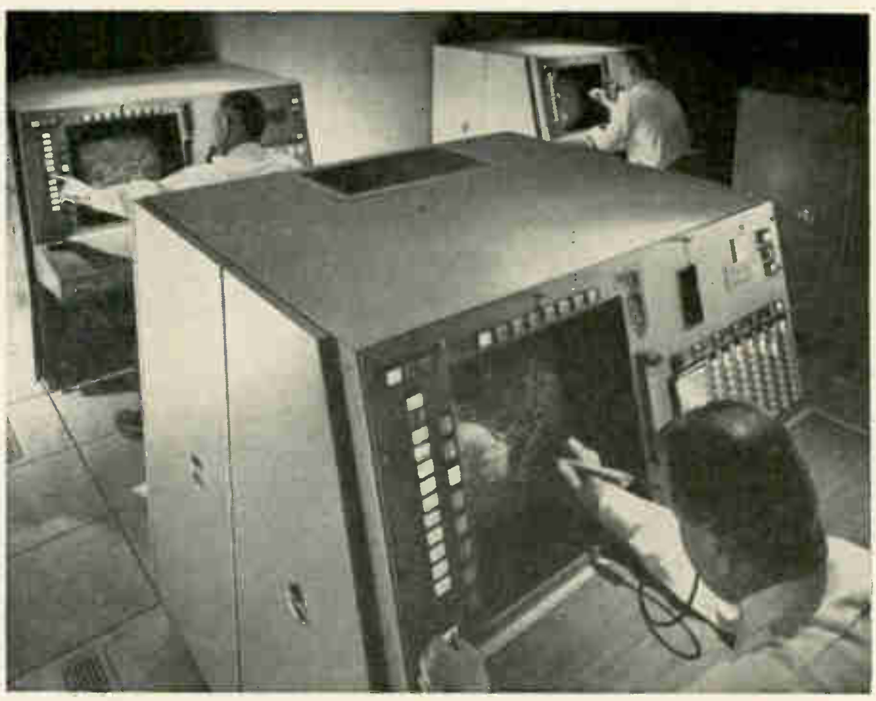
Not far from the small town of North Truro on Cape Cod, Mass., the Air Defense Command last week ceremoniously took possession of a windowless, concrete building, 1,000-feet square. It is the first of 19 structures that will house an air defense system called Buic, for backup interceptor control. The system will cost an estimated $200 million; its job is to defend the United States against enemy bomber attack should the big $5-billion Sage air defense system be knocked out of action. Buic is being developed and built under the management of the Air Force Electronic Systems division, Hanscom Field, Mass.

Before the end of the year, 13 similar blockhouses in other parts of the country will be built for the command. Later, another five—more complex than the first 14—will have joined the network.

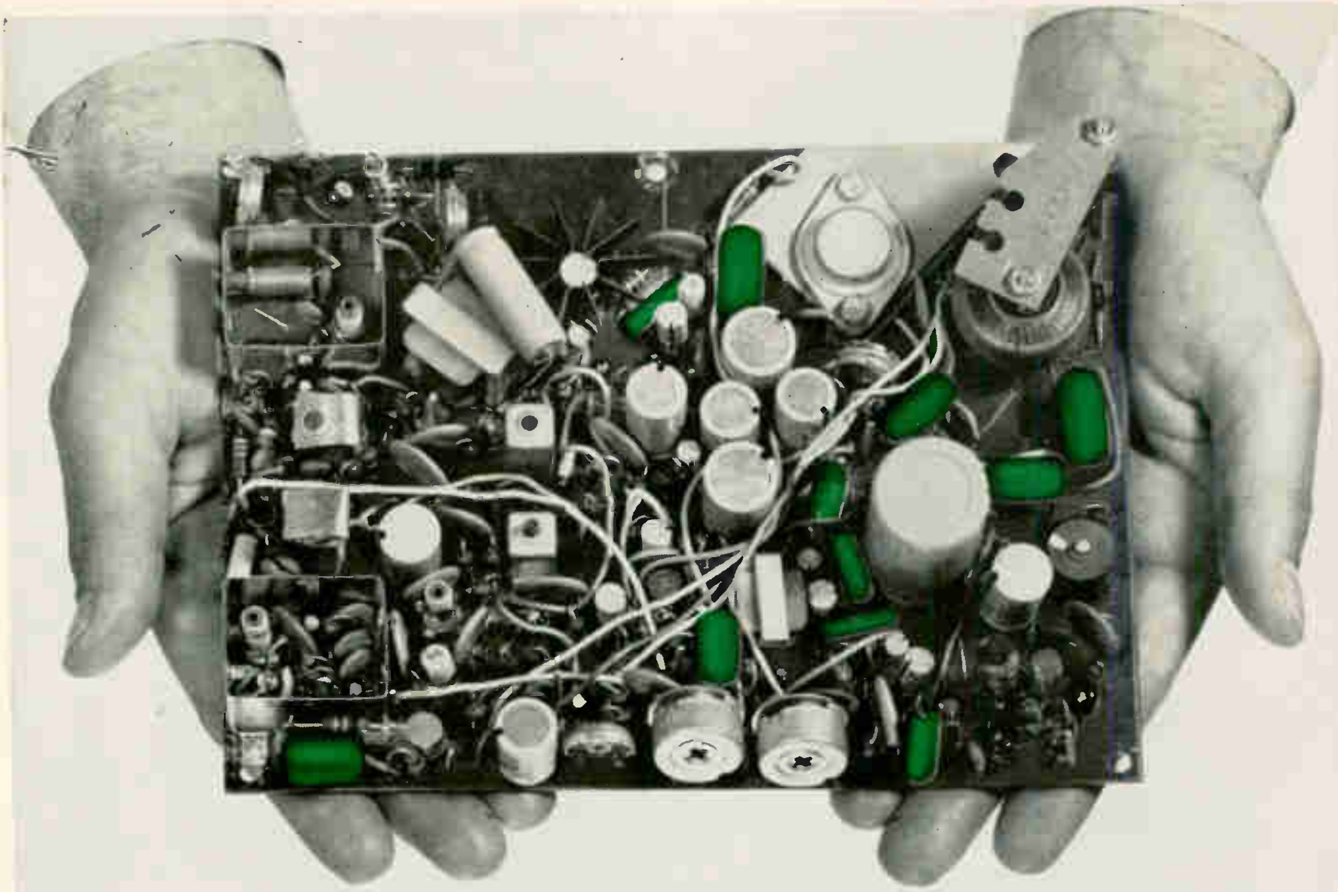
Buildup. Buic is one of several programs for better air defense. Another, closely linked to the Sage-Buic network, and known as 416N, involves modifying the radars of these systems to detect sea-launched ballistic missiles as well as enemy bombers [Electronics, Feb. 8, 1965, p. 96].

I. Buic and Sage

The Buic centers will be smaller, less sophisticated replicas of the Sage installations. Buic centers will be distant from Sage sites, which would probably be the number one target of enemy bombers. They



Tv-like consoles show approaching aircraft and the retaliatory forces available. Operators talk with computers by placing a light pen on the aircraft under question.



General Electric says size is important, but reliability is more important.

(Now you know two reasons why G.E. uses capacitors of Mylar® in its 9″ TV.)

In its "play-anywhere" TV shown above, G.E. uses dipped, molded and wrap-and-fill capacitors of MYLAR*, and also capacitors that are self-cased units where extra wraps of MYLAR provide protection and anchorage for the leads. All are considerably smaller than paper capacitors of equivalent rating.

"But no matter how small they were," says Jim Nease, Component Engineer, "we wouldn't even consider using capacitors of MYLAR if they weren't reliable. Our tests have proven the outstanding reliability of these capacitors. That's the main reason we use them, not only in our 9″ set, but throughout our line."

Reliability . . . reduced size. Two big reasons G.E. uses capacitors of MYLAR. But there's a third reason, too. Price. Capacitors of MYLAR cost no more, and often cost less than paper capacitors.

For more information to help you investigate the ways capacitors of MYLAR can help your designs for home entertainment and similar circuits, write Du Pont Co., Room 2797, Wilmington, Delaware 19898. *In Canada:* Du Pont of Canada, Ltd., P.O. Box 660, Montreal, Quebec.

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will be widely dispersed and resistant to nuclear fallout, though not to blast, and they will be close to their radar sites. Sage systems, set up far from their radars, must rely on miles of vulnerable communications lines when they use their all-important sensors for tracking the enemy and directing friendly interceptors.

Facilities. The Buic center uses the Sage radars but has its own solid state data processing equipment, built around the Burroughs Corp.'s D-825 general purpose military computer. Five consoles with extremely fast television-type displays and the computer will be cross-linked by communications lines so that each center will be able to manage an air battle over the adjacent Sage sector as well as over its own terrain.

Each console provides its operator with a visual presentation from stored information in the computer and continuous new information relayed from other air, land or seaborne radar sensors. The consoles are push-button controlled and modular constructed so they can be used interchangeably in case one or more consoles becomes inoperative. Each has a full capability for air surveillance, weapons control, direction of air battles and simulation exercises.

Air battle. When the Sage radars pick up a target the Buic center accepts the inputs from the sensors, generates tracks that show the location of target aircraft, and presents the data for display to the console operators. The Buic equipment can display weapons available for the region and analyze the commitment of weapons to make sure interception is possible. Following prelaunch and firing commands, the system computes and transmits guidance commands to the intercepting weapons.

Buic doesn't have everything Sage has. Sage can automatically guide manned interceptors back to base, but the backup network cannot. Also, each Sage direction center has two computers, one in operation and the other doing diagnostic routines and serving as a standby. Buic has only one computer but its modular construction permits duplexing individual modules without duplexing the entire system. Modules are switched back

and forth between operational and monitoring tasks.

The first eight Buic centers will be installed by the Burroughs Corp., and the remaining eleven by the Air Force Ground Electronics Engineering Installation Agency. System engineering was provided by the Mitre Corp. and system programing by the System Development Corp.

II. Double-duty radars

The cost of the 416N program to modify the Sage-Buic radars has not been disclosed. It won't be more than $50 million and could be as low as $16 million. A prime contractor has been selected but not announced. Price negotiations are under way between the contractor and the Air Force Electronic Systems division and a contract will probably be signed in November.

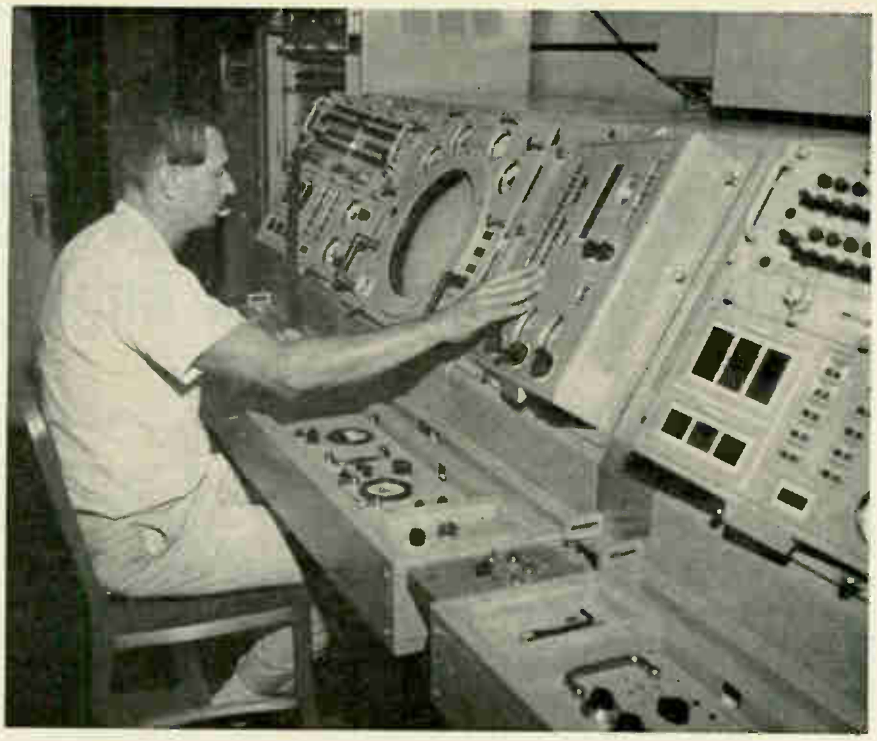
One of the techniques reportedly under consideration for converting radar to detect missiles as well as aircraft is to build a second radar at each Sage site. The second radar would then overlap the Sage radar's scan period to detect missiles and analyze their trajectories.

Information on enemy aircraft would be used at the Sage or Buic center while information on submarine-launched missiles would go to the North American Air Defense Command at Colorado Springs.

III. Sage overseas

Bids are due this month at Hanscom Field for a contract to automate the manual airspace surveillance and weapons control network for the Ryukyu Island chain southwest of Japan. Although the Ryukyu air defense system (RADS) is expected to be similar to 412L, the $300-million Baby Sage now operating in West Germany, industry has been given complete freedom in submitting proposals. The control center for RADS will be on Okinawa. Like Buic, RADS will be widely dispersed.

The next Sage-type network under consideration is one called HADS, for Hawaiian Air Defense System. The Air Force Electronics Systems division has completed a study requested by the Pentagon and proposals for the system are now at Air Force headquarters.



This radar operator will spot an approaching fighter plane four miles off a carrier's flight deck. He can talk the pilot down or he can let the SPN-10 landing system take over the plane's controls.

Avionics

'No-hands' carrier landings

The Kitty Hawk is deliberately hunting bad weather to carry out tests on an all-weather landing system

By W.J. Evanzia
Avionics Editor

For the past two weeks, the aircraft carrier Kitty Hawk has been off the coast of San Diego looking for the worst weather it could find. Ideally, that would be a rainy night with no visibility, high seas, and a rough wind. So, when the weather is bad, a Navy pilot takes off in an F-4 fighter, flies around for a few minutes, and lines the plane up for a landing. He's still four miles from the deck and 1,200 feet above the sea; but barring a waveoff, his part in the mission is over.

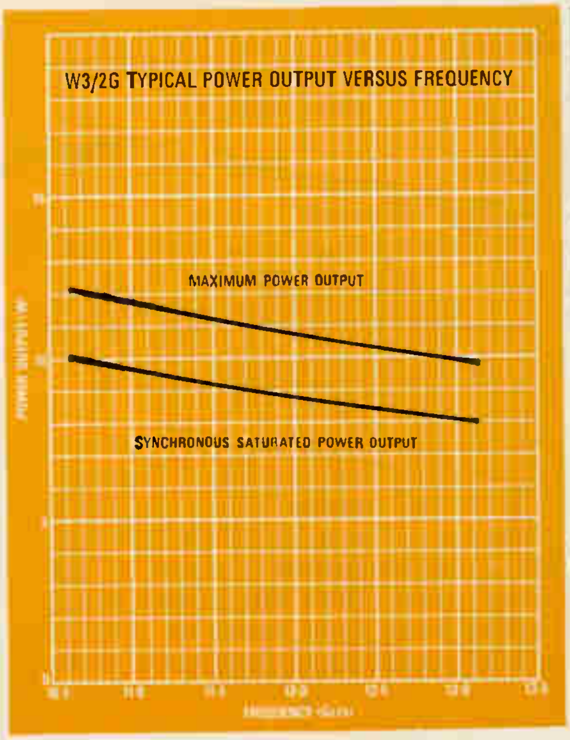
He relinquishes the controls to an automatic system that guides the plane down to the flight deck, which is pitching and rolling, for a perfect landing.

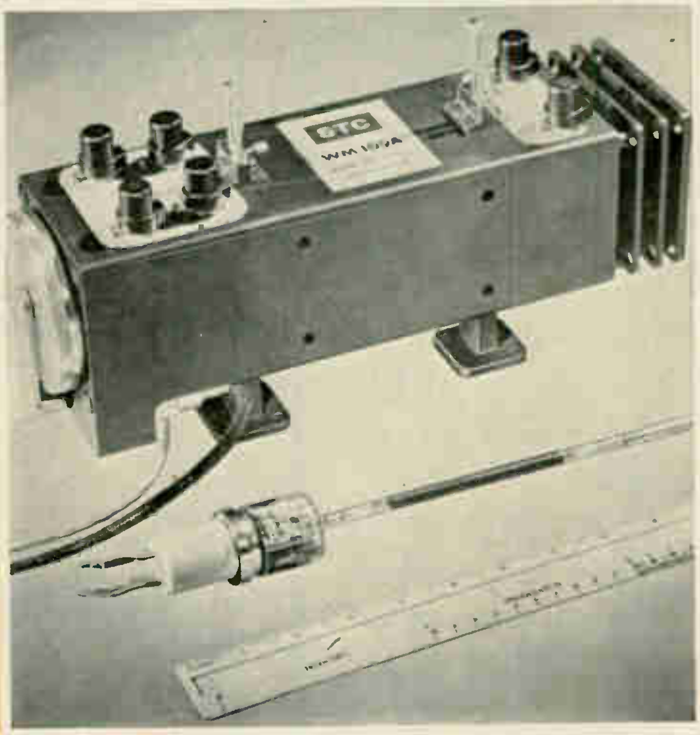
I. Time schedule

The landing equipment is known as the AN/SPN-10. Made by the Bell Aerosystems Co., a subsidiary of Textron, Inc., it has existed as hardware, in one form or another, since 1954. With the improvements built into the equipment currently under test, the Navy hopes to achieve an operational Mode I landing system—an automatic, hands-off system that will land a plane on a deck in zero-zero visibility.

Current tests are for technical evaluation of Mode I landing. Operational evaluation has not yet been scheduled.

However, the SPN-10 has been





New TWT promotes high channel capacity in J-band microwave links

STC's type W3/2G travelling-wave amplifier tube, which has a maximum power output of 12 watts, is designed for communications service in the frequency band 10·7 to 13·2 Gc/s with possible extension to 15 Gc/s. It thus brings to J-Band the facility for high channel capacity already available in the 4 Gc/s and 6 Gc/s bands.

The tube is 'field replaceable' and operates in a compact mount, type WM109. This incorporates a permanent magnet system, r.f. coupling and matching elements, mechanical alignment and deflection adjustments and a convection cooler. The tube ejector control can be fitted at either end of the mount.

Abridged data for the W3/2G and a selection of other STC travelling wave amplifiers are included in the table below:

Tube Type	Frequency Range (Gc/s)	Max. Power Output (W)	Typical Operation: Gain (dB) at	Typical Operation: Output Power (W)	Mount Type	RF Connection (WG Flange)
W3/2G	10·7 to 13·2	12	40 to 45	5	WM109	WR75
W4/2G	7·0 to 8·5	15	40 to 46	5	WM108	UG51/U
W5/2G	5·85 to 7·2	25	36 to 45	10-15	WM107	UG344U*
	7·2 to 8·2	18	36 to 45	7-10		
W5/3G†	5·85 to 6·5	20	37 to 43	10-15	WM107	UG344U*
W7/4G	3·6 to 4·2	15	35 to 42	6	495-LVA-101B	12A or WR229

*Alternative waveguide flanges available.
†This tube has a typical AM/PM conversion factor of 0·75°d/B.

For full information write, 'phone or telex for data sheets to STC Valve Division, Brixham Road, Paignton, Devon, England.

U.S.A. enquiries for price and delivery to ITT Electron Tube Division, Box 100, Easton, Pennsylvania.

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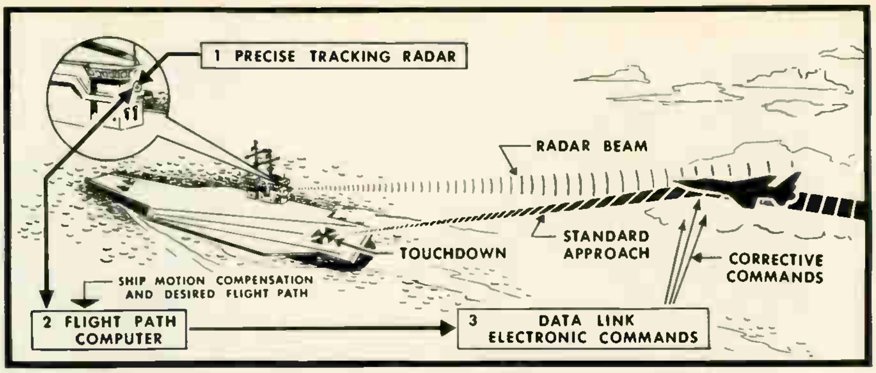


Data from a precision tracking radar is analyzed and returned to the aircraft as electronic commands, which direct the plane along the glide slope.

operational in Mode III on four carriers, since April. In that mode, the pilot does the landing under verbal instructions from the radar man on the ship. Mode II, in which the pilot lands the plane with visual instructions on a cockpit display, underwent technical evaluation last year and will get operational tests later this month. The minimum ceiling for Mode II and Mode III is 200 feet, the minimum visibility a half-mile.

