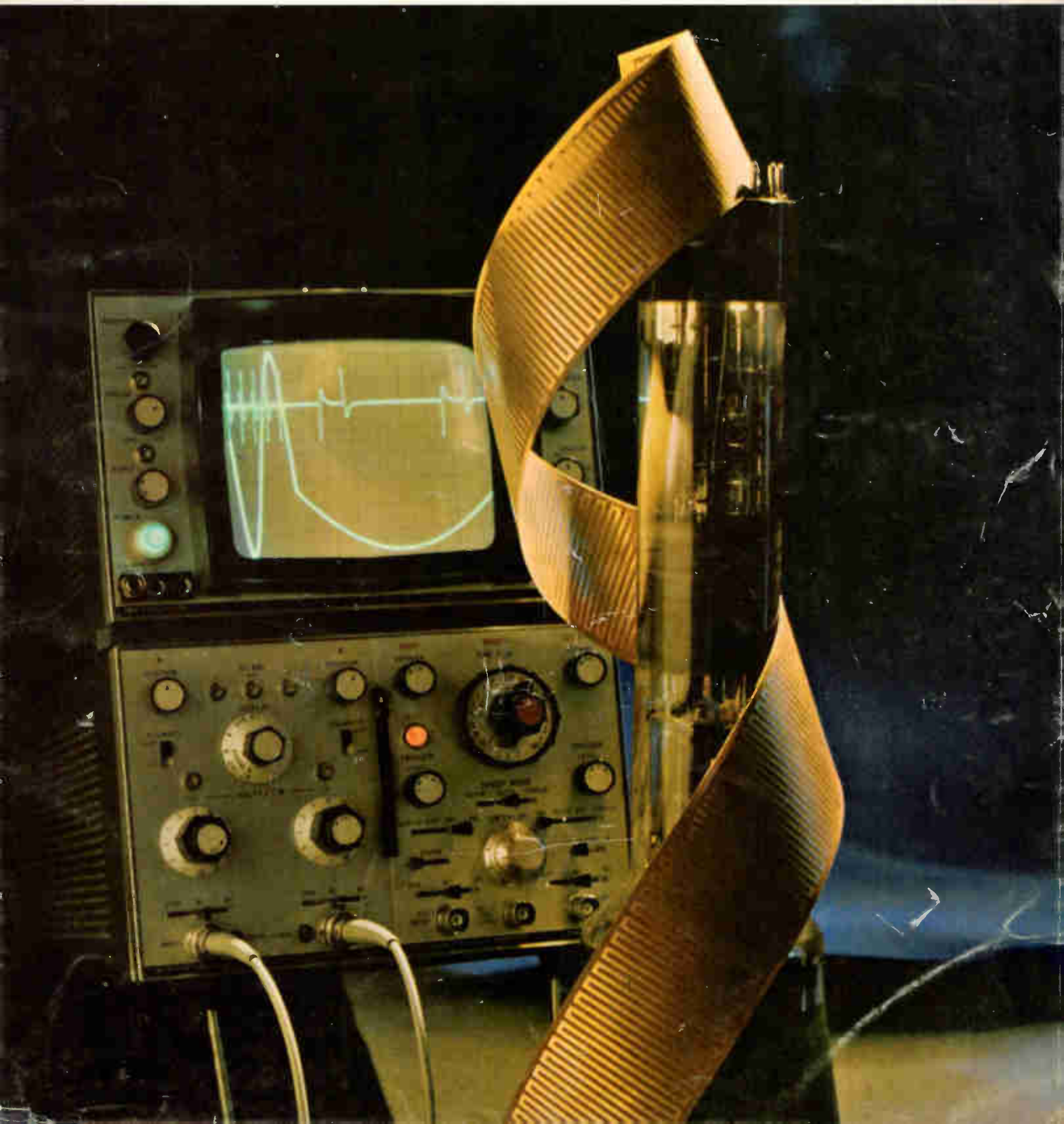
Electronics®

Holography's practical dimension: page 88
Military talk with digital symbols: page 108
Making parallel-gap welding feasible: page 115

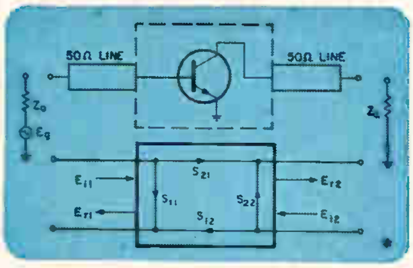
July 25, 1966
75 cents
A McGraw-Hill Publication

Below: Stripline delay line in new high-frequency scope, page 95



Transistor Parameter Measurements
with the hp 8405A Vector Voltmeter

Measurement of transistor h, y or z parameters becomes increasingly difficult above 100 MHz through an inability to obtain consistently good open- and short-circuits. Tedious adjustment of tuning stubs is usually required for each measurement frequency, and unwanted circuit oscillations often occur.



With the 8405A Vector Voltmeter, however, it is easy to measure a slightly different set of parameters—the "s" or scattering parameters. Measurement is simple over a wide frequency range and since the parameters are measured with a Z_0 load, there is little chance for oscillation. The measured s parameters can be plotted directly on a Smith Chart and easily manipulated to establish optimum gain with matching networks. Or the s parameters can be translated into h, y, or z parameters if desired.

Free Application Data

Hewlett-Packard has prepared an application note on s parameter measurements. Write today for your copy of Application Note #77-1, "Transistor Parameter Measurement", to 1501 Page Mill Road, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

The hp 8405A Vector Voltmeter is a new, wideband, 2-channel RF millivoltmeter-phasemeter. With the 8405A, measurements that were formerly difficult or impossible can now be made quickly, easily and accurately.

Major Specifications, HP 8405A Vector Voltmeter

Frequency Range is 1 to 1000 MHz in 21 overlapping octave bands; automatic tuning within each band.

Voltage Range for Channel A (synchronizing channel), 300 μv to 1 v rms (5-500 MHz), 500 μv to 1 v rms (500-1000 MHz), 1.5 mv to 1 v rms (1-5 MHz).

Voltage Range for Channel B (input to Channel A required), 100 μv to 1 v rms, full scale. Full-scale meter ranges from 100 μv to 1 v in 10 db steps. Both channels can be extended to 10 v rms with 10214A 10:1 Divider.

Phase Range of 360° indicated on zero-center meter with end-scale ranges of ±180°, ±60°, ±18°, ±6°. Phase meter OFFSET of ±180° in 10° steps permits use of ±6° range for 0.1° phase resolution at any phase angle.

Price: $2500.

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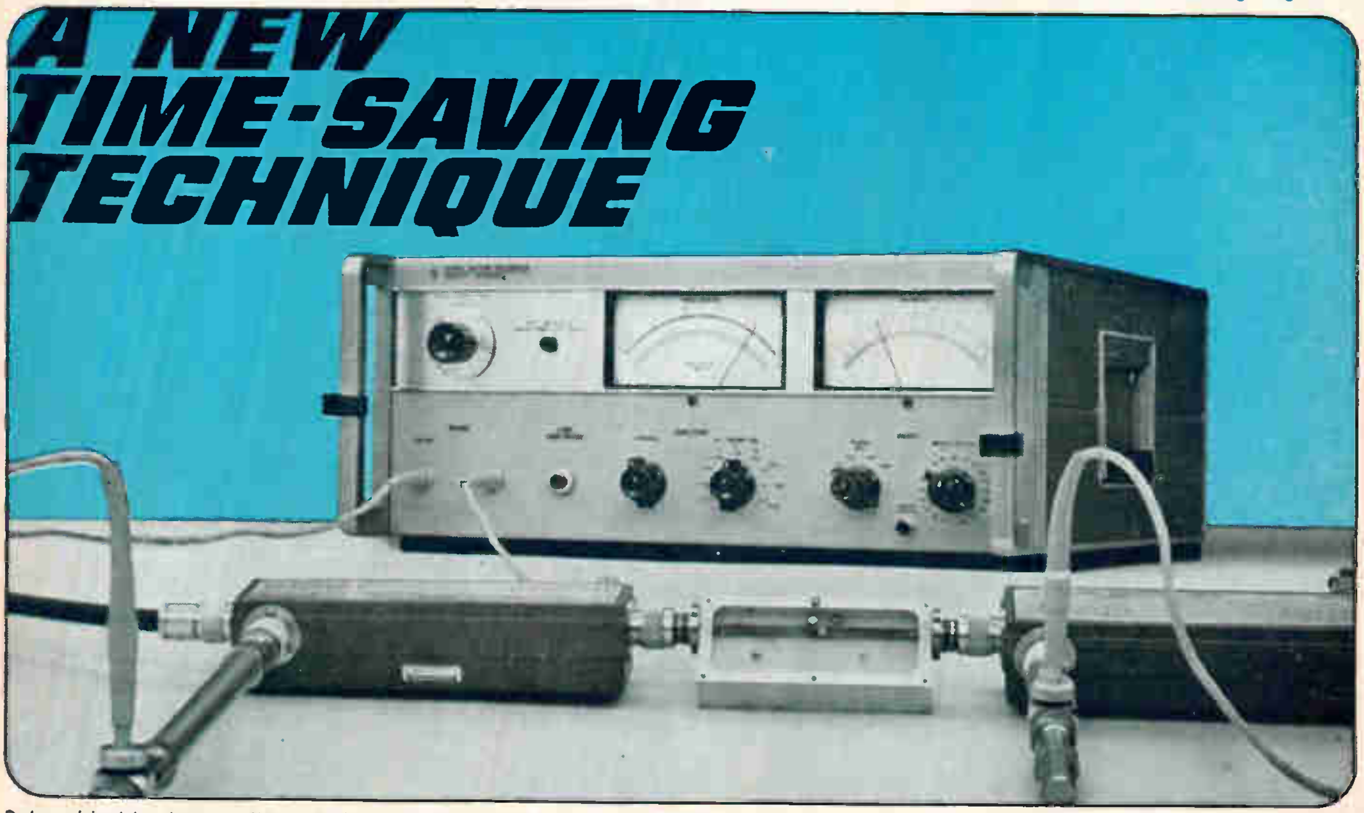

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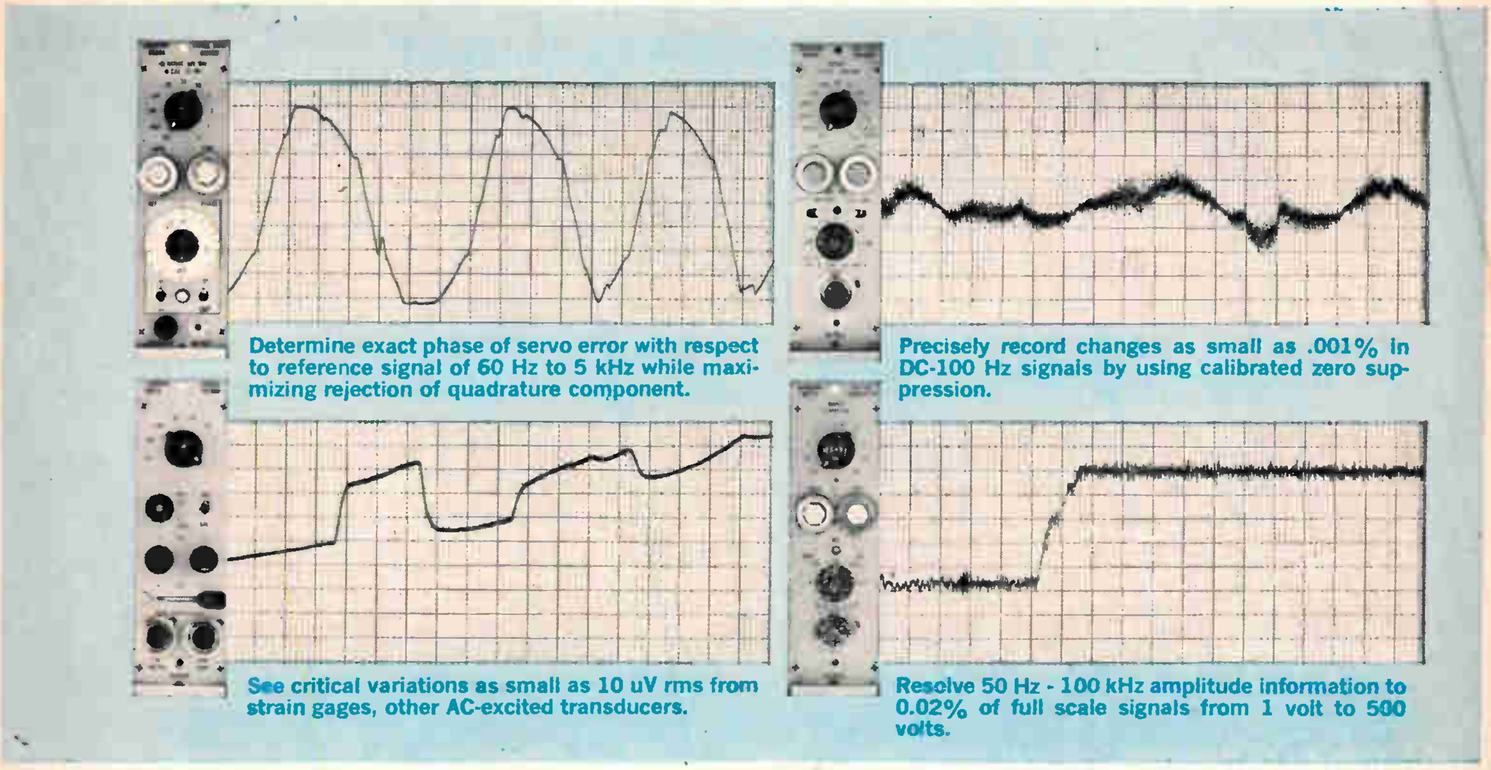

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Electronics

July 25, 1966
Volume 39, Number 15

Electronics Review

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II. Applications

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Readers Comment

Seeing stars

To the Editor

I read with interest "Seeing stars" [May 16, p. 39] and the description of how laser-scanning techniques were used to spot differences in star positions in photographs taken years apart . . . and that the previous technique was literally a laborious "point-by-point" comparison.

There is, however, the possibility of visually scanning such material, and I demonstrated this in April 1960.

I visually fused the two pictures that demonstrated two long-period cepheids, and noted in the caption that these were taken at two different times. When fused, the variations in emitted light of the two cepheids appear as a disturbance in the visual field. Could this technique then be used with photographs of any portion of the universe to quickly locate cepheids? Further, I experienced the feeling of a certain degree of relief between the various stars. I recognize, of course, that this could be an illusion, and could even be the result of the half-tone screening of the photos.

At this point, I attempted to reason as to the possibility or probability of producing photographs of the universe that would achieve sufficient relative displacement of the various visible elements as to produce a stereoptic effect. The first possibility would be to use as a base the approximate 186,000,000-mile displacement of the earth achieved at opposite points anywhere on its eclipse around the sun. This alone would provide for a binocular effect to a distance of approximately 393,760,000 miles—far short of the distance to the nearest star in our galaxy.

Present theories hold, however, that the universe is rapidly expanding outward, and so, over a period of time between photographs, each element is changing in its relationship to all other elements. If six months is not a sufficient period of time to provide noticeable relative change, would photographs taken years apart, of the same area, provide sufficient change to produce

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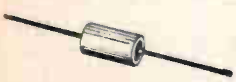	260P	hermetically-sealed metal-clad tubular	metallized Metfilm* 'K' (polycarbonate film)	—55 C, +105 C	no specification	2705
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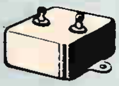
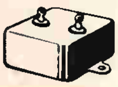
	143P	hermetically-sealed metal-clad "bathtub" case	metallized paper	—55 C, +125 C	no specification	2220A
	144P	hermetically-sealed metal-clad "bathtub" case	metallized Difilm® (polyester film and paper)	—55 C, +125 C	CH53, CH54, CH55 Characteristic N	2221A
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a visual displacement when viewed stereoptically? And, if so, what would the interpretation be? Would it indicate relative velocities?

I have no knowledge of any work conducted in the area of stereoptic techniques applied to celestial viewing. Quite possibly this has been thoroughly explored and found to have some value, or to have been proved worthless. In either event, I would be very interested in any comments your readers wish to make on this subject.

T.C. Pickett
Manager, Marketing Services
Westel Co.
Redwood City, Calif.

Label it fresh air

To the Editor:

I object to your labeling the article "The myth of obsolescent knowledge" [June 13, p. 42], Opinion. Since contrary subject matter has never been similarly tagged and since other articles in this issue are not labeled Fact, it is implicit that you are saying "incorrect opinion."

You are wrong. This breath of fresh air, is long overdue in the stagnant and oppressive atmosphere generated, nurtured and dominated by incompetent educators, managers, mercenary employers and sheep-like engineers.

Three cheers for Gerd Wallenstein; now let's elect him president of the IEEE so that he can set about correcting that situation.

Richard G. Devaney
Registered Professional Engineer
Kingsport,
Tenn.

▪ Opinion is a new department in Electronics in which an author can express his view of a controversial subject of interest, professionally, to our readers. The department heading by no means implies that the opinion is incorrect.

Patent options

To the Editor:

The comment about patents in "Washington Newsletter" [May 30, p. 67] is interesting and accurate.

Your readers may be interested to know that, in the system which you expect to be recommended by the President's Commission on the Patent System, the details appear radical: a selective examination system is a radical departure from present practice. But one feature which is not generally understood is that the system expected to be proposed is full of options to the applicant.

Under one of these options, an applicant may have his case handled exactly as it is today. In that case, the system will not be changed at all. This comes about because, under selective examination, a period as long as seven years is provided during which full examination can be provided. This means that an applicant who wishes fast action can request the full examination procedure concurrently with the filing of his patent application.

Obviously, if a large number of applicants prefer to defer examination, those who wish early examination will get prompter action from the U.S. Patent Office than is now possible.

T.L. Bowes
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People

What happens to the Apollo program after the United States lands a man on the moon?

To answer that question the National Aeronautics and Space Administration has set up an Apollo applications program office at the Manned Spacecraft Center. Named temporary program manager was George Low, deputy director of the center. But the man who's expected to take over Low's post soon is **Robert F. Thompson,** the assistant program manager.

Thompson, a 41-year-old aeronautical engineer, was director of NASA's landing and recovery division before being named Low's assistant.

The job of the new office will be to prepare detailed plans of the Apollo application program. "We see it as a series of orbital and lunar missions principally utilizing the hardware developed in Apollo," says Thompson.

Among the proposals that will be weighed, he says, will be the orbiting of space platforms for oceanographic or weather investigations.

The exploitation of the oceans, for both industrial and military uses, to a large extent hinges on the development of a new breed of electronics. The equipment must withstand an environment as hostile, and in some cases as little understood, as outer space. One man who appreciates these difficulties is **Chester L. Buchanan** of the Naval Research Laboratories.

Buchanan was honored last month by the Marine Technology Society for his pioneering efforts in the field of oceanology. Specifically, he was saluted by the organization

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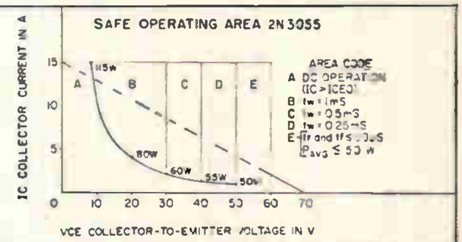
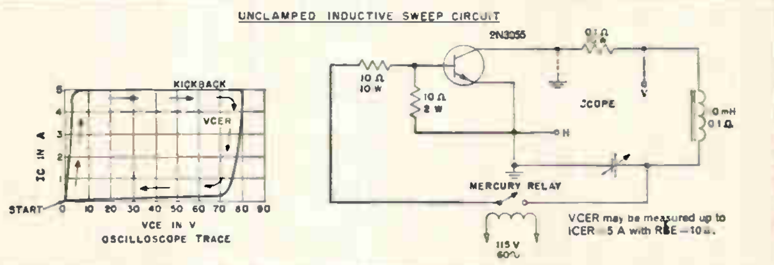
tf = 1 μs Typ }

TO-3





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for his technical contributions in finding the sunken hull of the nuclear submarine Thresher, which was lost with all hands in 1963, and in locating the hydrogen bomb missing off the coast of Spain this year [Electronics, July 11, p. 42].

Buchanan is the crusty director for the naval lab's deep sea research branch of the ocean sciences and engineering division in Washington. Until this past spring his group was called the sonar systems branch, sound division, but with the accelerated interest in ocean sciences, the unit was renamed.

Tools for the ocean. Buchanan is not interested in collecting oceanographic data, but in developing the instruments so that other oceanographers can. Many of his instruments are the type that can be dragged below surface vessels to study such things as ocean-bottom composition and mountain ridges.

Buchanan is a bantam-sized ball of fire. To visitors he is a picture of perpetual motion, pacing his office, puffing on a pipe and pulling out documents from a mass of bookcases and file cabinets. The peripatetic Buchanan lectured or presented papers to more than 50 professional and university groups in 1965.

The search. It was Buchanan's intimate knowledge of deep-sea search techniques and equipment that prompted Navy officials last January to name him leader of a special task force to aid in the search for the missing H-bomb. Under Navy orders, he went to Philadelphia, where he assembled the necessary electronic search gear, including the Naval Research Laboratories' surface search and rescue vessel, the Mizar. For three months his team joined thousands of other military personnel in the search for the sunken H-bomb.

Although the tiny deep-diving submarine Alvin found the bomb, the Mizar was credited with a major assist, because it was combing a much larger area and provided the necessary support and navigation for the Alvin and its sister sub in the search, the Aluminaut.

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Meetings

Research Conference on Instrumentation Science, Instrument Society of America; Hobart and William Smith Colleges, Geneva, N.Y., **Aug. 1-5.**

U. S. Navy Second Marine Systems and ASW Conference, American Institute of Aeronautics and Astronautics; Lafayette Hotel, Long Beach, Calif., **Aug. 8-10.**

Guidance and Control Conference, American Institute of Aeronautics and Astronautics; University of Washington, Seattle, **Aug. 15-17.**

NATO Advanced Study Institute, NATO; University of Keele, Staffordshire, England, **Aug. 15-26.**

Joint Automatic Control Conference, Automatic Control Group; University of Washington, Seattle, **Aug. 17-19.**

Symposium on Computer and Information Science (COINS), Columbus Laboratories of Battelle Memorial Institute, Office of Naval Research, Ohio State University; Columbus, Ohio, **Aug. 22-24.**

Technical Symposium, Society of Photo-Optical Instrumentation Engineers; St. Louis, Mo., **Aug. 22-26.**

Television and Radio Show; Earls Court, London, **Aug. 22-26.**

International Electronic Circuit Packaging Symposium, Electrical Design News; Sports Arena, Los Angeles, **Aug. 23-24.**

International Conference on Luminescence, Research Institute for Technical Physics, Hungary Academy of Science; Budapest, Hungary, **Aug. 23-26.**

Western Electronics Show and Convention, IEEE and Western Electronic Manufacturers Association; the Sports Arena and Hollywood Park, Los Angeles, **Aug. 23-26.**

International Congress of Electron Microscopy, Institute for Chemical Research; Kyoto, Japan, **Aug 28-Sept. 4.**

Electronics Materials Technical Conference, Metallurgical Society of the American Institute of Mining, Metallurgical and Petroleum Engineers; Sheraton Boston Hotel, Boston, **Aug. 29-31.**

International Conference on Instrumentation in Aerospace Simulation Facilities, Aerospace and Electronic Systems Group; Stanford University, Stanford, Calif., **Aug. 29-31.**

National Conference of the Association for Computing Machinery, Association for Computing Machinery; Washington Hilton Hotel, Washington, D.C., **Aug. 29-31.**

Ocean Electronics Symposium, IEEE; Ilikai Hotel Convention Hall, Honolulu, Hawaii, **Aug. 29-31.**

Technical Conference on Preparation and Properties of Electronic Materials for the Control of Radiative Processes, Metallurgical Society and the Boston Section American Institute of Mining, Metallurgical and Petroleum Engineers, Inc.; Sheraton-Boston Hotel, Boston, Mass., **Aug. 29-31.**

Swiss Electronics Television, Radio and Phonograph Exhibition; Exhibition Grounds of the Zuspa, Zurich, **Aug. 31-Sept. 5.**

International Conference on Microwave and Optical Generation, Institution of Electrical Engineers and the Institution of Electronic and Radio Engineers, Cambridge, England, **Sept. 12-16.***

Call for papers

International Electron Devices Meeting, sponsored by IEEE, at Sheraton-Park Hotel, Washington, Oct. 26-28. **Sept. 15** is deadline for submitting papers to Joseph F. Hull, technical program chairman, Litton Industries, 960 Industrial Road, San Carlos, Calif. 94070.

Relay Conference, Oklahoma State University, sponsored by National Association of Relay Manufacturers and Oklahoma State University April 24-25. **Oct. 15** is deadline for submitting papers to Dwayne R. Wilson, administrative assistant, School of Electrical Engineering, Oklahoma State University, Stillwater, Okla. 74074.

* Meeting preview on page 16

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Meeting preview

Optics and microwaves

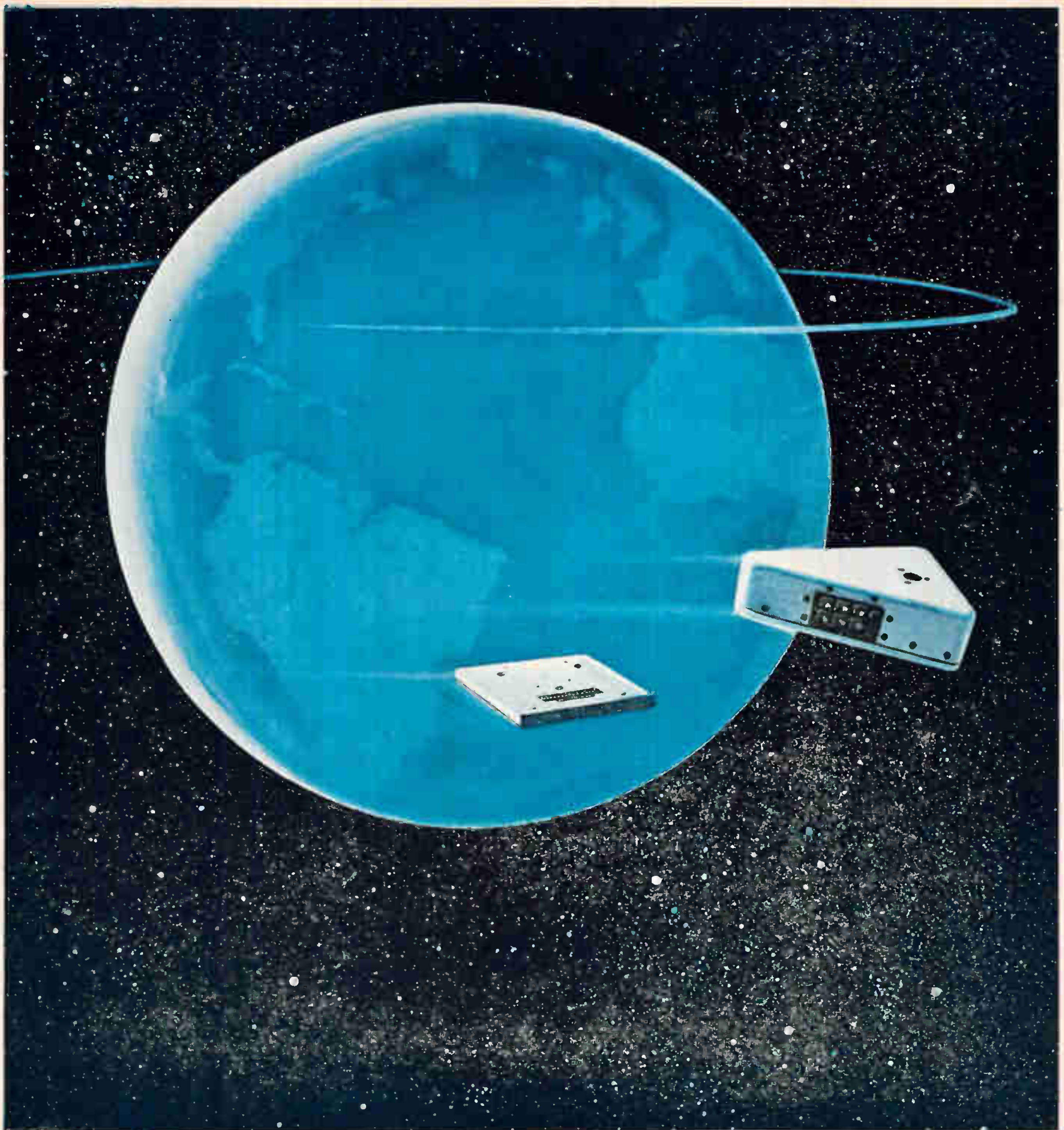
Linear-beam systems and solid state devices will share top billing at the International Conference on Microwave and Optical Generation, Sept. 12 to 16, in Cambridge, England.

The British organizers of the meeting—the Institution of Electrical Engineers and the Institution of Electronic and Radio Engineers—expect about 400 engineers to turn up for the meeting.

A growing, worldwide interest in Gunn-effect devices will be evident at Cambridge. A featured speaker will be J.B. Gunn of the International Business Machines Corp. He will talk about oscillation mechanisms in gallium arsenide (GaAs) crystals, a phenomenon he discovered. Varian Associates, of California, will report on high-power GaAs pulse oscillators. According to Varian's report, oscillators can be designed for frequencies between 500 and 10,000 megahertz. Power output depends on frequency—from 220 watts peak at 1.1 gigahertz to 1 watt at 9 Ghz. A British paper will describe a Gunn diode used as a self-tuned parametric amplifier. The device has a tuning range of 1 octave.

Klystrons. Reports on linear-beam devices, though, will outnumber papers on other topics. Generally, contributions from the United States stick to specifics—like Litton Industries, Inc.'s S-band klystron with electrostatic focusing and 1-megawatt peak power. The European papers, by contrast, most often treat general problems like noise measurement, signal stability and the interaction in microwave tubes.

One component that figures to arouse interest is an S-band traveling-wave tube developed by Mullard Research Laboratories, Ltd., of Great Britain. Instead of a thermionic cathode, it uses a photocathode to detect microwave modulation on light beams. The modulated light hitting the cathode produces an electron beam bunched at microwave frequency that is detected by passing it through a slow-wave structure. Operating range runs up to 4 Ghz.