II. Window above the sea

The SPN-10's radar spots an approaching aircraft by scanning the approach to the flight deck; at a distance of four miles, the area under surveillance is about 10,000 feet wide and 800 feet high, with the center of the window about 1,200 feet above the sea. As a plane enters this rectangular space, the radar locks on and begins to track.

Range and angle are fed into a flight path computer, processed and transmitted to the plane. At 12½ seconds before touchdown, deck motion is added to the computation loop to synchronize the plane with the roll and pitch of the carrier flight deck.

Preparing for Mode I. To upgrade the system to operate automatically, changes had to be made. There could be no errors in the information the data link transmitted to the autopilot in the plane, and a visible presentation was needed to show the pilot what was going on so he would have confidence in the system. The technique used during the last 12½ seconds before touchdown was changed to assure a smoother landing, and the reliability of the entire system was improved.

To assure the validity of the radio-frequency data link between ship and plane, a monitor was installed aboard the carrier. Flight information generated by the navigational computer is sent to the ship's tactical data system, where it is converted from analog to digital form and then transmitted to the aircraft. A receiving antenna on the carrier picks up the same message; this receiver sends the message back to the navigational computer for comparison with the original message. If the two differ in any way, the pilot is waved off—told not to land, but to go around again.

III. Down the slope

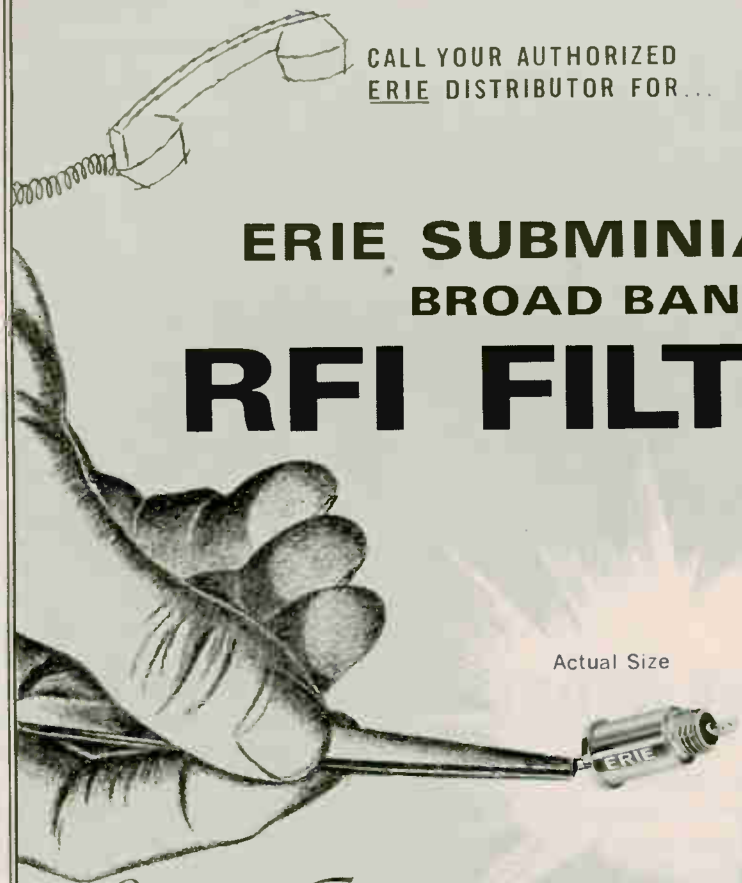
To let the pilot know where he is, and to give him confidence in the automatic landing procedure, an improved visual situation display was provided.

Previously, the landing message from the ship's tactical data system consisted of command signals to the autopilot and range-to-go information for the pilot.

In the new system, the data blocks used for range-to-go were replaced with blocks that provide visual information on the plane's error in glide slope, altitude and azimuth.

Touchdown. The trickiest part of landing is in synchronizing the plane's motion with the rolling and pitching of the flight deck. Earlier equipment predicted the position of the deck several seconds before touchdown; the plane flew a collision course with that spot, and "landed" whether the deck was there or not.

In the new technique, data on deck motion is added to the glide path signals for the last 12½ seconds of flight. The plane and the



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ERIE SUBMINIATURE
BROAD BAND
RFI FILTERS

Actual Size

Exclusive Features!

HIGH ATTENUATION • HERMETICALLY SEALED
SUBMINIATURE • RELIABLE • IN-STOCK

Erie's Subminiature Broad Band RFI Filters are only *one-fourth* the size of conventional filters . . . yet they provide better attenuation performance in the 10KC to 10KMC frequency range. That's why they are selected for major Aerospace Systems . . . size and efficiency.

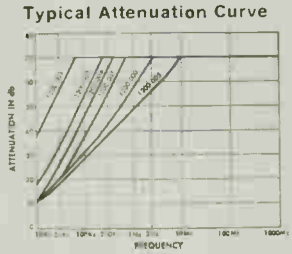
These hermetically sealed Filters are designed to eliminate the problem of Electro-Magnetic Interference caused by switches, relays, motor commutators, SCR and transistor switching. No longer is it necessary to use bulky paper capacitor-coil combinations . . . or large conventional filters. Erie Broad Band Filters provide better attenuation *in only a fraction of the space.* AND THEY ARE AVAILABLE FROM STOCK . . . NOW.

The attractive price of these reliable filters makes them ideal for Commercial and Industrial applications as well as for Aerospace circuitry. Mounting arrangements to suit application.

In addition to Broad Brand RFI Filters, Erie produces a complete range of subminiature filters suitable for YOUR SPECIFIC application. These too are available from stock.

Call or write now for quality ERIE RFI FILTERS. Remember, your ERIE distributor is your one-stop filter source.

Typical Attenuation Curve



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deck are in synchronization until one second before touchdown.

IV. Upgrading the equipment

One of the system's biggest problems has been reliability. Under a Navy contract, engineers at Cornell Aeronautical Laboratory are looking for quick fixes as well as long-term improvements. So far, 17 reliability problems have been detected and corrected.

Quick fixes were made on synchronizer tubes, modulators, drivers, receiver-transmitter units, the 450-cycle-per-second power oscillator, the position computer, the azimuth-elevation indicator, the magnetron, the pulse forming networks, RT tubes, the 60/400 cps converter, the spin motor, pilot lights, and operational amplifiers.

Many of the quick-fix problems were solved by replacing poorly operating components. A relay, for example, that would not carry the heavy current required was replaced with one that would. Components with low reliability were thrown out.

Mean-time-between-failures is now 37 hours, about five times better than it was.

More changes. Additional improvements are also in the works. Bell Aerosystems has a new contract to digitize the SPN-10. The radar will be changed to solid state, and the system will make extensive use of integrated circuits. The CP-789/UYK (Univac 1218) will replace the present analog computer. These changes alone will increase the MTBG to about 150 hours, the Navy believes.

The first digitized system is scheduled for delivery to the Navy's Patuxent River test facility in July of next year. Plans now are to put the new system aboard the larger carriers, although some of the smaller ships may get them, too.

The shipboard portion of a landing system is expected to cost nearly $2 million. Data links for ships and aircraft will cost nearly $100 million. Industry has submitted proposals to Navy's Bureau of Weapons for development and production of data link equipment. By the end of next year, 1,000 planes are scheduled to be equipped with the landing system, and the Navy will be ready for all-weather flying.

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We've Increased The Range
We've Improved The Warranty

To bring you the best buy yet in a universal counter-timer!

Starting July 1, TSI Model 361 All Solid-State Universal Counter-Timer carries a new price tag. Plus new specs—boosting its frequency range to 2.5 megacycles. And a new improved warranty—*covering all parts, unconditionally*, for 2 years.

These new prices make the 361 the lowest cost 2.5 mc counter-timer on the market!

Model	Old Price	New Price
6-digits	$1250	$995
5-digits	1175	925
4-digits	1100	855

How can we do it? Production efficiencies resulting from five years of manufacturing experience with these instruments.

Model 361 contains every facility required for counting events and frequency, measuring period, frequency ratios, pulse width, time interval and phase angle—without plug-ins, adapters or attachments. In price, in performance—it's your best counter-timer buy for both today's and tomorrow's requirements.

Want proof? Send for the 361 specs today.

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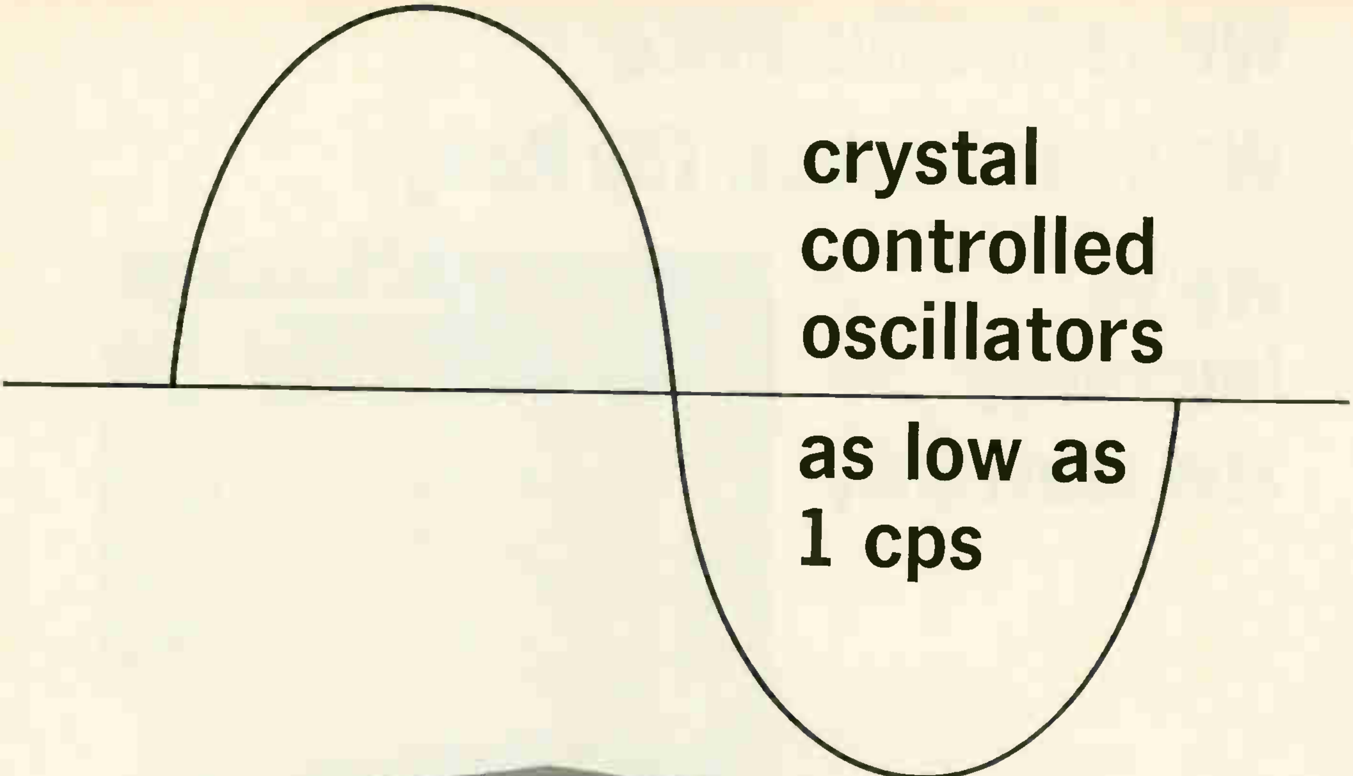

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as low as 1 cps

If you use tuning fork oscillators, you will be interested in our crystal-controlled low-frequency units.

These solid-state oscillators provide a stable low frequency output through the use of a crystal-controlled oscillator followed by a unique and highly reliable unijunction count-down system. An excellent output waveform is provided. Amplitude stability over the temperature and supply voltage range is closely controlled. These solid-state oscillators are not effected by magnetic fields or severe mechanical vibration and shock. Write or phone for more information.

Frequencies Available: 1 cps to 20 kc
Frequency Control: Quartz Crystal
Frequency Accuracy: See Table
Output Waveform: (Specify)
- Square Wave: Duty cycle 50% ±1%, Rise time <500nsec
- Sine Wave: (> 50 cps only), Distortion <5%

Output Amplitude:
- Square Wave: 10Vpp nominal into 10K load
- Sine Wave: 5Vrms nominal into 10K load

Amplitude Stability: ±2% over temperature & supply voltage range
Oscillator Supply Voltage: 12Vdc ±10% normally required; 20 to 32Vdc can be accommodated by addition of built-in Zener regulator
Oscillator Supply Current: 35Ma nominal with 12Vdc supply
Oven Supply Voltage:
- "150" Series: No oven required
- "210" Series: 28V or 115V as specified

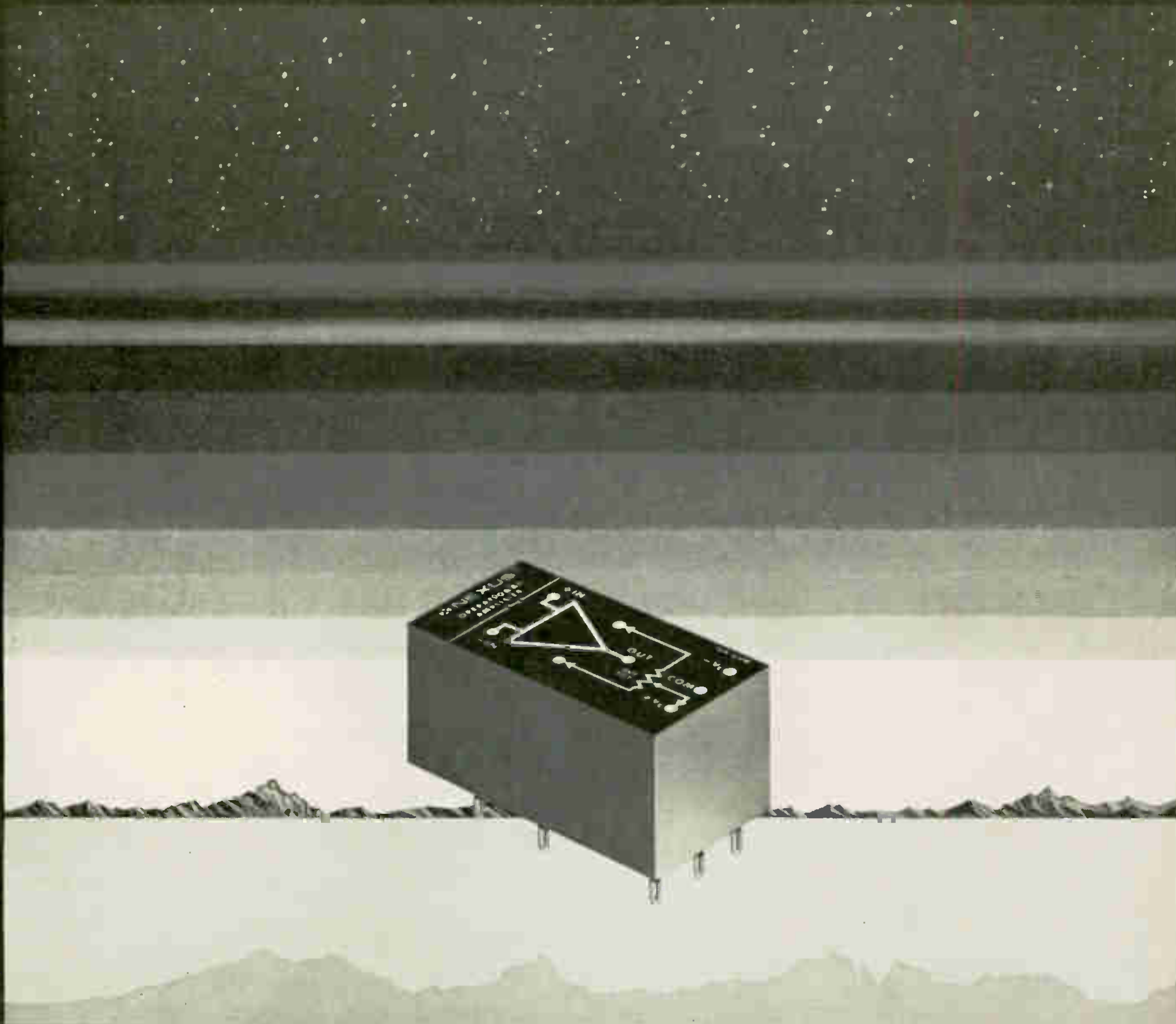
model	frequency accuracy	case size
P210N S210N	±.001% 0°C to +50°C	2" square 3½" high
P210A S210A	±.005% −55°C to +85°C	2" square 3½" high
P150N S150N	±.005% 0°C to +50°C	1½" square 2½" high
P150A S150A	±.02% −25°C to +85°C	1½" square 2½" high

Termination is indicated by first letter in model number: P-Octal Plug, S-Solder Hooks

CONNOR-WINFIELD CORPORATION

Winfield, Illinois 60190, Phone (312) 231-5270

ANOTHER ANALOG FIRST FROM NEXUS



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MIL-ORIENTED FOR EVERY ENVIRONMENT

Nexus operational amplifiers seem too good to be true! Here are d-c operational amplifiers that expertly combine all the following outstanding features: **solid-state • MIL-oriented designs • all-silicon semiconductors • fully encapsulated • available off the shelf • MIL / QPL parts (can be assembled to NASA specs.) • new low published prices.**

Nexus solid-state operational amplifiers are your sure-cure for shaking off those analog-designing blues. These tiny but mighty operational amplifiers are currently finding wide application in space satellites, doppler beam navigation, radar, analog computers, oceanography . . . in most extreme environments and temperature ranges.

Nexus operational amplifiers offer you the ultimate in d-c stability, small size modular design, proven high-reliability, and long operating life. These quality-made components can very well be the solution you have been looking for, for your present analog application.

On the performance side of the picture, *Nexus* amplifiers provide high input impedance — up to 1 megohm (500 megohms common mode); low offset — as low as $\pm 3\ \mu v/°C$ and ± 0.02 na/°C, new FET amplifiers provide differential input impedance to 10^5 megohms and have virtually no offset current.

Here are some typical *Nexus* MIL-oriented amplifier prices:

Type	1-9 units	10-24 units
DA-1a (M)	$119 ea	$108 ea.
CDA-3a (M)	179	160
CDA-12a (M)	187	169
CDA-22 (M)	213	191
FSL-12 (M)	204	184

Make today be your day for sending for full details on *Nexus* operational amplifiers. Write for the new *Nexus* Catalog . . . your convenient guide to quick, easy component selection.

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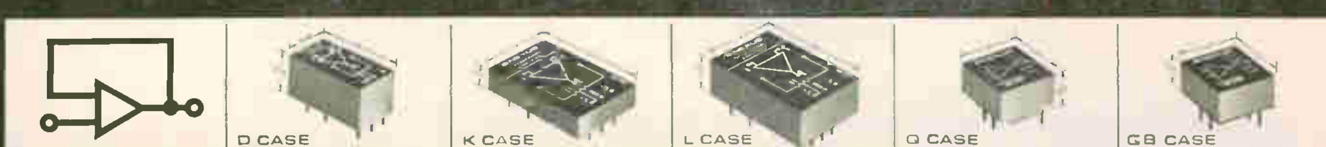
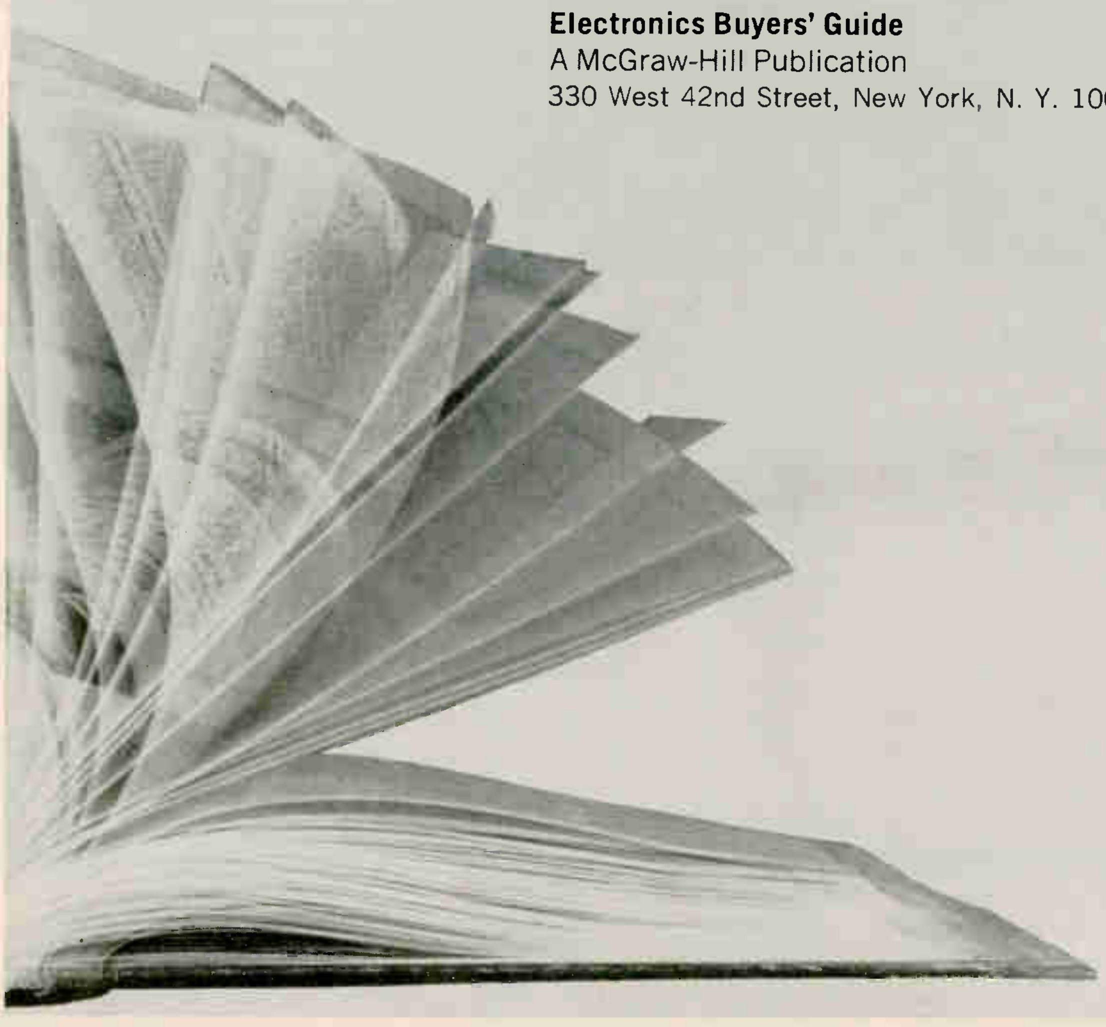
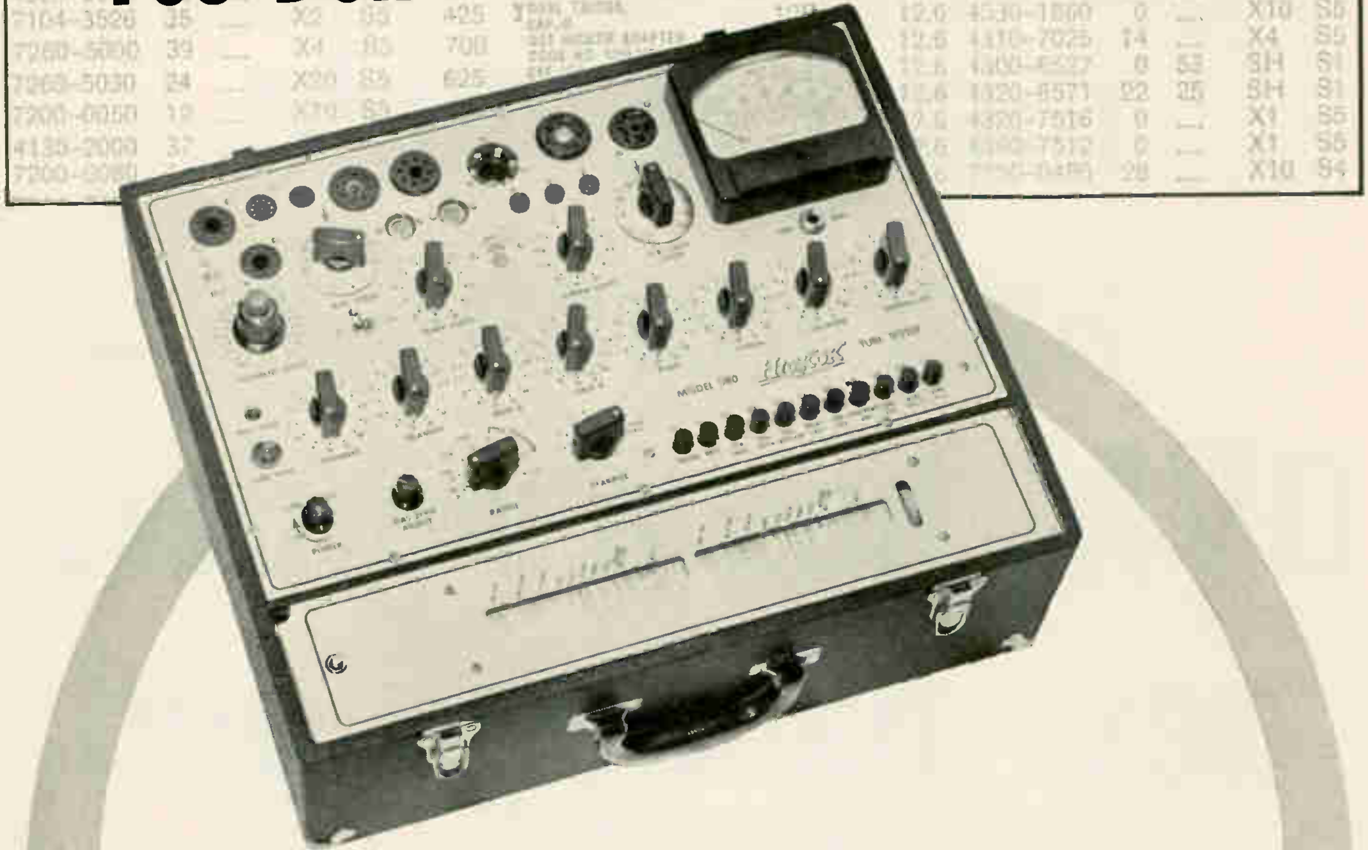




You Don't Need The Roll Chart



with a HICKOK Model 580

. . . . . even though it has one, because the 580 is a totally **different** tube tester. Its unique design permits direct read-in of a wide range of test parameters—which means it can be set up directly from the tube handbook, for instance. For the first time in **any** tube tester you can measure Gm under conditions of your own choosing. Of course, it has a roll chart, too—for your convenience. In addition, the model 580 makes complete "fringe" tests, including measurement of gas effects down to 0.05 μa and leakage to 50 megohms.

See your HICKOK distributor or write for circular #TT-644.

HICKOK

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Circle 129 on reader service card

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Ratio	.005%
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Polarity:	Automatic
Accessories:	Optional

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If you consider price, features, and quality . . . the Cubic DV-271 is your best digital voltmeter buy! Based on the time-proved design of the famous Cubic V-71, this new transistorized 4-digit DVM offers a clean-cut front panel for easy read-out . . . **and sells for only $1395!**

Versatile DV-271 is ideal for your most highly-specialized measurement needs. It is the only low-cost DVM available with both dependable reed-relay operation and built-in ratiometer!

For complete information on this and other digital equipment, write: Cubic Corporation, Industrial Division, Dept. D-208, San Diego, California 92123.

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VACUUM RELAYS

HYVAC TYPE	HVS-1	HVS-3	HVS-4	HVS-10	H-5	H-7	H-8
Contact arrangement	SPDT	SPDT	SPDT	SPDT	SPST N.O.	SPDT	SPDT
Rated Operating Voltage (KV)	17	20	17	17	5	5	15
Test Voltage (KV)	22	25	22	25	7.5	7.5	20
Continuous Current, max. (amps RMS)	7	10	8	8	4	4	15
Contact resistance, max. (ohms)	0.015	0.015	0.020	0.015	0.015	0.020	0.015
Operating time, max. (ms)	20	20	15	20	10	10	15
Coil resistance (ohms ± 10%)	128	1500	40	65	250	200	250
Coil voltage (vdc, nominal)	28	115	24	40	24	24	26.5
Nominal Dimensions (inches – L × H)	4¾ x 5	4¾ x 3¾	4¾ x 4½	4¾ x 3¼	¾ x 2	2⅞ x 2½	1⅛D x 2¾
Mounting Style*	foot bracket	coil clamp	foot bracket	foot bracket	foot bracket	foot bracket	threaded base
Approximate unit price (1-9 pcs)	$55	$68	$42	$55	$62	$62	$98

*Other styles available

HYVAC TYPE	H-9	H-11/S2	H-12	H-14	H-16	H-17	H-35
Contact arrangement	SPST N.C.	SPST N.O.	SPDT	DPDT	DPDT	SPDT	SPDT
Rated Operating Voltage (KV)	15	12-air 18-oil	8-air 12-oil	8-air 12-oil	12-air 18-oil	25-air	35
Test Voltage (KV)	20	15-air 20-oil	12-air 15-oil	12-air 15-oil	15-air 20-oil	30-air	40
Continuous Current, max. (amps RMS)	15	15	15	15	15	25	10
Contact resistance, max. (ohms)	0.015	0.015	0.015	0.015	0.030	0.015	0.015
Operating time, max. (ms)	15	18	18	18	20	25	30
Coil resistance (ohms ± 10%)	250	250	250	250	120	120	50
Coil voltage (vdc, nominal)	26.5	26.5	26.5	26.5	26.5	26.5	28
Nominal Dimensions (inches – L × H)	1⅜D x 2¾	1D x 1 13/16	1 1/16 D x 1 13/16	2⅛D x 2¾	1⅜D x 3	2D x 3½	8 x 5
Mounting Style*	solder flange	threaded base	threaded base	threaded base	threaded base	flange base	mounting bracket
Approximate unit price (1-9 pcs)	$98	$105	$110	$128	$128	$128	$110

*Other styles available

Hyvac, specialists in vacuum electronic components, manufactures a complete line of high voltage vacuum relays for prompt, and in many cases, immediate off-the-shelf delivery. These relays are widely used in ECM, communications, sonar, radar, pulse-forming networks, medical electronics, and other high voltage equipment. Many Hyvac models are completely interchangeable with other manufacturers types.

Hyvac also maintains a special "QUICK REACTION" model shop for prototype design and production for extra fast delivery of your special and urgent relay requirements. Frequently, prototypes for your test and evaluation can be delivered in 10 to 20 days.

For complete technical information call your nearest Hyvac engineering representative or write directly to us.

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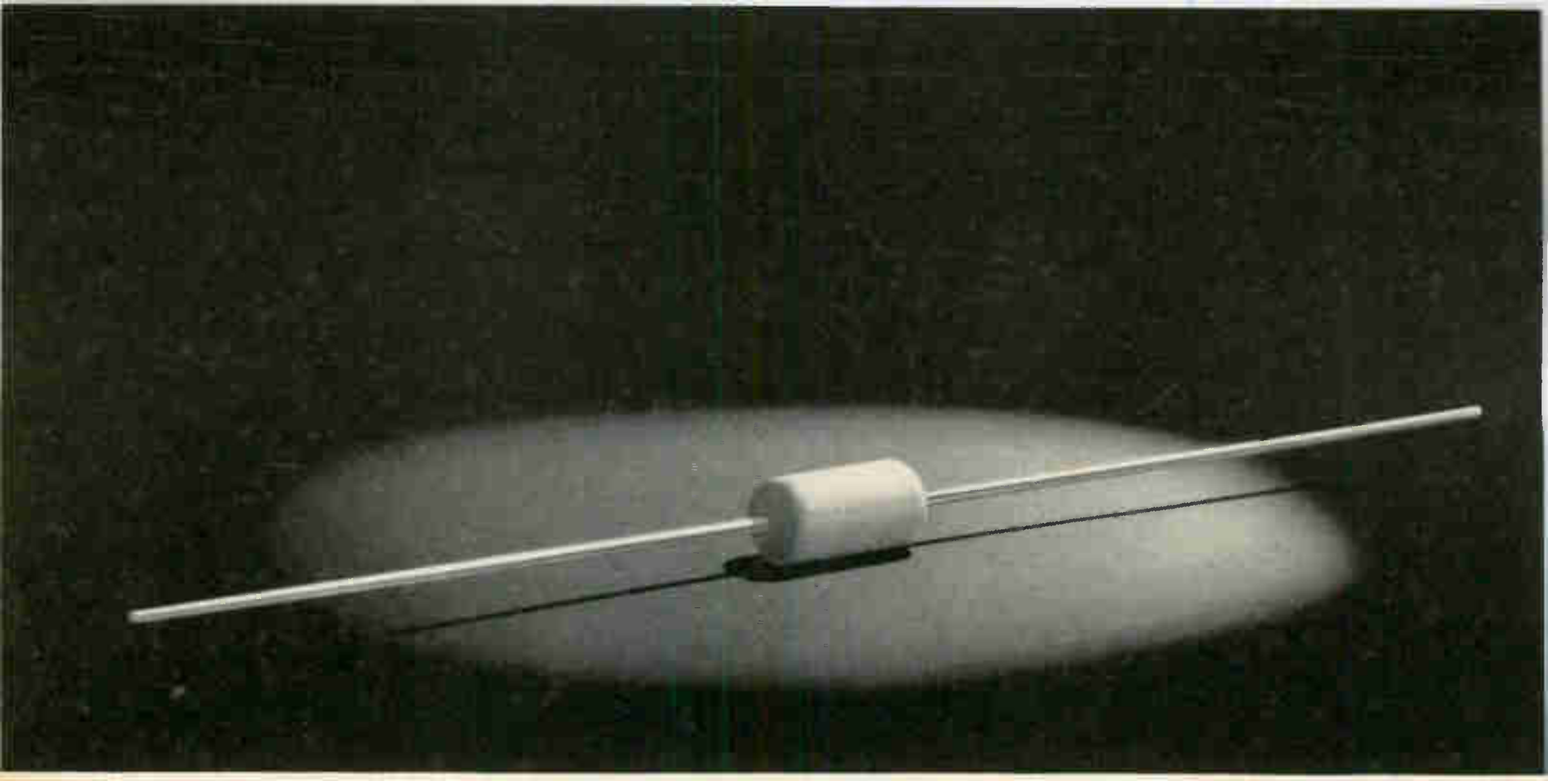

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ULTRA RELIABILITY METAL FILM Type XLT for MIL-R-38101, MIL-R-55182 and Minuteman. Failure rate of .0001/1000 hours, full rated load at 125°C, at 60% confidence. 4 ratings and 3 T.C.'s available.	HIGH RELIABILITY METAL FILM Type GEM for MIL-R-55182 and wide commercial applications. Failure rate of .01%/1000 hours, full rated load at 125°C, at 60% confidence. Hermetic glass seal. 4 ratings and 2 T.C.'s.	ASSURED RELIABILITY COATED METAL FILM Type CC for MIL-R-55182. 100% screening for reliability. Failure rate of .0056%/1000 hours, full rated load at 125°C, at 60% confidence. 3 ratings and 8 T.C.'s.	ESTABLISHED RELIABILITY CARBON COMPOSITION Type GBT for MIL-R-39008, levels M, P and R. ½ watt RCR 20 style. Failure rate of .0006%/1000 hours, full rated load at 70°C, at 60% confidence. 5% tolerance.

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IRC

INTERNATIONAL RESISTANCE COMPANY
PHILADELPHIA, PA. 19108

Circle 132 on reader service card

Accelerometer goes digital

Converting analog signal to digital form before amplification preserves accuracy of original measurement

Conventional accelerometers are analog devices with transducer output signals measured in milliamperes. Because of this low output level, some amplification or other signal conditioning is usually necessary before the signal is transmitted from the measurement station, and this processing can distort the original measurement.

But a digital signal is not so easily distorted, since it consists merely of pulses and not a complex waveform. The CG Electronics division of Gulton Industries, Inc., has developed an accelerometer that digitizes the signal before amplification, thus preserving the accuracy of the measurement by divorcing it from the associated electronics.

In some cases, accelerometer output must be digitized anyway; for instance, to obtain distance and velocity information for navigation systems, the output must be integrated one or more times, and thus it must be converted before being fed to a digital computer. The CG Electronics system ensures that the output is ready for direct entry into a computer, recorder, or telemetry transmitter without the use of complex analog-to-digital conversion equipment. The system is available with output in various codes and formats, such as straight binary, binary-coded decimal, and biphase.

The CG designers employed a voltage-to-time conversion technique for changing the analog data to a digital form. The transducer's analog output is compared with a ramp signal which establishes an accurate time reference. The input signal is sampled, or compared to the negative sloped ramp, 500 times a second. When the two signals are equal, the ramp comparator turns on a fixed, 3.072-Mc oscillator. The oscillator is turned off when the ramp reaches zero volts. The number of cycles at the oscillator's output, representing the time it was on, are counted and entered into a shift register for further processing. Signal scaling is done in the ramp generator by controlling the slope, in volts per second, of the ramp.

Micrologic circuits are mounted on printed circuit board. Size of future units will be reduced when microcircuits are available to replace the discrete components necessary now.

Digital accelerometer is attached to vehicle by four clearance holes on the mounting flange.

The complete package, including the accelerometer, power supply, and digital logic circuit, is enclosed in a cylindrical container measuring approximately 5 inches high by 3½ inches in diameter. The complete unit has an accuracy of ±0.2% and a linearity of ±0.1% within the specified environmental conditions. Being self-contained, it is almost entirely unaffected by such conditions as power supply changes, transmitter frequency shifts, and converter inaccuracies, which would contribute errors in a conventional system.

Integrated circuits are used in the present models only in the digital portion because of the limited availability of off-the-shelf micromodules. New circuits are being designed so that integrated circuits may be used throughout, reducing size even further. The integrated circuits are supplied by the Fairchild Semiconductor division of the Fairchild Camera & Instrument Corp.

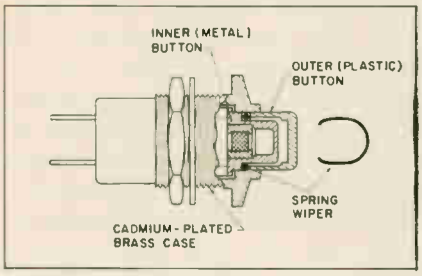
Units can be supplied to measure pressure or temperature as well as acceleration. There is also a model available that can measure acceleration on 3 orthogonal axes.

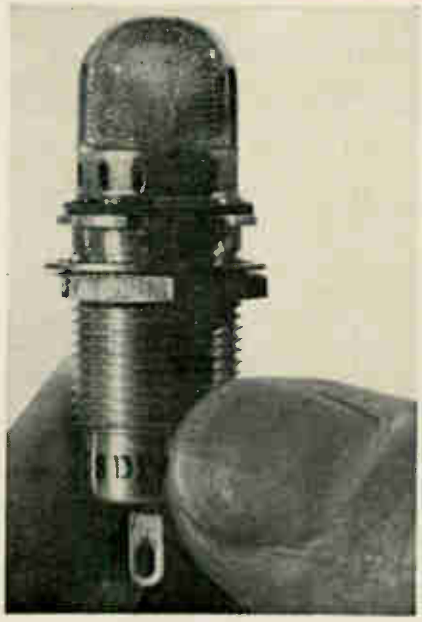
Specifications

Power	28 volts d-c at 250 milliamperes
Word rate	500 per second
Bits per word	9 binary or 12 binary-coded-decimal
Bit rate	6,000 bits per second ±1
Accuracy:	
Binary	±1 bit (least significant bit) over specified environment
Binary-coded decimal	±2 bits (least significant bit) over specified environment
Linearity	±0.1%
Acceleration range	1 to 16 g's with rate of change 0 to 50 cps over entire range

CG Electronics, a division of Gulton Industries, Inc., P.O. Box 8345, Albuquerque, N.M., 87108. [350]

Lights and switches are rfi-proof





Radio frequency interference, leaking through indicator lights and push-button switches, can introduce false information in computers and hamper operation of avionic and industrial control equipment.

The front-of-panel holes required for mounting components are the source of much of the rfi leakage problem. If the components do not fit perfectly, they will be imperfectly grounded to the chassis and rfi will pass through, producing undesirable stray signals in surrounding equipment.

The Control Switch division of the Controls Co. of America, at Folcroft, Pa., has come up with a rather inexpensive solution to 90% of all shielding problems. The company has designed a family of lights and switches with rfi protection built into the components themselves. Both lights and switches block rfi over the range of 150 cycles to 1,000 megacycles, without extra circuitry (such as inductance-capacitance networks to provide a path to ground for the rfi) or the custom design of specific components.

To protect indicator lights, Control Switch put a metal mesh shield inside the plastic lens. In sealed models, this shield is bonded to the indicator case; in removable-lens models, the shield is connected to the case by a special conductive gasket. The cadmium-plated brass case completes the path to ground.