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The Ring Laser Gyro pioneered by Sperry Electro-Optics has come a long way since we made the world's first one operate in 1963. Since then we've made the first ring laser hardware deliveries to a contract spec—two units each to the USAF/Research and Technology Division and NASA Marshall Space Flight Center. We've tested laser gyros in high G environments, demonstrated inertial quality data, and a high resolution-to-size factor. □ Some key features of the Sperry RLG are its inherent digital output (not a pick-off); small size; absence of moving parts; instant turn-on; low threshold number—and then, of course, low cost (probably 1/10th that of a conventional platform). Surface-to-surface tactical missiles, tactical aircraft, space vehicles all stand to benefit. And ballistic missiles, as well as seagoing craft. are just around the corner. Do you have an application in mind? Give us a ring. Area Code 516—LR 4-2268, LR 4-2804, LR 4-1404.

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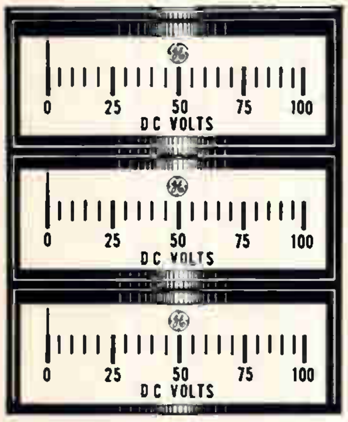
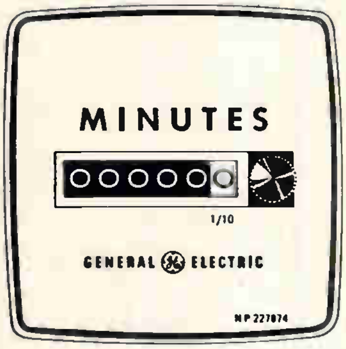


style-matched time meters?



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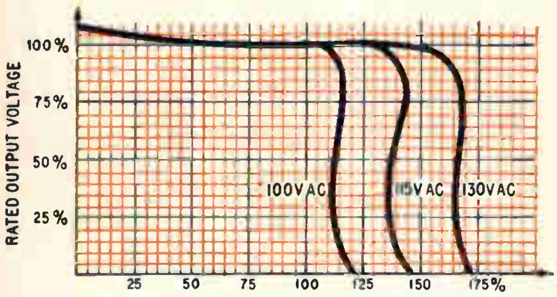

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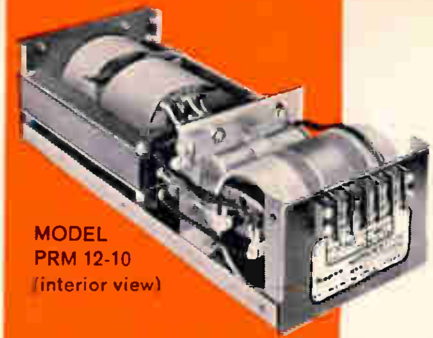
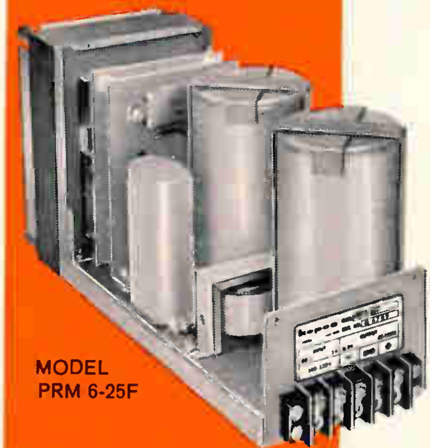
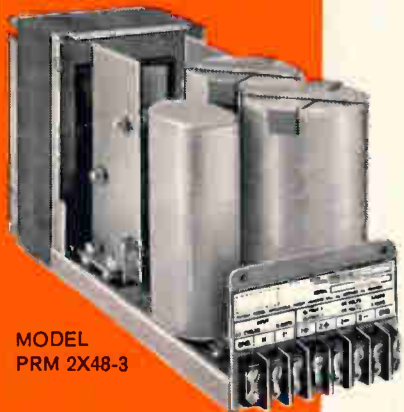


MODEL PRM 12-10 (interior view)

MODEL PRM 28-7



MODEL PRM 6-25F



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PRM 18–6.7	18	0–6.7
PRM 24–5	24	0–5
PRM 28–4.3	28	0–4.3
PRM 36–3.3	36	0–3.3
PRM 48–2.5	48	0–2.5
PRM 60–2	60	0–2
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PRM 18–10	18	0–10
PRM 24–8	24	0–8
PRM 28–7	28	0–7
PRM 36–5	36	0–5
PRM 48–4	48	0–4
PRM 60–3	60	0–3
PRM 120–1.5	120	0–1.5

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PRM 18–10F	18	0–10
PRM 24–8F	24	0–8
PRM 28–7F	28	0–7
PRM 36–5F	36	0–5
PRM 48–4F	48	0–4
PRM 60–3F	60	0–3
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PRM 2X 6–20	6.3 6.3	0–20 0–20
PRM 2X 12–12	12 12	0–12 0–12
PRM 2X 15–10	15 15	0–10 0–10
PRM 2X 18–8	18 18	0–8 0–8
PRM 2X 24–6	24 24	0–6 0–6
PRM 2X 28–5	28 28	0–5 0–5
PRM 2X 36–4	36 36	0–4 0–4
PRM 2X 48–3	48 48	0–3 0–3
PRM 2X 60–2.5	60 60	0–2.5 0–2.5

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Editorial

Trade with the East

Part 2: the technology gap

"Technology grows faster in capitalist countries. This problem of technical progress is the most important one we have to solve." That is how Dr. Bohdan Glinski, at the Institute for Planning in Warsaw, sums up the technology lag that faces the Communist countries of East Europe. In electronics the gap is particularly accentuated because all of these countries have slighted light industry and concentrated on heavy industry like steel making, chemicals and machine tool building. Electronics engineers estimate the gap ranges from 3 to 12 years depending on the part of the technology under scrutiny.

Yet these countries must improve the flow of technology if they are to maintain high rates of economic growth. Because they are not closing the gap themselves—in fact it seems to be widening—the countries of East Europe have turned to the West for help.

On paper, the most frequent solution has been to order the newest equipment operating under the latest technology or to license technology. But the embargo enforced by NATO countries has prevented the delivery of the newest and the latest in electronics.

In addition, the way many of the East European countries operate their economies has a tendency to negate purchases and licenses of new technology. "Negotiations for electronic equipment can take so long, the equipment is obsolete by the time an East European country finally sends you the order," says an executive at a French company which has done some business with Communist countries.

In Czechoslovakia, a government executive says licensing has not helped the country. "We've ordered turnkey plants with technology under license, but it takes six years from the time we decided to seek such a plant until the production starts. By the time we are in production, we are making the product with an obsolete process."

As serious as these problems have been, they are not the most critical deterrent to catching up in electronics. The fault lies, in the opinion of many Easterners, in the heavy emphasis on theoretical work and the almost complete absence of engineering development, new product planning and new process development by hardware-oriented engineers.

Theoretical work has always been encouraged in Communist countries on doctrinaire lines—Marxist theory believes in a keen interest in science, as well as a separation of the functions of production and research—and because it is cheaper than hardware research and development. Under previous economic plans, little money was allocated for such research. In a research institute, or a university, or an Academy of Science office, an engineer can work with a pencil and paper inexpensively, producing a paper that can be published in a technical journal or even a newspaper. On the surface, at minimum cost, the country's progress in technology is assured.

Because the jobs in these ivory towers are so well paid and so highly respected—they often get the holders to foreign countries to attend technical meetings, an added attraction—newly graduated engineers prefer them, not surprisingly. In fact, they prefer them to the extent that many will work in factories only under protest.

As a result the engineering staffs at existing electronics plants are minuscule. Some large plants have only 20 or 30 engineers to design new products, improve old ones and develop new manufacturing processes. Some of the product development work has been pushed off on research institutes where there are concentrations of engineers. But too many of the workers at these institutes are out of touch with what the market really needs and the designs are not practical.

Even if the Communist countries could buy the newest electronics equipment and could license the newest technology, the problem of keeping up would not be solved until they are willing to face the realities demanded by modern day production. For example, all of them have licensed transistor manufacturing technology from Western companies or the Soviet Union, but they still produce only those types they licensed as long as 10 years ago. There is no engineering force to devise new devices or new processes. To catch up in semiconductor technology almost all the Eastern countries are sitting back waiting for a chance to sign new licensing agreements.

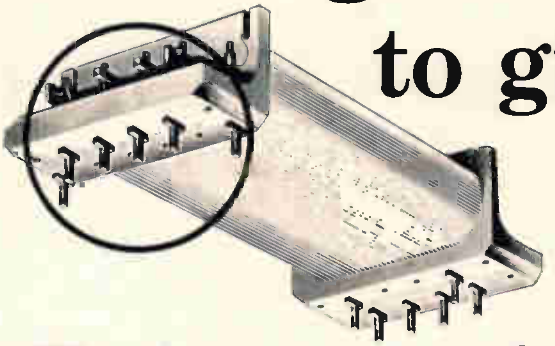
There is a moral in all this for Western companies too. The temptation is great to concentrate on theory, on research where there is no possible application in sight. On page 149 we report on just such a situation in the world of automatic control: the theoreticians have far outstripped the hardware oriented-engineers so that none of the sophisticated theories like adaptive control or optimal control are being used.

The engineers's job can't be ceded to the physicist or the mathematician. Until the countries of East Europe understand this, they will find themselves continually sliding regardless of what they buy or license.

The secret for keeping pace with technology is a proper blend of aggressive theoretical work and hardware-oriented research and development.

This is the second of three editorials on East-West trade, the result of a month-long tour of Eastern Europe by Electronics Editor-in-Chief Lewis H. Young. The next will examine the United States position on trade with East Europe.

these terminals are engineered to give

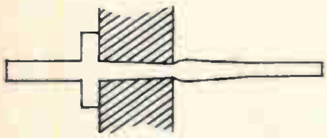


P&B dry reed relays extra stability

Now you can have the assurance of P&B quality in a complete new line of dry reed relays.

JR standard size reed relays are available in assemblies of 1 to 5 switches. In the JRM miniature series up to 6 reeds are available in one assembly. Both sizes come in a standard range of coil voltages and various combinations of Form A and Form C contact arrangements.

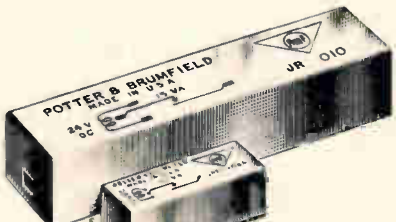
BOBBIN FLANGE SUPPORTS TERMINALS FOR STRESS PROTECTION



P&B reed relays employ an unusually sturdy terminal configuration. Extensions of the molded coil bobbin support the cross-shaped terminal pins. Stresses that otherwise would be transmitted to the reed extensions are confined, instead, to the bobbin thus protecting the glass-to-metal seal of the capsule.

METAL HOUSING PROVIDES MAGNETIC SHIELDING, INCREASES SENSITIVITY

Metal housings for the various assemblies provide magnetic shielding, eliminate stray magnetic fields and protect the relays from mechanical damage. JRM miniature relays are potted in a high melting point compound to insure mechanical stability. Speeds of less than 1 millisecond are attainable.



MAY REPLACE EXPENSIVE SOLID STATE DEVICES

In many applications JR and JRM reed relays may be used in place of more expensive solid state devices over which they have one basic advantage . . . they are not subject to inadvertent switching by ambient or line transients.

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JR and JRM are especially suited for applications where fast operating time, low power and long life are required. Their high sensitivity and compact size recommend them for data processing, computer equipment, logic circuitry, for voltage or current sensing and various other types of sophisticated control circuits.

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P&B Dry Reed Relays are now available from authorized Electronic Parts Distributors

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Electronics Newsletter

July 25, 1966

New firm selling first commercial Gunn-effect device

The first commercially available Gunn-effect device is being offered by a year-old New England company. The firm, International Semiconductor, Inc., of Newburyport, Mass., reached the market with its bulk device before any other electronics company—many of which are investing heavily in Gunn-effect research. The International Semiconductor product produces 50 to 70 milliwatts of continuous-wave power at 2 to 3 gigahertz; the sale price is $175.

Others doing extensive research and development work on Gunn-effect devices are Microwave Associates, Inc., the Radio Corp. of America and Texas Instruments Incorporated.

Meanwhile, Gunn-effect oscillators are producing higher c-w power at higher frequencies. Bell Telephone Laboratories says its epitaxial gallium-arsenide oscillators produce 110 mw at 11 Ghz and 1 mw at 35 Ghz. Pulse Gunn-effect devices are operating as high as 40 Ghz, with an RCA device recently reported at 40 mw peak power at that frequency.

Busy schedules prod firms to cut vacation shutdowns

A sign of the booming economy and the tight labor market: an increasing number of companies around the nation have decided to forgo the usual two-week summer-vacation closedown. Also, companies are either paying hourly workers and engineers extra money to put off vacations until later in the year, when staggered schedules can be worked out, or are scampering about looking for part-time help to fill vacation gaps.

The Connector division of Amphenol-Borg Electronics Corp., for example, decided this year to cancel its usual two-week shutdown and to stagger vacations. The division is hiring vacationing college students. The Radio division of the Bendix Corp. cut its closedown from two weeks to one. And the Stromberg-Carlson Corp., is urging some of its staff to accept extra pay instead of taking vacations now.

New-generation nuclear detectors to be orbited in '67

The first launching of a pair of improved Vela nuclear-detection satellites will be attempted early next year—possibly around Easter. If successful, the new satellites will become part of the Advanced Research Projects Agency's operational system to detect artificial nuclear radiation as far away as Mars. Two pairs of the redesigned satellite are being built by TRW, Inc.'s Systems division at Redondo Beach, Calif., and the company is hopeful that launches will continue at a one-a-year rate to replenish and update the satellite net. Next year's launch will be the first to use the Air Force's Titan-3C booster. The original research-and-development program (formerly called Vela Hotel) needed only one launch to meet all objectives of the five-shot schedule. As a result, three sets of the R&D satellites ended up as an operational system and the program became a cause celebre in the Pentagon's cost-reduction program [For details, see p. 153]. By eliminating the last two pairs of satellites and their boosters, the Defense Department was able to save more than $30 million on the R&D program.

The new satellites reportedly will have station-keeping capabilities so that the two satellites will remain 180 degrees apart in their circular orbit 50,000 to 60,000 miles above the earth.

Swiss IC's for watches?

The dominant company in the Swiss watchmaking industry, Ebauches S.A., and four other Swiss firms have joined forces with N.V. Philips Gloeilampenfabrieken of the Netherlands to establish a semiconductor manufacturing company at Neuchâtel. The company, Fabrication des Semiconductors S.A., will produce transistors and diodes at the outset. Eventually, though, it will make integrated circuits for an electronic watch now under development at the watchmaking industry's electronics center [Electronics, Jan. 25, 1965, p. 155].

The companies plan a \$2.3-million initial investment in the plant; later they foresee upping the ante to \$9.2 million. Along with Ebauches, other Swiss companies in the venture are Fédération Horlogère Electronic Holding S.A., Brown-Boveri & Cie. AG, Autophon AG and Landis & Gyr AG.

MOL progress: West to get tracking station

As the Manned Orbiting Laboratory (MOL) program picks up speed, the Air Force's Western Test Range is beefing up its down-range tracking network. A California tracking station will be built about 150 miles south of Vandenberg Air Force Base. The facility—to be similar to the Eastern Test Range's Grand Bahama Island station—will fill the tracking gap caused by booster engine flame, which attenuates signals.

Whether new hardware will be purchased for the new station depends on whether the National Range Division can use equipment now in its inventory. Work is also proceeding on the first MOL shot—an unmanned test later this year. The first manned launch is slated for 1969.

McDonnell suggests adding swing-wing to Phantom F-4

Defense Secretary Robert S. McNamara sees the F-111 (née TFX) as all things to all the military services: fighter, bomber, interceptor, reconnaissance craft. But in some Navy quarters the plane is considered overweight and overrated. Hoping to take advantage of the Navy's displeasure with the F-111 the McDonnell Aircraft Co., in an unsolicited proposal, suggested that the best feature of the F-111—its variable-sweep swing wing—be adopted for the company's old reliable Phantom F-4.

The Phantom's avionics subcontractors—including the General Electric Co., the Westinghouse Electric Corp., Litton Industries, Inc., and Lear Siegler Inc., are watching McDonnell's maneuver very closely, hoping it will mean a major extension of their production contracts for F-4 electronic items. But the chances of this occurring are slim. It's more likely that, if the swing-wing F-4 is approved, the Navy will seek a new, improved avionics system that borrows techniques and technology from the Mark 2, the integrated avionics for the Air Force's version of the F-111 [Electronics, July 11, p. 139]. The company with the inside track on this system is North American Aviation, Inc., which has the Mark 2 order.

European color tv deadlock confirmed at CCIR session

As expected, Europe's last chance for a single color-tv standard died last week as the plenary session of the International Radio Consultative Committee (CCIR) at Oslo ended hopelessly deadlocked. France and the Soviet block will adopt the French Secam system; other European countries will use the West German PAL system.

Negotiations begin on fast-deployment cargo ships

The Navy began negotiations last week with three bidders on its fast-deployment cargo ship (FDL) program and is expected to name the companies that will design the new class of vessels sometime this week. Two shipyards have withdrawn their bids, and the list of contenders now includes only the Lockheed Aircraft Corp., Litton Industries, Inc., and the General Dynamics Corp. Plans had been to have a competitive contract-definition phase so the betting is that two, or most likely all three companies, will be funded for the work.

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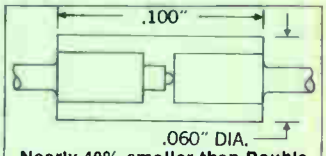
MHD is here— the newest, small diode

They're here already — the next generation after the DHD's. Just as rugged and just as reliable, tiny G-E Milli Heatsink Diodes are perfect for high-density circuit card and memory applications, and for "cordwood" construction. The new diodes are available in JEDEC types 1N4531-34 and 1N4536. Each features high conductance, low capacitance and nanosecond recovery time. Circle inquiry card **Number 90** for more facts.

Actual size



Nearly 40% smaller than Double Heatsink Diodes, new G-E Milli Heatsink Diodes offer the same inherent reliability.

Here's your key to low-cost voltage stabilization

Every G-E voltage stabilizer supplies constant output voltage to within ±1%—even with fluctuations up to 15%. For special economy, core-and-coil units provide the lowest cost voltage regulation obtainable. They help meet tight space requirements, make wiring connections easier, and provide all the mounting flexibility you can ask for. At General Electric, voltage stabilizers are available in ratings from 15 to 15000 volt-amperes in both standard and custom designed models. Ask your G-E engineer/salesman for publication GEA-7376 or circle magazine inquiry card **Number 91** for all details.

Typical General Electric a-c voltage stabilizer

Smaller size— yet higher power capability with this new Grid Pulse Triode

2.0 KW at 1090 MC or 2300 MC. Or a full 1.0 KW at 4300 MC. That's the capability of General Electric's new Y1549 ceramic triode for grid-pulse applications. Each new triode is rated at 2000 volts, 2.5 amps peak, 0.001 duty, and 0.5 microsecond pulse width. Significant performance improvements are a certainty with its new, specially tailored cathodes and high-performance grid construction. What's more, the Y1549 is extremely tolerant of adverse environments (as are all G-E planar ceramic triodes). Typical applications include airborne navigational and communication equipment, and L-, S-, and C-band radar beacons. Circle **Number 92.**

Actual size

Try G-E high-voltage reed relays. They're small . . . fast . . . and reliable

For military and special applications

Rated up to 5000 volts or 50 volt-amps, these G-E reed relays are ideal for applications requiring high reliability and long life. Dimensions, excluding leads: only 0.70 inch tall, 1.09 inches wide, and 2.80 inches long. G-E Type 3SAS reed relays operate in 3 milli-seconds maximum; release time: 100 micro-seconds maximum. Ask your G-E engineer/salesman about these high-voltage reed relays, or circle magazine inquiry card **Number 93.**

For those really tough applications— specify G-E Metallized Polycarbonate Capacitors

They're 50% smaller than comparably-rated foil electrode units. Stable, too. A G-E metallized polycarbonate capacitor's maximum change (in per cent of 25C capacitance) will not exceed −2.5% +2.0% over its temperature range from −55C to 125C. Ratings: 200, 300 and 400 VDC at 125C; 0.1 to 10.0 microfarads. And they're self-healing. Each features low dissipation factor, high insulation resistance and superior high-frequency characteristics. Ideal for many a-c applications. Circle **Number 94.**

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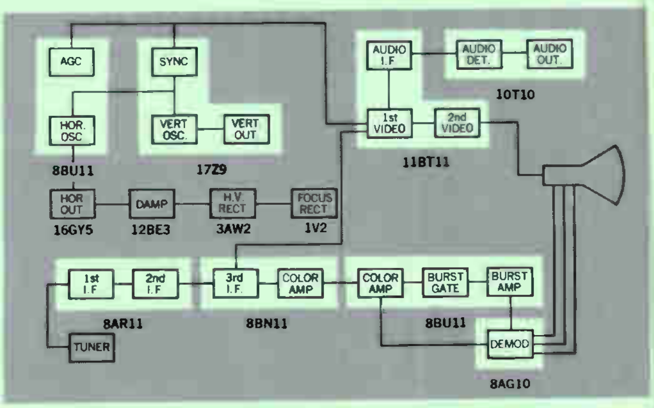
New cooling fan assemblies for your equipment cabinets

For computers and electronic equipment

Test them yourself. They're new. They're able to generate up to 500 CMF air flow in either suction or blower applications. They're designed for all-angle mounting. Quiet, reliable G-E fan units come in either 115- or 230-volt ratings for 60-cycle operation. Each is equipped with a 10-inch diameter venturi for easy mounting. Its 5-blade fan is well-protected by a wire mesh front screen and heavy duty back grill. And the proven, unit-bearing motor insures many years of reliable operation. Optional designs are also available. Circle magazine inquiry card **Number 95.**

8 compactrons replaced 15 tubes in this color TV circuit

Depend on General Electric compactrons for circuit savings . . . for outstanding performance . . . for full-scale production availability. Nearly 60 different available compactrons are particularly suited to color TV receivers. Ask your G-E engineer/salesman about color-TV compactrons or circle **Number 96** on the magazine inquiry card.



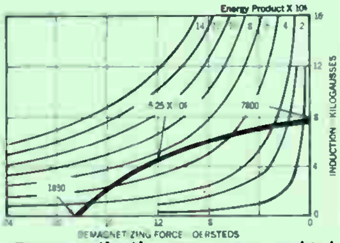
15-inch transformerless compactron color TV

Many advantages offered by G-E fast-recovery rectifiers

Some applications are just too demanding for normal silicon rectifier diodes. Take advantage of reduced recovery transients, increased circuit efficiency, and low RFI. Try G-E fast-recovery rectifiers. General Electric offers a complete line of these devices in 6-, 12-, 20- and 30-amp ratings, and with maximum recovery time of either 100 or 200 nanoseconds. Applications where they're sure to be particularly useful include free-wheeling rectifiers, sonar and ultrasonic equipment, DC-to-AC inverters, and other systems requiring high-frequency switching. You'll like their prices, too. Circle **Number 97.**

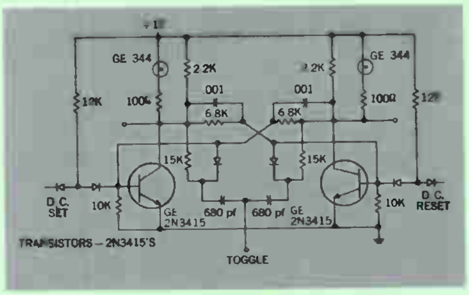
New magnetic material breakthrough—improved Alnico 8

Given the right size, shape and directionalization, this new G-E magnetic material can produce a nominal coercive force of 1850 oersteds. This means that, in some applications, you can reduce the size of your mechanism as much as 40% . . . save dollars as well as space. Higher useful recoil energy is also a fact with improved Alnico 8. Ideally suited for motors, latching applications and torque drive devices. Ask one of our experts to help you design it into your newest application. Circle **Number 98.**



Demagnetization vs. energy output

No separate driver needed for this incandescent bulb circuit



Binary counter with incandescent readout

Combine the high gain of the 2N3415 economy transistor with the low-current requirements of the G-E #344 lamp in this circuit, and you've eliminated the need for separate driver stages to drive the incandescent bulbs. This circuit will continue to operate with either or both of its bulbs burned out. It can also drive other circuits just like it to form a binary counter chain. Circle inquiry card **Number 99** to learn more about it.

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GENERAL ELECTRIC

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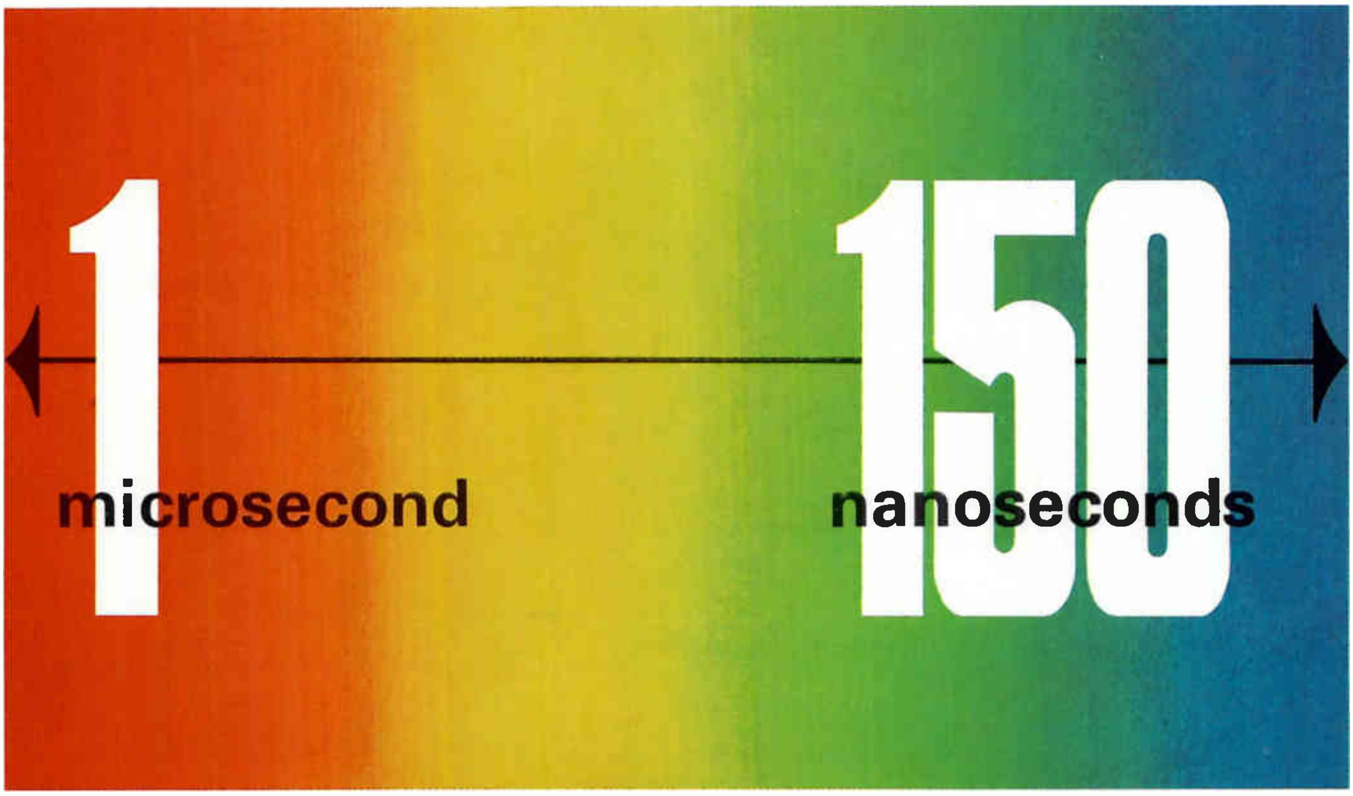

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The Fabri-Tek FAST Line concept represents a significant departure from the discrete memory speeds of equipment currently available. FAST Line provides a free selection of any memory speed between 1 usec and 150 nsec without specific incremental restrictions.

Now, you can select an optimized memory stack or system from the FAST Line spectrum which matches exactly the logical organization and internal circuit speeds of your computer design.