The shielded lights are available in a standard size with replaceable incandescent or neon lamps or as a permanently sealed 50,000 hour subminiature lamp.

Push buttons have an internal U-shaped metal spring wiper (see photo), around the inner metal button of the switch. The wiper grounds all metal parts inside the switch that do not conduct current to the switch case.

The new lights and switches have helped protect a military line

Specifications

Lamp assemblies	
Standard	7/16 inch diam. lens, dome shape; incandescent, neon, or without lamps
Subminiature	9/32 inch diam. lens, dome shape, flat, or flush mount
Voltages	28 volts d-c to 5 volts d-c
Switches	
Types	⅞ and ⅜ inch diameter buttons
Dielectric strength	1,000 volts
Minimum life	25,000 operations
Shock	withstands 50 g
Vibration	withstands 20 g

Circle 135 on reader service card

Circle 137 on reader service card

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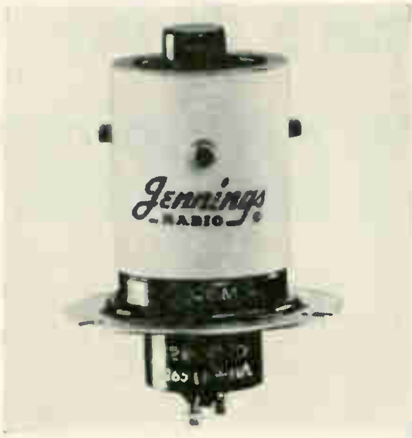
printer from interference at frequencies between 14 kilocycles and 20 Mc, generated by noisy switching peak currents of 250 amps at 35 volts d-c. They have also been used to eliminate rfi from a control unit designed to monitor the temperature, pressure and volume of a vital coolant in the lunar excursion module, and to protect a computer from rfi generated by the power supply.

Control Switch Division, Controls Co. of America, 1420 Delmar Drive, Folcroft, Pa. [351]

Miniature relay in rugged housing

A miniature relay now being offered can withstand high voltage and has high r-f current-carrying characteristics. The RJ2A will withstand test voltages of 18 kv peak



and carry continuous r-f currents of 15 amps rms at 16 Mc, yet it weighs only 3 oz. and measures only 2⅜ in. long.

The RJ2A also offers the advantages of a vacuum dielectric in a rugged ceramic and metal housing. The use of ceramic permits processing at high temperatures which insures the cleanest possible contacts. The higher r-f current rating is also possible because of the ceramic housing.

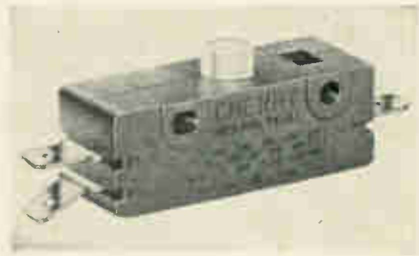
Jennings Radio Mfg. Corp., P.O. Box 1278, San Jose, Calif., 95108. [352]

Switch design eliminates rivets

Design of a basic, general-purpose snap-action switch eliminates rivets by using a unique clinching method that locks switch-case halves securely. Clinching is done by crimping two prongs on each terminal into slotted seats molded in phenolic case halves. The result is a tightly locked switch case that seals out dust, eliminates terminal wobble and increases dielectric strength.

Switch-mounting holes are on 1-in. centers, and quick-connect

New Components



terminals accept a standard ¼-in. connector. The model E13-00E has a list price of 75 cents with net cost of $0.345 in quantities of 2,000 and lower prices on higher quantities.
Cherry Electrical Products Corp., P.O. Box 438, Highland Park, Ill., 60036. [353]

Tool eases extraction of logic modules

Extraction tool 2876-1 is part of a complete line of auxiliary hardware engineered for use with the Cambion line of digital logic modules. It aids technicians in extracting modules from densely packaged circuits where removal by fingers is impossible.

Use of the extraction tool prevents damage to the module pins due to bending. The tool may be used on both the 12-pin germanium line, 100 kc, and the new 2 Mc silicon line of modules.

The tools are available from stock and are priced at $12 each in quantities of 1 to 9.
Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass., 02138. [354]

Integrated-circuit testing boards

Company engineers report that the 030 series board units will greatly simplify the testing, power aging and breadboarding of integrated circuits in all standard sizes of TO-5 and flatpack cases. For specialized applications, the 030 units are available with a variety of the latest sockets. Sockets are mounted in varying positions of multiples of five. For example, one standard

When a connector's connector pins are smaller, it stands to reason you can have more contacts in the connector.

Bendix Double-Density "Pancake" connectors let you be unreasonable about how many contacts you can have in a connector.

You can have as many as 135 contacts in one Bendix® Pancake connector. Center-to-center spacing can be as compact as .090 inch.

And you still have a smaller, lighter connector. In most aerospace applications, our Pancake connectors have up to 50% less length and 60% less weight than comparable-performance connectors. Weight reduction is cumulative, too: the more Pancake connectors, the more total connector length and weight goes down.

And these are off-the-shelf connectors we're talking about, with proven dependability. Contact pin bending resistance is greater, contact retention is greater. Rigid glass-filled epoxy inserts eliminate contact splaying and dielectric puncture, and unitized sandwich construction reduces components for reduced failure rate.

Pancakes come in crimp and solder, and in over 5 shell types and 9 sizes with 25 multiple-key position insert patterns in 8- through 24-size shells, many of them MIL standard layouts.

For details, write us in Sidney, N. Y. And be unreasonable in what you expect.

That's what we're in business for.

Up to 125% more contacts in one smaller, lighter Pancake connector means up to 50% less connector length and 60% less connector weight here.

Scintilla Division THE Bendix CORPORATION

Circle 139 on reader service card

board, the 030-001, has 30 positions of Quik-Sert flatpack sockets terminated in turret lugs with 16 busses.

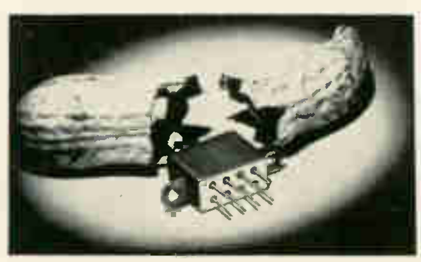
For easy insertion and optimum protection of delicate devices, all sockets for TO-5's have large pyramidal entrances with polarization marks. Sockets for flatpacks feature a unique flip-top cover and latch assembly with automatic component positioning. Boards are also available with mating connectors for use with interchangeable sockets.

Both sockets and boards feature ease of use and long life. Sockets, for example, have a conservatively rated typical life of 50,000 insertions or more. All socket contacts are wiping type with nickel over gold plating. Standard boards for flatpacks are rated +125° to −65°C. Special high-temperature sockets are available for temperatures above +125°C. Standard boards for TO-5's are rated +150° to −65°C.

Barnes Development Co., 24 Lansdowne Ave., Lansdowne, Pa. **[355]**

Miniature relay switches 1 amp

A double-pole, double-throw JR relay is available in a 1/6 crystal can size. It meets requirements of MIL-R-5757/19. Voltage ranges offered



EMC Introduces A Complete Family of 100 Kcps Digital Logic  Modules Which Operate Over An Ambient Temperature  Range Of –55° To +70°C! Here Is Highest Quality, Rugged Reliability  (Over 4½ Million Hours MTBF) At Lowest Cost.*

* S·R flip-flop module as low as $3.95 each in quantities of 100.

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Modules Potted in TIMONIUM

Circle 141 on reader service card

New Components

are 6, 12, and 24 v d-c, and corresponding coil resistances are 100, 400, and 1600 ohms. The JR relay has a minimum operating life of 150,000 operations, and has an insulation resistance of 1,000 megohms at 25°C.

The unit operates over the Class B temperature range of −65° to +125°C; withstands 30 g at 10 to 3,000 cps vibration; withstands 100 g shock for 11 milliseconds; and is not damaged by 150 g acceleration. Volume of this relay is only 0.04 cu in.

Four case styles and three header styles are available to satisfy all mounting requirements.

Branson Corp., P.O. Box 845, Denville, N.J. [356]

Connector facilitates switch replacement

Instant replacement of standard stepping switches is now possible with a new connector design. The connector is shaped to the configuration of the stepping switch and is mounted directly to the equipment cabinet. When maintenance or repair is required, the stepping switch is disengaged from the connector by releasing two jack screws and the new switch is inserted.

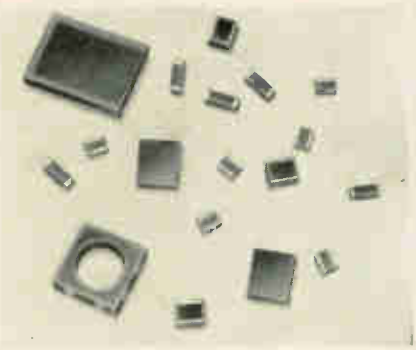
Besides reducing down time during replacement or repair, the connector can be pre-wired to a wire harness which may be pre-checked before mounting in the equipment. Use of solderless, crimp-type contacts allows easy insertion and removal of the harness leads. Also, faster preparation of a wiring harness is possible with the manufacturer's high-speed crimping tools.

Other features include redundant

electrical contact areas for low contact resistance; positive alignment assured by guide track design; and quality contact plating of gold over nickel.

AMP Inc., Harrisburg, Pa. **[357]**

Uncased capacitors for microelectronics



A variety of layered construction, uncased Ceralam capacitors have been developed for mounting directly on integrated circuit substrates.

Because of their dense, stacked structure Ceralam capacitors are said to have a higher capacity to volume ratio than other ceramic capacitors. The units, which may readily be fitted to any package requirement, can be supplied in any geometric configuration and are available with either axial or radial leads of tinned copper, weldable and weldable/solderable alloy materials.

Hi-Q division of Aerovox Corp., Olean, N.Y. **[358]**

Stepping programer controls 99 circuits

A low-cost stepping programer, model 189, is suited for complex sequencing or programing applications. This electromechanical timer accurately controls up to 99 circuits and offers 100 discrete cam positions. Its switches are tripped in a preset sequence by easily removable program pins. Switch contacts are rated at 15 amps at 120 v a-c.

E. W. Bliss Co., Eagle Signal Division, Federal St., Davenport, Iowa. **[359]**

Now Lambda offers two complete lines of all-silicon .... Modular ... Subrack

LM SERIES

Multi-Position-Rated™ and Multi-Current-Rated™ for 40°, 50°, 60° and 71°C

You can select from 22 models starting at $79 voltages up to 60 VDC, from 0.08 AMPS. to 8.3 AMPS....and mount these modules three ways on a chassis or in a rack

A-C Input—105-132 VAC
45-440 CPS

Reg. Line—.05% + 4 MV
Load—.03% + 3 MV

Ripple—1 MV rms—3 MV peak-to-peak

Temp. Coef.—.03%/°C

- Meet RFI Specifications—MIL-I-16910
- Maximum Ratings Without External Heat Sinking or Forced Air
- Thermally Protected and Short Circuit Proof—Current Limiting
- Remote Programing

mounted this way

mounted this way

mounted this way

4 DC OUTPUTS IN 3½" RACK

mounted this way

Mounting provisions for use with chassis slides

Package A
3³⁄₁₆" x 3¾" x 6½"

Model	VDC	I MAX. AMPS[1] 40°C	50°C	60°C	71°C	Price
LM 201	0-7[2]	0.85	0.75	0.70	0.55	$ 79
LM 202	0-7[2]	1.7	1.5	1.4	1.1	99
LM 203	0-14[3]	0.45	0.40	0.38	0.28	79
LM 204	0-14[3]	0.90	0.80	0.75	0.55	99
LM 205	0-32[4]	0.25	0.23	0.20	0.15	79
LM 206	0-32[4]	0.50	0.45	0.40	0.30	99
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	109

Package B
3³⁄₁₆" x 4¹⁵⁄₁₆" x 6½"

Model	VDC	I MAX. AMPS[1] 40°C	50°C	60°C	71°C	Price
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

New
Both LM and LH Series meet these Mil. Environment Specifications:
Vibration — Shock — Humidity — Temp. Shock
Altitude — Marking — Q.C.

LH SERIES

¼ and ½ rack power supplies are Multi-Current-Rated™ for 30°, 50°, 60°

You can choose from 10 ¼ and ½ rack models... voltages up to 120 VDC, up to 9 AMPS.... for rack, bench and chassis mounting

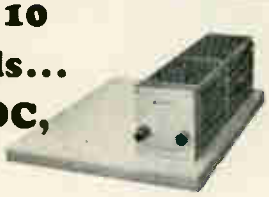
A-C Input—105-135 VAC
45-480 CPS

Reg.—.015% or 1 MV line or load

Ripple—¼ MV rms, 1 MV p to p

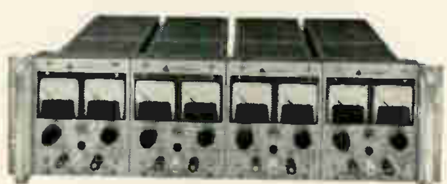
Temp. Coef.—.015%/°C

RFI—MIL-I-16910

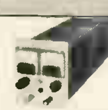


flush chassis mounting

minimum bench width



4 DC outputs in a single rack



LH124FM

LH124

¼ RACK metered and non-metered
SIZE 5³⁄₁₆" x 4³⁄₁₆" x 15½"

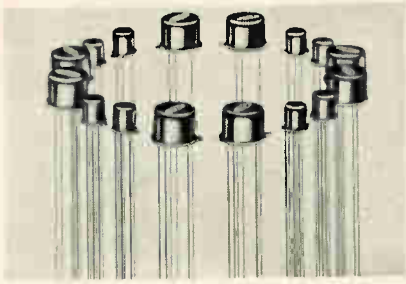
Model[2]	VDC	I MAX. AMPS.[1] 40°C	50°C	60°C	71°C	Price[2]
LH 118	0-10	4.0	3.5	2.9	2.3	$175
LH 121	0-20	2.4	2.2	1.8	1.5	159
LH 124	0-40	1.3	1.1	0.9	0.7	154
LH 127	0-60	0.9	0.7	0.6	0.5	184
LH 130	0-120	0.50	0.40	0.35	0.25	225

[1] Current rating is from zero to I max. and applies over entire voltage range.
[2] Prices are for non-metered models. For metered models add suffix (FM) to model number and add $25.00 to

LAMBDA ELECTRONICS CORP.
515 BROAD HOLLOW ROAD, MELVILLE, L. I., NEW YORK • 11749

Circle 144 on reader service card

New Semiconductors



Sensitive scr's offer 2-μa triggering

Six TO-5 and TO-18 families of silicon controlled rectifiers, for 2-ma to 1.6-amp applications, feature gate trigger levels to 2 μa and voltage ratings to 400 v. They permit a new design approach to high gain-high voltage circuits, which can achieve major simplification and increased reliability, according to the manufacturer.

The AA100-118 and AD100-118 families include threshold detectors, timing circuits, level sensing, relay and solenoid driving, ring counters, protective and warning circuits, encoding and decoding, motor driving, pulse generation, lamp driving, gating, magnetic amplifier and thyratron replacement. Units are available in 100-lot prices starting at $1.90 each.

Solid State Products, Inc., One Pingree St., Salem, Mass. [371]

Alloy and diffused zener chip diodes

Low-temperature glass passivation and alloy junction in an area 0.050 square and 0.030 in. deep are the outstanding characteristics of the new hermetic zener chip diodes. Electrical characteristics are said to meet or exceed equivalent 400-mw glass diodes. The manufacturer has perfected a process that permits zeners to be passivated without causing diffusion of the sharp alloy junction. Alloy junctions permit standard zeners to be produced in the range of 3.3 v to 12 v—similar to 1N746-1N756.

Passivation is accomplished at temperatures below 70°C. Diffused zeners in chip form cover the range of 7.5 v to 100 v—similar to 1N958-1N985. Units of both types pass seal and humidity tests that cause silicon dioxide passivated units to fail. Mounted on a gold-plated Kovar tab, the diffused series can be soldered into place while the alloyed series can be soldered on one side and a spring contact made to the other.

U.S. Semcor, 3540 W. Osborn Rd., Phoenix, Ariz., 85019. [372]

Thin-film flip-flop meets Mil-Std-750

This complementary pulse counter dissipates less than 1 mw and is capable of speeds up to 1 Mc. As a result of modern thin film techniques, there are no inserted passive components. The resulting package including transistors in TO-18 cans is 0.45 in. by 0.65 in. by 0.1 in. and weighs less than 5 grams. Kovar leads on 0.1-in. centers emanate from two sides of the package. With a +6 v d-c supply the flip-flop is insensitive to noise below 1 v, and is capable of accepting information from four different scalers as well as driving a load approximately four times its own basic power consumption.

Designed for space applications, the flip-flop will operate over temperature, humidity, shock, and vibration conditions in accordance with Mil-Std-750. Fabrication of multiple devices, which are then diced, provides economy as well as similarity of components.

Alpha MicroElectronics Co., Inc., 10501 Rhode Island Ave., Beltsville, Md. [373]

Silicon rectifiers feature speedy recovery

Ultrafast recovery time of 200 nsec maximum is offered by a new series of high-current silicon rectifiers. Labeled 1N3909-1N3913, the rectifiers are rated at 30 amps at 100°C, case, 50 to 400 v. They offer high surge current capability of up to 300 amps, improved radiation tolerance, and high-frequency, high rectification efficiency of up to 200 kc. They are available in the JEDEC DO-5 stud package in both forward and reverse polarity.

With a typical recovery time of 70 nsec, the rectifiers are well suited for use as high-frequency power supplies in high-speed switching and multiphase rectifier applications. In converters and inverters, the fast recovery characteristics permit h-f operation with significant reduction in size and weight of magnetic components—transformers and inductors—and important increases in rectification efficiency.

Texas Instruments Incorporated, 13500 North Central Expressway, Dallas, Texas. [374]

Power rectifiers rated to 40 amps

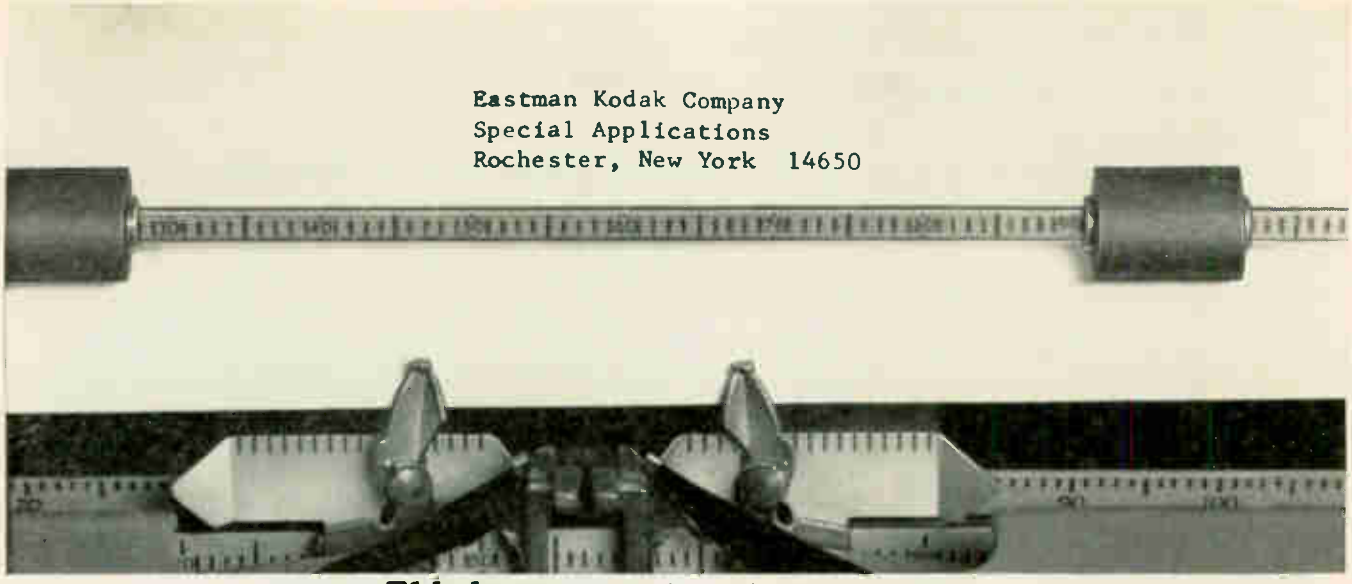
Low-cost power rectifiers are available with current ratings to 40 amps average and peak reverse voltages to 400 v at 180°C maximum operating temperature. The units are hermetically sealed in a stud mounted package with eyelet terminal (40 HF and 1N3209 series) or flexible lead (41HF series). They can be supplied in standard (cathode stud) or reverse polarity configuration. Stud thread is ¼ in.-28 UNF-2A.