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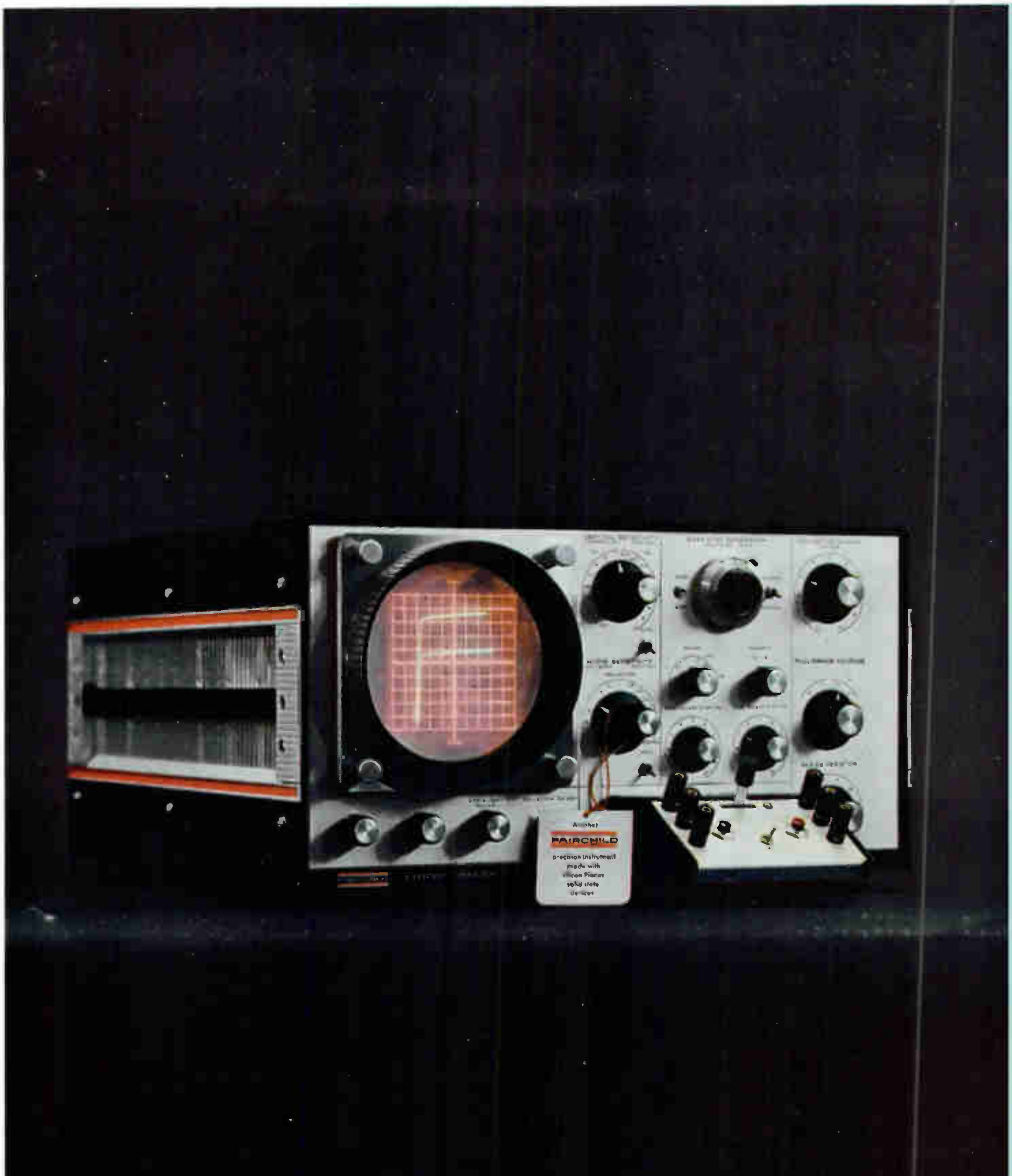
The Leader in Memory Technology


FAIRCHILD
precision instrument
made with
solid state

Nowadays, Anyone Can Make An Integrated Circuit...

INDUSTRIAL APPLICATIONS FOR FAIRCHILD INTEGRATED CIRCUITS

1

of a series

The Switch to IC'S: Reasons and Applications.

(See reverse side)

DISCRETE COMPONENTS ARE OUT. If you are a design engineer working on electrical or electro-mechanical circuitry, particularly in industrial controls, you have a unique opportunity to gain a strong competitive advantage for your company by switching to integrated circuits. It doesn't matter whether your present equipment is solid-state, or whether you are still working with vacuum tubes and/or relays. The time to switch is now.

We predict that within a very short time every manufacturer of control instrumentation will have gone to IC's. The first one to do so will be able to offer a smaller, more reliable, better performing unit than his competition — and at a lower cost. The rest of the industry will have to follow suit. There are several good reasons why this change has not taken place yet. There are equally good reasons why the right time is right now.

COST: When integrated circuits first came out, their prices were very high. In those days yields were low, the demand was limited, and manufacturers had R & D costs to write off. As a result you could pick up all the components and assemble the circuit for less than the cost of the integrated equivalent. The situation is reversed now. Development costs have been amortized, the demand is rising, and the yields are high. As a result IC pricing has taken a considerable drop. You can now pick up an industrial integrated circuit at roughly the cost of the discrete components (of equal quality) that are required to make up an equivalent circuit. And that's the cost of the components alone — without any of the labor that goes into assembly. On the reverse side we show a typical control application: an X-Y control table. We used 18 printed circuit boards to build the unit. To build the same logic out of discrete components would require 120 boards. Even if you assume the same rate of productivity for discrete boards as for IC boards, you have a reduction in labor cost of 85%. To say nothing of the cost of the boards. Furthermore, design time is reduced greatly when you use integrated circuits, because most of the circuitry has been pre-designed in convenient, functional modules.

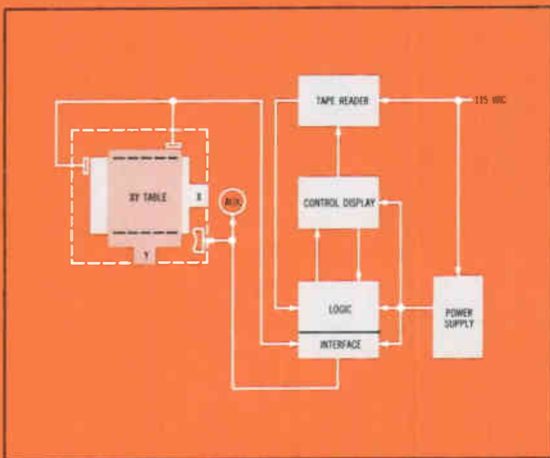
RELIABILITY: Three years ago no one could tell you anything provable about the reliability of integrated circuits. They were too new, and except for applications where size was the controlling criterion, no one was willing to take a chance. Now you can get reliable reliability data and solid documentation. Furthermore, these circuits have proven themselves in field use over thousands of hours and under severe conditions. They are more reliable than discrete components. That should come as no surprise. The more components you have, the greater your chance of error, and of malfunction. With IC's you reduce the number of interconnections to a minimum — traditionally the chief cause of circuit malfunctions. Finally, in an integrated circuit all your components are matched, suited to the circuit requirements, and of consistent quality. There is no chance of a cheap component creeping in to become the weak link in your chain.

SIZE: Size is of less importance in an industrial piece of equipment than it is in something like a missile guidance system. But, let's face it, space costs money too. The integrated unit on the reverse side takes up a third of a drawer in a standard rack. The discrete equivalent takes two full drawers. In a space restricted workshop this becomes yet another competitive advantage, which you can use to close your sale.

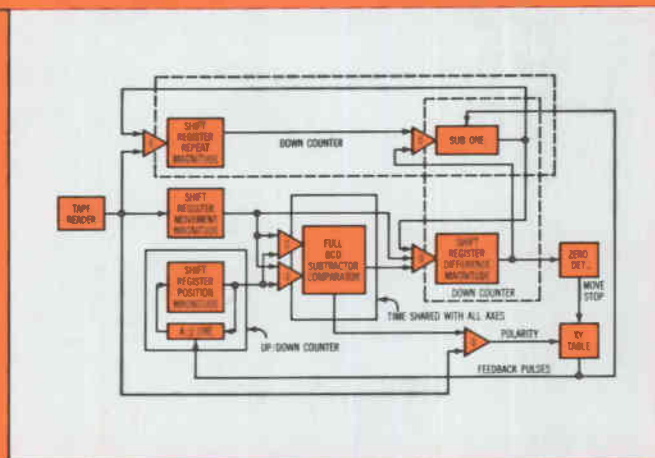
AVAILABILITY: Early in the game, integrated circuits were hard to come by. The majority went to those applications which could afford to pay premium prices. This is still true to some extent where the newest, most sophisticated circuits are concerned. But it is not true in the case of industrial integrated circuits. These circuits have been around for more than two years, they are mass produced, the manufacturing bugs have been eliminated, their yields are high. Right now is the ideal time to buy them. There is one catch, however: once the rush to integrated circuits is on, there is a good chance that the demand will exceed the supply. And then it's first come — first served.

INFORMATION: One barrier to the use of integrated circuits in the industrial field has been lack of solid applications information. Now even this is no longer a valid reason: on the reverse side you'll find the first of a series of application stories which will suggest where and how you can use integrated circuits. Furthermore, if you don't want to wait till we get around to the one you're interested in, return the attached card and ask for info on a specific application. We'll pull information out of our file, or sit down with you and work out the problem face to face.

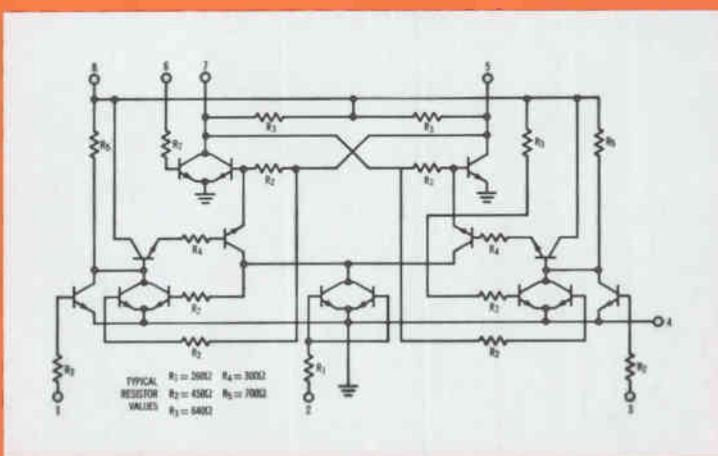
Integrated X-Y Controller



Tape Driven X-Y Controller, System Diagram



Tape Driven X-Y Controller, Logic Diagram



Schematic of integrated circuit flip-flop, one of the Fairchild integrated circuits used for X-Y Controller.

Left to right: Mechanically positioned X-Y Table, Logic Card Rack, Tape Reader. Numeric Generator used as a display.

DESCRIPTION: The unit, as built, receives information through a paper tape reader, and has a mechanical position as an output. Many other kinds of output could be utilized, and there are other ways of solving the logic problem for this unit. We have selected this as one example. The system utilizes 18 P.C. boards, 4.5″ x 5.0″ each, with 20 to 43 integrated circuits per board. Circuits used were Fairchild RTμL circuits, as shown in the table below. The logic diagram shown is for a single axis, and similar logic circuits, with the exception of the tape reader and the full BCD subtractor, are used for other axes in the system. The output range is 99,999 units, and the magnitude of the units is arbitrary. If the setting is in tens of thousandths of an inch, the unit range would be from 0.0001″ to 9.9999″. Considerable savings in hardware resulted from the time sharing of some functions, made possible by the inherent speed of the integrated circuitry.

FAIRCHILD SEMICONDUCTOR

FUNCTION COMPARISON TABLE

Function	I.C.	Quantity	Discrete Components in Equivalent Circuit	
			Transistors	Resistors
1. Shift Register (four total)	μL900	2	6	12
	μL923	20	300	340
	μL927	1	4	8
2. Add/Sub. ONE (2 total)	μL914	21	84	126
	μL926	1	19	26
3. Sub. ONE (2 total)	μL914	20	80	120
	μL923	1	15	17
4. Full BCD Sub. (1 total)	μL914	43	172	258
	μL926	1	19	26
	μL927	1	4	8
5. Zero Detector (1 total)	μL914	17	68	102
	μL915	3	18	24
	μL927	3	12	24
6. Control and Multiplexing (1 total)	μL900	4	12	24
	μL914	149	596	894
	μL915	25	150	200
	μL926	18	342	468
	μL927	14	56	112

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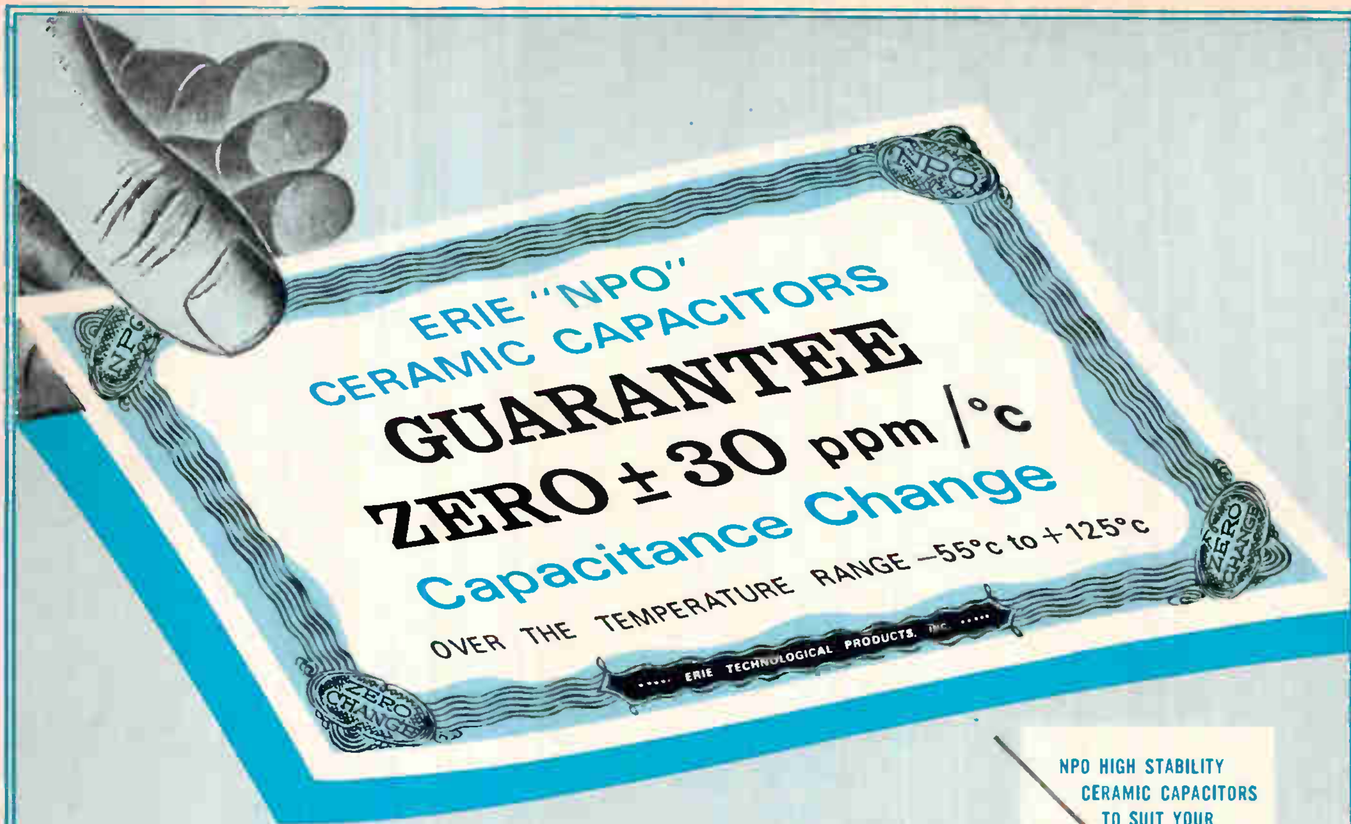

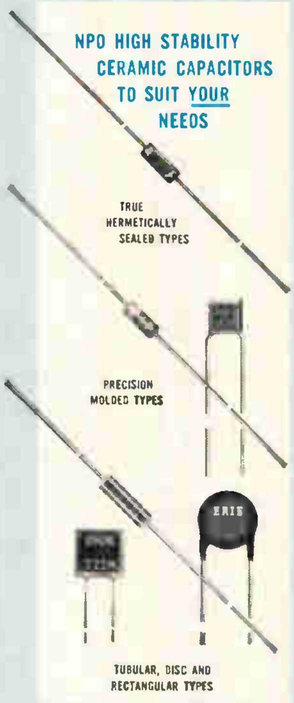

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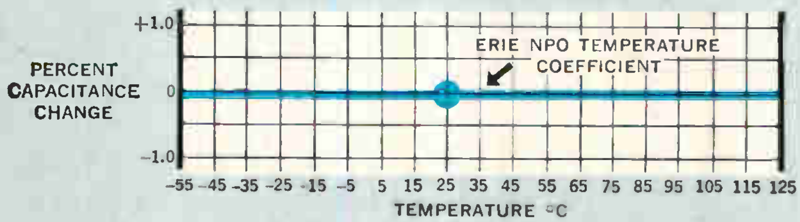
CAPACITANCE CHANGE VS. TEMPERATURE



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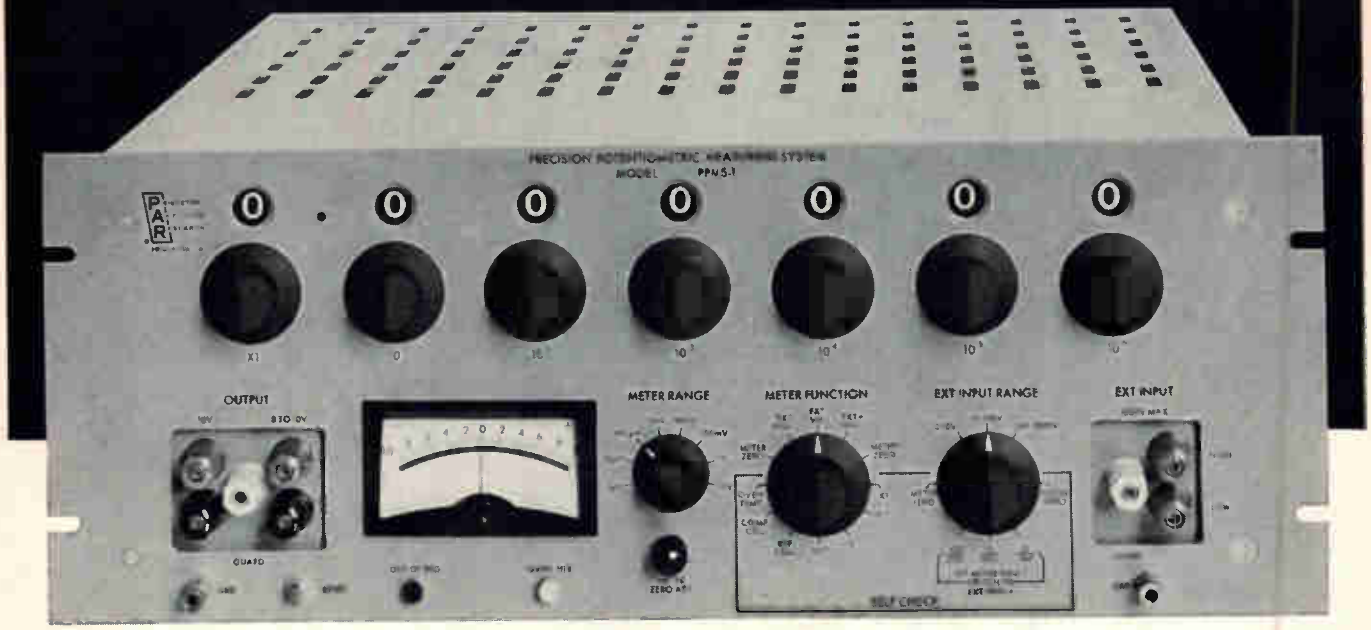

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An output signal fully isolated from, but proportional to the deflection of the null meter is provided to drive strip-chart recorders and thereby function as a self-contained monitor of the stability of other voltage supplies. In addition, this unit can serve as the controlling element in ultra-stable variable voltage or current supplies with the addition of power amplifiers which are available as accessory items.

A unique method of self-calibrating the four most significant decades of the Kelvin-Varley divider without additional equipment as well as means of verifying oven temperature and standard cell voltage are provided. Price $4950.

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Electronics Review

Volume 39
Number 15

Displays

Flat-screen tv?

A New York company that specializes in polarizing materials has developed a glass panel that can be made clear or opaque—with the flip of a switch. Developed originally for glass-panel buildings, the product is now being explored as a flat display panel for moving or still pictures and possibly for flat-screen television.

At the moment only the full panel can be made to change from clear to opaque. "But," says Morton Marks, executive vice president of the company. Marks Polarized Corp., "we found that we can excite very small spots on the panel, so that discrete areas as tiny as 0.02 inch can be made to switch." To demonstrate this, Marks explained, a needle probe was placed against the panel and at that point the glass was turned "on" or "off" simply by introducing a small voltage.

Light pass. The material that makes the glass change opacity is a liquid suspension of submicroscopic dipoles. When a voltage is applied to the material, the electrical field aligns the dipoles, permitting light to pass. When no voltage is present, the dipoles return to a random arrangement, blocking the light. By varying the amount of voltage, the panel can be made partially opaque.

To apply the technique for use as a window or a wall panel, the liquid conductor is sandwiched between two glass panels. But for a display or tv screen a different arrangement must be worked out.

One possibility, Marks says, is to print the glass with a grid of fine conductive lines. Then, by flooding the back of the panel with light and by controlling the voltage at the crossover points of the lines, a picture can be produced; the light passes only at the points where the voltage is sufficient to align the dipoles. Marks estimates that it would take about 500 volts to switch a foot-square panel.

Switching speed is not a problem, explains Marks. The material can be made to switch in microseconds —fast enough for use as an all-in-one flat television tube and screen.

In fact, Marks adds, several television companies are currently examining its potential. However, the executive declined to identify them.

For the conductive material, the company is using an organic crystal called herapthite, a compound that's similar to a polarizer. "But," says Marks, "we're also working on other materials, especially metals, that would perform in the same way." One approach would be to use dipoles made of dendritic single crystals—like the whiskers that sometimes grow in waveguides.

The developer of the product, Alvin M. Marks, Morton's brother and president of the company, says that the glass could be used as a building's exterior wall. On a sunny day, the panel could be turned partly opaque, reflecting away the hot sun. And on a cloudy day the panel could be kept clear, allowing daylight to enter the building freely.

The company estimates that such panels would cost between $5 and $10 a square foot in production.

Advanced technology

Memorable material

Potassium nitrate (KNO_3), the inexpensive ferroelectric material that's used extensively in microphones, filters and frequency-modulator discriminators, may someday have a new job—in computer memories.

Scientists James P. Nolta and Norman W. Schubring at the General Motors Corp.'s research laboratories in Warren, Mich., predict that KNO_3 memories potentially can store a higher density of data than either ferrite-core or thin-film ferromagnetic memories.

The key to the ferroelectric memory was first turned in 1962, when the GM team discovered that bulk KNO_3 exhibits a threshold in its hysteresis loop at room temperature. Such a hysteresis threshold is a basic requirement for any material to be used as a computer memory. The ferroelectric material responds to an applied electric field in much the same way that a ferromagnetic material, from which conventional ferrite-core memories are made, responds to an applied magnetic field. Ferroelectric crystals, however, are electrically asymmetrical and therefore behave like a dipole.

"When subjected to an electric field of sufficient strength," Nolta says, "these microscopic dipoles turn to line up with the field. When the field is removed, internal friction prevents the dipoles from returning to their original position." Hence, hysteresis.

On the threshold. But to prepare the material for this application, it had to be heated and then quickly cooled. Earlier, it was thought that KNO_3 could achieve threshold only at temperatures of about 250°F.

Now, the GM team has developed a way to make the material achieve hysteresis threshold without elaborate quick-cooling. When the KNO_3 was prepared as a thin film rather than in bulk form, the team found cooling was simpler—and the KNO_3 still had a threshold at room temperature.

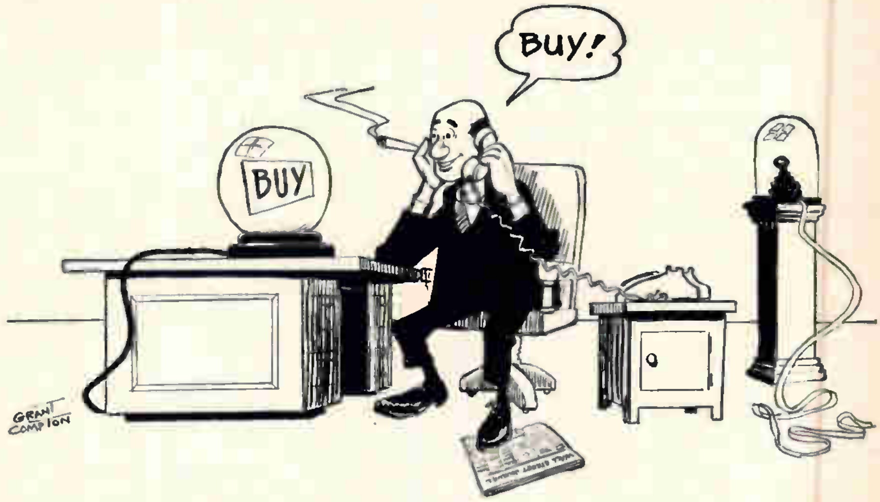
For use as a computer memory, researchers Nolta and Schubring prepared an experimental model: thin films were sandwiched between two layers of vacuum-deposited electrode strips at right angles to each other. Then, they discovered, if the layers were stacked, one atop the other, a memory array could be built up, and tens of thousands of bits stored in one cubic inch of material.

But problems still exist, they concede. For one, the KNO_3 memory is slow compared with ferromagnetic memories. The ferroelectric memory switches in about 10 microseconds while the ferromagnetic memories switch in fractions of a microsecond. However, the researchers are optimistic that speeds can be boosted by changing film thickness and altering other parameters.

How they stack up. When compared for power consumption, both materials are about even.

The single factor that gives ferroelectric memories the potential for holding more data per cubic inch is its geometry. Magnetic thin films, for example, are essentially two-dimensional. But a ferroelectric memory can be stacked, layer upon layer.

It would be difficult, if not impossible, to build a multilayer ferromagnetic memory because the magnetic field that causes switching goes around the conductors, disturbing the nearby magnetic material. In the ferroelectric memory, however, the only field of consequence would be between the two conductors, and therefore nearby ferroelectric materials wouldn't be disturbed.



Computers

Stock answers

Too often a stock broker's recommendation to buy or sell a stock is based not on the latest market situation or a thorough analysis of the company but on self-interest: the more transactions he can generate, the larger his commission. But if an investor had his own computer to assess complex market trends and the general health of a security he could bypass the broker and make split-second decisions on what shares to buy and sell. At least that's what a small investment counseling company in Princeton, N.J., thinks.

The firm, ISEC Corp., in cooperation with Data Instruments, Inc., has developed a desk-top analog computer that can assess the risk of investing in about 1,000 different stocks. And the assessment is delivered instantly.

ISEC is offering the service as a package deal. For $485 the investor buys the computer plus a year's subscription to a fortnightly investment bulletin that contains coded evaluations of all the stocks. The investor can't use one without the other. For $150 he can renew his subscription to the bulletin for another year.

Profit motive. The machine is programed to base its decision on maximum stock appreciation—not dividend yield or some other investment objectives.

Two of the computer's data inputs can be gained from the daily newspaper or through a call to a broker: the stock's current price and the latest Dow-Jones figures. These inputs, plus three others which are in code (the company won't describe them or tell how they are derived), are entered into the computer by adjusting dials. Immediately, the computer has its answer: a dial swings to the left for high-risk stock or to the right for low-risk investments.

Like all other analog computers, the new machine contains an array of operational amplifiers, integrators, adders and multipliers that process the information. In conventional general-purpose analog machines these components are connected through externally wired patchboards; the connections are defined by the problem to be solved.

In the investment computer, however, the connections are all internal, following a mathematical formula worked out by ISEC. Anyone who finds out what the formula is could patch up a general-purpose computer to produce the same results; but he would have to obtain the three factors that make up the fortnightly reports.

The computer can also be used to establish "stop levels"—that is, the price at which an investor should buy or sell a stock.

ISEC is considering the development of similar machines, wired differently, that would analyze retail markets and other complex financial situations.

Contracts

Appealing invitation

A San Francisco Federal district court judge ruled that the General Accounting Office can probe the cost structure of items purchased by the Federal Government under negotiated contract. But in an aside from the bench he warned of the potential abuse of such audits, and urged the company to seek reversal of the ruling by "wiser, better paid" jurists.

Ruling last month on the Hewlett-Packard Co.'s refusal to open its books to Federal auditors, Judge Lloyd H. Burke agreed that a 1951 law gives the GAO the right to demand underlying cost data even for off-the-shelf products.

Fight expected. Appeal by Hewlett-Packard, which has fought the Federal watchdog agency on this point for more than three years [Electronics, Jan. 25, 1965, p. 34], is rated a virtual certainty. Judge Burke's order to the company to produce its records on production costs will be stayed in the event of an appeal.

Until there is a final ruling, possibly by the U.S. Supreme Court, the accounting agency has no plans to act against several other electronics concerns, including the Collins Radio Co., which have also refused to supply cost data on catalog items. As a result of pressure from Congress, the GAO lately has moved gingerly in field audits that irritate sensitive business nerves.

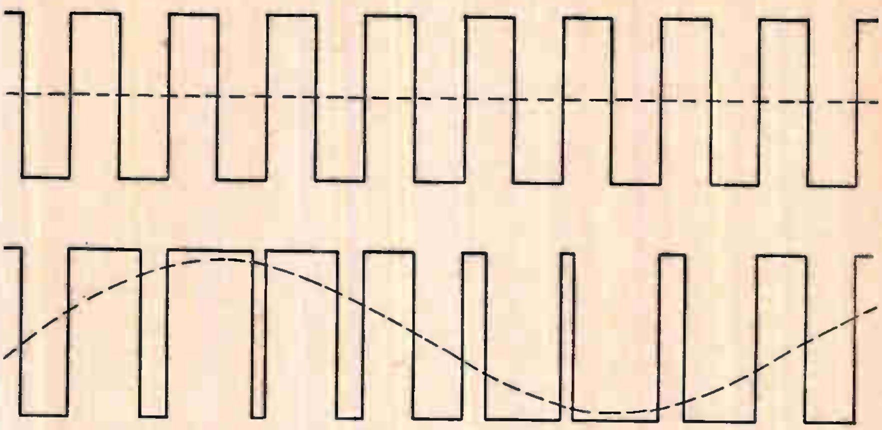
The legal controversy swings on the question of what Congress meant when it gave the GAO authority to demand any business records directly pertinent to performance of a Government contract.

Both sides agree that the $2 million in electronic gear supplied between 1959 and 1961 under four Air Force contracts were standard commercial items regularly bought by private customers. They also agree that there was no mention of production costs when the contracts were negotiated. Even if an audit determined that Hewlett-Packard's profits on the transactions were too high there would be no way to reclaim the excess.

The accounting office insists that it needs backup data to study the relationship between equipment and spare parts prices and that it could ask Hewlett-Packard for such information because costs are involved in any negotiated contract.

The company contends that costs are irrelevant when the contracts involve catalog items where reasonable prices have been established through fair competition.

It claims GAO's position amounts to "a sweeping price-control function over all American industry."



A pulse train (top, unmodulated and bottom, modulated) achieves amplification in Mallory's linear amplifiers. Only envelope of pulse train is shown.

Solid state

Circuit revival

A veteran component manufacturer will enter the integrated-circuit market—possibly by updating a veteran circuit technique. P.R. Mallory & Co. is exploiting pulse-width modulation, a technique largely unused in its 35-year life despite its advantage in efficiency: theoretically 100% when used for audio amplification. In comparison, the widely used class A method has a theoretical top efficiency of only 50% and for class B, the limit is 78%.

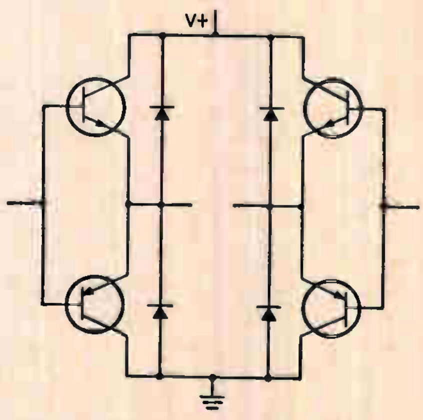
Using the pulse-width technique, also called two-state or class D amplification, Mallory has built a prototype circuit of individual chip transistors, resistors and capacitors that provides a watt at 90% efficiency. The amplifier's response is from d-c to 15 kilohertz, ±3 decibels, and its distortion is less than 1%. Mallory thinks the circuit, when built in monolithic form, will be the only amplifier of comparable performance that needs no outboard components.

Pulse-width modulation has several advantages over class A or B operation which should make it particularly attractive for IC audio and servo amplifiers.

- Efficiency is higher, which means that for a given output, power dissipation is reduced and therefore the circuits can be made smaller.
- Critical stages are either fully "on" or fully "off," eliminating the need for bias current and reducing the need for tight component tolerances.
- Transistor gain variations do not affect the gain and linearity of the amplifier.
- There is no lower cutoff frequency, since all stages are d-c coupled.
- Supply voltage is not critical.
- Load impedance can be varied without affecting efficiency.

Pulse chopping. The pulse-width modulation technique avoids linear reproduction of the signal; instead it produces a high-frequency pulse train that is modulated by chopping it into chunks of varying widths.

The technique was not used with discrete-component circuits be-



A practical output stage for pulse-width modulated amplifier uses complementary transistors in a bridge configuration. It reduces transistor current for given output cause it required many transistors (or tubes), which sent costs soaring. Mallory thought the method worthy of revaluation since IC transistors are cheap. The first Mallory circuits had 35 transistors, compared with about 17 for an integrated class B version. Circuit improvements have enabled Mallory engineers to build the same device with only a dozen transistors. One key to the improved circuits was the development of integrated high-current, low-power output transistors.

The next step, say its developers at Mallory's laboratory for physical services, Burlington, Mass., is to build the amplifier in monolithic form. This circuit and similar ones may enable Mallory to crack the market for IC's in high-volume consumer applications, such as radio and television.

The present devices, built as a feasibility test, may be too low powered for wide use. If so, Mallory will build units with more than a watt output. They will incorporate npn and pnp transistors in the same block.

No isolation. The process for building npn and pnp devices together, says Mallory, will not require isolation techniques, and the end product will be inexpensive, high-power, high-efficiency IC amplifiers.

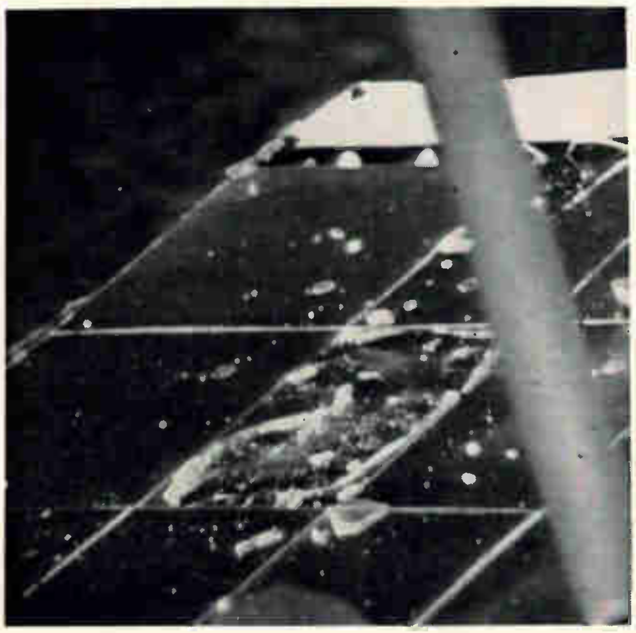
Space electronics

Pride and regret

With a mixture of pride and regret, scientists and technicians at the Jet Propulsion Laboratory stood vigil last week as the lunar night again closed in on Surveyor 1. The plucky, spider-shaped moon photographer had performed like a champion and even as its end approached, after six weeks on the moon, it snapped a final flurry of 741 pictures.

In all, the spacecraft took 11,500 photos and flawlessly transmitted them to earth. But the craft did more than provide a profusion of lunarscapes; it saved face for the lab, which designed the craft and managed the program for the National Aeronautics and Space Administration.

Hot and cold. Surveyor 1 proved that the design was all but perfect —so perfect, in fact, that hardly a change in plans is being contemplated for the next generation of Surveyors. Its ability to withstand the heat of the lunar day, which is 14 earth days long, and the cold of the lunar night amazed the lab's workers; but even more amazing was the craft's ability to make spectacular comebacks from the edge of disaster.



Surveyor photographs its ills: crack was caused by cold.

After having performed far beyond expectations during its first lunar day, Surveyor 1 dramatically sprang back to life part way through the second lunar day. But clearly, all was not well.

Soon after its solar cells began to recharge the battery, the first emergency appeared: the craft telemetered earth that its battery's internal temperature had jumped to 140°F. Everything indicated a short had developed in the battery and the prognosis was sure death. But then, for no apparent reason, the temperature dropped. Engineers speculate that the short might have "healed" itself by burning away from the shorting contact.

Panic button. Another panic occurred when gas pressure in the sealed battery case sank to zero. But again, in some unexplained way, the problem was corrected without a signal from earth. After that, though, the battery had clearly outlived its design intention and began to die, cell by cell.

Communications

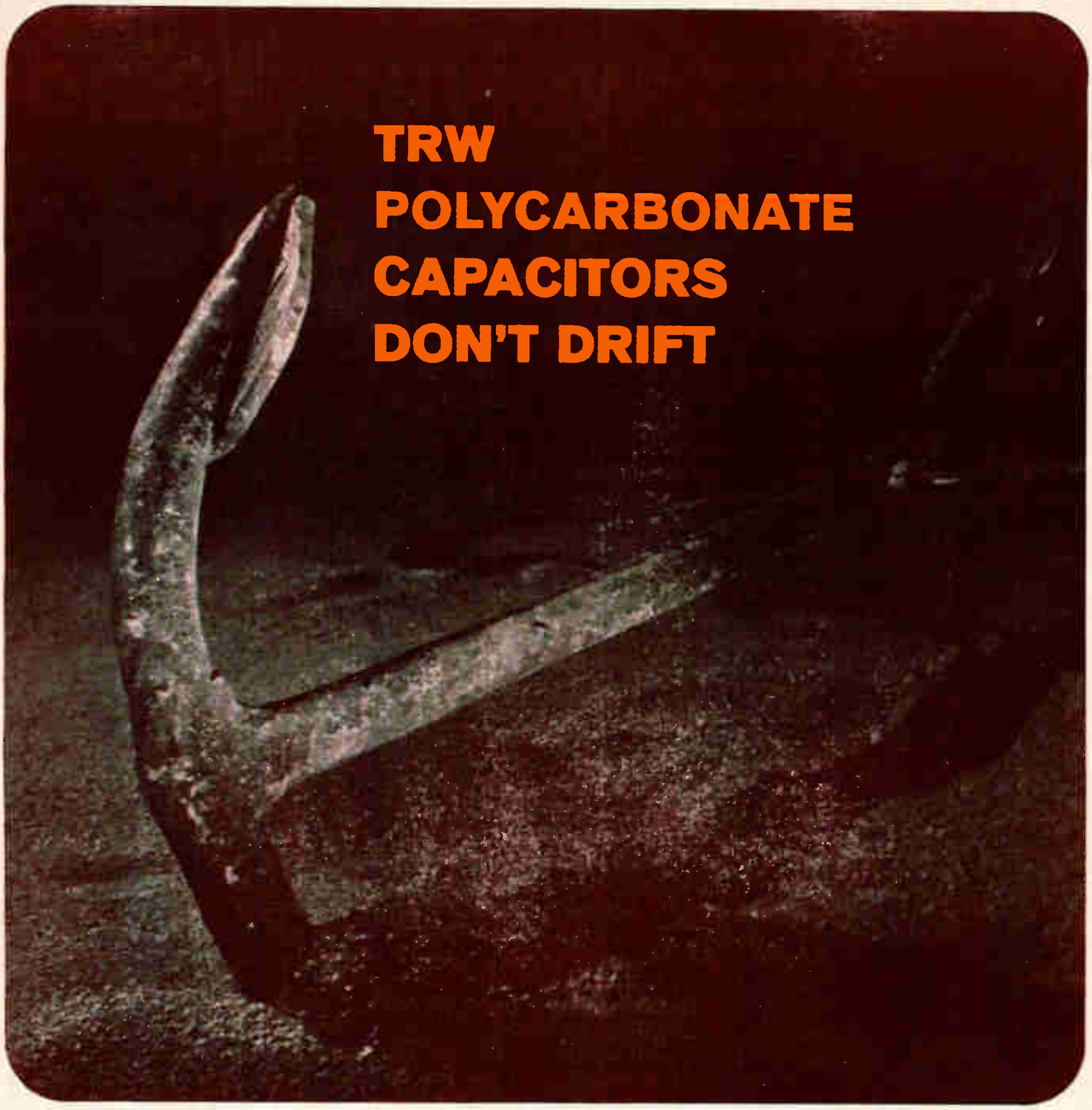
Standing firm

The pressure from the White House is intense and building steadily, but so far the Federal Communications Commission refuses to budge. Its argument: as an independent agency it has every right to rule that the Defense Department cannot sign a contract with the Communications Satellite Corp. for transpacific links—a ruling the Pentagon has ignored.

The FCC is preparing to issue formal orders later this month spelling out who qualifies as an "authorized user" of Comsat services and the "unique and exceptional circumstances" for approving other users.

So far, only the National Aeronautics and Space Administration has received FCC blessing as an authorized direct user, and then only for communications during the Apollo's assault on the moon at the end of this decade.

Hell . . . In the law that estab-



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TRW CAPACITORS

Circle 45 on reader service card

lished Comsat as a quasi-public corporation, service to the Federal Government is mentioned as one of its functions. Quips an official of the Defense Communications Agency (DCA), which initiated the controversy last May by inviting Comsat and four common communications carriers to bid for 30 channels serving the military in Southeast Asia: "Hell, we're the Government—we're an authorized user."

DCA refuses to accept an exception on narrow legal grounds, but instead wants a basic clarification of its rights. For example, it could, but won't, plead that fighting a war in South Vietnam constitutes a "unique and exceptional circumstance"; this potentially face-saving provision was promulgated by the FCC just before the Pentagon announced that it would accept Comsat's proposal over all the others.

Although Comsat's price was lower than the offers of the common carriers, the DCA maintains that it wasn't the price that swung it to Comsat—it was the urgent need for 30 reliable Pacific satellite channels early in 1967. And apparently, the DCA decided, Comsat has the inside track on such service by 1967. Under the disputed agreement, the DCA will use ground stations that Comsat will build in Japan, the Philippines and Thailand.

In a frontal assault, Gen. James D. O'Connell, director of the President's Office of Telecommunications Management, has called on the FCC to reconsider its stand and "avoid the necessity of a lengthy review of this matter in the courts and in the Congress."

The stakes. The battle does not turn on a moot legal point. At stake is whether Comsat will emerge as an independent company with its own financial route to the billions of dollars spent yearly by Government agencies on communications or whether it will be a "carriers' carrier," whose income derives indirectly from Government contracts negotiated through the carriers; obviously, the independent status is far more lucrative.

On another Comsat battlefront, the common carriers—in their battle for ownership of ground stations—have lost another supporter. Western Union International has joined the American Telephone and Telegraph Co., the Hawaiian Telephone Co. and the United States Independent Telephone Association in saying it is willing to share ownership of ground stations to be used in international communications.

The other two major carriers, RCA Communications, Inc., and ITT World Communications, Inc., largely favor individual or joint carrier ownership only. Comsat, naturally, wants sole ownership of the stations. The FCC has given Comsat sole ownership of three of them, at Andover, Maine, Brewster Flat, Wash., and Hawaii, on an interim basis. And now, it has requested permission to build stations in West Virginia and the Caribbean with a request for a station in the southwestern U. S. expected soon.

Ownership of the stations to be used in international communications may or may not set the precedent for the far more lucrative network of domestic ground stations that eventually will be built.

An FCC decision on this issue likely won't come for some months. And sources close to the dispute give Comsat the edge to win sole ownership of the international stations with a shared-ownership arrangement to come on domestic stations.

Instrumentation

Bombing circuits

Lining up a collection of electronic components near an atom bomb and then setting off a blast would be one way of testing their resistance to nuclear radiation. A more practical alternative would be to subject the components to bursts of neutrons from a generator, but up till now neutron generators haven't been able to deliver neutron bursts powerful enough to make such testing useful.

Kaman Nuclear, a division of Kaman Aircraft Corp., however, has developed a technique for producing a neutron-flux density 1,000 times greater than previously possible.

In fact, the Defense Department already is bombarding components with the new generator to determine their resistance to radiation. Pentagon engineers are subjecting active solid state components to 14 million electron volt (mev) neutron fluxes to measure their transient response.

The instrument's application is not limited to testing circuits, the producer says. It could, for example, be used to calibrate neutron detectors.

A fusion reaction. The technique for creating such a powerful, dense burst of neutrons is based on a phenomenon that has been the subject of much research but has never before been put to use—a fusion reaction in a gas of deuterium and tritium. The phenomenon was uncovered by Joseph Mather, a scientist for the Atomic Energy Commission, during work on Project Sherwood, the program aimed at obtaining a controlled nuclear fusion.

In traditional neutron generators, tritium is bombarded with accelerated nuclei of deuterium. In Kaman's generator, however, the fusion reaction occurs in a gas that is at a high temperature and pressure; with this environment, the collisions between the two elements occur 1,000 times more frequently than in the conventional generator. At the sample position of the generator, for example, densities are produced that are greater than 10^{16} neutrons per square centimeter-second.

Current pincher. The high temperature and pressure needed are created by the pinch effect. A high current (about 100,000 amperes generated by a bank of capacitors) is discharged between the walls of a gas-filled cylinder. The magnetic field created by the high current squeezes the current path into an exceedingly thin beam. The high current density causes the beam to reach temperatures of about 40,-000,000 C at a pressure of several thousand atmospheres, setting off

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INTERNATIONAL SUBSIDIARIES: GENEVA; MUNICH; GLENROTHES, SCOTLAND; TOKYO; PARIS; CAPETOWN; LONDON; MEXICO CITY the fusion reaction.

The neutron pulse width is approximately 0.10 microsecond at half the maximum density.

So far the instrument isn't for sale to industry. Kaman plans to rent it for $800 per day, plus $50 per shot.

Oceanology

Ocean view

Next month Navy researchers will anchor a 40-foot diameter electronics-crammed buoy in 18,000 feet of water off the coast of Bermuda. If the test is a success, it may prompt the Navy to seek the go-ahead for a $150 million-plus project that calls for dotting the seven seas with unattended buoys to keep a computer-controlled watch on weather and oceans.

The prototype buoy, developed and built by the Convair division of the General Dynamics Corp., will contain both environmental sensors and telemetry gear. The test is being conducted by the Office of Naval Research.

There is, however, still a question in the minds of some scientists on what is the best size for such unattended information-gathering stations—General Dynamics' "monster buoy" or smaller models also under development and test. Funds and the necessary international arrangements for the worldwide system are still a way off.

Year-long test. However, if General Dynamics' buoy is successful, Navy scientists are expected to push for funds from Congress in fiscal 1967 to start on an operational system. Their hand will be considerably strengthened if the buoy's electronics, sealed in modular packages, operates a full year without any maintenance.

While the prototype test off Bermuda will include only line-of-sight radio propagation for telemetering data 22 miles to shore-based data collectors, the final system—if it becomes operational—would be designed for 2,500-mile transmissions. The designers of the buoy's electronics subsystems decided that the transmitter in the follow-on system should operate upon command, on three or four frequencies, between 3 and 30 megahertz.

The data system will handle 100 scientific channels. Measurements will be stored in memory banks for hourly integration. The data will be telemetered in binary bits as a pulse-code modulated signal on a frequency-shift keyed subcarrier. Single-sideband radio equipment will be used with an average output of 100 watts.

Water check. The buoy will gather data on current direction and velocity, water temperature, salinity, dissolved oxygen and carbon dioxide, sound velocity, irradiance and surface-wave profiles for the oceanographers. The weatherman will get data on wind direction and velocity, air temperature, relative humidity, incident and reflected solar radiation, surface barometric pressure and precipitation.

General Dynamics has computed that an operational system in the Northern Hemisphere should consist of 333 individual stations spaced 300 miles apart. The initial cost for a system of this size is estimated by the company to be $147 million. Another $4 million would be required annually for system maintenance and operation, the company believes.

Electronics notes

▪ **Atom power.** The 15-year-old, still fruitless effort to control nuclear fusion for peaceful purposes is due for another shot in the arm. Atomic Energy Commission officials are concerned that Soviet scientists may be making more progress in the field than U.S. scientists. The experimental effort to squeeze plasma in magnetic "bottles" until the stripped nuclei get hot enough to fuse is currently costing about $20 million a year. A special study panel recently recommended doubling the effort and the AEC now is pressing that work be stepped up. With the pressure of Vietnam and social welfare programs on the Federal budget, however, the AEC's drive for more fusion research faces an uphill battle. The release of the AEC study coincides with the start of serious budget planning within the Government for the budget President Johnson will present to Congress in January, for fiscal 1968, which starts next July 1. The significance of the report is that the AEC has decided that among its research goals, fusion deserves more funds. If the Administration agrees, it will mean more money also for the range of electronic control equipment that would be required also.

▪ **Learning at work.** LTV Electrosystems, Inc., engineers will be attending graduate courses in electronics this fall—and they won't have to leave the plant. Through closed-circuit television, LTV will link its plant in Greenville, Texas, with classrooms at the Southern Methodist University in Dallas. The company, a subsidiary of Ling-Temco-Vought, Inc., will pay for the 60-mile microwave relay link. Engineers will be able to join in class discussions through an extra voice link. The company may broaden the program to include LTV plants in the Dallas area.

▪ **Vidio recorder.** The General Electric Co. will introduce a line of black-and-white video tape recorders this fall and a line of color recorders early next year. The tape decks are being produced for GE by the Sony Corp. The helical-scan units represent GE's entry into the video tape recorder business. Prices of the black-and-white recorder will start at under $850, while prices of color units will be more than $2,000. GE will produce the auxiliary equipment for the recorders: cameras and receivers.

▪ **Mars flyby.** Six experiment packages for the next flight of Mariner have been tentatively selected by the National Aeronautics and Space Administration. The Mars flyby will occur between February and April 1969. The equipment assigned to the craft includes two television cameras, an infrared spectrometer, an infrared radiometer, an ultraviolet spectrometer, a celestial mechanics package and a S-band occultation package.

■ **Out of space.** The Philco Corp.'s Western Development Laboratory is weighing the possibility of marketing to industry a modified version of the visual control panel it supplied to the National Aeronautics and Space Administration's Manned Spacecraft Center in Houston. The console would allow a person sitting at a special desk to call up data from a computer. The system would work with existing computers and would display symbols and graphs in both black-and-white and color. It eliminates the conventional television camera by directly converting digital information for viewing on the screen. Each element of the displayed image is modified in an adjacent raster storage memory. Because the raster storage is held within each individual video channel, computer instructions, such as updating and erasures, can be translated automatically into raster elements without additional programing.

■ **Circuit wrapper.** Taking a tip from the supermarket meat counter, Lockheed Electronics is now wrapping circuit boards in heat-sealed polypropylene plastic for storage and shipment. But Lockheed has gone a step further: after the wrap is sealed by a manually operated machine, manufactured by the Weldotron Corp. of Newark, N.J., a conveyor moves the boards to a heating chamber where rapidly circulating hot air shrinks the film to a skintight fit. The package, Lockheed says, is about a third cheaper than the polyethylene bags used before. In addition, the tight plastic film, either a half or three-quarters of a mil thick, is so clear that final inspection can be made after packaging. The Maywood, Calif., plant of Lockheed's avionics uses the process. Lockheed Electronics is a subsidiary of the Lockheed Aircraft Corp.

Circle 49 on reader service card

The AE Type 45 Rotary Stepping Switch can solve almost any circuit-transfer problem

There's an economical, rugged and reliable way to simplify many of today's complex switching circuits. Just replace entire groups of relays or transistors with an AE Type 45 "stepper." One of these large-size, general-duty rotary stepping switches can provide up to twelve 25-point bank levels, or up to eight 50-point bank levels.

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For helpful application information, we offer the 160-page book, "How to Use Rotary Stepping Switches." To get your copy, just ask your AE representative. Or write the Director, Relay Control Equipment Sales, Automatic Electric, Northlake, Illinois 60164.

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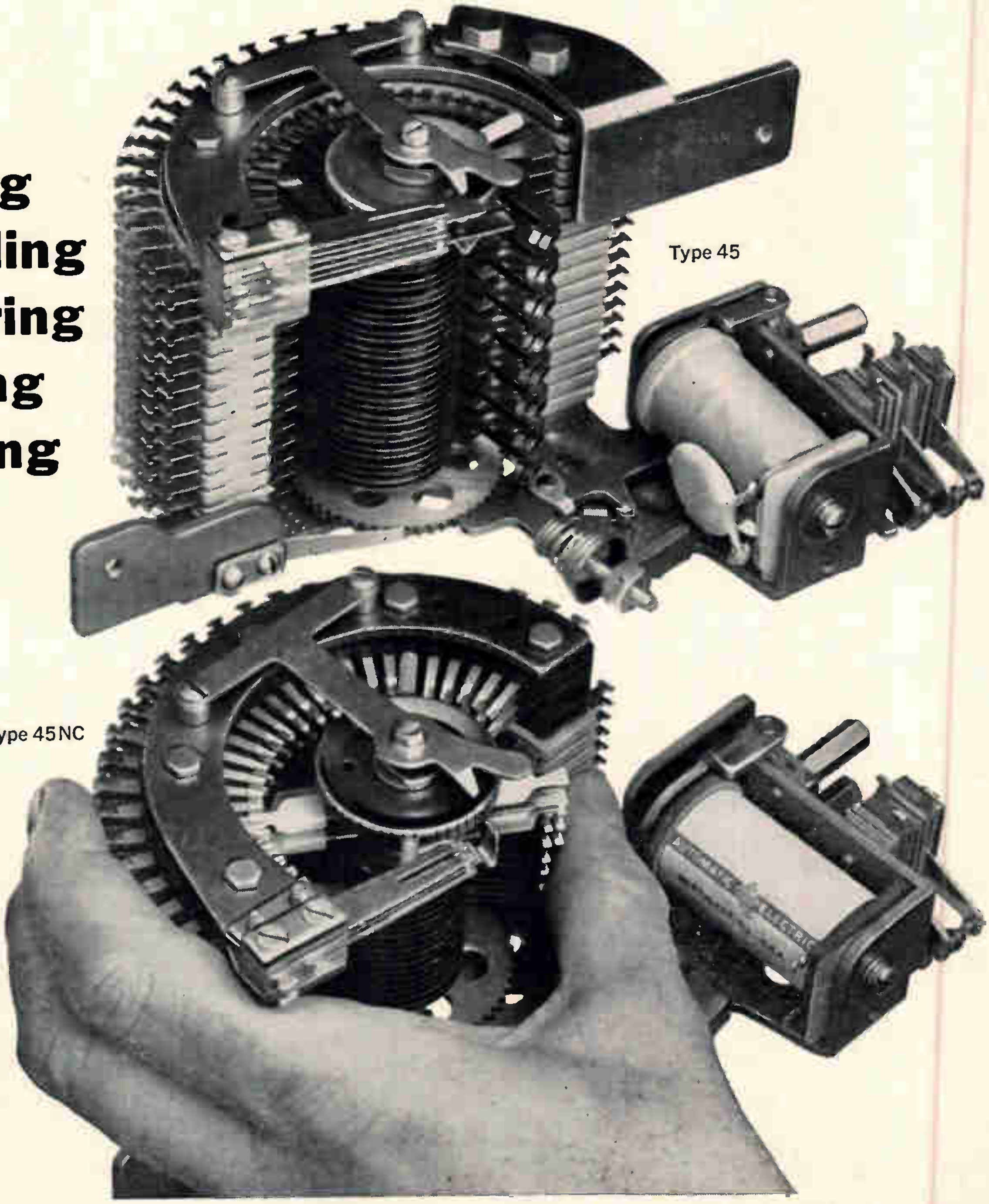

When you look at electronic components are you missing the woods for the trees?

Most engineers and buyers look first at price, performance and delivery — and then start looking for more. An increasing number of them find it at Mullard, makers of Britain's biggest range of electronic components.

That's why, for instance, there are Mullard travelling wave tubes in North American microwave links, and a 1700 lb. proton resonance magnet in Harvard's Lyman Laboratory. Apart from Mullard's R & D capability, Mullard plants are among the most efficient anywhere, with the reputation for quantity production of tight-tolerance devices to proved standards of reliability. And Mullard's experience in circuitry stems from the fact that they have the best equipped applications laboratories in Britain.

Mullard embody all their know-how in the kind of comprehensive performance specs, survey documents and applications reports that are just that much more useful to the designer. So to make sure *you* don't miss the woods for the trees, why not ask Mullard to help you with some of your component problems?

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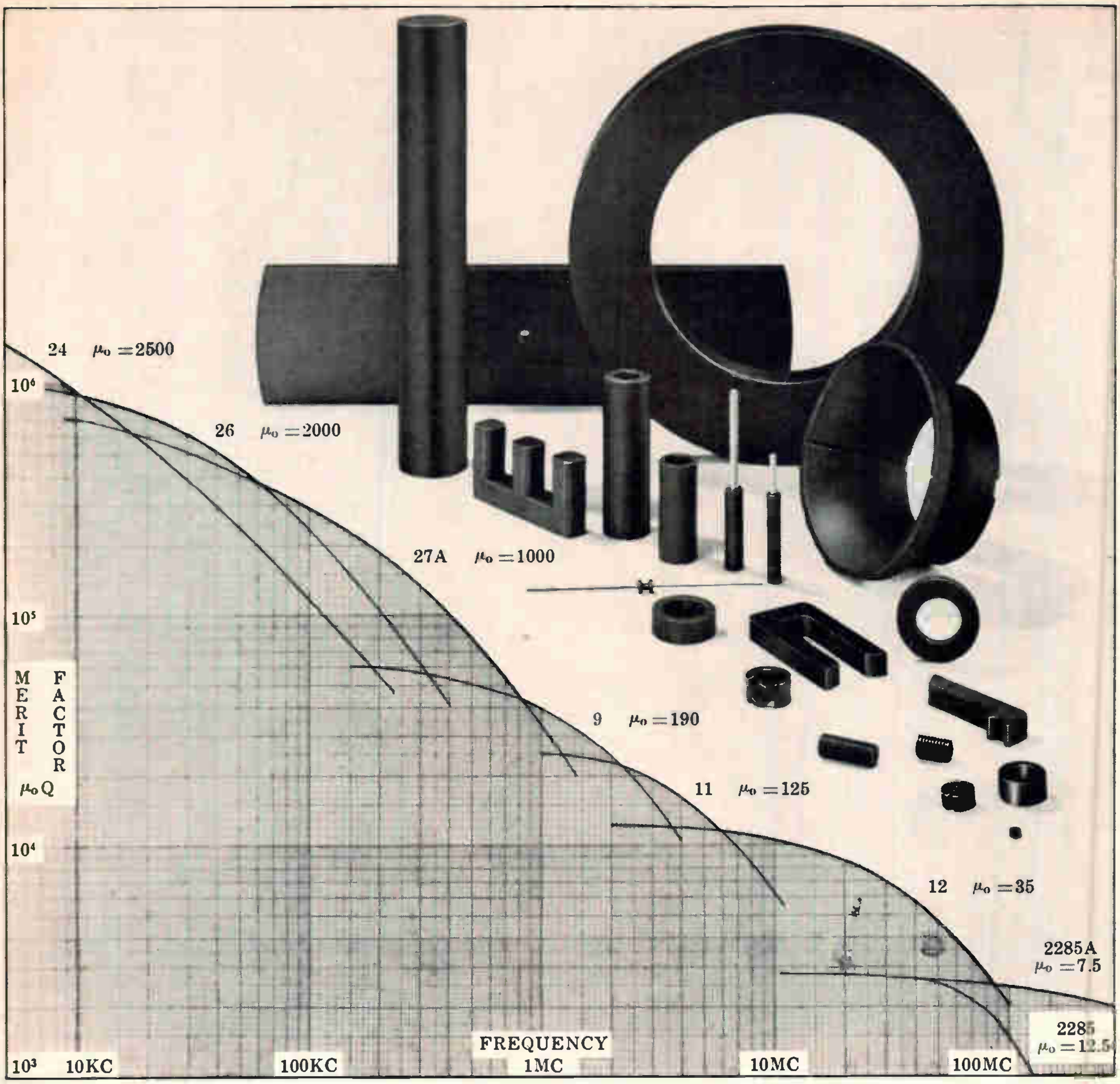

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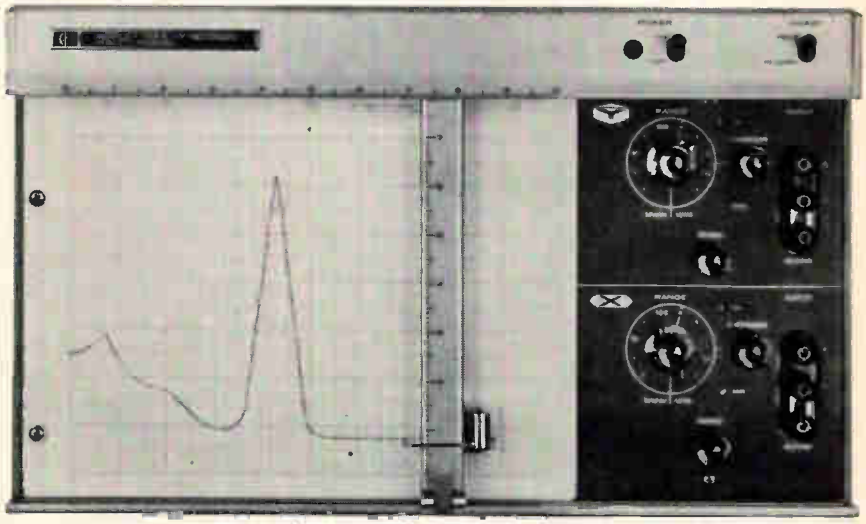