Junctions are made by the double diffused process and hard solder is used in the junction assembly. These features assure a highly reliable device under mechanical and thermal shock.

For higher power applications, the 40 and 41HF series offer low d-c leakage current of 3.5 ma maximum at rated prv; 150°C junction temperature; nonrepetitive surge current rating of 350 amps and the ability to operate at up to 1,000 cps without derating.

Devices are available in quantity at $1.30 to $2.85, depending on prv, for quantities up to 99.

International Rectifier Corp., 233 Kansas St., El Segundo, Calif., 90246. [375]



This is one way to get an answer

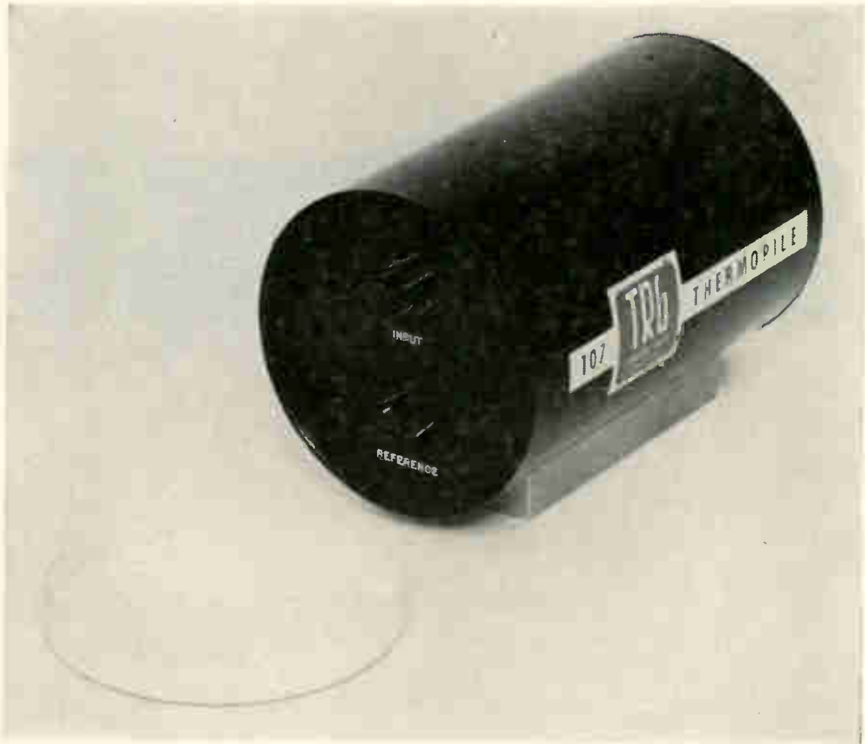
This is another

Your need for data capture is specific to the job at hand, and photography is a possible answer. So you put your problem to us in a letter (a phone call to 716-325-2000, Ext. 5129, may do just as well). If the photographic method is not a practical answer for you, we tell you so. If it is, we get you together with the two or three photo-engineers on our staff who are best qualified to respond to your special requirements.

We can extend this broad-gauge invitation because a new line of Kodak films designed for quick, compact, fuss-free processing offer a new potential for removing the nuisance aspects of photorecording and leaving only its great benefits. Now we are ready for many high-volume data-recording applications. Yours may be one.

Kodak

Thermopiles measure millijoules, gigawatts



In many laser applications, it is necessary to determine accurately the laser's output energy and power. One such application is high-power laser radar, where the range of the system is dependent on the beam's intensity. TRG, Inc., is making two new ballistic thermopiles that can measure laser energies from millijoules up to 1,000 joules in the normal mode, and peak powers up to a gigawatt.

The thermopile is an arrangement of two bright nickel-silver plated cones—one to receive the laser beam and another to provide a reference standard. The laser beam enters the receiver cone, whose surface is specially coated to prevent the cone from being destroyed by the beam, and is almost totally absorbed, its energy being transferred to the cone as heat. The dimensions of the cone are selected so that it behaves like a black body, or perfect absorber.

Iron-constantan thermocouples connected in series, have their hot junctions connected to the receiver cone and their cold junctions to the reference. The temperature differential between the receiver cone and the reference causes electromotive force (emf) to be generated in the thermocouples; it is read out on an externally connected microvoltmeter. The peak emf (in microvolts) is linearly related to the total pulse energy (in joules) by a fixed calibration factor set for each unit (in microvolts per joule) by the manufacturer.

The model 107 thermopile can measure the energy of lasers up to about 300 joules. It has a receiver cone of one-centimeter diameter, which means it can measure the output from most laser systems without requiring a focusing lens, thus eliminating the problems of air sparking and lens losses.

For energy levels greater than about 300 joules, the laser beam more than fills the input-cone aperture of the model 107. To measure these very powerful lasers, it is necessary to use the model 108.

Model 108 has a two-centimeter aperture and a photodiode (rise time, 4 nanoseconds) to receive a compact Tektronix oscilloscope

easily adapted to particular needs

Here's a high-performance oscilloscope featuring operational simplicity and versatility through a new series of plug-in units. Presently, you can select from 12 amplifier units and 5 time-base units.

Knowing your application area, you select those units that fit your needs. Some of the plug-in unit combinations available include those for low-level, differential, multi-trace and sweep-delay applications.

Special-purpose plug-in combinations equip the oscilloscope for sampling applications, in which the instrument becomes a low-drift sampling system as easy to operate as a conventional oscilloscope, but with sensitivity and bandwidth possible only through sampling.

With any combination of plug-in units in the oscilloscope—including the same type amplifier units in both channels for X-Y displays—this new value package provides you with "no-parallax" displays and sharp trace photography.

OSCILLOSCOPE FEATURES

NEW CRT with an internal graticule and controllable edge lighting • regulated power supplies • regulated dc heater supply • Z-axis input • 3.5-kv accelerating potential • amplitude calibrator • and operation from 105v to 125v or 210v to 250v. (The Type 561A operates from 50-400 cps and the Type RM561A operates from 50-60 cps.)

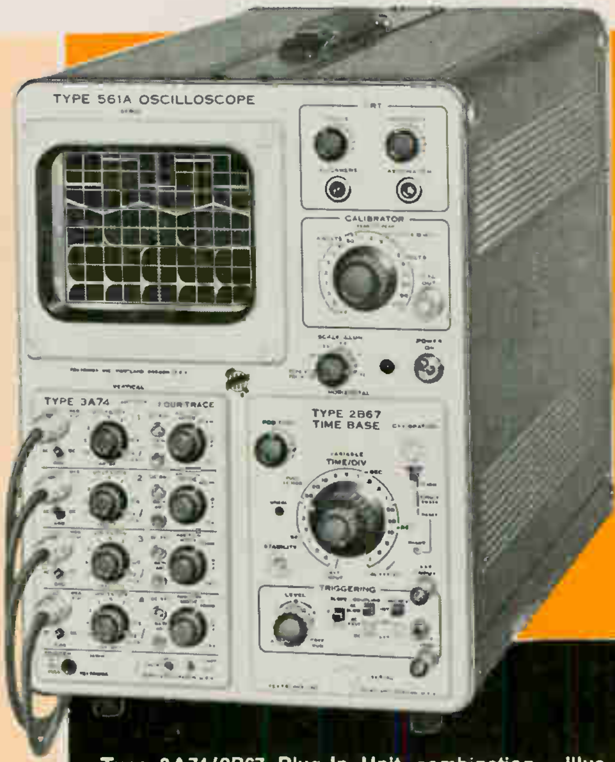
Type 561A (shown in four-trace application) $500

Type RM561A (shown in sweep-delay application) $550

Oscilloscope prices without plug-in units.

Plug-In Units: Prices as low as $105 for vertical amplifier and $210 for time-base generator.

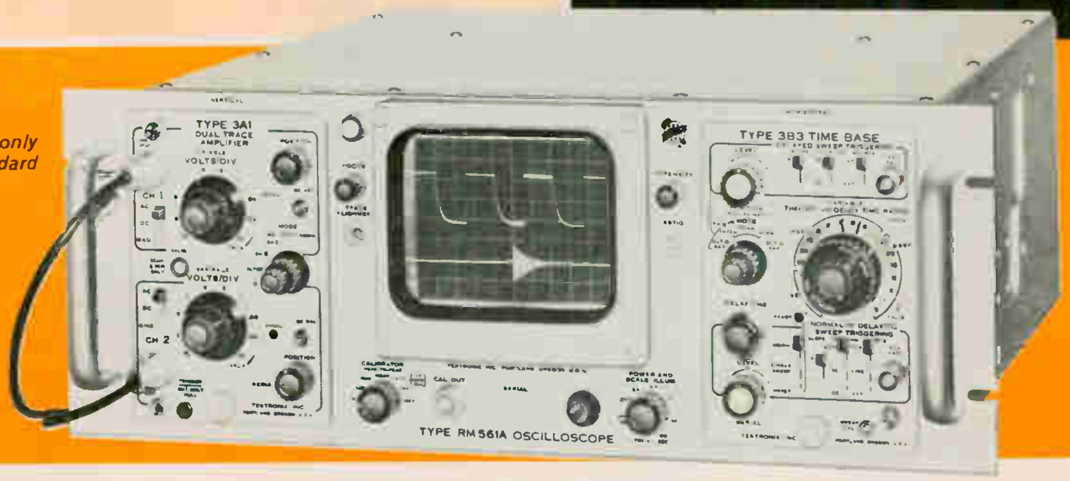
U.S. Sales Prices f.o.b. Beaverton, Oregon



Type 3A74/2B67 Plug-In Unit combination—illustrated with Type 561A—equips the oscilloscope for *up-to-four-trace applications.*

The 3A1/3B3 Plug-In Unit combination—illustrated with the rack-mount model, Type RM561A—equips the oscilloscope for *high-sensitivity, dual-trace operation and sweep-delay applications.*

The rack-mount model occupies only 7 inches of standard rack height.



FOR MORE INFORMATION ON EITHER MODEL OF THIS NEW OSCILLOSCOPE AND ANY COMBINATION OF PLUG-IN UNITS, PLEASE CALL YOUR TEKTRONIX FIELD ENGINEER.

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Tektronix International A.G., Zug, Switzerland • Tektronix Ltd., Guernsey, C. I. • Tektronix U. K. Ltd., Harpenden, Herts

Circle 149 on reader service card

small fraction of the light input. Pulse wave shape is observed on an oscilloscope that can be connected to the rear panel of the unit. The pulse width divided into the energy (from the voltmeter) gives a peak power value.

In earlier models, the apertures of the two cones faced in opposite directions. But convection currents near the reference cone created by the beam entering the receiver cone affected the ambient temperature to which the reference is sensitive. TRG's models 107 and 108 have the apertures facing the same way, eliminating such inaccuracies.

Each thermopile is calibrated against a National Bureau of Standards source. Recalibration will be performed by the manufacturer for a charge of $25.00.

Specifications

Maximum energy input	1000 joules
Maximum power input	1 gigawatt
Dynamic range	10^7
Sensitivity	35 microvolts/joule minimum
Output impedance	100 ohms
Size	6⅜ x ¾" diameter
Mounting	Optical bench or tripod
Price, Model 107	$550
Model 108	$750
Delivery	Two weeks

TRG, Inc., Melville, N. Y. [381]

Six-digit indicator shows elapsed time

An elapsed-time indicator, designed for commercial and industrial use, is available in three mounting configurations. The instrument combines high accuracy, ruggedness and dependability with low unit cost. The six-digit display can be supplied to read hours and tenths, minutes and tenths, or seconds. All models have synchronous motors and are available for operation at 6, 12, 24, 115 or 230 v a-c, 60 cps, and for 115 or 230 v a-c, 50 cps. Power requirement is 2.5 w nominal. Accuracy is ±0.050

NOW... MORE CAPABILITIES FROM LTV ELECTROSYSTEMS

LTV Military Electronics Division general manager is Dr. Harold Goldberg, one of the electronics industry's most versatile and experienced executives.

LTV Continental Electronics companies president is James O. Weldon (right), America's first super-power electronics communications engineer.

AIRBORNE RECONNAISSANCE AND INTELLIGENCE SYSTEMS

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AUTOMATED BROADCAST SYSTEM

GUIDANCE AND CONTROLS

DATA DISPLAY SYSTEMS

COMMUNICATIONS AND INSTRUMENTATION

AUTOMATIC TEST EQUIPMENT

TEST LABORATORIES

ADVANCED ENCAPSULATION

LTV Electrosystems top management team includes (front to rear) D. L. Hearn and Carl Bentley, vice presidents, and Fred Buehring, president, shown here inside ABC^3, the Airborne Battlefield Command and Control Center built from scratch in 98 days.

Through growth, expansion and diversification, LTV Electrosystems has become an unexcelled leader in defense electronics, specializing in the design, development and production of electronic systems having ground, airborne and space applications. Beginning as LTV Temco Aerosystems Division, the company developed its reputation through quick reaction to military needs, on time and within costs, and set a growth record by doubling annual sales twice in less than 10 years.

Established as one of the three major subsidiary companies of Ling-Temco-Vought, Inc. at the beginning of 1965, LTV Electrosystems has been quick to react in its new status. Knowing a company improves its capability best by broadening its base, LTV Electrosystems acquired at mid-year the assets of two important divisions of the parent company: LTV Continental Electronics and LTV Military Electronics Division.

With Continental, LTV Electrosystems acquired the Free World's most experienced organization specializing in super-power electronics and a major participant in all of the large VLF (very low frequency) radio installations of the past decade, including Voice of America, Voice of Polaris, and NATO VLF installation at Anthorn, England.

With the acquisition of Military Electronics Division, LTV Electrosystems gains a substantial growth building block with established and proven capability in guidance and controls, data display and information systems, communications and instrumentation, automatic test equipment, test laboratories and advanced encapsulation.

Today at LTV Electrosystems you have one primary source for total capability in the field of electronics. It has the experience, knowledge, facilities and resources to conceive, design, engineer, manage, manufacture, test and deliver high quality defense, space and electronic systems and associated equipment from prototype to long-production-run quantities.

LTV Electrosystems, Inc. / A Subsidiary of Ling-Temco-Vought, Inc. / P. O. Box 1056 / Greenville, Texas.

LTV
ELECTROSYSTEMS, INC.

Circle 151 on reader service card

sec per start-stop operation at rated voltage and frequency. Ambient temperature range is —20° F to 140° F. The rectangular case measures $2\frac{9}{16}$ in. wide by 2¼ in. high by 2¼ in. deep and can be mounted in front of or behind the panel. Bezel dimensions are 2⅞ in. each side for the square mount and 3½ in. diameter for the circular. Case depth is $2\frac{1}{16}$ in. for each.

The A.W. Haydon Co., 232 North Elm St., Waterbury, Conn., 06720. [382]

Analyzer evaluates bit synchronizers

A self-contained bit synchronizer analyzer requires no external test equipment. It measures and displays bit error rate and sync acquisition time directly on a decimal display.

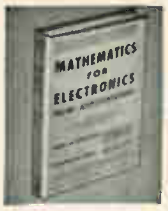
The versatile model BA-101 can accept a wide range of bit rates from 1.2 to 1.2-million bits per second and provides a means of evaluating operation of a pcm bit synchronizer (signal conditioner) for preflight confidence checks or other analytical purposes. The analyzer, with a built-in pcm test simulator, has been designed so that a synchronizer may be performance-tested under specified test conditions or using a range of conditions that may exist during operation. Variable signal-to-noise ratio from —10 to +20 db can be selected along with transition density of 1-to-2 up to 1-to-64. Transition density consists in the number of changes in code per unit time required for sync acquisition.

The analyzer has a built-in gaussian noise source and allows measurement of minimum signal/noise required to acquire synchronization, sync acquisition time, minimum signal/noise required to maintain sync, transition density to acquire and maintain sync, and data error rate.

The bit synchronizer analyzer has output terminals for monitoring and recording test results and has low Z output of variable amplitude and d-c offset.

Defense Electronics, Inc., Rockville, Md. [383]

Introduction to Radar Systems, by M. Skolnik. Publisher's Price, $14.50. Club Price $12.35.



Mathematics for Electronics with Applications, by H. M. Nodelman and F. W. Smith, Jr. Pub. Price, $7.00. Club Price, $5.95

Transistor Circuit Design, prepared by Engrg. Staff of Texas Instruments Inc. Pub. Price, $15.00. Club Price, $12.75.

Electronic Amplifier Circuits, by J. M. Pettit and M. M. McWhorter. Publisher's Price, $10.50. Club Price, $8.95.

Electronic Measuring Instruments, by H. Soisson. Publisher's Price, $7.50. Club Price, $6.40.

Modern Digital Circuits, by S. Weber. Publisher's Price, $9.50. Club Price, $8.10.

Electronic and Radio Engineering, by F. E. Terman. 4th Ed. Publisher's Price, $16.00. Club Price, $13.60.

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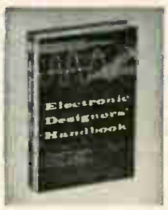

Electronic Designers' Handbook, edit. by R. W. Landee, D. C. Davis, and A. P. Albrecht. Pub. Price, $18.50. Club Price, $15.75.

Nonlinear - Magnetic Control Devices, by W. A. Geyger. Publisher's Price, $12.50. Club Price, $10.65.

Printed and Integrated Circuitry, by T. Schlabach and D. Rider. Publisher's Price, $13.50. Club Price, $11.50.

Electrical Engineering for Professional Engineers' Examinations, by J. D. Constance. Pub. Price, $ 0.00. Club Price, $4.50.

Control Engineers' Handbook, by J. C. Truxal. Publisher's Price, $23.50. Club Price, $19.95.

Single Sideband Principles and Circuits, by E. W. Pappenfus, W. B. Bruene, and E. O. Schoenike. Pub. Price, $15.00. Club Price, $12.75.

Tunnel-Diode and Semiconductor Circuits, edit. by J. M. Carroll. Publisher's Price, $9.75. Club Price, $8.30.

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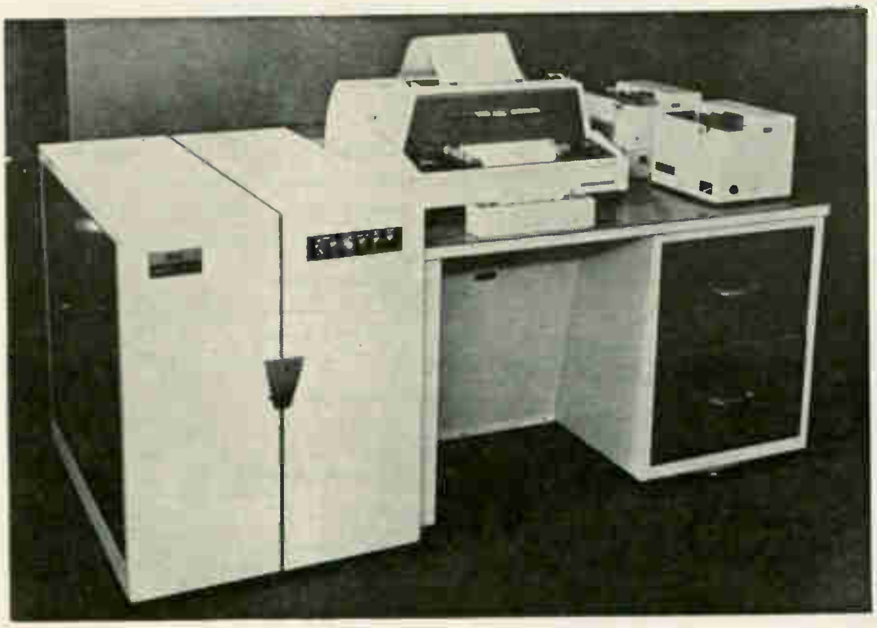
Majority-logic computer from Japan



A desk-sized computer built with components that work with majority logic instead of AND-OR logic will be available in the United States for the first time. The computer is the NEAC 1210, built by the Nippon Electric Co., of Tokyo.

The basic majority-logic circuit is the parametron, a device whose output state depends on the state of any two out of three inputs. The parametron is a resonant circuit containing a ferrite core and a capacitor, which makes it very cheap and reliable. The signals with which the parametron operates are electric oscillations that are either in or out of phase with a reference oscillation; these oscillations correspond to the 1 and 0 states of conventional computer logic, represented by voltage levels or pulses.

Logic functions generally can be implemented in majority logic with fewer circuits than in conventional AND-OR logic. The binary output Z of a majority-logic device with three binary inputs A, B, C can be expressed as

Z = (A and B and not-C) or (A and not-B and C) or (not-A and B and C) or (A and B and C)

or in Boolean algebra

$$Z = ABC + AB\bar{C} + ABC + ABC$$

This can be mathematically simplified to

$$Z = AB + BC + AC$$

which is read as

Z = (A and B) or (B and C) or (A and C)

This function would require nine diodes and up to four transistors in conventional logic.