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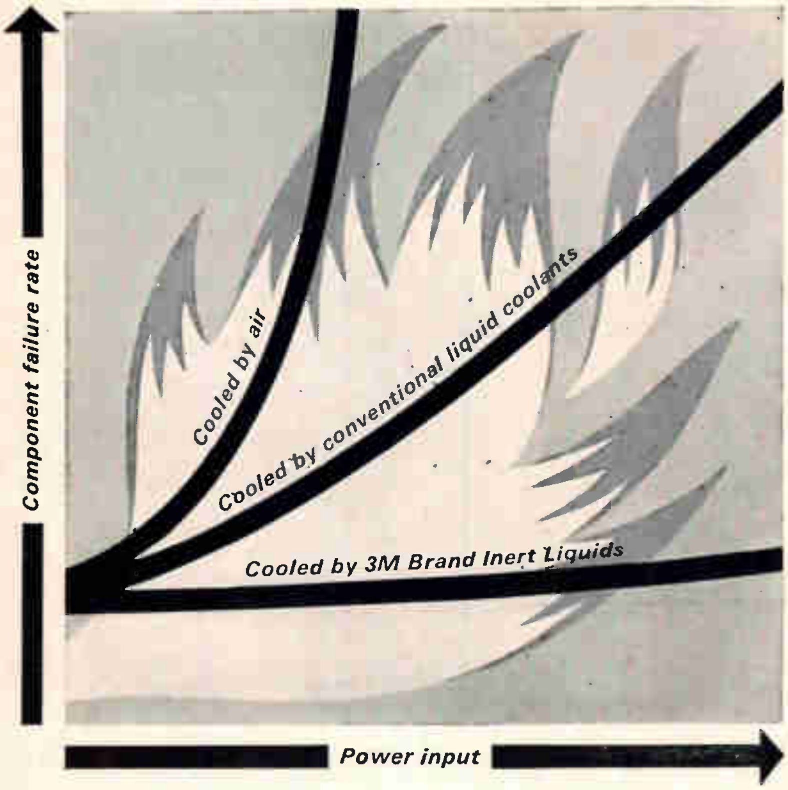

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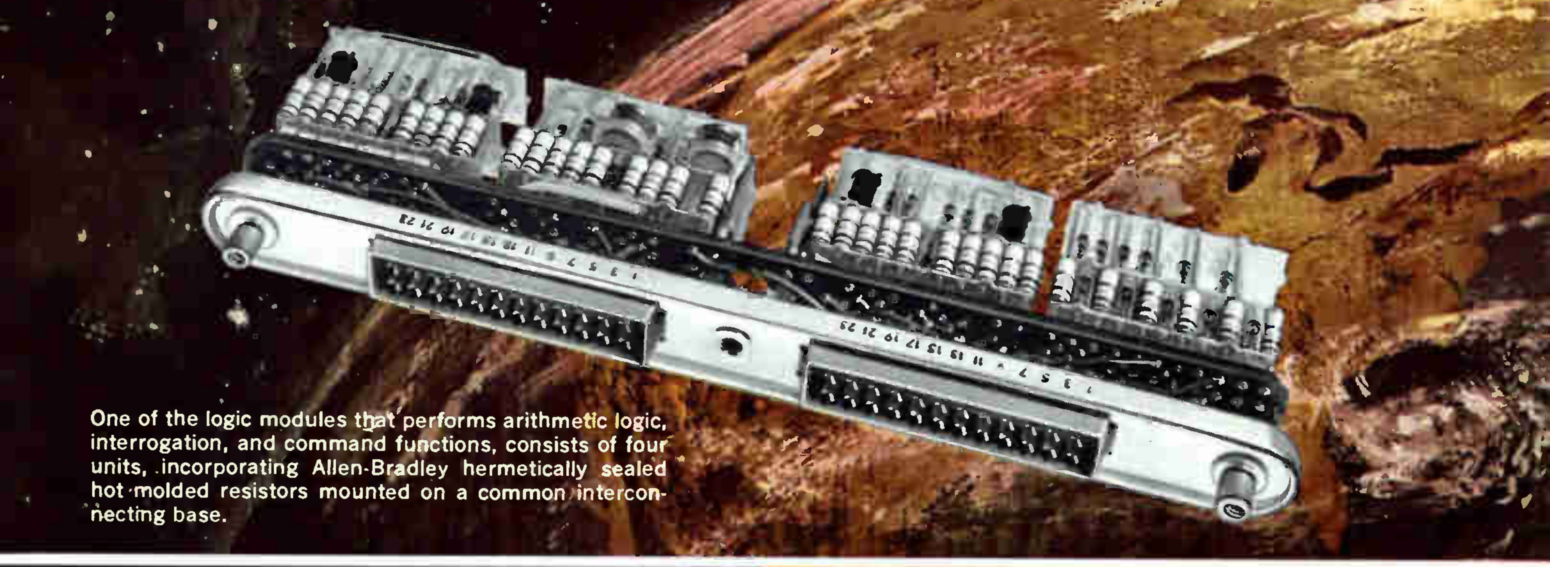
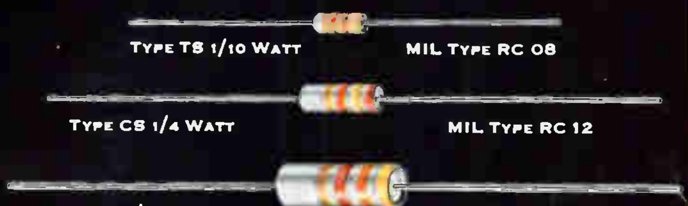
Allen-Bradley hermetically sealed hot molded resistors help guidance computer in Saturn I space vehicle put payload into orbit



One of the logic modules that performs arithmetic logic, interrogation, and command functions, consists of four units, incorporating Allen-Bradley hermetically sealed hot-molded resistors mounted on a common intercon-necting base.



HERMETICALLY SEALED HOT MOLDED RESISTORS available in all standard EIA and MIL-R-11 resistance values and ±2% or ±5% tolerances. Other than standard values can be furnished. Shown actual size.

Saturn I guidance computer continuously determined the vehicle's course to achieve orbit. In six test flights, these computers in the NASA Saturn I vehicle controlled the direction and thrust of six second-stage engines. The computer on four of the flights controlled four of the first-stage engines as well, and also timed engine cut-off.

■ From the instant of "blast-off" this guidance computer set the course of the space vehicle. The ultimate in precision was essential, for even the slightest misdirection could mean total failure. Reliability had to be maintained under hardly believable conditions of shock and vibration. Given such conditions, it is small wonder that the A-B hermetically sealed hot molded resistors were selected for this assignment.

All Allen-Bradley resistors are made by an exclusive process—pioneered and perfected by A-B—in which the resistance element and the insulating jacket are hot molded into a solid integral element. For the ultimate in environmental protection, this unit is then hermetically sealed in a ceramic tube. The hot molding process results in such exact uniformity from one resistor to the next—and from one year to the next—that long term resistor performance can be accurately predicted. Furthermore, unlike film resistors, no A-B hot molded resistor has ever been known to fail catastrophically.

For more complete specifications on the Allen-Bradley hot molded resistors, please write for Performance Specifications 5003: Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Ave., New York, N.Y., U.S.A. 10017.

These are the same hot molded resistors as used in the hermetically sealed construction described above. Shown actual size.

59-04-6E

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You'll be more fair with your customers when you permit your resistor dollar to buy for you the ultimate in dependability, performance, and uniformity of Allen-Bradley hot molded resistors. Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee, Wisconsin 53204. Export Office: 630 Third Ave., New York, N.Y., U.S.A. 10017.

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AB

ALLEN-BRADLEY

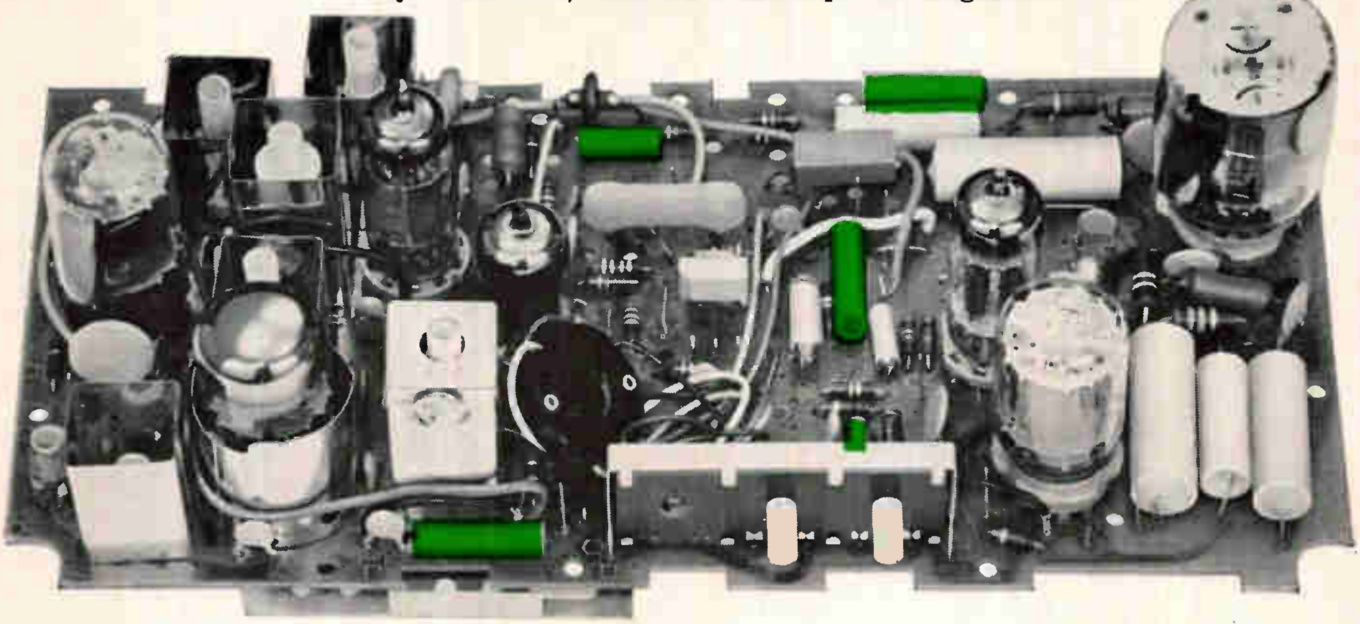
QUALITY ELECTRONIC COMPONENTS

57-12-5E

Admiral's new 9″ tube-chassis portable TV is small, but very reliable.

Capacitors of MYLAR® help make it that way.

"And they meet all standard voltage ratings up to 600 volts," says David Oliva, Admiral's Chief Components Engineer.



The new Admiral "Playmate" is America's first 9″ portable TV with a tube chassis. It weighs only 12 pounds because components were selected not only for reliability, but also for savings in size and weight. That's why Admiral Corporation chose capacitors of MYLAR* polyester film.

Mr. Oliva puts it this way: "Capacitors of MYLAR are really rugged. They meet all standard voltage ratings up to 600 volts. In our tests, they withstood rough handling, excessive humidity and high-altitude conditions far beyond anything you'd expect to find in normal TV usage. Because MYLAR has high dielectric strength in thin gauges, it makes a smaller, lighter capacitor. Compared with paper, capacitors of MYLAR give us far more reliability at the same or less cost per microfarad."

Chances are you can take advantage of the greater reliability and design potential offered by capacitors of MYLAR. For complete information write to: DuPont Co., Room 3367A, Wilmington, Delaware 19898. (In Canada: Du Pont of Canada Ltd., P.O. Box 660, Montreal, Quebec.)

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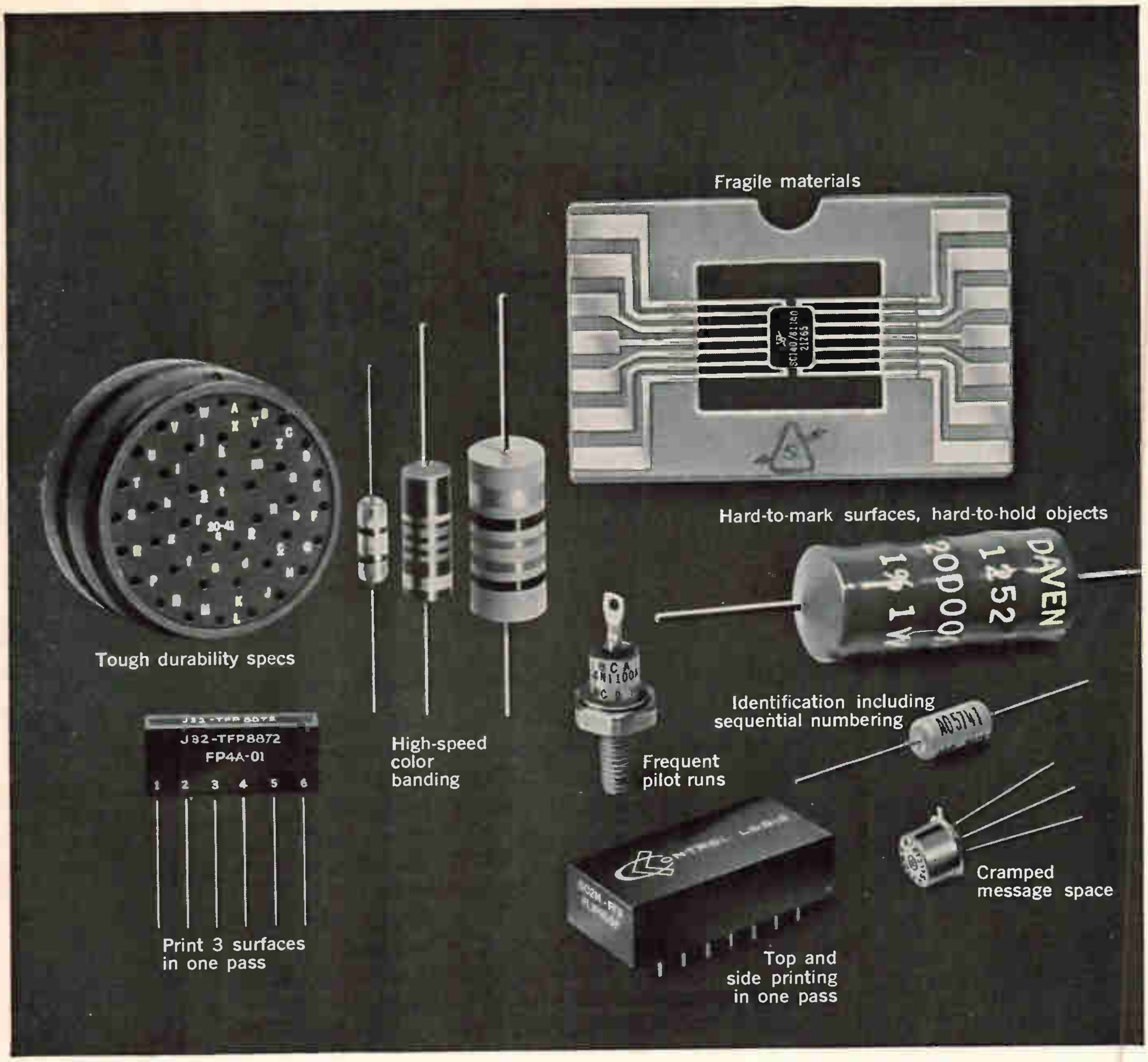

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Independent Vertical Systems use Type 1A1 or 1A2 Plug-In Units for 50 MHz operation; also accept any other 1-series or letter-series plug-ins.

Independent Sweep Systems provide 24 calibrated steps from 0.1 μs/cm to 5 s/cm; the X10 Magnifier extends the fastest sweep rates to 10 ns/cm.

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Single-Sweep Operation enables one-shot displays of normal or *delayed* sweeps.

Independent Triggering Systems provide stable displays to beyond 50 MHz. Either input signal can be used to trigger either or both time-bases.

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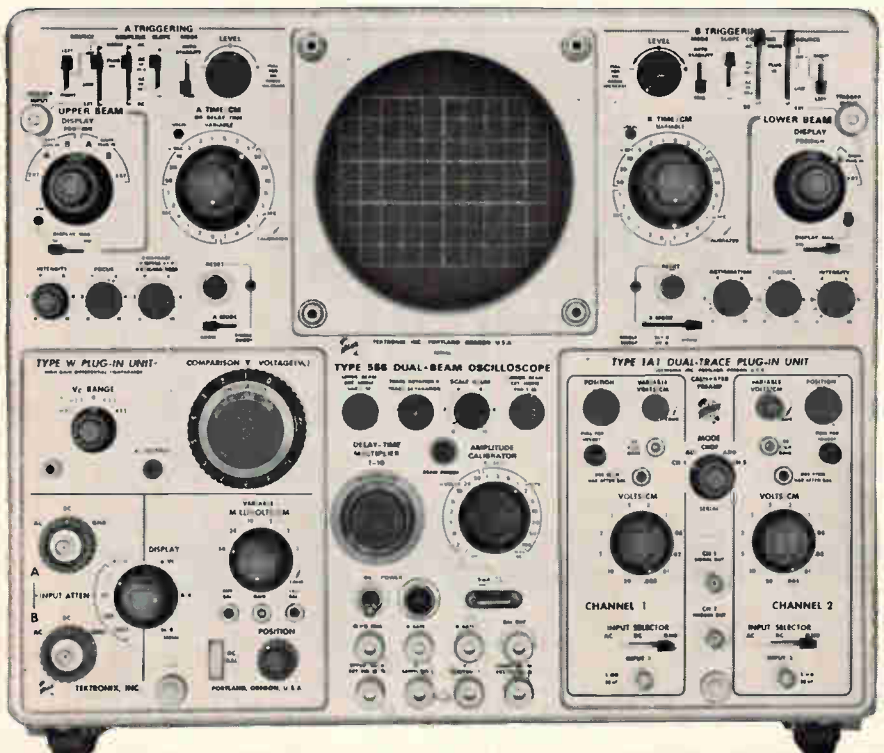
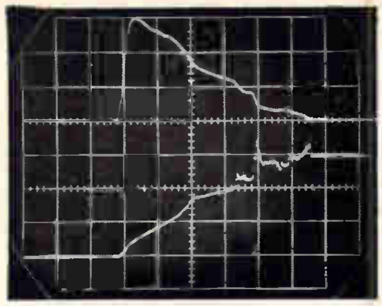
EMI (RFI) Suppression — meets interference specifications of MIL-I-6181D over these frequency ranges: 150 kHz to 1 GHz — Radiated (with CRT mesh filter installed), and 150 kHz to 25 MHz — Conducted (power line).

Size is 15" x 17" x 24".

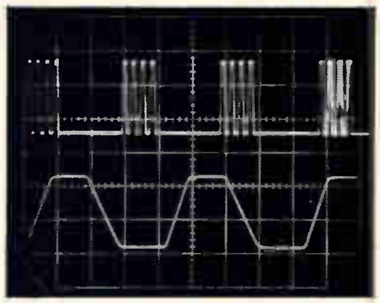
Weight is ≈ 80 pounds, without plug-ins.

Power Requirement is 100-130 V or 200-260 V, 50-60 Hz ≈ 850 watts.





Simultaneous Single-Shot Displays. Current versus voltage display of a .75 ampere, fast-blow fuse during destructive overload. Both beams are driven by B Time-Base at 50 μs/cm which is delayed by pre-triggered A Time-Base to provide base reference lines before and after the event. The upper beam shows the current waveform at 30 A/cm while the lower beam shows the corresponding voltage across the fuse at 100 V/cm.



Single-Input Dual-Beam Displays. Upper beam shows **bursts of 2.5 MHz pulses** on Time Base A with time variation between bursts. This shows up as increasing time-jitter between the first and successive bursts. The lower beam shows B Sweep (0.1 μs/cm) delayed by A Sweep and triggered on the second pulse of the last burst to provide a jitter-free expanded display of the A Sweep intensified zone. The use of only one probe and one plug-in input simplifies signal connection and provides minimum loading on the source.

Plug-ins illustrated

Type 1A1 Dual-Trace Unit . . $600 (Dual-Trace—50 mV/cm at DC-to-50 MHz, 5 mV/cm at DC-to-28 MHz. Single-Trace—500 μV/cm at 2 Hz-to-15 MHz. 5 Display Modes—Channel 1, Channel 2, Alternate, Chopped, Added Algebraically. Front-panel signal output.)

Type W Differential Comparator Unit . . . . . . $575 (*Conventional Preamplifier*—50 mV/cm at DC-to-23 MHz to 1 mV/cm at DC-to-8 MHz. Decade Input Attenuator to X1000. *Differential Input Preamplifier*—CMRR of 20,000 to 1, DC-to-20 kHz. Max. Peak Input of ±15 V, XI Attenuation. *Calibrated Differential Comparator*—Vc Supply of 0 to ±11 V. Accuracy of ±0.15% of output ±0.05% FS.)

Type 556 Dual-Beam Oscilloscope . . . $3150
Rack Mount Type R556 Oscilloscope . . $3250

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For complete information, contact your nearby Tektronix field engineer or write:
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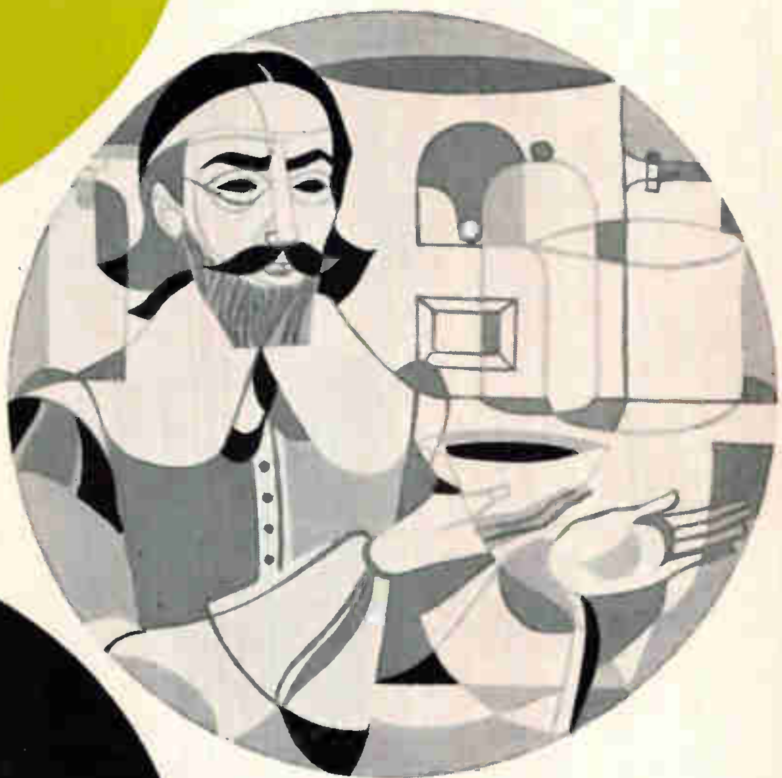
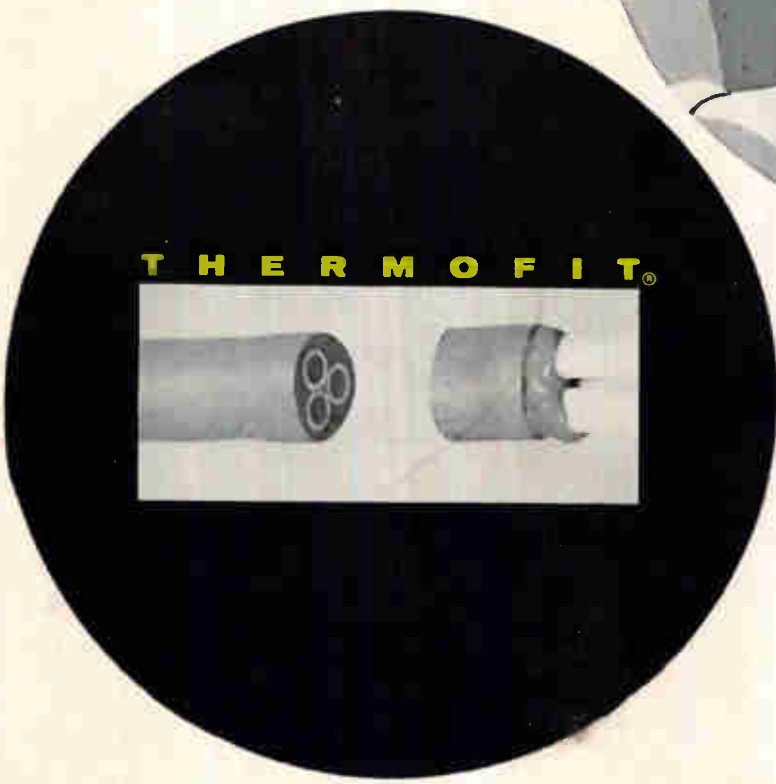
INNOVATION IS THE PULSE OF PROGRESS

In 1669 a German alchemist, Hennig Brand, made what was at that time a remarkable discovery. Following the age-old ambition of alchemists, Brand attempted to make gold from cheaper materials. In a unique experiment, he combined urine and sand and heated them together in a furnace. Although he did not synthesize gold, he isolated a soft, waxy material which fluoresced in the dark and ignited spontaneously. Brand named his new material "phosphorus" meaning, "I bear light." Thus was the element phosphorus discovered.





In 1957 Raychem pioneered a series of innovations in the field of radiation chemistry. One of these, introduced in 1962, is a heat-shrinkable sleeve with an inner wall which melts. In one operation the outer wall shrinks to form a tough, form-fitting casing while the inner meltable material completely "pots" and seals the connection or termination.

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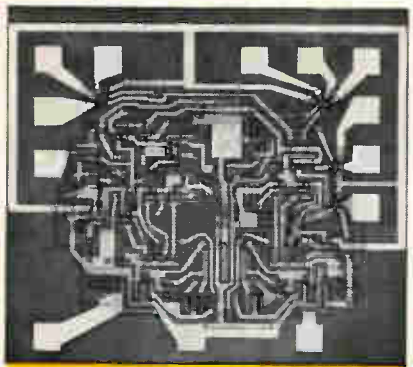
NEW functions extend state-of-the-art capabilities of versatile HLTTL series

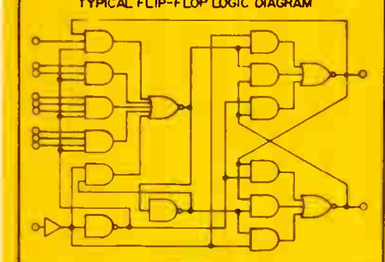


new 50mc flip-flop with OR input gating

■ Transitron's TFF3512 and TFF3514 raceless, dual-rank, high-speed "D"-type flip-flops represent a new addition to what is already the broadest line of flip-flops in a single logic family

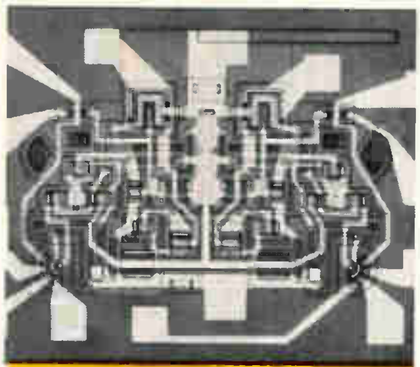
■ The new high-speed unit complements, typically, on a 50-megacycle input signal The unusually high operating speeds, which are particularly insensitive to heavy loading, have been achieved by dual steering of the second rank flip-flop.

TYPICAL FLIP-FLOP LOGIC DIAGRAM



■ A maximum of input gating is provided to simplify external gating requirements. The configuration chosen eliminates redundant inputs and the necessity of supplying the data complement to form the "set" function, thereby reducing interconnections. Connections for holding a logic "1" have also been incorporated into the flip-flop. A built-in clock buffer reduces the clock line driving requirements. Noise immunity in excess of 1.0 volt, and fanouts in excess of 15 are typical, with other characteristics and logic levels representative of HLTTL circuitry.

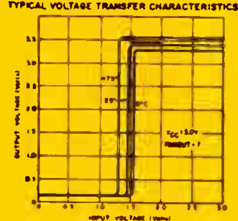
■ The high speed and extended gating capability of these units make them extremely desirable for arithmetic and general register applications.



new non-inverting gates

■ A new generation of non-inverting "AND" and "OR" gates has been added to Transitron's broad HLTTL family Developed for use in systems where simplification and higher speeds are important factors, the new gates exhibit the high capacitive drive capability, high noise margin, and high speed characteristic of the HLTTL design

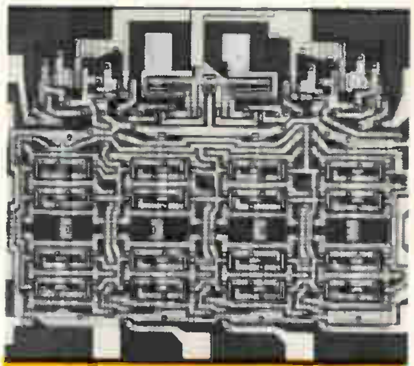
TYPICAL VOLTAGE TRANSFER CHARACTERISTICS



■ **Functions in the series include:**

TNG6222 and 6224 — Dual 4 input "AND" gate with transient control
TNG6252 and 6254 — Expandable dual 4 input "AND" gate
TNG6262 and 6264 — Expandable dual 3 input "AND" gate with transient control
TNG6522 and 6524 — Expandable single 4 input driver gate with transient control
TNG7252 and 7254 — Expandable dual 2 + 2 input "OR" gates
TNG7712 — 8 + 3 input expander gate
TNG7812 — 4 + 4 + 3 input expander gate
TNG7912 — Dual 2 + 3 input expander gates

■ Extremely sharp voltage transfer characteristics are provided by the series, resulting in noise margins typically in excess of 1.3 volts. Fast charge removal from the output transistor provides the ultimate in reduction of supply current during switching. Double inversion is utilized to provide the non-inverted feature with no sacrifice in propagation delay. Typical propagation delay times are 12 nanoseconds with 15 pf load and fanout of 1 Some of the circuits offer the possibility of controlling output transients through the use of an external capacitor This is particularly useful in applications where length of interconnections would result in excessive noise coupling.



new 16-bit memory cell

■ A new 16-bit, bit-oriented, non-destructive readout, integrated circuit memory cell utilizing HLTTL technology is now available from Transitron for "scratch pad" memory applications.

■ The new memory cells, designated TMC3162 and TMC3164, consist of 16 two-transistor flip-flops arranged in a 4 X 4 matrix which provides the information storage Two write amplifiers and two sense amplifiers are also built into the element. Extremely high speed operation is achieved through a unique circuit design. The unit exhibits delay times of less than 20 nanoseconds between addressing and writing or sensing. Both data and data complement are available at the sensing terminals, which can be paralleled with those of similar units to form larger arrays.

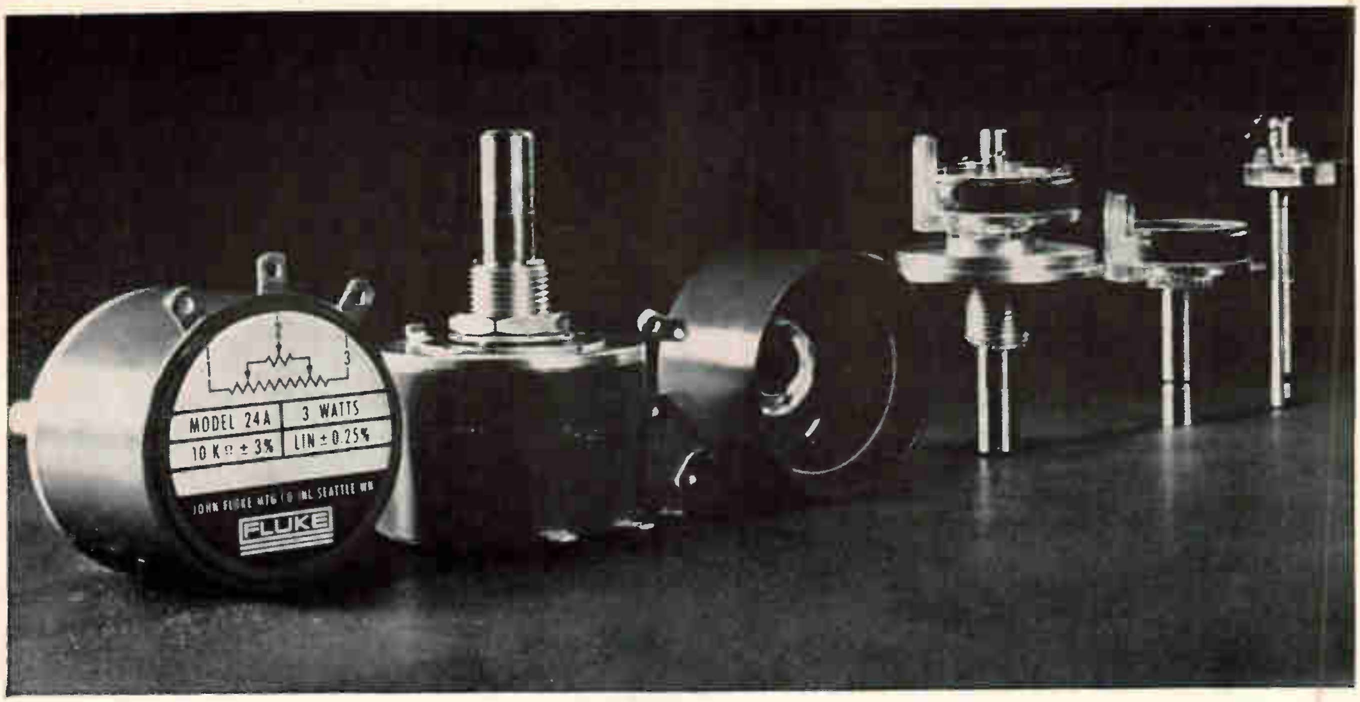
■ The memory cell operates from a nominal supply voltage of 5 volts with addressing, writing and sensing voltage levels compatible with HLTTL logic circuitry Typical high noise margins are in excess of 1.0 volt.

PACKAGING — All of the new HLTTL units shown here are available in a 14-lead flat package (designated by the suffix "F" added to the type number), or a 14-lead dual in-line package (suffix "P" added to type number).

NEW LITERATURE — Write today for complete specifications and details on these new additions to Transitron's broad HLTTL line.

Transitron electronic corporation
Wakefield. Massachusetts

Circle 63 on reader service card



If you could take 8½ turns off your 10 turn precision pot and still get higher resolution, better terminal linearity, five times faster setting, smaller size, lower price, and meet MIL spec requirements...

If you could, you would, wouldn't you?

Precision potentiometer technology hasn't changed much in the past few years... that is except for our new Model 24A Vernier Precision Potentiometer.

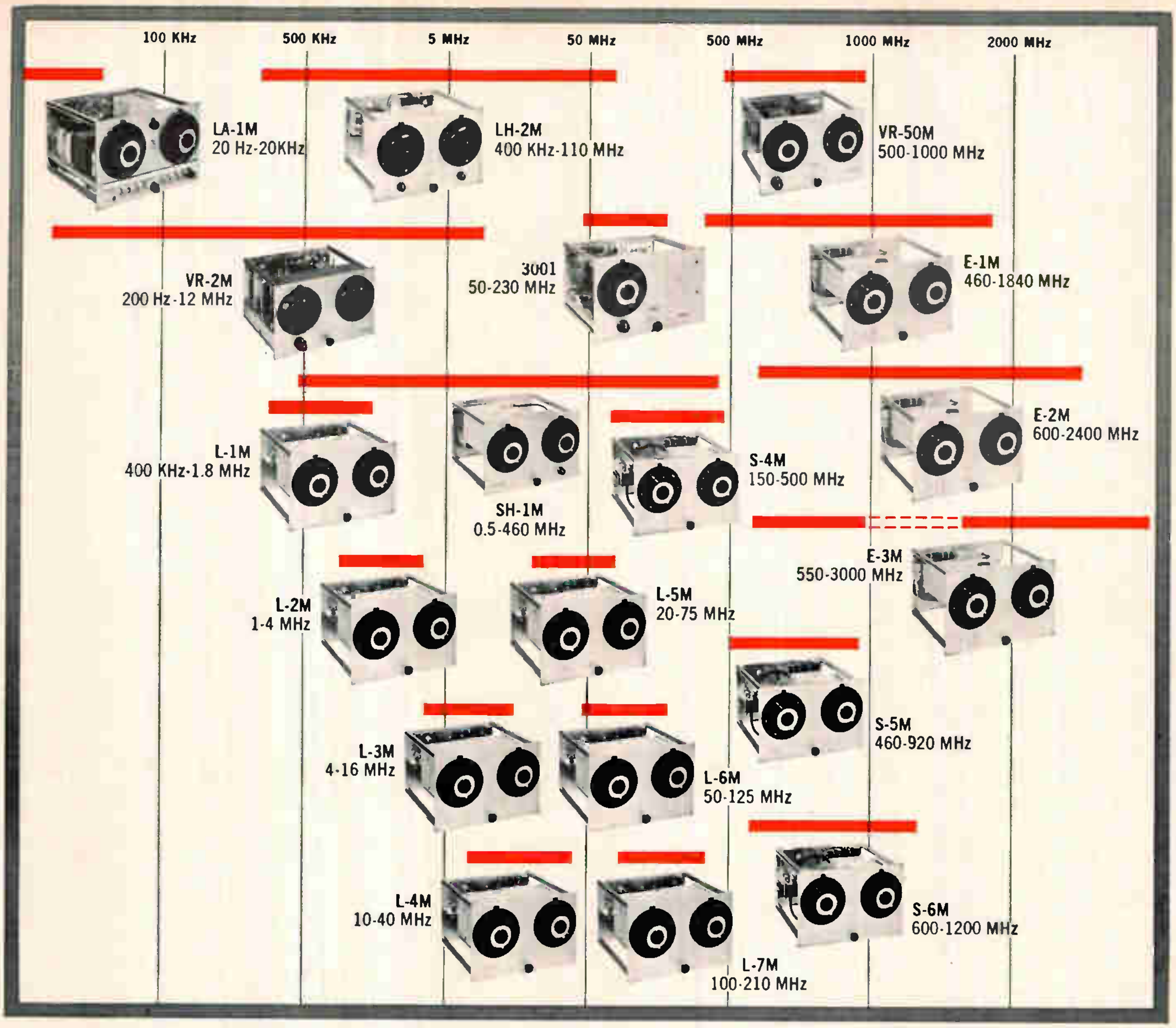
This unique device offers better resolution than any pot of comparable size and price. Terminal linearity is excellent with no offset at either zero or 100 per cent. Noise is less than 100 ohms ENR. End resistance is less than 1 ohm. Over a wide frequency range, there is zero phase shift (analog computer designers, please note).

We've built this pot to take the gaff too. The case is quality glass filled diallyl-phthylate. Anti-rotation plates are supplied for optional use. Terminations are welded. The bushing is an integral part of the front plate, which eliminates installation damage. Shafts are fully supported on both ends. The vernier pickoff uses bifurcated contacts. Molded terminals will not loosen or turn.

Cost is low, $8.50 for single units (quantity discounts apply).

Write for complete information. Please address Frank Partin, P. O. Box 7428, Seattle, Wash. Telephone (206) PR 6-1171.

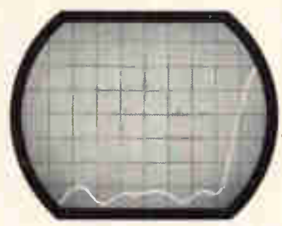
FLUKE



Frequency–From 19 Points of View

The benefits of swept frequency measurement in terms of quicker testing and more precise answers easily justifies the employment of a Sweep Generator in both lab and production applications. Now, Telonic's SM-2000 Sweep Generator (left) offers these benefits in a configuration that gives the instrument maximum versatility at a low equipment investment. The SM-2000 accepts the 19 different oscillators, shown above, ranging from the LA-1M that covers 20 Hz to 20 KHz to the E-3 that goes to 3120 MHz. The entire spectrum from DC to 3 Gc can be viewed with as much detail as needed. In some cases a whole octave may be displayed on the scope at one time.

The SM-2000 Sweep Generator provides the method, the machinery, and the flexibility for a myriad of frequency measurement applications. Your local Telonic representative would be glad to show you how.



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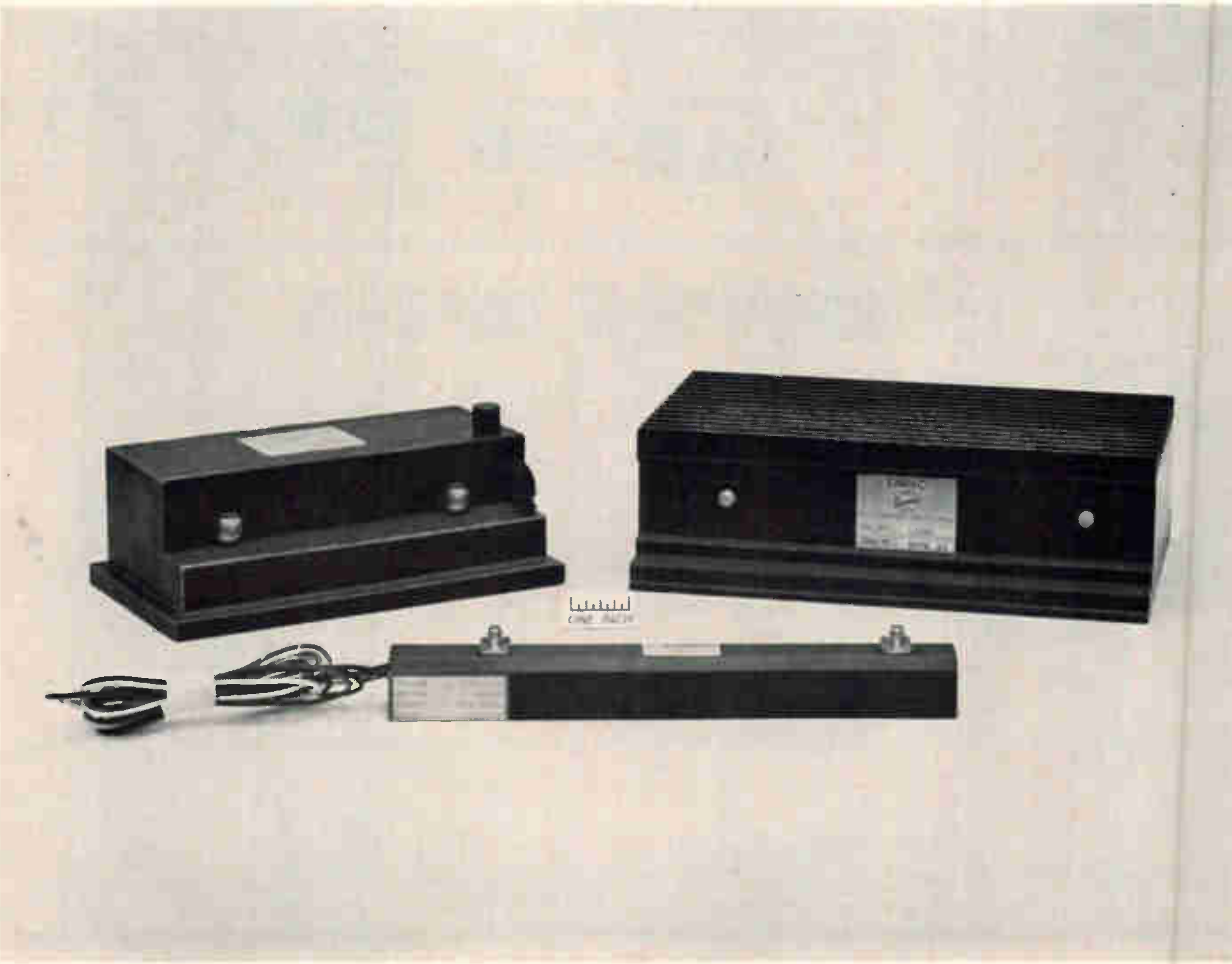
EIMAC announces next-generation TWT/power packages for radar augmentation

Here's a new family of miniaturized lightweight traveling wave tubes and power packages from Eimac. They're designed to answer your needs for radar augmenters. These next-generation packages provide power from 2 to 20 watts, and instantaneously amplify any frequency from S through X bands. All incorporate PPM-focused high performance TWT's providing high gain consistent with minimum size and weight. Tubes are available with depressed collectors for increased efficiency, and meet environmental specs for missile applications. No temperature compensation is required for operation at −54° to +74° C. Write for complete technical and applications information.

CHARACTERISTICS (MINIMUM)

Package type	EM-1184	EM-1186	EM-1193
Frequency (Gc)	5-11	8-12	2-4
Power output (watts)	2	20	5
Small signal gain (db)	60	60	50
Tube type	X-1044	X-1056	X-1061
Dimensions (in) (Tube/Package)	6x3x10	6x3x12	6x3x10
Weight (lbs)	7	8	7

EIMAC
San Carlos, California 94070
A Division of Varian Associates



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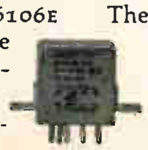

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They're remarkably reliable, too. When the armature steps the wiper assembly to the next position, it also *locks* the rotor. Overthrow is impossible, thanks to this *positive positioning*—a unique AE design feature. There are no armature pawl stops to wear out, or get out of adjustment. Also... improved shock-resistant spring assemblies; excellent low-maintenance record.

You can get these AE compact stepping switches in numerous variations—many available directly from stock. If you need a "custom" variant, we can tailor it to your specifications, quickly and economically.

For helpful application information, get the 160-page book, "How to Use Rotary Stepping Switches." Just ask your AE representative, or write Director, Relay Control Equipment Sales, Automatic Electric, Northlake, Ill. 60164.

(A) TYPE 40 No bigger than a pack of king-size cigarettes. A decimal switch with up to five bank levels—but only 10 points per level. Eliminates extra steps when counting decimally.

(B) TYPE 80 A decimal switch with a larger capacity than the Type 40. From six to twelve 10-point levels.

(C) TYPE 44 Available with up to eight 10-point levels—or 11 points on all levels where specified.

(D) TYPE 88 A larger-capacity version of the Type 44, with up to twelve 11-point levels where specified.

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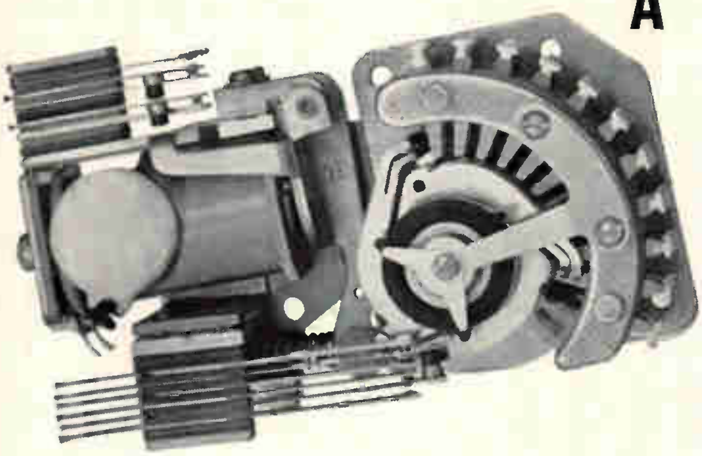
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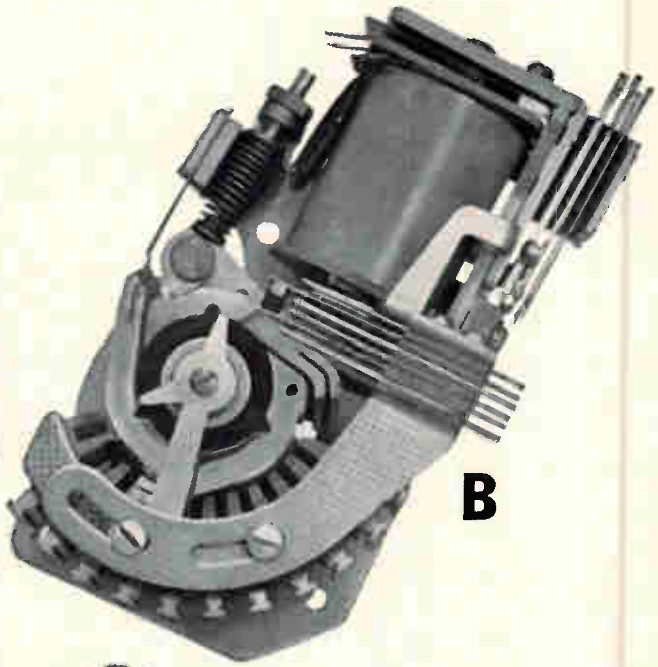
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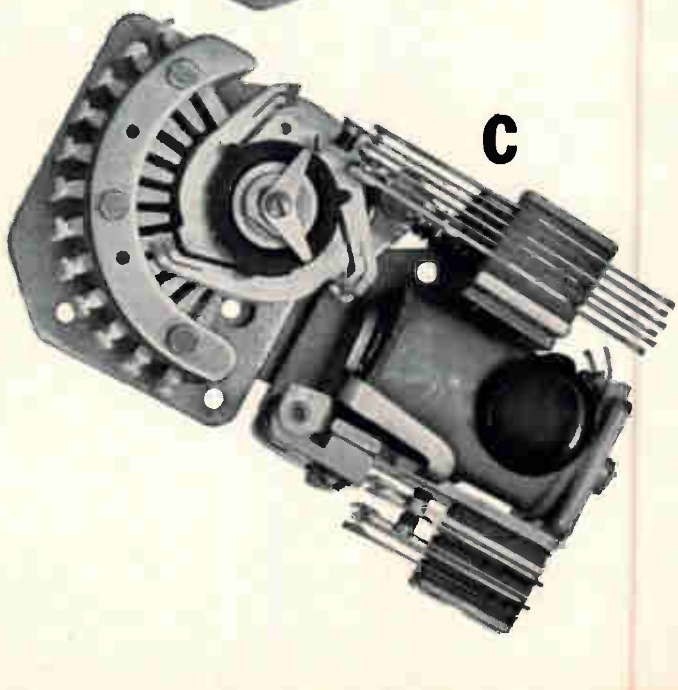
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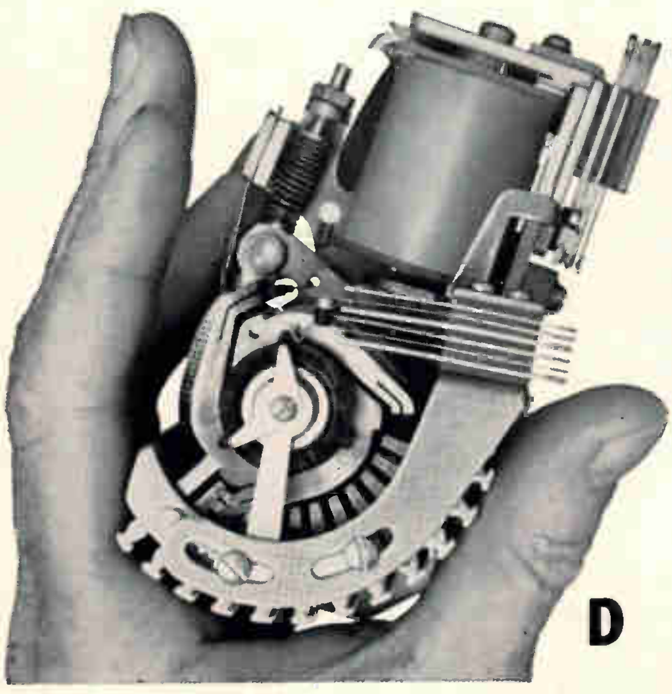
D

Spectrol pots that meet MIL-R-12934D...

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Model 121	**Model 301**	**Model 501**	**Model 801**	**Model 191**	**Model 701**	**Model 401**	**Model 871**
(RR1100)	(RR2000)	(RR1000)	(RR2100)	(RR1500)	(RR0900)	(RR3000)	(RR1600)
Meets	Meets	Meets	Meets	Meets	Meets	Meets	Meets
MIL-R-12934D!	**MIL-R-12934D!**	**MIL-R-12934D!**	**MIL-R-12934D!**	**MIL-R-12934D!**	**MIL-R-12934D!**	**MIL-R-12934D!**	**MIL-R-12934D!**

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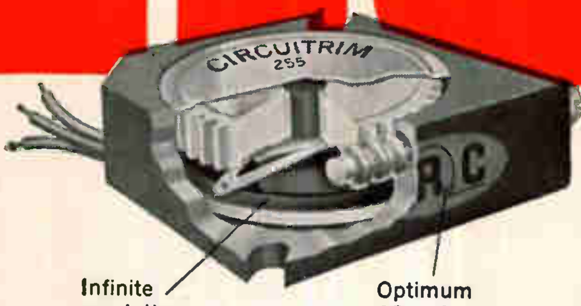

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MIL performance at industrial prices

Value engineered for precision and economy, these new CIRCUITRIM trimmers offer upgraded circuit performance for industrial applications and considerable cost savings for military equipment.

METAL GLAZE TYPE 255 is built to specifications of MIL-R-22097, RJ22 style. It offers essentially infinite resolution, higher resistance values and excellent high frequency characteristics.

WIREWOUND TYPE 205 is built to specifications of MIL-R-27208, RT22 style. Designed to "set and forget," it offers wirewound stability and indestructible silver brazed terminations.

Increased reliability results from simplified design and IRC's years of experience in building high-quality trimmers. High-temperature thermosetting plastic housings are moisture sealed, and resist effects of automatic soldering and cleaning. Choice of terminations. Write for data and prices. IRC, Inc., 401 N. Broad St., Philadelphia, Pa. 19108

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Wirewound or infinite resolution elements

CAPSULE SPECIFICATIONS

	TYPE 255	TYPE 205
POWER:	¾ watt @ 70°C	1 watt @ 70°C
TEMPERATURE:	−55°C to 150°C	−55°C to 150°C
RESISTANCE:	100 ohms to 1 meg.	10 ohms to 50 K
TOLERANCE:	±10% std., ±5% and ±20% available	±5%

IRC®

Circle 71 on reader service card

Washington Newsletter

July 25, 1966

Red missile woes pose questions . . .

Electronic countermeasures and evasive tactics used by American aircraft over North Vietnam increasingly expose the shortcomings of the Soviet-built SA-2 surface-to-air missile. But the U.S. success also raises some important questions:

Do comparable U.S. antiaircraft missiles have the same inherent weaknesses? Will the Soviet's acute embarrassment over the SA-2 performance induce them to put the later-generation, improved SA-3 to test in North Vietnam?

There is some speculation—but so far no evidence—that the Soviet may supply SA-3 to the North Vietnamese. This is a missile with an on-board guidance system; it doesn't have to be guided to the target by ground-based radar. It's effective at low altitudes.

As American air attacks have moved to fuel depots in the heart of Hanoi and Haiphong, the firing of the radar-guided SA-2 has increased substantially. But jamming techniques and quick dives away from the missiles at high altitudes—where their lessened thrust slows reaction capability—have held American losses to only about 15 planes in some 300 missile encounters.

The U.S. employs a number of aircraft, principally the EC-121 Warning Star, as well as ground stations to gather real-time electronic intelligence on North Vietnam's radar warning net and its missile radars. So-called Pathfinder planes accompanying attack aircraft then use this information to jam and confuse the radar.

. . . do our missiles hit the target?

Their success has been so striking that the Army in recent weeks has tested the Douglas Aircraft Co.'s Nike Hercules, a comparable radar-guided, high-altitude antiaircraft missile, to see how well it would stand up against planes using the same countermeasures. Officials report that in most cases the American missile succeeded in getting through to its target. Exactly how is a secret.

The Army, meanwhile, is moving ahead with development of a replacement for both the Hawk and Nike Hercules. It expects early next month to select two and maybe three contractors from a field of four competitors for contract-definition work on the SAM-E air-defense missile to be operational in the 1970's. Competitors whose precontract-definition proposals are now under study are the General Dynamics Corp.; the Radio Corp. of America and the Beech Aircraft Corp. as a team; the Hughes Aircraft Co. and Douglas Aircraft as a team; and the Raytheon Co. and the Martin Co. as a team.

McNamara to cut production rates for weapons in 1967

Manufacturers of the Bullpup air-to-ground missile and the Shrike antiradar missile, as well as fuse makers, will be affected by Defense Secretary Robert S. McNamara's decision to scale down production ratios of air munitions in 1967.

No contracts will be canceled, nor will the accelerated production of weapons required for the Vietnam war be slowed for the remainder of this year. But starting in early 1967, McNamara will level off production rather than let it climb to the high level he once thought the war would require.

Two factors are behind his decision: consumption of air munitions in Vietnam is running below projections and production is moving faster than originally expected.

McNamara's action means that once-planned additions to existing contracts won't materialize, extra work shifts won't be needed and further expansion of production lines won't take place.

McNamara is considering a similar scaling down of long-range production rates for aircraft, helicopters and ground munitions.

A cutback in the production rate for the Shrike could be academic because the missile may soon be eliminated from the Defense Department's weapons arsenal [see next story].

Pentagon seeks to replace Shrike missile

The Defense Department is looking for an interim antiradar missile to replace the Navy-developed Shrike which performed disappointingly in Vietnam. The interim missile will be used until a more advanced weapon, the ARM-1, is ready. The ARM-1 is now moving from the research stage.

A choice will be made between converting the Hughes Aircraft Co.'s air-to-air Falcon and the General Dynamics Corp.'s surface-to-air Standard to the antiradar role. The Pentagon's research and engineering office and Navy and Air Force officials will make an evalution that may include a competitive shoot-off.

The Shrike's main drawback is it strays off course if the enemy target's radar emissions are suddenly switched off. It also lacks the required range, speed, destructive force and reaction capability.

Do patents foster monopolies?

The Justice Department has begun a broad investigation to see if patents are being used to violate the antitrust laws. Assistant Attorney General Donald F. Turner plans to focus the probe on two or three industries, but hasn't selected them yet.

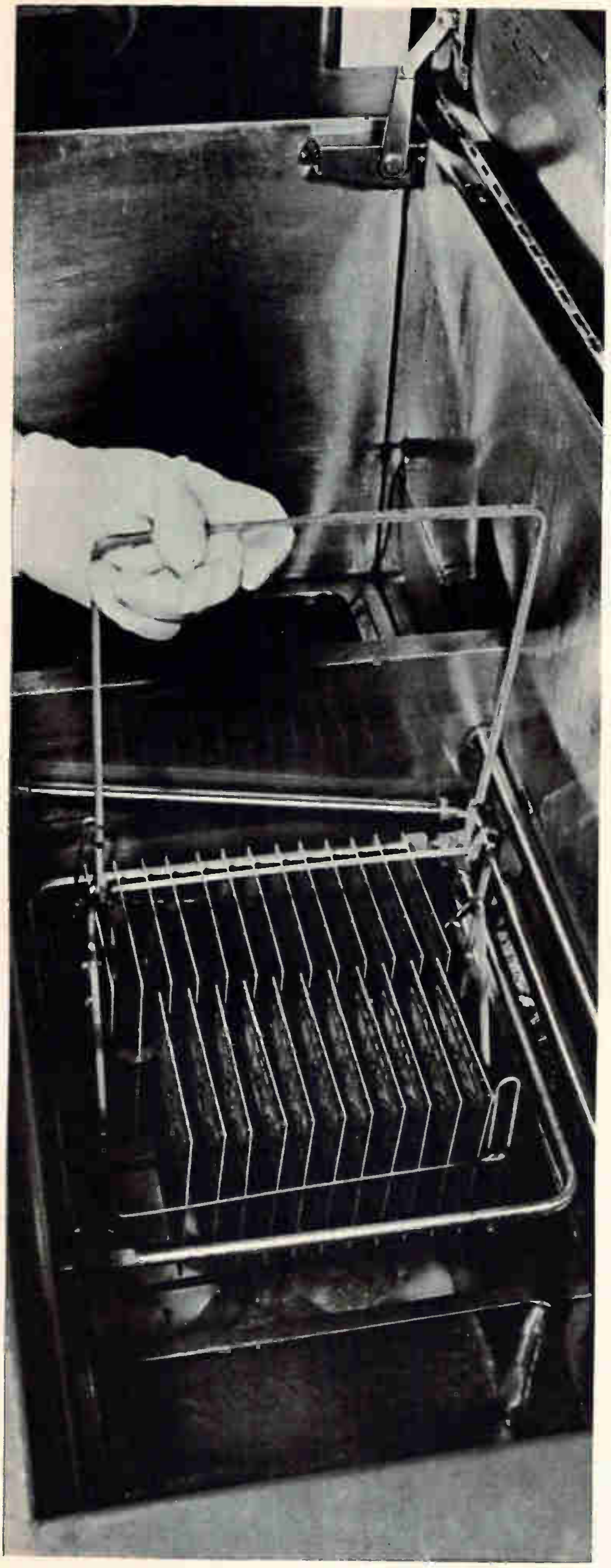
Turner takes a dim view of the patent system, and in a Supreme Court case last year expressed doubt that the system provided an incentive to invention. Later, in a discussion at George Washington University, Turner remarked that a law requiring a company to license its patents might not be a bad idea.