Some logical functions cannot be conveniently built in majority-logic elements; for these functions, parametrons can perform ordinary AND-OR logic if required. If one input of a three-input parametron is permanently connected to a logical 0, then both the other inputs must equal 1 for the output to equal 1, and the device has become a simple AND. Likewise, if one input is permanently connected to a logical 1, then the output equals 1 if either remaining input is 1, and the OR function is realized.

The parametron was invented in 1954 by Eiichi Goto, a Japanese physicist, and has been used in a number of different computers built by Nippon Electric. None of these has been offered in the United States up to now.

The 1210 has a magnetic drum memory for storage of data and instructions. The memory has a capacity of 3,000 decimal digits and an average access time of about

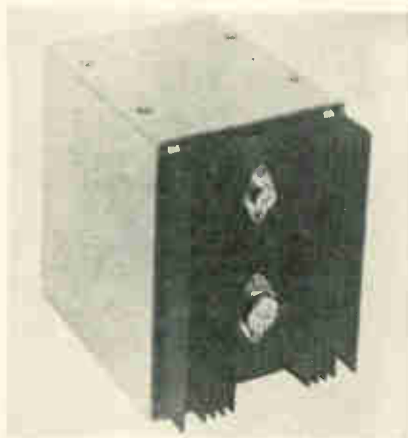
20 milliseconds. This is slow compared to all-electronic machines, and places the 1210 on the borderline between small computers and elaborate accounting machines. A software package is available with the machine to assist with the solution of many different types of problems such as discounting of bills, daily accounts, financial statements and dividend calculations. The machine will sell for $8,000.

Specifications

Memory capacity	3,000 decimal digits
Memory access time	20 milliseconds, average
Word length	Long—12 digits (11 plus sign) Short—8 digits (positive only)
Instructions—number	24
format	Single address
Internal coding	Fixed-point binary coded decimal
Execution times	
Add: 13 milliseconds	(plus access time)
Multiply: 30 milliseconds	(" " ")
Divide: 760 milliseconds	(" " ")
Input-output	
Electric typewriter, 250 characters per minute	
Paper tape / Edge-punched cards	520 char/min input 700 char/min output
Power requirements	117 volts a-c, single phase, 50-60 cps 1 kva or less

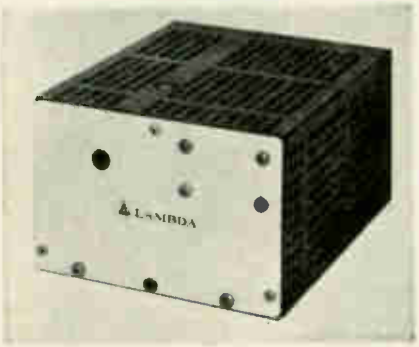
Nippon Electric Co., 200 Park Ave., New York, N.Y. 10017. [401]

Highly regulated d-c power module



The MS series all-silicon, d-c power module will be highly regulated in the range of ±0.25%, and with ripple and noise less than 1 mv. Response time is 50μsec and dynamic impedance is 0.0005 ohm. Operating as a free-standing unit, the device is self-cooled and requires no additional heat dissipating devices, enabling it to operate up to 81°C.

Protection devices include automatic electronic current limiting, short circuit protection and automatic overload protection. The module features remote sensing, output voltage adjust, remote voltage programing, and remote current limiting. It is available in voltage ranges from 3 to 100 v, in amperage ranges from 100 ma to 12 amps. Price is from $94 to $275.
Perkin Electronics Corp., 345 Kansas St., El Segundo, Calif. [402]



Silicon modular power supplies

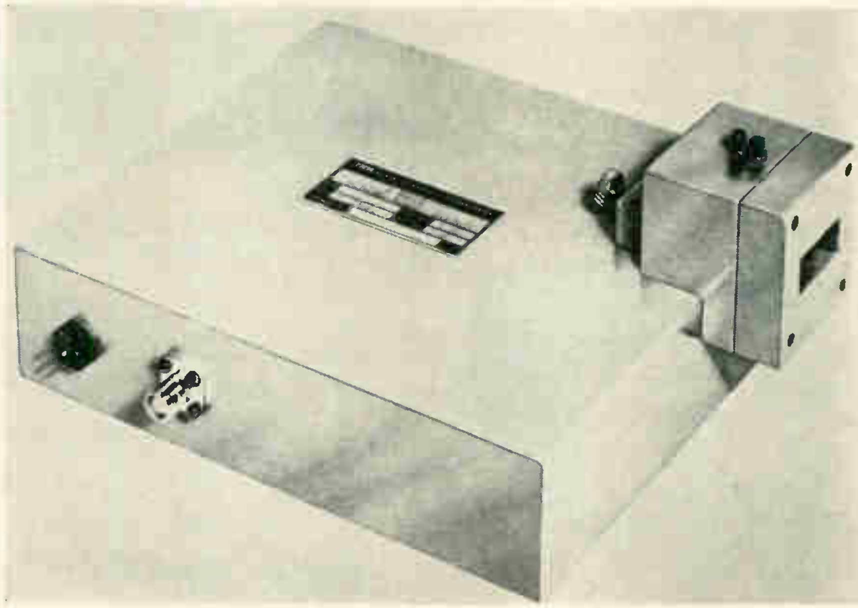
A line of all-silicon, modular power supplies has been announced for bench or chassis use. The LM series has multiple current ratings based on ambient temperature of 40°, 50°, 60° and 71°C. Included are 22 models in four package sizes, with voltages up to 60 v d-c, 0.08 amp to 8.3 amps. All models meet rfi specifications per MIL-I-16910 and also meet military environment specifications for vibration, shock, temperature shock, altitude, quality and marking.

LM series models are remotely programable—200 ohms per volt over the voltage range. All units have a-c input voltage and frequency range of 105 to 132 v a-c, 45 to 440 cps. Temperature coefficient is 0.03% per degree centigrade. Line regulation is 0.05% + 4 mv; load regulation 0.03% + 3 mv. Ripple is 1 mv rms, 3 mv peak-to-peak.

Units are protected against short circuit, electrical overload and excessive ambient temperatures. There are no voltage spikes due to "turn-on, turn-off" or power failure. Prices start at $79.
Lambda Electronics Corp., 515 Broad Hollow Road, Melville, L.I., N.Y. [403]

New Microwave

X-band transmitter boosts power output



Anticipating the need of communications systems manufacturers for off-the-shelf components to design into satellites and space vehicles, TRW Systems has developed a miniature solid state transmitter for up to X-band frequencies.

In addition to space vehicle communications the miniature transmitter can be used for telemetry, guidance, rendezvous and tracking. It weighs only four pounds and occupies 60 cubic inches. Power output is 17.5 watts at 325 megacycles and decreases with frequency to one watt at X band, which TRW says is twice the power output previously attainable at X band. The company hopes to boost the r-f power output to 2.5 watts at 10.4 gigacycles, and says that any of the present units can be retrofitted when increased power capability is available.

Depending on the user's requirements, modulation for the transmitter can be either phase, frequency or pulsed.

Reliability calculations show that the transmitter has a mean-time-between-failures (mtbf) greater than 60,000 hours.

The X-band transmitter frequency is obtained by tripling the output of a 108-Mc crystal oscillator in an idler circuit developed by TRW engineers, and then doubling the idler frequency five times with dual varactor doubler circuits. Only a few milliwatts of r-f drive power are required. Output frequency may be lowered and power increased by removing doublers. For example, the unit can provide 6 watts at 2.6 Gc and 17.5 watts at 325 Mc.

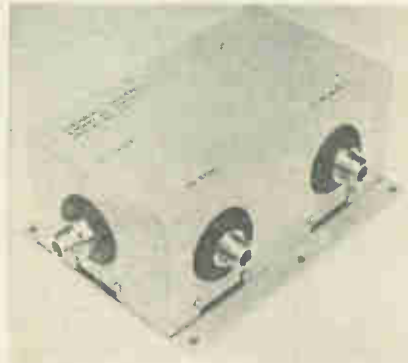
Specifications

Input power	67 watts d-c
Output power	17.5 watts at 325 Mc 6 watts at S band 1 watt at X band
Modulation	Phase, frequency or pulsed
Price	On request
Delivery	4 to 6 months

TRW Systems, Redondo Beach, Calif. [421]

Frequency diplexer employs YIG sphere

Simultaneous skin-beacon missile tracking without the necessity for receiver time-sharing is one of the applications for the model D16C1-12 diplexer. The unit employs a YIG sphere and works on the principle of a gyromagnetic coupling filter to obtain the band separation. The skin and beacon frequencies



may be brought as close as 30 Mc, and the D16C1-12 will divide the two into two output channels with a 15 db minimum isolation between channels. Greater isolation between channels is possible for skin-beacon separations in excess of 30 Mc.

Electronically tunable over the 5.4 to 5.9 Gc frequency range, the tuning coils of several D16C1-12 diplexers may be cascaded and tuned from a common driver for use in multichannel radars. Setting accuracy is ±2 Mc with a unit-to-unit accuracy of ±2 Mc being provided in cascaded diplexer applications. An internal heater is employed for operation from 0° to 60° C. Price is $2,400; delivery, 90 days.

Sperry Microwave Electronics Co., P.O. Box 1828, Clearwater, Fla. [422]

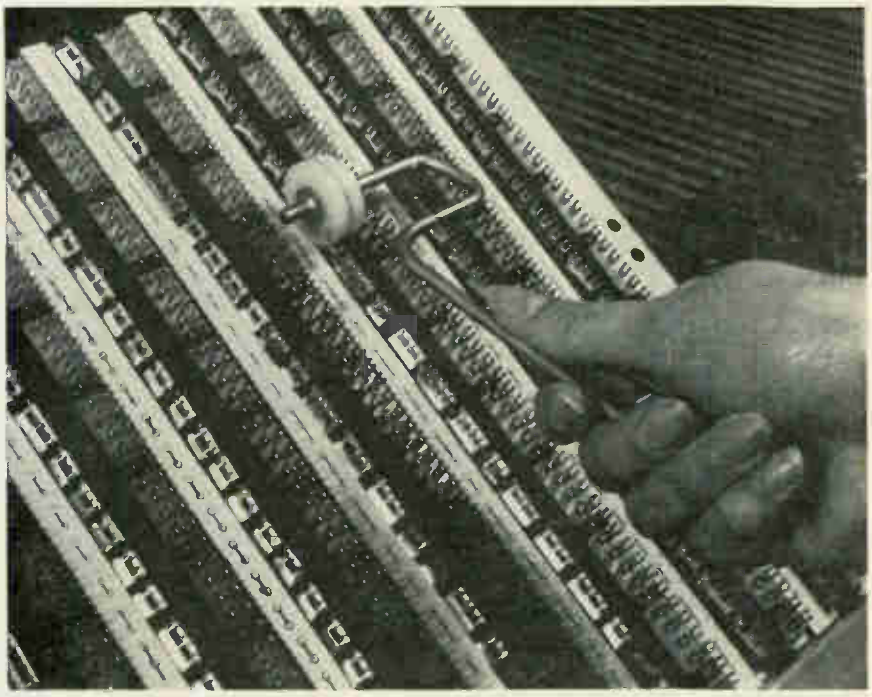
Co-ax dummy loads operate at 0.2 to 10 Gc

Three new series of coaxial dummy loads operate in the 0.2 to 10 Gc region and employ high temperature refractory material as the load elements. They are available with maximum power ratings up to 15 kw average and 40 Mw peak. The units are supplied with EIA or JAN flanges or type N connectors. Maximum vswr is 1.20.

The unfinned TT series and the transverse-finned TV series are designed for free air convection cooling. The TW series loads are high power, liquid-cooled units. Each series is available in 14 combinations of connector series and frequency ranges. All three series are priced from $400, with availability set at 4 weeks.

Microlab/FXR, Livingston, N.J. [423]

Templates guide logic assembly



Plastic roller crimps bus strips to connect groups of terminal pins

The time required to assemble computer logic boards can be reduced by 50% if templates are used to guide the placement and interconnection of components, reports the Bunker-Ramo Corp. The templates allow the assembler to put the components in place rapidly, eliminating the time it takes to consult the wiring lists and assembly-instruction diagrams that are normally used to guide assembly.

The techniques and tools that Bunker-Ramo devised are now being offered as a package by Admiral Controls, Inc., under a licensing and marketing agreement with Bunker-Ramo.

The board used is the type that has pairs of spade terminals in parallel rows. Components, such as diodes and resistors, are mounted by inserting their leads in the terminals. Connections between components are made by fastening jumpers or buses to groups of terminals. As buses, Bunker-Ramo uses tin-plate copper strips that are crimped to the pins by a plastic roller, as illustrated. The strips are precut in lengths corresponding to the number of pins to be connected in a group.

To guide placement of the buses, their lengths and locations are marked on long, thin lengths of aluminum, which fit between the rows of terminals. The aluminum fingers are fastened to a bar the width of the board, so the template can read-

Symbols on aluminum strips indicate types of components and their location, when template is placed on terminal board

ily be inserted into and removed from the pin matrix. It is removed after the buses are crimped.

A similar template guides component mounting. This template is marked with symbols corresponding to the type and polarity of each component. Numbers on the symbols correspond to numbered bins holding parts. Each bin contains one type of component with pretrimmed leads and the assembler doesn't have to stop to check parts lists or color codes.

The parts template can be left on the board as an inspection guide. After leads are soldered to the terminals, the template is removed by pulling the bar, thus sliding the aluminum fingers out from under the components.

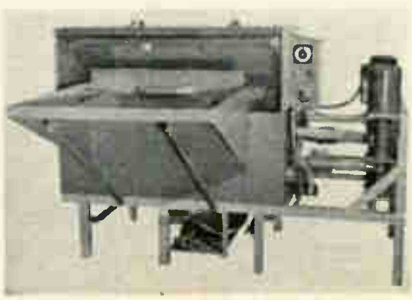
The templates, which are custom made, are available in six weeks and cost $25 each. The bus strips cost about 30 cents a foot and the crimping tool $3; both are stock items.

Admiral Controls, Inc., 4520 Cutter St., Los Angeles, Calif. 90039. [451]

Spray etchers rotate in horizontal plane

A new design in a line of spray etchers can be used to produce more precise chemically machined parts or printed circuit boards. The work rack on the new machine rotates in a horizontal plane.

The movement of the work between the fixed spray nozzles eliminates patterning and promotes a straight down etch. Uniform distribution throughout the spray pattern in addition to the etchant hitting the work at 90° causes greater resolution and precision. Increased etchant movement on the work promotes a faster etch.



Made from ½ in. PVC and titanium throughout, these etchers are ruggedly constructed to accept all common etching solutions without corrosion or leaking. This new design is available in an 18 in. by 24 in. tray size or a 24 in. by 36 in. tray size.

Colight, Inc., 123 North Third St., Minneapolis, Minn., 55401. [452]

Tool straightens component leads

Gentle handling by Delrinn plastic inserts is featured in the model 1100 component lead straightener. The rugged production tool has an adjustable pedestal for operator convenience.

Operating from 115-v 60-cps power, the model 1100 includes insert configurations to accept up to four TO-18 leads or up to ten TO-5 leads. In addition, blank inserts are available for preparation of special lead configurations.

Actuating plates are dry-lubricated to combine cleanliness with long life. On the production line, plastic inserts are effective for approximately eight hours, and are quickly and easily replaced by maintenance personnel.

Size of the unit is 5¼ in. high by 4¼ in. wide by 10 in. long, not including pedestal. Price, depending on quantity, is $625 to $695.

Macronetics, Inc., 220 California Ave., Palo Alto, Calif. 94306. [453]

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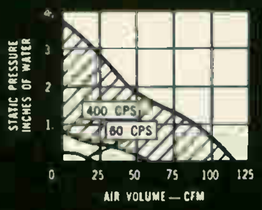

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OTHER MODELS: 610A 10 cps to 5 mc — $1175; 603A 20 cps to 5 mc — $495; 301A · DC to 40 cps — $1995; 321A DC to 120 cps — $2095; 311A DC to 40 cps and 10 cps to 20 kc — $2395; 312A DC to 120 cps and 10 cps to 20 kc — $2495; 331A 10 cps to 20 kc — $1295.

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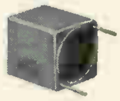

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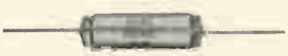

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New Books

Solid state

Semiconductor Junctions and Devices: Theory to Practice
William B. Burford III and H. Grey Verner, McGraw-Hill Book Co. 316 pp. $12

While intended primarily for scientists, engineers and technicians who are not working directly in the semiconductor field, this work will be of value to anyone seeking a basic understanding of junction properties and their practical applications in diodes, amplifiers and switches. To make the material readily understood by readers who do not have specialized formal training in the field, a simple, practical approach is employed throughout. The authors avoid using rigorous mathematical expressions wherever possible, replacing them with careful expositions of fundamental principles.

Special attention is given to the formation of the planar junction and its behavior in a wide variety of single-junction and multijunction devices.

The first six chapters cover the broad, basic background necessary for an understanding of the subject. They treat, among other things, the concept of conductivity in metals, insulators and semiconductors as related to their band structures; the role of impurities in the conduction process; the p-n product concept; derivation of the Fermi function and the relationship of the Fermi level to the band structure of metals and semiconductors; formation and properties of a p-n junction; and an examination of junction behavior under external bias for both symmetrical and asymmetrical junctions.

The meat of the book is contained in the subsequent chapters, which follow the transition of simple p-n junctions to contemporary commercial devices. The two-junction transistor is synthesized, and its design requirements and current relationships are presented; grounded-base, grounded-emitter and grounded-collector connections are compared; a black-box equivalent circuit analysis is developed for the grounded-base transistor, and this is extended to the grounded-emitter and grounded-collector configurations; a summary of practical performance characteristics and frequency limitations leads to a detailed discussion of typical commercial applications.

Recently published

Diode Reference Book, D.G. Kilpatrick, W.A. Dittrich, M.W. Lads Publishing Co., 261 pp., $3.95

Handbook of Laplace Transformation: Fundamentals, Applications, Tables, and Examples, Second Edition, F.E. Nixon, Prentice-Hall, Inc., 260 pp., $10

Problems in Electrical Engineering for Technical Students, B. Hamill, Iliffe Books, Ltd., 197 pp., $3.50

Electronic Systems for Convenience, Safety, and Enjoyment, E.A. Altshuler, The Bobbs-Merrill Co., 255 pp., $4.95

Quantum Electronics and Coherent Light, Course 31, Edited by C.H. Townes, P.A. Miles, Academic Press Inc., 371 pp., $16

Chemical Effects of Nuclear Transformations, Vol. I, International Atomic Energy Agency, 442 pp., $9

Chemical Effects of Nuclear Transformations, Vol. II, International Atomic Energy Agency, 558 pp., $11

Finite Graphs and Networks, An Introduction with Applications, R.G. Busacker, T.L. Saaty, McGraw-Hill Book Co., 294 pp., $11.50

Automatic Indexing: A State-of-the-Art Report, National Bureau of Standards, 220 pp., $1.50

Scientific and Technical Manpower Resources, National Science Foundation, 184 pp., $1.25

Automatic Control of Aircraft and Missiles, J.H. Blakelock, John Wiley & Sons, Inc., 348 pp., $15.75

Electromechanical Control Systems and Devices, E.B. Canfield, John Wiley & Sons, Inc., 328 pp., $13.50

Systems Engineering Tools, H. Chestnut, John Wiley & Sons, Inc., 646 pp., $12.95

Telemetry Systems. L.E. Foster, John Wiley & Sons, Inc., 308 pp., $12.75

Mathematical Theory of Connecting Networks and Telephone Traffic, V.E. Benes, Academic Press Inc., 319 pp. $12

Basic Eleectronics "Autotext": A Programed Course in Circuits, edited by J.W. Friedman, H.G. Rice, G. McGinty, Prentice-Hall, Inc., 534 pp., $13

Handbook for Electronic Engineers and Technicians, H.E. Thomas, Prentice-Hall, Inc., 427 pp., $15

A History of the General Radio Company, A.E. Thiessen, General Radio Co., 116 pp.

In French

Les Radars de Veille Modernes, L. Thourel, Sofradel Edeurs and Masson & Cie., Paris, 282 pp., $13.12

Technical Abstracts

Porcelain capacitors

Factors influencing the current rating of r-f capacitors
Robert Swart, Vitramon, Inc., Bridgeport, Conn.
Leslie V. Bird, University of Bridgeport, Bridgeport, Conn.

Porcelain capacitors with axial leads are evaluated, particularly with respect to their ability to handle high r-f current at frequencies up to 30 megacycles.