Inflation may give bloated reading to R&D spending

Federal planners suspect that, contrary to earlier beliefs, actual research-and-development spending by the Federal Government may have been shrinking in recent years. By taking into consideration the rising cost of living, the planners calculate that $3 billion worth of inflation may be built into the reported $7-billion growth in Federal R&D spending since 1961, and may actually represent a cutback of as much as $500 million a year.

The figures, all tentative, emerge from an experimental index being developed by the Bureau of Labor Statistics for the National Science Foundation. The bureau applied cost-of-living indexing practices to some Army in-house and contracted expenditures to see if indexing can be applied to research-and-development outlays. They found, initially, an almost 5%-a-year cost increase in Army operations and a 2.5% increase in contractor costs.

The National Science Foundation's figures on Federal R&D outlays are used by most Government planners in computing research levels. A new way of determining these figures could have a significant effect on future research budgets. For example, they may provide the argument for boosting R&D spending.



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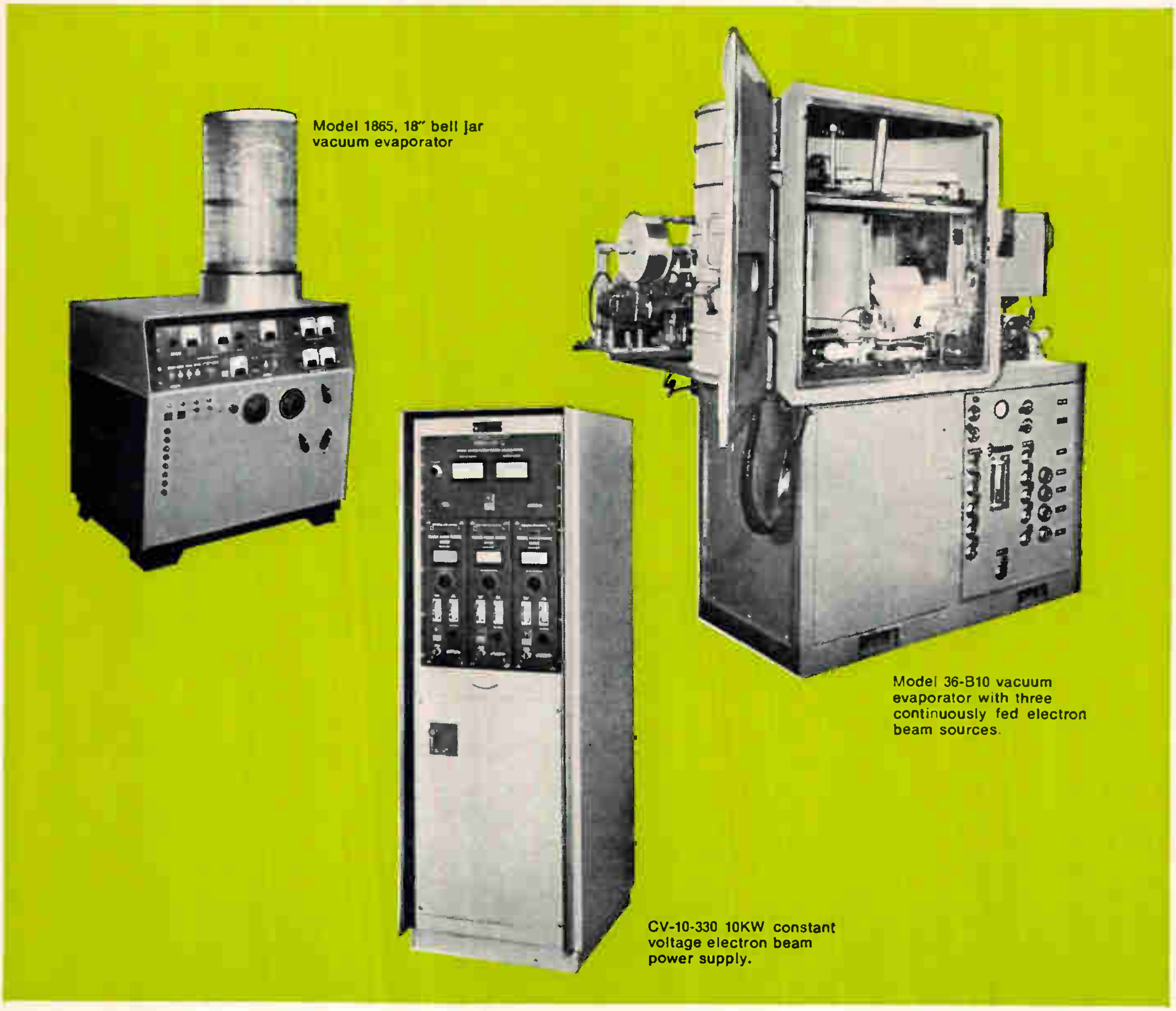

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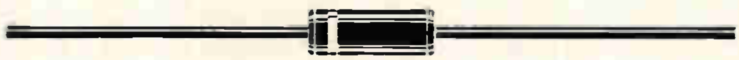

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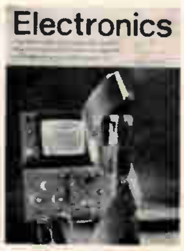
Technical Articles

Holography's practical dimension: page 88

Although the potential for three-dimensional entertainment exists, the real value of holography now is as a research tool to study vibration patterns, the effects of stress and to examine microscopic depths. One of the nation's best-known holography experts describes the theoretical background of the hologram and how it can be applied in a variety of studies.

A solid state 50-Mhz oscilloscope: page 95



Developing a new high-frequency instrument, engineers devised a way to make a small and fast delay line with stripline techniques. And they also developed a compact cathode-ray tube. Both developments may be useful in other instruments. For the cover, photographer Norton Pearl shot the scope with its new delay line spiraled around the compact cathode tube to show off its stripline construction.

Messages sent in symbols will link troops: page 108

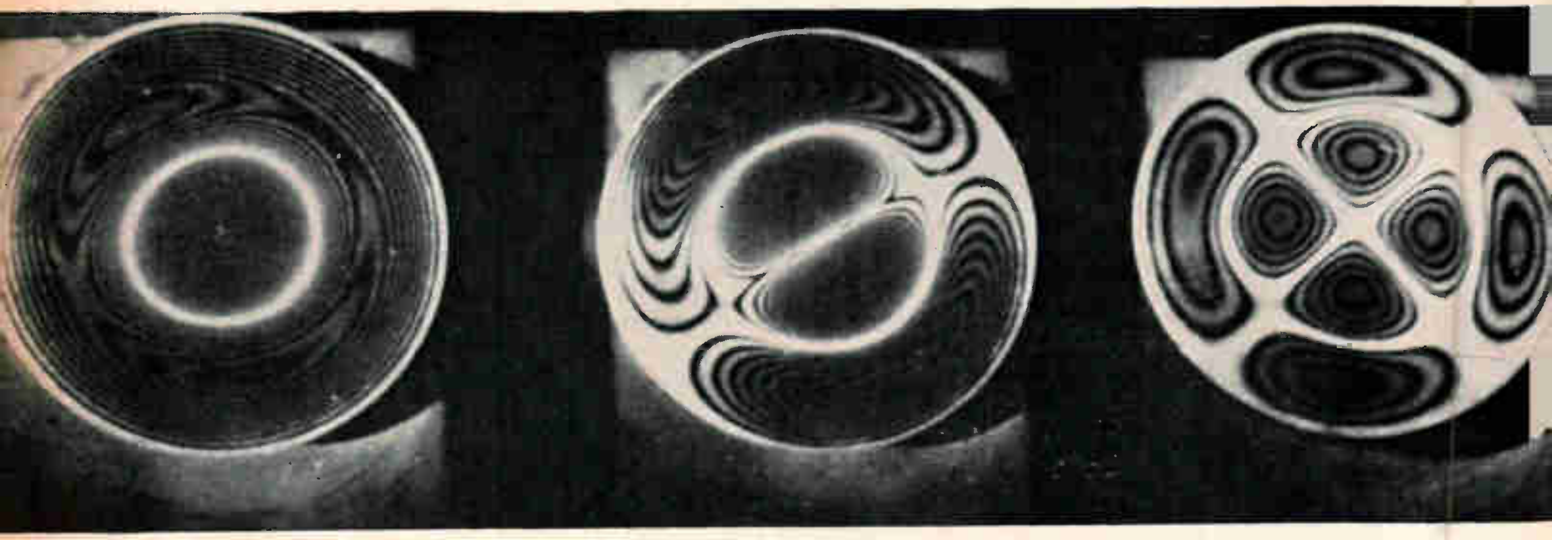
A new encoder-decoder for military communications is small enough to be carried even into jungles by infantrymen. It allows troops of different nationalities to talk to one another with symbols, overcoming language barriers. Working with the Army's manpack radios, the coder makes each unit a telemetry system with a transceiver display.

Gold-plated nickel wiring debugs parallel-gap welding of IC's: page 115

In principle, parallel-gap welding has always been a superior way to bond integrated circuits to printed circuit boards but, in practice, many flaws developed because of minor inadequacies of materials and methods. A basic change of material has now removed the shortcomings.

Coming August 8

- The boom in the West
- Avalanche transit diodes
- IC's go commercial in f-m receivers
- A new approach to making multilayer boards
- Opinion: A journey to Eastern Europe



Fringe patterns on the holographically produced image of a membrane give insight into stresses caused by vibration.

Advanced technology

Holography's practical dimension

Glamorous potential for three-dimensional entertainment exists, but the immediate application for wavefront reconstruction lies in its capabilities for scientific investigation

By Emmett Leith
The University of Michigan, Ann Arbor

Holography — three-dimensional imaging without lenses—may not soon produce dancing figures in 3-D television, but as a research tool, its value is here and now.

Wavefront reconstruction, which is what holography essentially is, eliminates spherical distortion, creating solid images in space.

It promises to improve motion and vibration studies, because in wavefront reconstruction the entire vibrational pattern of even complicated, diffusely reflecting objects can be seen at a glance.

In microscope techniques, particularly in X-ray, holography offers an opportunity for three-dimensional, depth study.

The effects of stress or other disturbances on translucent material can be uncovered by holography. And contour mapping of solid objects will permit precise measurement of holographic images.

Holography has a vast potential for storage, including recording images in full color.

The excitement about holography began in 1948 when Dennis Gabor demonstrated that the sharply focused image of an object could be formed from a photographic record of its interference pattern. He called the photographic record a hologram, from the Greek holos, or whole, indicating that the entire wave pattern, including phase and amplitude, is recorded.

With lasers, holograms have been made from solid objects. Reconstructed from the holograms are three-dimensional images, with all the visual properties of the original object, including parallax between its parts as the viewer shifts position.

Recording techniques based on holography have

The series of light and dark lines on the reconstructed image indicate contours of constant vibrational amplitude.

shown great promise. Recent developments have made it possible to:

- Store multiple holographic images on thick photographic media.
- Record Lippman-type holograms which produce three-dimensional images in full color when illuminated with white light.
- Produce holograms with monochromatic, spatially incoherent light.

The fundamentals

In one basic method for hologram construction, a beam of coherent light illuminates the object to be recorded. The scattered light strikes a photographic plate. A second beam of light (which can be obtained by placing a mirror nearby) also strikes the plate. The plate records the interference pattern generated by the light reflected from the object and the second beam of light, the reference beam. The light from the object impinging on the photographic plate can be described in the following general form:

$$u = a\,(x, y) \cos \omega t + \phi\,(x, y)$$

where a and ϕ are the amplitude and phase of the light wave and ω is its radian frequency. In addition, the amplitude and phase are functions of x and y, the distance coordinates in the plane of the photographic plate. All the information about the object is contained in the wave in the form of these modulations.

In holography, information is transferred from the temporal carrier, the light wave, to a spatial carrier. The transfer is accomplished by the reference beam which can be expressed as

$$u_o = a_o \cos (\omega t - \alpha x)$$

where a_o designates a uniform amplitude and αx designates a linear phase shift across the surface of the recording plate, indicating that the reference beam strikes the plate at an oblique angle. The obliquity of the reference beam is essential to the process, as will be shown.

The photographic plate records the time-averaged intensity of the incident light, thus acting as a square-law device. What is recorded is the function

$$< (u_o + u)^2 > = \tfrac{1}{2} a_o^2 + \tfrac{1}{2} a^2 + a_o a \cos (\alpha x + \phi)$$

where $< >$ indicates a time average. The reference beam functions as a local oscillator, and the photographic plate, in addition to its role as a storage device, functions as a mixer, producing the difference frequency term $a_o a \cos(\alpha x + \phi)$. The signal carried by the light beam is modulated onto a spatial carrier wave $\cos \alpha x$ and is stored on the photographic plate without degradation.

Reconstruction is essentially the inverse of the recording process. When the hologram is placed in a beam of coherent light, the interaction of the beam with the photographic record transfers the modulation on the recorded spatial carrier to the light beam. The new wave is a replica of the original wave reflected from the object. To an observer it seems as if it were emanating from the object. The observer seems to see the original object though it long since has been removed.

In readout, a duplicate of the reference beam impinges on the hologram, and the emergent light is

$$a_o \left(\tfrac{1}{2} a_o^2 + \tfrac{1}{2} a^2\right) \cos (\omega t - \alpha x) + \tfrac{1}{2} a_o^2 a \cos (\omega t + \phi) + \tfrac{1}{2} a_o^2 a \cos (\omega t - 2\alpha x - \phi)$$

Only the last two terms are of interest. Except for a constant coefficient, the middle term is an exact duplicate of the original wave field recorded by the plate. This term gives rise to an image located, relative to the hologram, in the same position as the original object when the exposure was made. The observer looks through the plate as if through a window and sees a replica of the original object.

The last term of the equation differs in two respects from the middle term. The factor $2\,\alpha x$ in the argument of the cosine term signifies only that the wave leaves the plate at an oblique angle, and, therefore, travels in a direction different from that of the previous term. Second, the phase term ϕ is preceded by a minus sign. The result is an image which forms in front of the photographic plate, figure at right, rather than behind it—a real image as opposed to the virtual image produced by the previous term. The real image is of little interest, except in special cases.

Needed, a good light

Most holography requires light of coherence that is both temporal and spatial. A high degree of temporal coherence implies that the light source is highly monochromatic. Representing the light wave as $\cos\omega t$ implies a single frequency. If the light is not monochromatic, there will be a band of frequency components, each acting independently, producing its own set of fringes; fringe patterns tend to cancel each other and no hologram is produced.

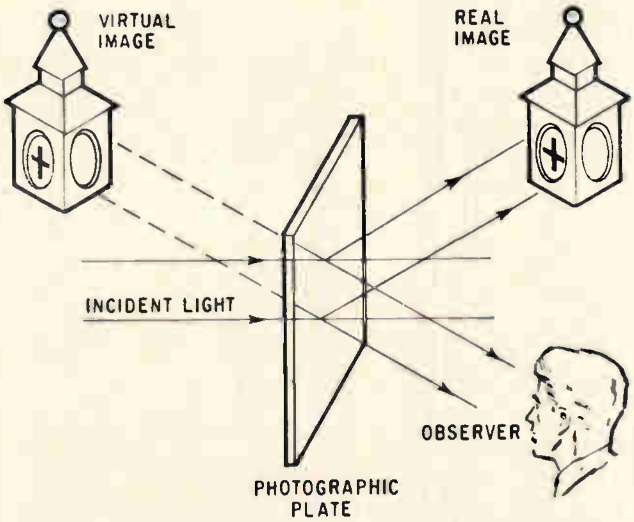
Spatial coherence is obtained when the light is derived from a point source and can be imaged to a small spot or point. If a radiating source is too broad to be considered a point source, then each point in the source will generate a set of fringes at the hologram plane—independent of the other elements of the source. The fringe patterns differ, and when superposed, tend to sum to a uniform distribution. Again, the fringe pattern is absent. Ordinary light lacks temporal and spatial coherence, but a laser can supply both to a high degree.

Recording in 3-D media

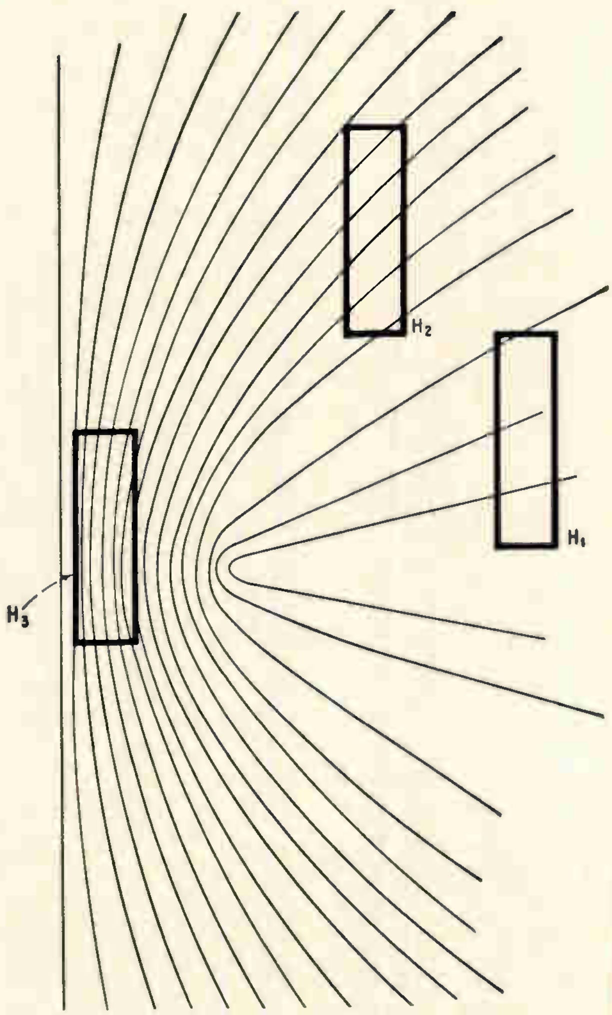
The theory of holography always assumed that the thickness of the recording medium could be neglected.[1] A paper in 1963 by the Russian Y.N. Denisyuk,[2] and another by P.J. van Heerden[3] of the Polaroid Corp. first described holography experiments with thick recording media. In general, they noted, a hologram stored in a three-dimensional medium can produce an image only when the incident light has the same wavelength as that used for making the hologram, and only when the light hits the hologram at the same angle of incidence as did the reference beam when the hologram was made. Thus, many images can be stored on the same plate by changing the wavelength of each exposure or by varying slightly the reference beam's angle of incidence. Rotating the plate after each exposure changes the angle.

In recent years holograms have been made on various thick media such as photochromic glasses. But most are produced on the Eastman Kodak Co.'s spectroscopic plate. With an emulsion thickness of about 15 microns, it can be regarded as either a two- or three-dimensional material, depending on how the hologram is made.

Gabor has described[4] a diagram for discussing recording on three-dimensional media, shown at right. The interference fringes produced by two point sources are represented by the lines shown



The original recorded object is reconstructed by directing a light beam at the hologram. The beam is modulated by the interference pattern on the plate, producing an image which has all the visual properties of the recorded object. Two images are generated, but the observer sees only the virtual image behind the plate.



Behavior of holograms recorded on thick emulsions depends on where the hologram is placed between two point sources. H_1, H_2 and H_3 represent three possible positions of holograms in the fringe pattern representing contours of constant phase difference between the two sources.

in the figure. One source is regarded as providing the reference beam, and the other as constituting a point of the object. By placing a photographic plate at some position to intercept and record a segment of the fringe pattern, a hologram is produced.

Depending upon the spacing and orientation of the fringe patterns, there are three categories of holograms, each with its own special properties.

In one, the hologram is made in a position approximating that of H_1 in the figure. The fringes are widely spaced, a spacing much greater than the emulsion thickness of typical photographic materials. Consequently, the thickness of the emulsion can be disregarded; the hologram properties associated with three-dimensional recording are absent. Most holograms have been made in this region.

In the second instance, the hologram is recorded in the vicinity of H_2, where the fringes are much closer together—a spacing comparable to the emulsion thickness.

A hologram made in the position H_2 exhibits great orientation sensitivity. This means that in the reconstruction process the orientation of the hologram in the illuminating beam is critical. If the plate is rotated slightly from the optimum reconstruction position—approximately 5° for Kodak's plate—the image disappears. This can be explained if the recorded interference fringes are thought of as mirror surfaces that reflect light from the zero order into the first diffracted order. The diffracted light must, at the same time, obey the usual diffraction-grating formula. If the surfaces are not oriented properly, the reflection condition and the grating formula are not simultaneously satisfied, and no diffraction occurs.

Using this rotation technique, an experiment described originally by Van Heerden[3] was performed at the University of Michigan. Five holographic images were stored in successive exposures, with the plate rotated slightly between exposures. When the plate was rotated in the readout beam, the images were produced in succession, and the result was a short hologram "movie." This experiment reproduced only five to seven pictures, but thicker emulsions could conceivably reproduce several hundred.

In the third case, the hologram is made in the vicinity of H_3, between the two coherent sources. The reference beam and the object beam are introduced from opposite sides of the plate. The recorded fringe patterns, in addition to being closely packed, lie roughly parallel to the emulsion surface.

This hologram has the greatest wavelength selectivity and yields white-light holographic reconstructions, a phenomenon that has drawn wide interest.

Introduction of the reference beam from the back surface was first described by Denisyuk who related it to Lippman's method of color photography.[5]

In Lippman photography color images are produced on black and white film by recording standing-wave patterns within the emulsion. It was developed about 1881, but has never been applied commercially. An image is formed on an emulsion of high resolving power. It enters the plate from the nonemulsion side. The emulsion is backed by a mercury bath, which acts as a mirror, reflecting the light back through the emulsion. The two oppositely traveling light waves set up an interference pattern. A series of surfaces are recorded within the emulsion, separated by half the wavelength of the light that produced the fringes.

When the photographic plate is illuminated with a beam of white light, each surface reflects a small fraction of the incident light. Light from the surfaces combine, and reinforcement occurs for the wavelength which produced the fringes, but not for other wavelengths. The plate is a resonant structure, similar to a conventional optical interference filter. Each part of the recorded image reflects the colors of the original image, and the observer sees, in the light reflected from the plate, the image in its natural color.

Denisyuk noted the similarity of the Lippman process to holography. In his system, a beam of coherent light passes through the plate, is reflected by an object lying on the other side of the plate, and the interference between the direct and reflected beams produces a recording within the plate. A color image, Densiyuk noted, is produced when this hologram is illuminated with white light. He reported on successful experiments where holograms were made with relatively simple images.

More recently, various groups have reported producing a color hologram with laser light, using relatively complex subjects. At a meeting of the Optical Society of America, and elsewhere, this type of hologram was described.[6,7,8]

Holograms in full color may be produced by using light beams of three primary colors in recording, as was demonstrated at Bell Telephone Laboratories.[9]

Making a contour map

Ordinary holography presents a three-dimensional image of an object in a dramatic way. However, the measurement of an object's depth is no surer than the measurement by a viewer of any object seen at a distance. An observer cannot tell precisely from the holographic image how far away each point in the image is, just as, in general he cannot judge distances with an accuracy of better than 5% to 10%. Contour holography brings precision to the technique.

To produce an image with contours, more than the usual amount of information must be put on the hologram. At the Optical Society meeting,[10] two methods of adding infornaton were described: the object may be illuminated with coherent light sources located at two different positions or with coherent light at two different frequencies. The two-frequency technique can best be described by considering a point object illuminated by a source containing two frequencies: for example, a laser operating in a multimode manner. The hologram records not only the intensity of the reflected holography are severe and have prevented its practical realization—although a laboratory demonstration of X-ray holograms was reported as far back as 1956.

Among the major difficulties is obtaining a source with sufficient intensity together with sufficient coherence.

Future outlook

Holographic motion pictures and television are feasible; however, a few decades will undoubtedly pass before the technology is developed to the point where three-dimensional entertainment is an everyday occurrence.

A holographic tv system that could produce a real-time, 3-D image could be designed right now. But the specifications for components exceed by several orders of magnitude that of equipment currently available.

For example, a hologram 10 inches square and having 1,000 lines per millimeter has 6 x 10^{10} picture elements, compared with 2.5 x 10^5 for a conventional television picture. If the scan rates of present tv systems were maintained, a 10^5 increase in bandwidth would be necessary, a jump from 6 to 600,000 megahertz. The entire radio-frequency spectrum, including the microwave region, would be inadequate to handle this.

Reasonable design compromises could reduce the problem by a factor of perhaps 100. For example, the field in the vertical dimension could be reduced without undue annoyance to the viewer; other trade-offs are also possible. In addition, coding techniques exist which take advantage of the redundancy in a television signal to reduce the transmission bandwidth. These techniques are too cumbersome to warrant use in conventional tv where it is preferable to transmit an uncoded, full bandwidth signal. However, they could play a worthwhile role in holographic tv.

The enormous bandwidths are needed because a holographic image is a kind of summation of many images. Each observer would receive a different picture from the hologram—with a different parallax. Although the bandwidth must be sufficient to accommodate all the pictures, each picture would be only moderately different from the neighboring ones, and the redundancy in a hologram image would be enormous, even compared with a conventional image. However, redundancy could be reduced by coding techniques. Another bandwidth reduction by a factor of 60 would result in a 100-Mhz bandwidth, which is within the capability of currently available microwave equipment.

The laser, which is responsible for holography to begin with, offers a long-range answer to the transmission difficulty. Theoretically, a single laser beam could handle the world's entire television and radio transmission. It could, therefore, provide the large bandwidth needed for holographic tv.

There still remain the formidable problems of the camera and receiver systems. The camera must have enormously high resolution, with perhaps 100 to 20,000 times more resolution elements than a conventional image orthicon. Although cathode-ray tubes with a 1-mil spot exist, building such a camera would be a fantastic undertaking.

In the receiver, the display would require coherent light, which rules out the conventional picture tube. Instead, a recording surface that can rapidly record the arriving signal, display it as a hologram, and then rapidly erase the data in time to receive the next scan, is envisioned. Candidates for this application include thermoplastics, photochromic materials, and similar high-resolution materials on which holograms can be produced in real time, without the delays, for example, of chemical development.

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in the figure. One source is regarded as providing the reference beam, and the other as constituting a point of the object. By placing a photographic plate at some position to intercept and record a segment of the fringe pattern, a hologram is produced.

Depending upon the spacing and orientation of the fringe patterns, there are three categories of holograms, each with its own special properties.

In one, the hologram is made in a position approximating that of H_1 in the figure. The fringes are widely spaced, a spacing much greater than the emulsion thickness of typical photographic materials. Consequently, the thickness of the emulsion can be disregarded; the hologram properties associated with three-dimensional recording are absent. Most holograms have been made in this region.

In the second instance, the hologram is recorded in the vicinity of H_2, where the fringes are much closer together—a spacing comparable to the emulsion thickness.

A hologram made in the position H_2 exhibits great orientation sensitivity. This means that in the reconstruction process the orientation of the hologram in the illuminating beam is critical. If the plate is rotated slightly from the optimum reconstruction position—approximately 5° for Kodak's plate—the image disappears. This can be explained if the recorded interference fringes are thought of as mirror surfaces that reflect light from the zero order into the first diffracted order. The diffracted light must, at the same time, obey the usual diffraction-grating formula. If the surfaces are not oriented properly, the reflection condition and the grating formula are not simultaneously satisfied, and no diffraction occurs.

Using this rotation technique, an experiment described originally by Van Heerden[3] was performed at the University of Michigan. Five holographic images were stored in successive exposures, with the plate rotated slightly between exposures. When the plate was rotated in the readout beam, the images were produced in succession, and the result was a short hologram "movie." This experiment reproduced only five to seven pictures, but thicker emulsions could conceivably reproduce several hundred.

In the third case, the hologram is made in the vicinity of H_3, between the two coherent sources. The reference beam and the object beam are introduced from opposite sides of the plate. The recorded fringe patterns, in addition to being closely packed, lie roughly parallel to the emulsion surface.

This hologram has the greatest wavelength selectivity and yields white-light holographic reconstructions, a phenomenon that has drawn wide interest.

Introduction of the reference beam from the back surface was first described by Denisyuk who related it to Lippman's method of color photography.[5]

In Lippman photography color images are produced on black and white film by recording standing-wave patterns within the emulsion. It was developed about 1881, but has never been applied commercially. An image is formed on an emulsion of high resolving power. It enters the plate from the nonemulsion side. The emulsion is backed by a mercury bath, which acts as a mirror, reflecting the light back through the emulsion. The two oppositely traveling light waves set up an interference pattern. A series of surfaces are recorded within the emulsion, separated by half the wavelength of the light that produced the fringes.

When the photographic plate is illuminated with a beam of white light, each surface reflects a small fraction of the incident light. Light from the surfaces combine, and reinforcement occurs for the wavelength which produced the fringes, but not for other wavelengths. The plate is a resonant structure, similar to a conventional optical interference filter. Each part of the recorded image reflects the colors of the original image, and the observer sees, in the light reflected from the plate, the image in its natural color.

Denisyuk noted the similarity of the Lippman process to holography. In his system, a beam of coherent light passes through the plate, is reflected by an object lying on the other side of the plate, and the interference between the direct and reflected beams produces a recording within the plate. A color image, Densiyuk noted, is produced when this hologram is illuminated with white light. He reported on successful experiments where holograms were made with relatively simple images.