Data shows that the uniform structure of the porcelain dielectric dissipates heat very effectively and is one of the most important influences on volumetric efficiency. The extremely low absorption of porcelain makes it possible to take high frequency signals without apparent loss of capacity. Tests show that the material is stable, has low permittivity and high dielectric strength. Capacitors were tested at various frequencies between 3 and 30 megacycles. Plots taken of current and voltage indicate the importance of enclosing all active electrodes completely within the dielectric to prevent corona breakdown at high values of r-f voltage.

Tests were conducted using an r-f generator that operated at 13.6 Mc, near the center of the test frequency range. Various styles of capacitors were arranged in series-parallel combinations to give the impedance that would operate all units above the established current rating of the tests.

As a result of the study, the terminals of new porcelain capacitors have been designed so that there is no chance for failure due to corona breakdown. The new capacitors have heat-sink terminals and are expected to find wide usage in pi networks, r-f filters and antenna couplers for capacitance values between 10 and 2,000 picofarads. More than 65,000 unit hours of successful test operation demonstrated the high order of reliability of the new capacitors under rated conditions. All parameters remain within the original measurement tolerances, indicating negligible drift under load.

Leon Glynn of the Collins Radio Corp. conducted preliminary tests and constructed the original measurement test circuit. Eugene J. Caires of Vitramon, Inc. performed the rating tests and constructed prototype models of high-current porcelain capacitors with heat-sink terminals.

Presented at the Electronics Components Conference, Washington, May 5-7

Reliability in space

Reliability for manned interplanetary travel
Roy B. Carpenter Jr.
North American Aviation, Inc.,
Downey, Calif.

The longer the mission in space, the greater the probability of some subsystem failures. On a round trip to Mars, lasting 500 to 700 days, subsystems which fail must be repaired; for, during 99% of the mission, the quickest way back to earth would be along the planned trajectory. Any abort maneuver would require very large changes in velocity, which are out of the question with present technology.

An "availability" reliability design technique, previously applied to continuously active ground systems like the Air Force's Sage, is being applied to the interplanetary flight problem. This technique predicts the probability of each subsystem's functioning at a specific time in the mission. The probability figure is based on the mean time between failure, the length of the mission, and the maximum time it will take to repair the more likely failures.

A typical subsystem for a Mars expedition was found to have an 0.999999987 probability of meeting its goal. The average number of repairs to be expected on the mission was computed to be 6.3, and the average repair time was figured at 24 minutes.

The availability procedure requires a detailed analysis of each subsystem. In a few cases, allowable downtime is limited, since some subsystems absolutely must function at certain points in the mission. Most subsystems, however, are only absolutely necessary for short periods.

The concept of availability assumes that spares can be carried to facilitate repairs; for a Mars mis-

sion, about 1,200 pounds of spares would be required. Monitoring equipment is also necessary, so that astronauts would have time to isolate a failure soon after it occurred.

Presented at the 4th Annual ASME Aerospace Reliability and Maintainability Conference, Los Angeles, July 29.

Error control

Comparison of various error-control techniques
A.H. Frey Jr.
Federal Systems Division,
International Business Machines Corp.,
Bethesda, Md.

There are three major modes of error control: error detection only, error detection and retransmission, and forward error correction. They can be evaluated on the basis of information theory, or on the way they perform in hypothetical or actual environments.

An error-detection-only system can be applied only in a limited number of cases where statistical data is transmitted, such as in tracking or telemetry systems, and the erroneous data can be discarded. This type of error-control is low in cost and has high reliability. For a given statistical characteristic of errors, it can be applied effectively on hf, troposcatter or wire channels.

Error detection and retransmission systems are also effective on any channel. With this type of system all messages can be used, because only those messages in which error is not detected are passed. But retransmission systems require a duplex facility, the major disadvantage, and the transmission delay is variable. Also, channel degradation decreases the amount of information transmitted.

In a forward-error-correction system, a return channel is not required, the delay is constant, and all messages can be used. On the other hand, this system has limited error detection reliability. Channel degradation increases undetected errors, throughput is limited, and suitable coding does not always exist.

Presented at the IEEE Communications Convention, Boulder, Colo., July 7-9.

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Programmer Analysts: Develop programming techniques for aerospace computations • Error propagation and loop stability • Principles of computer design • Scaling and loop time analysis • Operational programming in either data processing or scientific computation fields • Studies of error propagation effects, word lengths, number systems and machine architecture characteristics.

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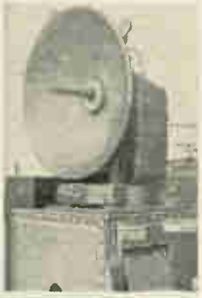

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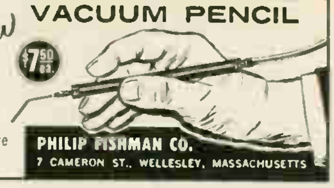

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New Literature

Printed-circuit connectors. Continental Connector Corp., 34-63 56th St., Woodside, N.Y., 11377, has available a 48-page printed-circuit connector catalog covering printed-card and tape-cable applications.
Circle **461** on reader service card

Time-delay relays. A.W. Haydon Co., 232 North Elm St., Waterbury, Conn., 06720. Bulletin ESF313 gives complete technical data on subminiature electronic time-delay relays. **[462]**

Integrated circuit assembly. High Reliability Circuit Systems, 1853 North Raymond Ave., Anaheim, Calif. Microminiature packaging and assembly of integrated circuits, employing all welded interconnections, are explained in bulletin 1001. **[463]**

D-c amplifier. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. Bulletin 1165 describes a low-cost, high-gain differential d-c amplifier. **[464]**

Microwave devices. Defense division of Armstrong Cork Co., Lancaster, Pa., 17604, offers a publication providing descriptive and technical data about Luneberg lens antennas and radar reflectors. **[465]**

Modular power supplies. Trygon Electronics, Inc., 111 Pleasant Ave., Roosevelt, N.Y., 11575, has published an eight-page brochure detailing its expanded line of all-silicon modular power supplies for use in critical system installations where reliability and size are of prime importance. **[466]**

Coaxial r-f switches. Bird Electronic Corp., 30303 Aurora Rd., Cleveland (Solon), Ohio, 44139. A four-page bulletin of manually operated coaxial r-f switches describes a line of rugged panel-mounted units ranging from single circuit with 2, 3, 4, 6, 8 and 10 positions to double circuit 2-position and reversing configurations. **[467]**

Hardware. Cinch Mfg. Co., 1026 South Homan Ave., Chicago, Ill., 60624. Catalog CC-50 contains an illustrated description of a broad range of terminal strip and binding post devices **[468]**

Push-button switch. Cherry Electrical Products Corp., P. O. Box 439, Highland Park, Ill. Bulletin 33GR describes a push-button switch that is actuated by a novel and reliable cam and pawl arrangement requiring a maximum operating force of only 24 ounces. **[469]**

Subminiature connectors. Gulton Industries, Inc., 212 Durham Ave., Metuchen, N.J. Data sheet AC50a covers the Glennite C-30 line of subminiature connectors with shielded four-conductor cables and sealed receptacles. **[470]**

Q determination. Boonton Electronics Corp., Parsippany, N.J. Two nomographs for determining Q capacitance or inductance measurements are provided in a four-page technical folder. **[471]**

Power supplies. Deltron Inc., Fourth & Cambria Streets, Philadelphia 33, Pa. Bulletin 107A describes a rugged, reliable and compact series of power supplies, comprised of 720 models and providing up to 1,800 watts output. **[472]**

Slotted lines. Phelps Dodge Electronic Products Corp., 60 Dodge Ave., North Haven, Conn., offers bulletin SL-1 describing slotted lines designed to measure impedance of large coaxial devices in their own diameters **[473]**

Core memory system. Fabri-Tek, Inc., Amery, Wis. A core memory system with one microsecond speed and large memory capacity is discussed in bulletin 6534. **[474]**

Electronic circuit modules. Bryant Computer Products, 850 Ladd Rd., Walled Lake, Mich. 48088. A data sheet is available describing and illustrating a complete family of series 8000 one-Mc electronic circuit modules. **[475]**

Reference diodes. Computer Diode Corp., Pollitt Dr. South, Fair Lawn, N.J. 07410. Data sheet TC-101A deals with 400-mw, temperature-compensated, silicon zener reference diodes. **[476]**

Forced air cooling. McLean Engineering Laboratories, P.O. Box 228, Princeton, N.J. A four-page manual evaluates two methods of forced air cooling of electronic enclosures—suction and pressure. It concludes that the pressure method is superior resulting in longer life and greater reliability of electronic components. **[477]**

Resistor-capacitor modules. CTS of Berne, Inc., Berne, Ind. Data sheet 3750 covers the series 750, a space-saving passive circuit network module combining the stability and reliability of Cermet resistors and capacitors with the heat dissipation characteristics of a thick alumina substrate. **[478]**

Subminiature a-c motor. Globe Industries, Inc., 2275 Stanley Ave., Dayton, Ohio, 45404. Type CC hysteresis synchronous motor is described in two-page bulletin B-1002. **[479]**

Differential operational amplifier. Zeltex Inc., 2350 Willow Pass Road, Concord, Calif., offers a data sheet describing the production model 131 FET differential operational amplifier having 3,000 megohm inputs and less than 1 na input currents. **[480]**

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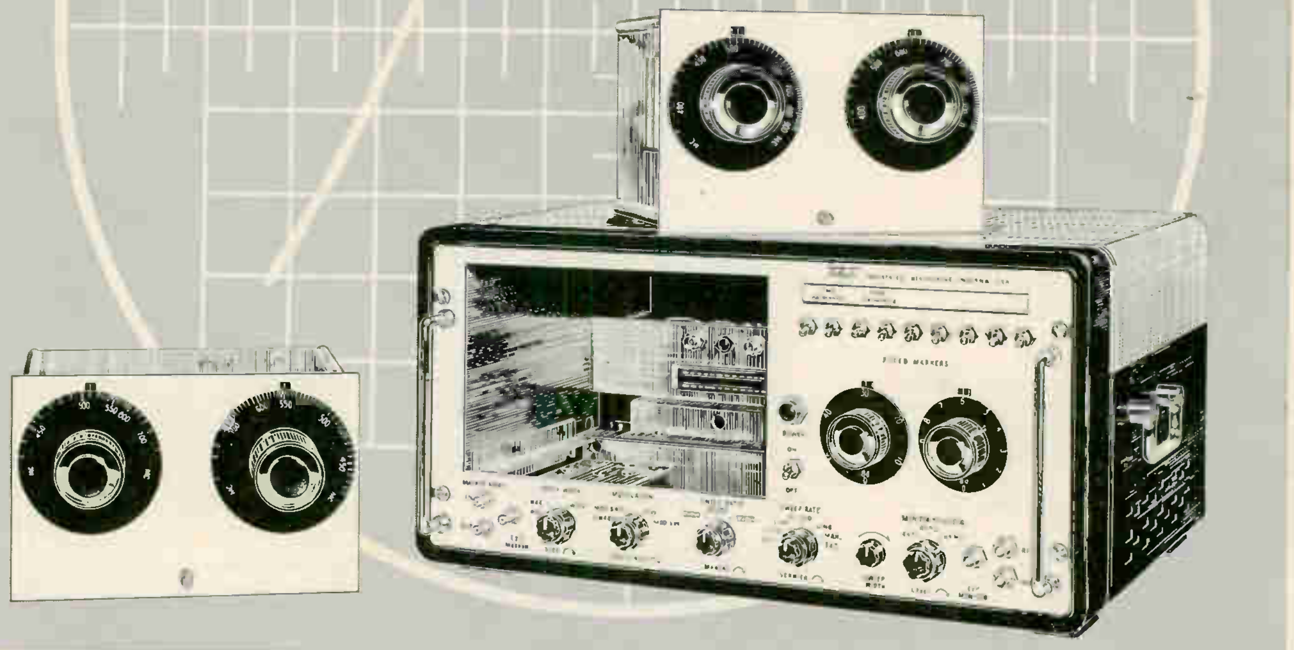

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Electronics Abroad

Volume 38
Number 18

International

Scr's on the track

In a West German coal mine, a locomotive's 3.6-megawatt motor is regulated by silicon controlled rectifiers.

In the Soviet Union, scr's are converting alternating current to direct current for the drive motors of 6.4-megawatt locomotives.

British Railways is testing a variable-frequency scr inverter that drives four a-c squirrel-cage induction motors, which are less expensive than d-c drive motors.

Japan National Railways is running a test in which 192 scr's in a single-phase bridge circuit control 2.2-megawatt locomotive motors.

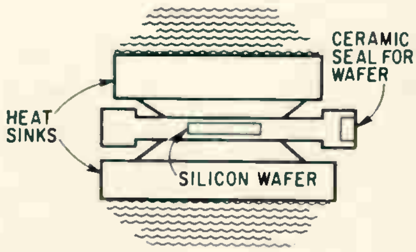
These developments dramatize the expanding role of the high-power scr in the nationalized railways of the world. It is in this application that foreign technology seems to be ahead of the United States'. In other industrial scr applications, such as metal rolling mills, electric furnaces and textile-machinery drives, the American state of the art is considered to be about two years ahead.

Germany. The scr seems to have doomed the mercury-arc rectifier in West Germany. In addition to the coal-mine locomotive, AEG—a big German producer—has delivered to the Federal Railways three electric locomotives that use solid state controls for 2.5-megawatt motors.

Siemens & Halske AG, the country's other major producer of high-power scr's, has a new configuration which it says will handle up to 1,100 amperes rms or 700 amperes average. Siemens sandwiches the scr pellet between two water-cooled heat sinks (see drawing).

Soviet Union. The Russians plan to convert nearly 10,000 miles of railway to alternating current (25,000 volts, 50 cycles per second) over the next five years.

The Soviet Union is still importing solid state rectifiers from France, but that is expected to end soon. The Tallin Electrical Works in Estonia is already mass producing 200-ampere, 400-volt scr's and is slowing its production of mercury rectifiers.



700-amp scr, made by Siemens & Halske in West Germany, consists of pellet sandwiched between two water-cooled heat sinks.

Britain. The experimental British locomotive uses an advanced solid state power conversion system. First, a 1,400-horsepower diesel engine drives a three-phase alternator. Then the alternator's output is rectified by silicon diodes to provide the direct current that feeds the speed-control inverter. The inverter consists of a three-phase scr bridge whose triggering is timed by a distributor circuit to produce the variable frequency that controls the a-c drive motor's speed.

The Brush Electrical Engineering Co., a member of the Hawker Siddeley Group, Ltd., designed and built the locomotive. A company official says the development may lead to a locomotive of 3,000 horsepower and more, with solid state controls.

Another British company, the International Rectifier Co., says it is developing a 2,000-ampere, 850-volt scr. The 2,000-amp figure is believed to be the highest current rating given by any company. The firm is an affiliate of the International Rectifier Corp. in California.

Sales of scr's by British companies are expected to climb to $4.48 million next year from a predicted $3.36 million this year. The United States market has been estimated at $30 million.

Japan. Two scr-controlled motors, one made by Hitachi, Ltd., the other by the Mitsubishi Electric Corp., are being tested by Japan National Railways. Both companies will share in the production, no matter which design is chosen. The government is expected to order 20 or more locomotives in a few months.

Hitachi's locomotive control uses two bridges. The four arms of each bridge contain 12 scr's in parallel for forward motion, and 12 for reverse.

Soviet Union

Space picture

While the United States relies increasingly on intricate electronic controls for its spacecraft, the Russians continue to exploit their superior ability to put heavier payloads into orbit.

The 12.2-ton spacecraft Proton 1, the heaviest payload ever shot into orbit, has encountered and measured the most powerful cosmic rays ever detected in space. Proton 1, which was launched July 16, uses 10 metric tons of steel—22,000 pounds—as a target for the cosmic rays.

Zond 3, the one-ton Soviet spacecraft that photographed the far side of the moon last month, used heavy shielding to protect the film from radiation while the pictures were being developed on board and transmitted to earth by a television-type scanner.

Space lab. Proton 1, a space laboratory for the study of high-energy cosmic rays, may also have a surprise for guidance experts in the United States. Russian scientists say the spacecraft will be retrieved; the United States is not known to have brought large instrument packages back to earth.

The Russian space lab uses an ordinary ionizing calorimeter. When a particle strikes this instrument, the particle interacts with nuclei of iron atoms. This collision produces secondary particles, which collide with iron nuclei to create third-generation particles, and so on. In this way, the primary particle's energy is absorbed into the calorimeter's thick block.

The absorption is accompanied by light flashes in polyethyline scintillators; these flashes are registered on a photocell. The flashes are counted to determine the strength of radiation that passes through various thicknesses of steel.

Space probe. Despite its novel approach to interplanetary photography, Zond 3 indicates serious shortcomings in power supply and long-range communications.

Zond 3's photograph sequence was fully automatic, the Russians say, activated by commands from the earth. On command, a moon-seeking sensor adjusted the spacecraft's attitude and photography began, one frame every 135 seconds, until 25 pictures were taken. Apparently the pictures were developed on board, put into digital form by an analog-to-digital converter, and transmitted to earth.

There are two transmission speeds: 135 seconds per picture and 34 minutes per picture; the slow speed gives a resolution of 1,100 lines. Soviet specialists say this dual system permits scientists on earth to select from among rough pictures, then command the scanner to transmit the selected pictures in detail.

American specialists, however, say the advantage is highly doubtful. Some U.S. experts believe the dual system may be designed to compensate for the Russians' inability to send pictures over very long distances. The high-resolution system seems inadequate for distances of hundreds of millions of miles, they explain, and the quality of the low-resolution system is probably far below that of pictures of Mars sent to the United States by Mariner 4.

Mariner 4's pictures were recorded on a miniature videotape recorder in digital form [Electronics, July 26, p. 25]. Each binary bit was made up of a number from 0 to 63; 0 meant white, 63 black, and other numbers shades of grey.

West Germany

On the road to Berlin

West Berlin has joined the trend to smaller computers for controlling bigger traffic tangles. For three months, two computers have regulated traffic on the major road leading out of the city to the Hanover Autobahn. The system has been free of failures so far.

The control system, made by Siemens & Halske AG, employs a signal processor for routine work and a Siemens-Halske 303 process computer for tasks that require complex decisions. The machines cost a total of $250,000.

In contrast, Toronto's traffic-control system uses a Univac 1107 and a 418, costing a total of $3 million. However, the Univacs perform data-processing tasks for the city in addition to controlling traffic.

The computers. The processor consists of an input data storage with a capacity of 300 signals that indicate whether each of 10 intersections has a red or green light in any direction; also 452 counting inputs for six-bit counters. The signal-program memory has a capacity of 12,288 words of 24 bits each. It can store up to 16 fixed-signal programs for 1,000 signal circuits, with a 30-microsecond cycle time.

The central processor, the 303, has a capacity of 16,384 words of 24 bits each, with a 30-microsecond cycle time. It selects control programs from a repertoire of 16.

Solderless connections are made by wrapping wires around square terminal pins.

The detectors. The computers receive information from three kinds of traffic detector: ultrasonic detectors mounted over the roadway, induction loops in the roadbed, and pneumatic detectors—rubber hoses—embedded in the roadway.

When a vehicle passes an overhead detector it reflects an ultrasonic beam that is created piezoelectrically by an ultrasonic frequency and radiated by a small transmitter. The time between the signal's transmission and reception indicates the car's speed; this time difference causes a pulse to be transmitted to the computer by an evaluating circuit.

The induction loop's electromagnetic field is altered when a car passes. A converter translates this change into an electrical pulse, which is fed to the computer.

The pneumatic detectors operate when a vehicle, crossing the rubber hose, actuates a membrane switch.

Comparison. German engineers say the pneumatic detector is the least accurate. Its signals are too weak to measure speed. Induction loops, which are employed exclusively in Toronto, are used in Berlin only to count vehicles; their signals also are considered too weak to measure speed.

The supersonic detectors, the most accurate indicators, determine the speed of traffic by a doppler frequency of 1,250 cycles per second, and position by a 30-kilocycle frequency. Their signals are transmitted to the control center by frequency multiplex, where they are programed to maintain the traffic speed as nearly as possible.

Flexibility. Under special circumstances, such as a parade, the computer's program can be overridden by perforating a five-bit tape; this superimposes orders onto a fixed signal plan.

Changes in traffic control are recorded by a teleprinter, which serves as a logbook. German courts accept its records as evidence, for example to determine the color of a light at an intersection at the time of an accident.

Siemens also has installed a control system in Neu-Ulm, in southern Germany, which uses radar detectors. In a previous setup in Hamburg, the company employed pneumatically operated strips to measure traffic flow and select a control program electronically.

France

Surgeon's beacon

Parkinson's disease is incurable, but surgery can reduce the violent trembling that characterizes the disorder by removing the tiny section of the thalamus where the tremor signals originate. The operation is dangerous; a mistake of only a few millimeters can destroy all sense of touch on one side of the body.

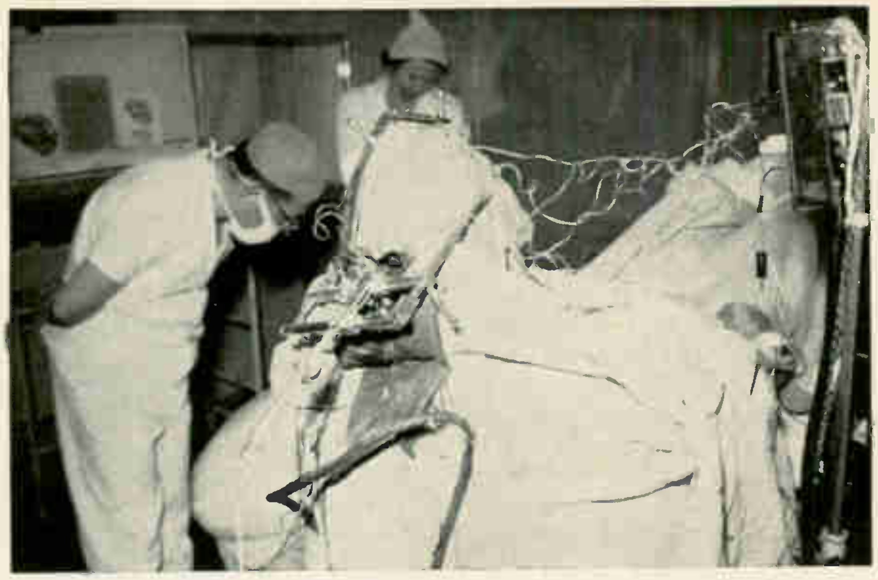
At the Foch Hospital in Paris, electronics is reducing the risk. It uses the tremor signal from the thalamus as a beacon, accurate to 0.5 millimeter.

In the past, surgeons relied on measurements from parts of the brain that show up on x-rays. But the human thalamus is only 40 millimeters across, and since brain dimensions vary, the measurements were not very accurate.

Matching frequencies. It has long been known that various parts of the brain emit electrical signals at characteristic frequencies. In 1960, Dr. Denise Albe-Fessard, a professor of physiology at the Sorbonne, discovered which brain cells emit the signals whose frequencies are the same as those of the tremors in the arms or legs of a person with Parkinson's disease.

The electronic system, devised by Mrs. Albe-Fessard and a team of neurosurgeons at Foch Hospital, conveys these signals to the surgeon visually on a cathode-ray tube, and aurally over a loudspeaker. The screen shows two types of brain signals: slow, regularly spaced waves occurring from 1 to 30 per second, and clusters of spikes—3 to 10—that occur every second or so and last a total of 5 to 50 milliseconds. The regularly spaced waves are inaudible on the microphone, but the spikes—which include manifestations of Parkinson's disease—come through as short, explosive bursts.

Spotting tremor signals. Brain signals are picked up by long metallic electrodes only 10 to 20 micrometers in diameter at the tip. The concentric, bipolar electrodes, designed for this operation, have a comparatively low resistance of 50,000 to 100,000 ohms.



During brain surgery, signals follow wires from patient's head to electronic equipment. The currents help to guide surgeon to correct section of brain.

A two-stage preamplifier picks up the spike signals of about 100 microvolts and amplifies them to 10 millivolts for display on the oscilloscope.

The preamplifier has positive feedback to suppress phase signals. It responds to sine waves as slow as one per second and as fast as 10,000 per second.

The spikes are identified by comparing each electrode's output with signals picked up from the patient's arm. Two beams are displayed on the crt simultaneously.

After he finds the region that produces the tremor signals, the surgeon destroys it by electrocoagulation.

Great Britain

Pay tv in London

Pay television, subject of a 13-year-old controversy in the United States, is about to spread to Britain. It will begin near the start of 1966 in the London boroughs of Westminster and Southwark, whose residents are considered a good cross-section of Britain's tv audience. Subsequent trials are planned in Sheffield and Yorkshire.

The shows will be packaged, sold and distributed by Pay-TV, Ltd., whose backers include the Associated British Picture Corp., British Relay Wireless and Television, Ltd., and several financial and book-publishing concerns.

Pay-TV will transmit its programs along wires leased from British Relay. For each program desired, a patron will deposit coins in a box mounted on the tv receiver. The cost to viewers has not yet been decided, but Pay-TV says it may range from 35 cents to several dollars per program. For the system to be profitable, the company figures it needs 10,000 subscribers.

Battle lines. Pay tv has been debated in Britain for at least five years. In 1960 the government-appointed Pilkington Committee decided that it would not be in the public interest to encourage a tv service catering only to those who could afford it. Pay tv would impoverish existing services by outbidding them for programs, the committee maintained. Its view was applauded by the British Broadcasting Corp. and the Independent Television Authority (ITA), which between them operate 14 program companies and 20 broadcasting stations.

Despite these objections, pay tv was approved by the General Post Office, which controls broadcasting both over the airwaves and over wire. The GPO ordered three years of trials, to "find out what are the good things [pay tv] can do and whether it will add a few dimensions to daily life."

The GPO's rigid terms caused four of the five applicants to withdraw from the pay-tv field. One of them, Rediffusion, Ltd., had spent $5 million to perfect a workable system. And D. B. Hirshfield, chairman of another dropout, Caledonian Television, Ltd., said, "We weren't happy about the geographic area . . . allocated to us."

Japan

Controlling a reactor

The reluctance to completely control nuclear reactors with computers has less to do with the intricacy of the process than with fear. Now Japanese scientists have taken a step to allay that fear by demonstrating a system that operates a swimming-pool reactor safely, under computer control.

The Tokyo Shibaura Electric Co. (Toshiba) claims a first in achieving complete digital control, although nuclear reactors are under some measure of computer control in the United States, Canada, France and elsewhere.

Broad implications. Toshiba's accomplishment with a small research reactor that generates only 100 kilowatts thermal has limited commercial value; one specialist in the United States compares the technique with using a gyroscope to help someone cross the street. But its implications are far-reaching; Toshiba plans to produce the system commercially if it can get permission from the Japanese government, and says the technique can be applied to power reactors.

An industry official says the system should "help to persuade users that digital control can be safe."

A swimming pool is a nuclear reactor whose core operates while submerged in a large tank of water. The water acts as moderator, coolant and shield. Fissionable material is mounted in a lattice at the bottom of a supporting tower.

Obsolete computer. In its experimental setup, Toshiba uses an obsolete computer and loads its 2,800-word memory five times during the procedure to obtain the necessary 12,000-word memory. In addition to startup, shutdown and power changes during the reactor's operation, the computer performs some 1,200 pre-startup operations such as reading meters, changing range and taking notes. Toshiba says it takes a skilled operator 1½ hours to perform these pre-startup checks, which the computer makes in 30 minutes.

Hiroshi Kamogawa, manager of Toshiba's research department, says the keys to computer control are an alarm scanner and digital monitoring of reactor flux at low power levels. The scanner feeds inputs to the computer, and monitors these inputs to insure that they remain within predetermined limits.

There is also a 150-channel matrix scanner, which routes other inputs from reactor sensors to the computer, providing random access to any of the 150 inputs commanded by the computer.

Digital inputs. The only digital inputs to the computer are those used to monitor reactor flux at low power levels; at these levels, an analog signal would be too noisy.

The digital neutron sensor is an alpha chamber, a gas-filled detector that counts up to 150 particles a second. At up to two watts, digital output is obtained from a fission chamber functioning at up to 50,000 counts per second. At 2 watts to 100 kilowatts, a compensated ionization chamber delivers an analog output. Seventy output channels control relays which operate conventional reactor controls.

For emergencies, there is a provision for manual switchover to conventional control. As a further safeguard, the reactor is monitored by a compensated ionization chamber whose readout is independent of all operating controls.

The swimming-pool reactor, which was completed in 1960, cost about $556,000. The experimental computer control system cost about $140,000.

Australia

Defense dilemma

As they gird to meet Communist threats from the north, Australia's armed services are coming under increasing domestic attack for buying most of their military equipment from the United States and Great Britain.

Particularly outspoken are officials of the electronics industry. A big chunk of Australia's $764.6-million defense budget goes for electronics gear, more than half of which is purchased abroad.

They blame two factors: last-minute ordering requiring fast deliveries that can only be made by big industries abroad, and a power struggle between military and civilian interests within Australia's Defense Department.

Lead time. The small but vigorous electronics industry insists that it can meet most of Australia's military needs if it is given enough lead time. Instead, officials say, the armed services procrastinate and then order off-the-shelf gear, usually off an American shelf.

Only last month the Australian government placed a $4.7-million order with the Westinghouse Electric Corp. in the United States for two air-transportable radar stations.

A more serious charge is that the armed services bypass the Supply Department, a central procurement agency, and order their own gear merely to maintain their independence from civilian authority.

U.S. affiliates. Some of Australia's most active electronics companies are affiliates of American concerns. An Australian subsidiary of the Collins Radio Co. of Dallas says 12% of its sales are for military and space communications.

Standard Telephones & Cables, Ltd., a subsidiary of the International Telephone and Telegraph Corp., says its defense contracts now total $7 million a year and the company expects this total to rise 15% to 20% by 1968.

Another American-owned company is Ducon Industries, Ltd., which produces only components.

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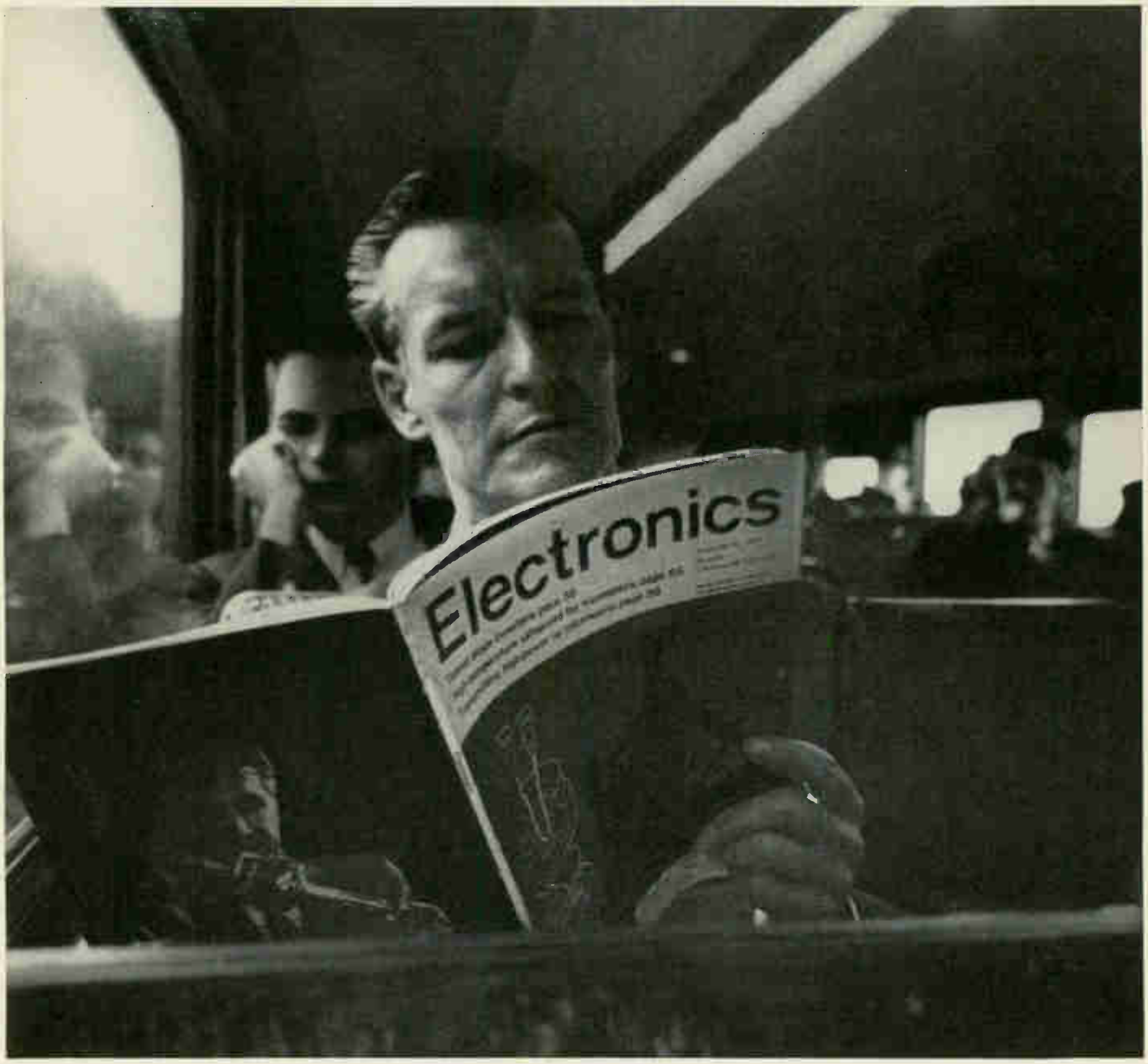

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September 6, 1965

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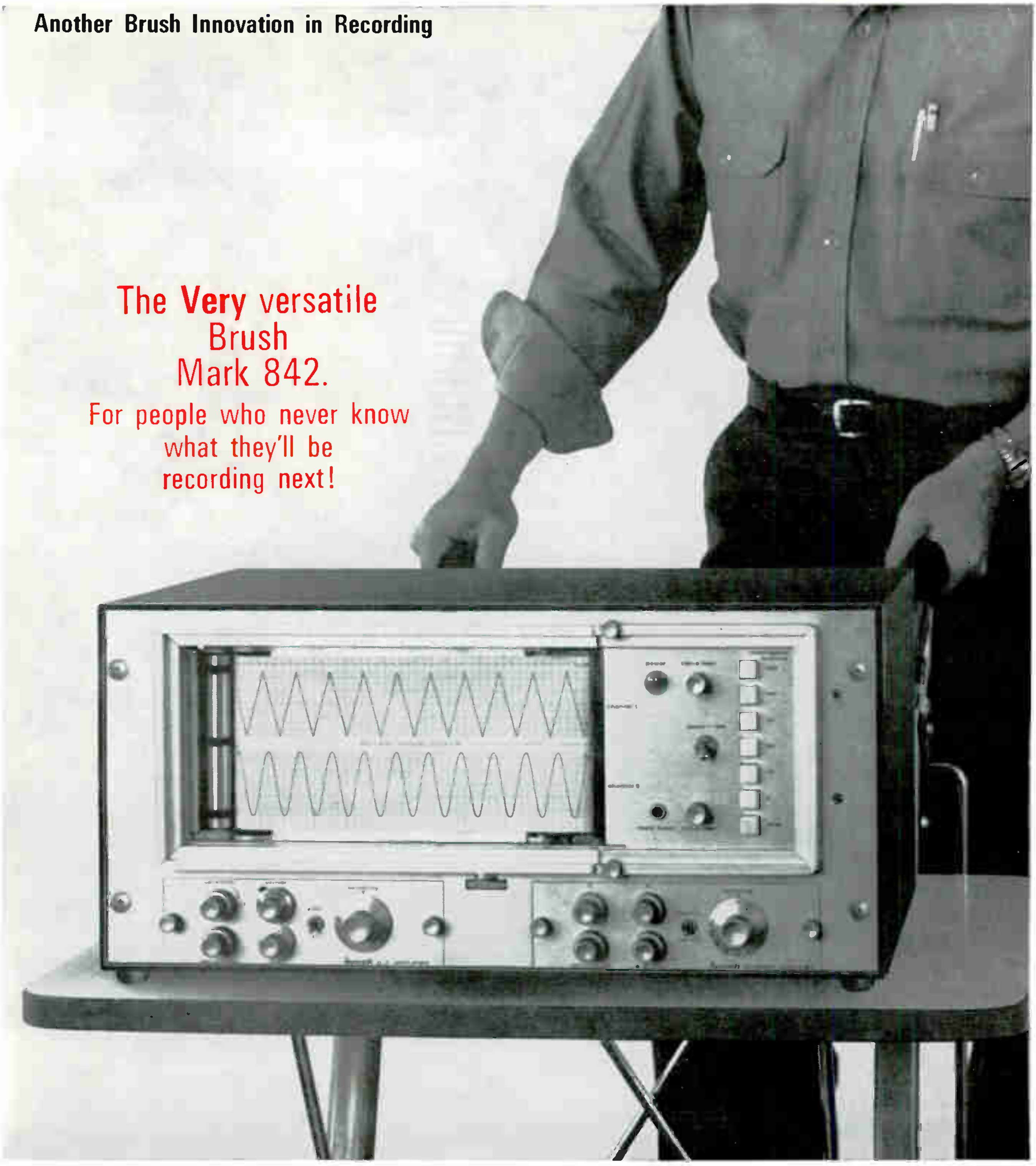

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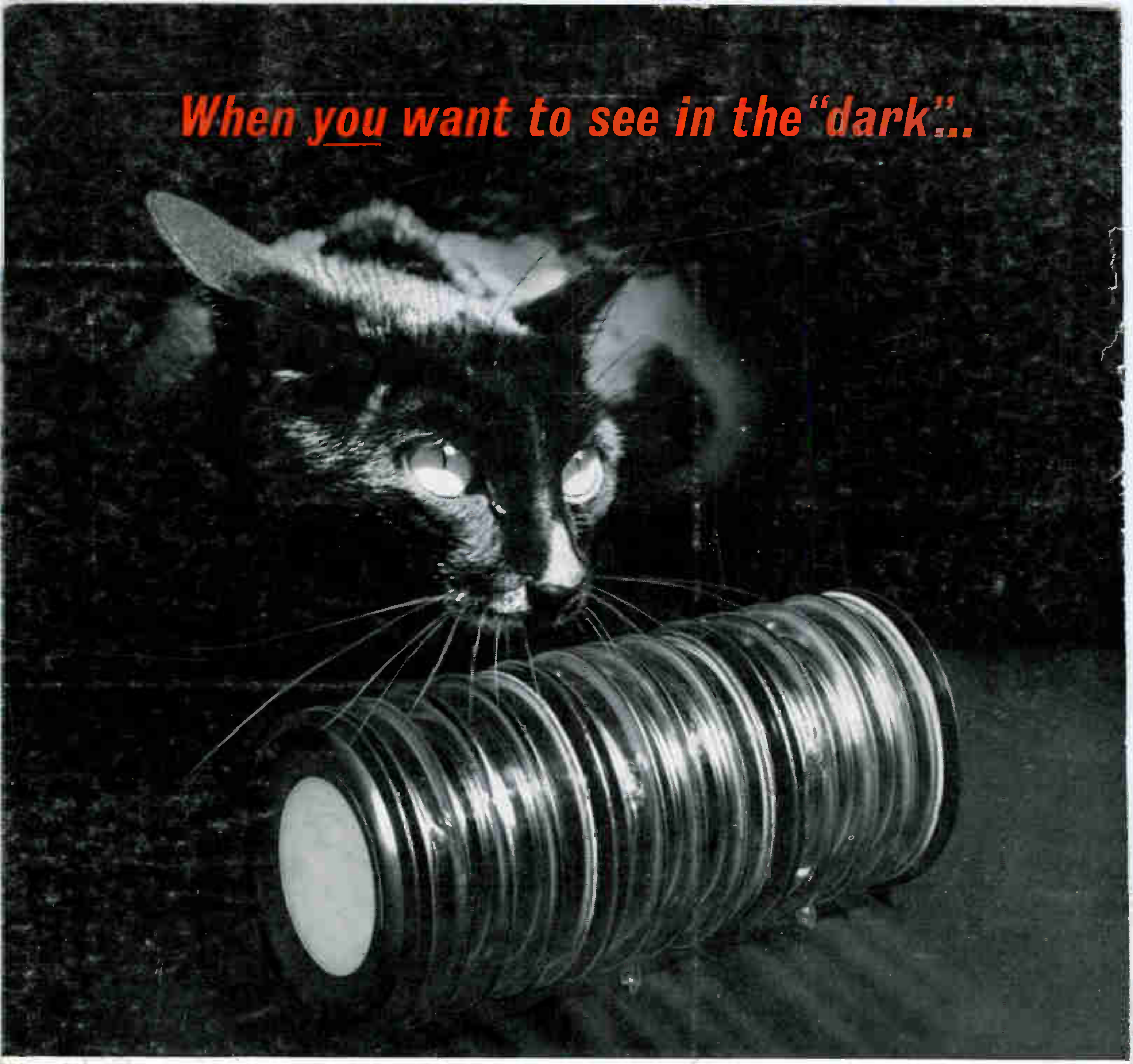

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