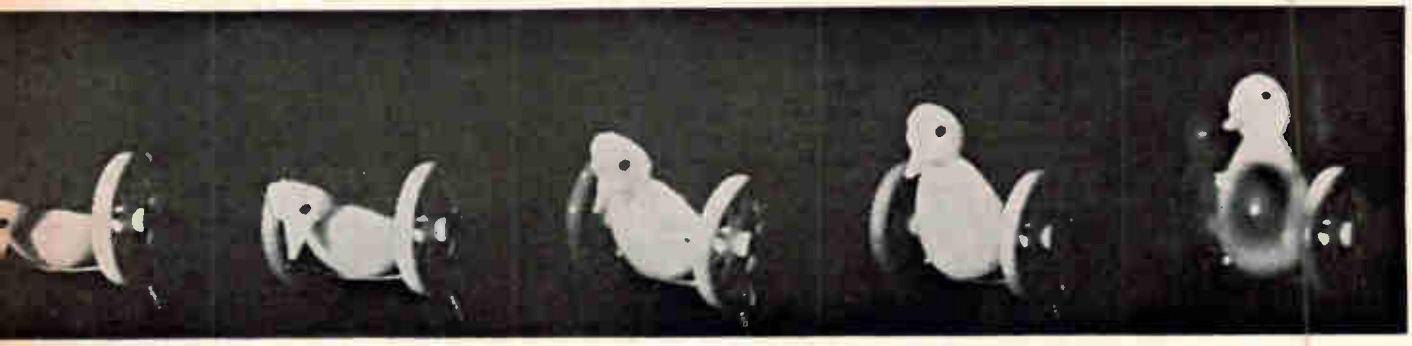
More recently, various groups have reported producing a color hologram with laser light, using relatively complex subjects. At a meeting of the Optical Society of America, and elsewhere, this type of hologram was described.[6,7,8]

Holograms in full color may be produced by using light beams of three primary colors in recording, as was demonstrated at Bell Telephone Laboratories.[9]

Making a contour map

Ordinary holography presents a three-dimensional image of an object in a dramatic way. However, the measurement of an object's depth is no surer than the measurement by a viewer of any object seen at a distance. An observer cannot tell precisely from the holographic image how far away each point in the image is, just as, in general he cannot judge distances with an accuracy of better than 5% to 10%. Contour holography brings precision to the technique.

To produce an image with contours, more than the usual amount of information must be put on the hologram. At the Optical Society meeting,[10] two methods of adding informaton were described: the object may be illuminated with coherent light sources located at two different positions or with coherent light at two different frequencies. The two-frequency technique can best be described by considering a point object illuminated by a source containing two frequencies: for example, a laser operating in a multimode manner. The hologram records not only the intensity of the reflected



Movie made by recording five frames holographically on a thick emulsion. The photographic plate was rotated slightly between exposures to store the successive pictures. The movie was read out by repeating the rotation while the plate was illuminated with the light beam.

light but its phase as well. The phase depends upon the object's distance, measured in wavelengths, from the recording plate. The phase is different for different wavelengths and each wavelength component independently produces its own reconstructed image. The images superimpose, and produce either constructive or destructive interference, depending on the phase relations.

If the object point lies at a distance such that the relative phase difference between the two waves is a multiple of 2π, or an integral number of wavelengths, the two recorded holographic images are in phase and the result is a bright line. If the object point is slightly farther away, the relative phase delay between the two waves changes, the recorded images are out of phase, and the line is less bright. Thus, an extended object will produce a holographic image having a sequence of light and dark bands that represent contours of constant distance from the hologram recording plate. Theory shows that successive contours are separated by a distance $\lambda^2/2\Delta\lambda$, where λ is the mean wavelength, and $\Delta\lambda$ is the difference between the two wavelengths. The contour interval, therefore, can be chosen by selecting the appropriate frequency separation.

Though a gross oversimplification, this explanation does provide insight into how the contour-map process works.

Holograms with incoherent light

Coherent light generally is needed to construct a hologram. However, methods using monochromatic, spatially incoherent light have been described.[11, 12, 13] Recent incoherent light schemes hinge on the idea of forming two images, and producing interference between them. In one such system[14] the light from the object passes through a beam splitter and is divided into two portions, each passing through a lens to a mirror and back again through the lens. Each forms an image, but in a different place. Although within each image all the image points are incoherent with each other, each point of one image is coherent with the corresponding point of the other image. At a specific plane each such coherent pair of points produces an interference pattern, and the summation of all patterns constitutes a hologram, from which an image can be regenerated.

The scheme works well for a simple object, of only a few points, but breaks down as the object becomes more complex. This is because the light intensity from each coherent point pair is of the form

$a_0 + a_1 \cos \phi\ (x, y)$

where ϕ is a function determined by the path difference between the interfering points. The second term represents the fringe pattern and carries all the information. The hologram of a complex object is formed from a summation of many such expressions, one for each point pair. The a_0 terms add directly, but the a_1 terms add randomly since ϕ is different for each pair. As the number of image points increases, the constant a_0 or bias term grows more rapidly, and the fringe contrast decreases. Eventually, the fringes are lost in the system noise.

A method has been described for removing the a_0 terms before making the hologram.[15] Vibrating one of the two interferometer mirrors so that it undergoes a periodic displacement $d = d_0 \cos pt$ produces a similar time modulation of the fringe component but not of the bias. An array of photodetectors, one for each resolution element, is substituted for the hologram. Connected to each detector is a bandpass filter that passes the time-varying component but rejects the bias component. The signal is converted back to light, on a point by point basis, and recorded as a hologram. With the bias term eliminated, the obstacle to incoherent-light holography has been overcome.

This system may seem enormously complex, but in practice the many required photodetectors and filters can be replaced, for example, by an image orthicon and associated electronics.

Recording vibrations

An immediately promising area in wavefront reconstruction is holographic interferometry. When a vibrating object is photographed holographically, a series of fringes—contours of constant amplitude, page 88—are superimposed on the holographic image.[16] As a result, the entire vibrational pattern of even very complicated, diffusely reflecting objects can be seen at a glance.

An interpretation of this phenomenon is that, due to the vibration, a number of successive holograms are produced, each recording objects in a slightly different position. In the reconstruction, an image is produced for each object position, and the images add coherently to produce the interference effects.

The vibrating object can be regarded as the limiting case of N successive holographic exposures, where N becomes very large. A potentially important case is where $N = 2$: a double exposure. If, between the first and second exposure, the object is minutely disturbed, the disturbance will show up in the interference fringes that result from the coherent superposition of the two images.

Experimenters at TRW Systems Group devised a spectacular vibration experiment in which a bullet was fired through a volume of atmosphere.[17] Two holographic images were made of the volume in rapid succession by means of a pulsed laser. The interference between the two images revealed the pattern of the bullet's shock wave.

Projecting a holographic image onto an original object produces interference fringes. Small distortions, brought about by stress, have been measured in this way.[18] Other holographic interferometric work has been done at Bell Telephone Laboratories[19] and by J.M. Burch[20] in England.

Imagery through a diffusing media

With holography, images can be passed through a translucent medium which ordinarily diffuses light, destroying its image-forming ability.[21, 22] A diffuser, such as ground glass, is placed between the object and the recording plate. When read out the hologram produces an image of the diffuser, or at least of its surface.

However, if during reconstruction of the image the diffuser is placed in the path of the light from the hologram so that the diffuser coincides with its own real image, a sharp, clear picture of the original object is produced, as if the diffuser were of clear glass.

This imaging occurs because of peculiar properties of the hologram: the real image produced by the hologram is phase-inverted with respect to the original object. If the diffusing material is considered purely in terms of its phase characteristics, having the form $e^{j\phi(x,y)}$, where $\phi(x,y)$ is a pseudorandom noise-like function, then the real image of the diffuser has the form $e^{-j\phi(x,y)}$. When the diffuser and the real image from the hologram are superposed, the phase effects cancel and the diffuser effectively becomes a clear plate of glass. The original object—previously obscured—now emerges.

The cancellation will be incomplete, however, unless the diffuser and its holographic image are brought into exact coincidence. And this can be exceedingly laborious, since a misalignment of even 2 or 3 microns can lose the image.

The same diffuser must be used in both steps. The original image can be recovered only with the piece of material used in producing the hologram. A section of ground glass 1-centimeter square could contain 10^9 distinct resolution elements, each of which retards in some random manner the transmitted light. It's not probable that two samples could be sufficiently similar to allow an image to form.

This diffuser system has great potential for measuring stresses or the effects of other disturbances in translucent media, as in holographic interferometry. If the diffusing medium is disturbed between the time the hologram is made and the time of reconstruction, the reconstruction will be imperfect or will fail to materialize. The disturbance could be caused by stresses in the diffuser, thermal expansion, or a change of the refractive index through a chemical process.

Failure of the diffusing material and its image to coincide produces a noise-like pattern instead of an image of the original object. The signal-to-noise ratio of the reconstruction, therefore, can be a measure of the alteration of the diffusing material.

Microscopy

Holography had its origins in an attempt to improve electron microscopy 10 years ago. Unfortunately, many of the problems in its application to microscopy still exist.

At visible wavelengths arbitrary magnification without use of lenses is easily achieved by diverging the light beams while making the hologram or while reading out the image.

Lens elimination would appear to offer significant advantages, but, in fact, the hologram itself behaves like a lens: giving rise to spherical aberration, astigmatism, coma, distortion and curvature of field. These aberrations occur whenever magnification is attempted. But against this disadvantage, and the relatively cumbersome techniques of holography, must be weighed the advantage of sharply focusing an image at any plane in the depth dimension. Some believe this capability offers a niche for visible-light holography.

For holography at nonvisible wavelengths, the situation is vastly different: the technical difficulties are great, but the rewards could be considerable. X-ray holography, in particular, could be an invaluable technique. Enormous magnification is possible, produced in part by diverging beams and in part by the wavelength ratio between the X-rays used in producing the hologram and the visible light used for readout.

In principle, there exists the possibility of excellent resolution—of a magnitude unavailable with present techniques. Lenses are not used for X-rays; X-ray images are shadowgraph projections and the ultimate resolution—down to the diffraction limit of a wavelength or so—is never attained. With X-ray holography, the reconstruction step could be carried out with visible light, producing a sharply focused image.

Unfortunately, the technical problems of X-ray holography are severe and have prevented its practical realization—although a laboratory demonstration of X-ray holograms was reported as far back as 1956.

Among the major difficulties is obtaining a source with sufficient intensity together with sufficient coherence.

Future outlook

Holographic motion pictures and television are feasible; however, a few decades will undoubtedly pass before the technology is developed to the point where three-dimensional entertainment is an everyday occurrence.

A holographic tv system that could produce a real-time, 3-D image could be designed right now. But the specifications for components exceed by several orders of magnitude that of equipment currently available.

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The gamble that paid off: a solid state 50-Mhz oscilloscope

Engineers had to develop a compact cathode-ray tube and a small, fast delay line before creating a high-performance oscilloscope; the results were even better than expected

By William Grein, Milton Russell and Johan Sverdrup
Hewlett-Packard Co., Colorado Springs, Colo.

The target was an ambitious one: a solid state 50-megahertz general-purpose oscilloscope accurate enough for laboratory work; fast and long-lived for production line duty; and portable, rugged and versatile enough for field service. But the project was begun by the Hewlett-Packard Co. in 1964 despite the fact that certain crucial components were unavailable or too costly. The result is the high-performance oscilloscope on page 98 that incorporates many components not in existence when the development began. These include:

- A compact cathode-ray tube, shorter than previous ones but with 30% greater screen area.
- A delay line with fast rise time that fits into a small scope plug-in.

Components worthy of serious notice that had not yet reached required levels of performance or cost when work on the scope began, are:

- Field effect transistors to replace tubes in the input circuits—to reduce warm-up time and turn-on drift, and to avoid jitter.
- Complementary pnp/npn transistors that are fast and have high breakdown voltage for use in the horizontal deflection amplifier.

Boost for the beam

In building an oscilloscope to operate above 5 Mhz, it becomes necessary to use a crt having some form of post-deflection beam acceleration because of the high writing speeds needed to display a high-frequency signal; brightness drops significantly if the beam is not given an "assist" to speed it toward the screen. The beam must impinge upon the phosphor with greater velocity since it acts upon a given spot for a shorter time.

Post-accelerator tubes vary in principal and construction [see "The long and short of crt's" p. 97]. In one, the accelerating field bends the beam toward the tube axis. The result is a smaller display and the tube must be lengthened to compensate. In another, a mesh is inserted inside the crt to alter the field and to straighten the beam. In this version, called a radial-field crt, the display does not shrink. In both tubes, a resistive helix along the inner wall of the envelope is used to increase the beam's velocity.

A spherical, fine-gauge mesh or a fine array of parallel wires in the radial-field tube modifies the field between the deflection plates and the screen of the crt. The mesh is biased at about —50 volts with respect to the horizontal deflection plates. This prevents secondary electrons, produced when the beam strikes the plates, from reaching the phosphor screen.

'Long' crt in short envelope

The tube developed for the 50-Mhz scope is a logical extension of the radial-field mesh tube. Designers asked: if the mesh technique can reexpand the display in a post-accelerator crt, cannot a modified mesh overexpand or magnify the display? It could.

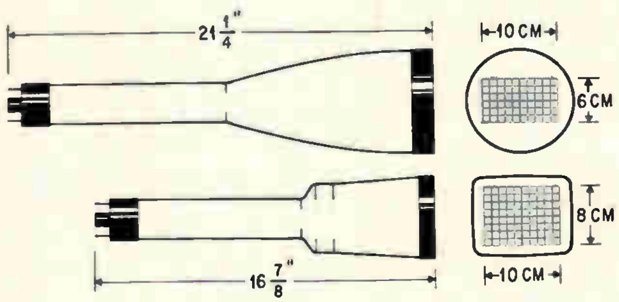
This was accomplished by a specially shaped mesh that's immersed directly into the high potential region. The new crt has no helix, but its interior conductive coating (at high potential) covers the sides of the envelope past the point where the mesh is located. Since the mesh is near ground potential, a high field strength is developed. The mesh has a greater curvature than the mesh in the radial-field tube, causing the equipotential lines to assume a sharp contour. This high-mesh contour means the center of curvature is farther from the horizontal plates. As a result, the deflected beam intercepts the field lines (normal to the mesh and equipotentials) at a relatively high angle, causing it to be acted upon by a force outward from the axis of the crt, and thus magnifying the display.

The mesh is not spherical, but is contoured to provide high linearity of the display. Thus, the screen of the scope can be closer to the horizontal deflection plates and the tube still provides a large scan area, a good deflection factor and low deflection defocusing. See comparison table, page 98.

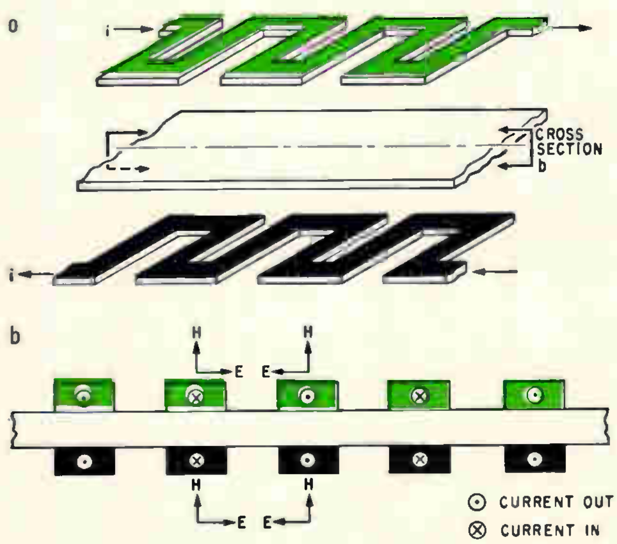
Bonus: sharper spot

Since the tube is shorter over-all, it becomes possible to "steal" a little of the length that is saved and add it to the distance, P, between the cathode crossover and the focus lens [see "The long and short of crt's"] while the distance, Q, between the focus lens and the faceplate of an equivalent monoaccelerator crt remains constant. Increasing P decreases the beam magnification, Q/P, and sharpens the magnitude of the spot on the screen. In the 50-Mhz tube, the spot size equals or is a little less than the spot size of the longer radial-field mesh tube of comparable screen area. And the new tube is 4 inches shorter and has 2 centimeters more vertical scan than a radial-field crt of an equivalent deflection factor. The new scope's spot is specified as 0.014 inch at 200 foot-lamberts. For high brightness, the acceleration potential is 12 kilovolts.

The new scope also has an auxiliary cathode, called a flood-gun cathode, behind the mesh and ahead of the accelerator to increase the brightness of the graticule. A positive potential applied to the mesh causes electrons to be drawn from the auxiliary cathode at a relatively low speed. The electrons pass through the mesh and scatter against the phosphor screen, illuminating it sufficiently for observing and photographing the graticule when ambient illumination is low. The temperature of the flood-gun cathode and illumination intensity are controlled by adjusting the filament voltage.



New crt provides 30% greater viewing area yet is 4.25 inches shorter than previous model. Both have 3v/cm vertical deflection factor and 12-kv accelerating potential.



Differential delay line for vertical amplifier is etched on a double-sided copper-plated Teflon-glass substrate. Exploded view shows how lateral portions of top metallic conductor, color, and bottom metallic conductor, black, are coincident. Arrows indicate direction of current flow. Cross section through delay line shows how electric fields cancel, magnetic fields add.

Strip-line delay line

In high-frequency scopes (above 10 Mhz) the signal must be delayed by about 150 to 200 nanoseconds before it is applied to the vertical deflection plates. This is to allow time for the undelayed signal to trigger the sweep. The vertical amplifier is faster than the horizontal sweep amplifier; inadequate vertical delay would make it impossible to view the leading edge of a fast rise time pulse.

The specifications for the delay line required for the oscilloscope were: 160-nsec delay, 140-Mhz bandpass, and 2.5-nsec rise time. Since it was to be a laboratory precision scope, a balanced delay line to accompany the vertical differential amplifier was needed because the two signals (identical and 180° out of phase) must be delayed.

The solution to the problem was a differential strip line on a copper-clad Teflon-glass substrate. The strip line, at the left, is 2 inches wide by 36.850 inches long before being rolled up to fit a space 6.850 × 2.405 × 1.325 inches. Total length of the conductors is a little over 50 feet.

For a single-ended, metallic-strip delay line, the delay T_D is $S\sqrt{\epsilon_r}$ per foot, where ϵ_r is the relative dielectric constant of the material insulating the line from ground and S is the distance a wave travels in 1 nsec (about one foot). For a differential delay line, the expression for T_D is multiplied by k, a constant which is a function of the coupling between the conductors. Then ϵ_r is the relative dielectric constant of the material separating the two conductors.

Obviously, then, the differential delay line can be shorter than the single-ended line if k is greater than unity. For the delay line in question, k is 1.95.

How it works

The superiority of the new strip delay line is attributed largely to the way in which the fields

The long and short of crt's

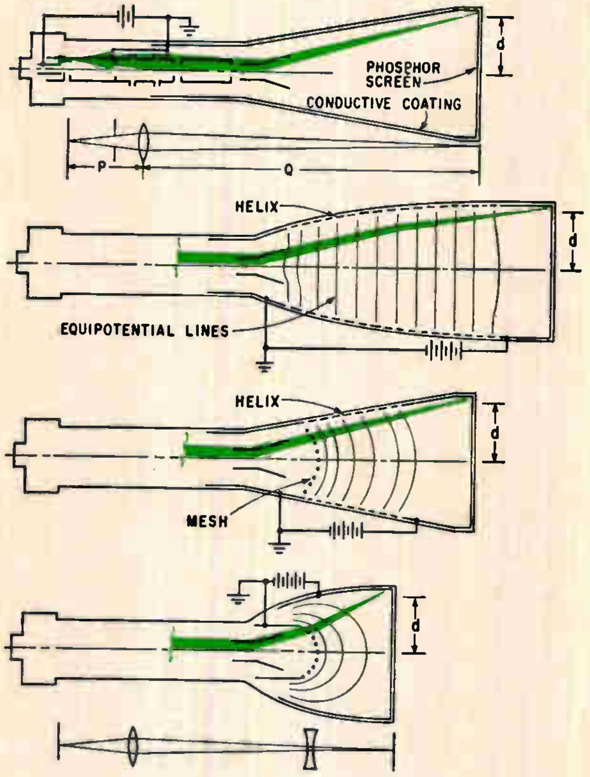
The single-accelerator (monoaccelerator) cathode-ray tube, top figure, has done yeoman service in oscilloscopes for viewing relatively low frequency signals (below 1–5 megahertz). In it, the beam is given all its acceleration before it passes through the deflection plates and arrives at the screen with sufficient velocity to present a bright display for relatively low writing speeds.

At higher writing speeds, the beam must be accelerated after deflection to produce a bright display. The post-accelerator crt, second from top, uses a resistive spiral helix inside the tube envelope upon which is impressed an accelerating voltage of the order of 10 kilovolts. But the accelerating field tends to bend the beam toward the axis, thus demagnifying the waveform displayed, or, in effect, decreasing deflection sensitivity. To achieve a display of equivalent size to that of the monoaccelerator tube, the spiral-helix post-accelerator tube must be made longer.

If a spherical mesh is inserted into the spiral-helix tube, the accelerating field is straightened out as in the third crt from the top and the compression of the display in the conventional post-accelerator crt is avoided. This is called a radial-field mesh crt, and its sensitivity and display size equals that of a monoaccelerator tube the same length. In practice, however, the tube is usually made longer to achieve the higher sensitivity needed for high frequency.

Carried one step further, the spiral helix can be eliminated and the mesh shaped into a configuration that will expand or magnify the display. The result is a short tube, as in the bottom figure, that behaves like a long one. This crt, called a high-expansion (or high-magnification) mesh tube, is the tube developed for use in the new 50-Mhz scope.

A diagram of how the beam is focused is given beneath the monoaccelerator crt. P represents the distance from the cathode crossover to focus lens and Q is the distance from the focus lens to the screen. The diagram beneath the high-expansion mesh crt shows that the mesh acts as a concave lens to expand the display. Q of this tube is equivalent to that of the monoaccelerator tube.



interact. Note that the currents in the long, coincident portions of the upper and lower conductors flow in the same direction, as shown in portion b of the figure on the opposite page, depicting a section along the center of the delay line.

Because each conductor doubles back on itself, electric fields cancel while magnetic fields add. When the conductors are very close, the inductance of the line approaches four times that of a single-ended line.

Since the characteristic impedance of the delay line Z_o is equal to $\sqrt{L/C}$, and $T_D = \sqrt{LC}$, then Z_o may be calculated by substituting the expression for C. Thus:

$$Z_o \approx \frac{k\,t\,10^3}{2.7\,A\sqrt{\epsilon_r}}$$

where A = area of a 1-inch length of the metallic conductor on one side of the strip line
t = thickness of the separating material.
ϵ_r = relative dielectric constant of the separating material

The characteristic impedance for the delay line is 90 ohms. The substrate is 0.015-inch thick and the copper on either side is 0.002-inch thick. Conductors are 0.625-inch wide and are separated by 0.0545-inch. After the delay line is rolled into a package, page 98—much as a metallized capacitor is made—time-domain reflectometry[1] is used to detect faults.

Field effect inputs

Field effect transistors have several advantages over vacuum tubes in the vertical, horizontal and trigger input circuits of the oscilloscope. FET's reduce amplifier drift considerably. Also, differential pairs can be mounted on common heat sinks to encourage good thermal tracking. As a result, turn-on drift can be substantially eliminated. Accurate measurements can be made as soon as the crt warms up (in about 15 seconds) and the trace reappears at the same position after successive turn-on and turn-off operations. Thirty seconds after turn on, typically, the display has settled to within 0.2 cm of its final vertical position.

The FET's used are junction type devices with high I_{DSS} (zero-gate-voltage drain current) and high transconductance over a wide current range. They are biased to operate at about 0.1 I_{DSS} to provide good V_{GS} (gate-to-source voltage) stability with temperature. In the vertical system the amplifier inputs are balanced. The circuit for one-half the vertical input amplifier is shown on page 99.

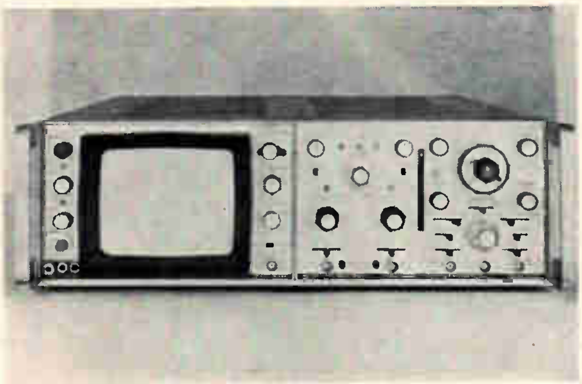
Complementary-transistor load

The output section of the horizontal deflection amplifier differs from the conventional design. Its load is not a resistor, but is a complementary pnp transistor biased to a low d-c current which is needed for feedback bias and low-frequency operation. However, the pnp transistors (type 2N3635) that complement the npn devices (type 2N3119) were not commercially available when the work began.

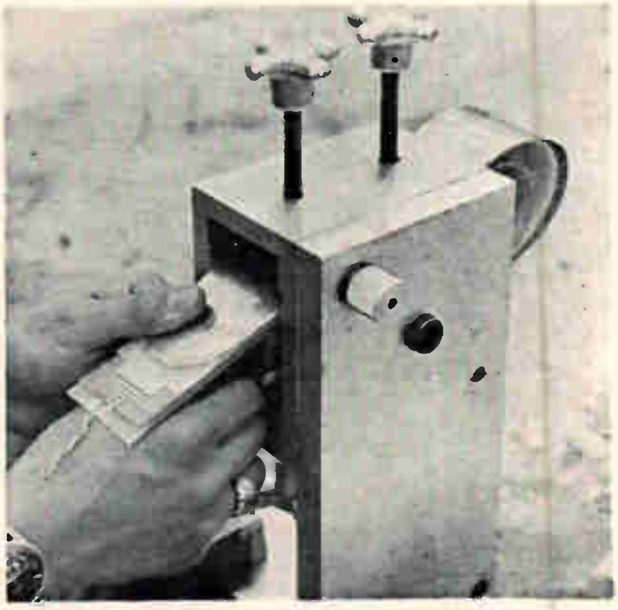
Essentially what has been accomplished is to provide a low-impedance driving source for the deflection plates to insure good bandwidth since the crt plates present a capacitive load to the amplifier.

The diagram on page 99 shows how the complementary transistor circuit works: at low frequencies (slow sweeps) the operational amplifiers function normally to drive the crt deflection plates; at faster sweeps (as input dv/dt increases) C_1 and C_2 couple more signal to the complementary load transistors. At these faster sweeps, Q_2 is turned on harder to offer a low impedance to discharge the deflection plate capacity, while Q_4 is turned on harder to provide a low-impedance current source to supply the necessary current to the plates. The process is reversed during sweep flyback; Q_3 and Q_1 are turned on harder, while current through Q_2 and Q_4 decreases.

The challenge met: speedy and solid state, too



Surpassing previous state-of-the-art oscilloscopes, the solid state Hewlett-Packard 180A features 5 mv/cm vertical deflection sensitivity at 50 Mhz. Except for the cathode-ray tube, the scope contains no vacuum tubes. Its display is presented on an 8 x 10 centimeter screen one-third again as large as that of previous comparable crt's. Key design features include the compact crt, a new fast rise-time strip-line delay line, field effect amplifier transistors for low drift and fast warmup and a unique horizontal amplifier circuit. The unit weighs 30 pounds and consumes 95 watts.



Delay line is assembled by sandwiching it between the Teflon dielectrics and brass strip (ground plane). It is then rolled onto a spool. The delay line and its case weighs one pound; measures 6.850 × 2.405 × 1.325 inches. It provides a delay of 160 nanoseconds and has a bandwidth of 140 megahertz.

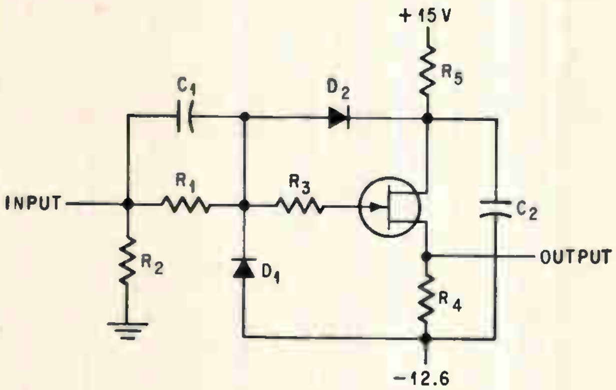
Cathode-ray tube performance characteristics

Type	Accelerating voltage (kv)	Display size (v/cm)	Deflection factor vertical (v/cm)	Deflection factor horizontal (v/cm)	Length (inches)	Spot size (mils) 25 foot-lamberts	Spot size (mils) center 200 foot-lamberts	Spot size (mils) edge 200 foot-lamberts	Photography writing rate** (cm/μsec)
Mono-accelerator (5AQP31)	3.0	10×10*	16	21	17¾	18	N/A	N/A	N/A
Post-accelerator (5BHP31)	10.0	4×10	7	30	18¼	7	14	34	530
Radial-mesh HP-175A	12.0	6×10	3	12	21¼	12	15	15	450
High-expansion mesh HP-180A	12.0	8×10	3	9	17	12	14	14	700

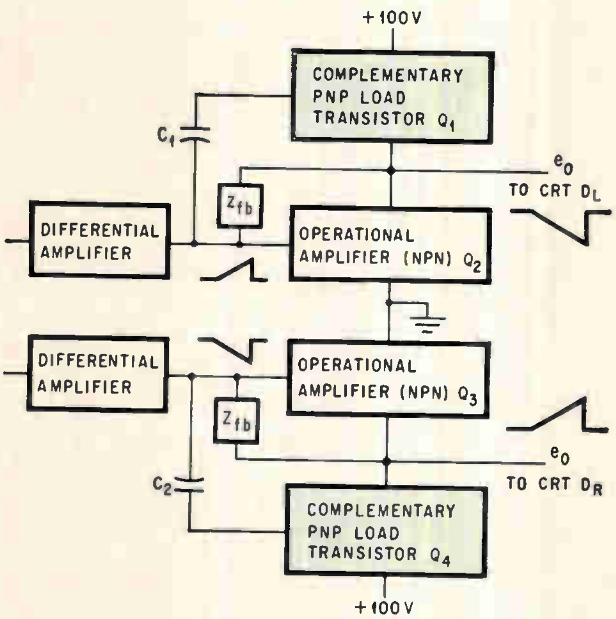
* 12 cm^2 of corner is unused because of round faceplate.
** Using P31 phosphor, F/1-9 lens, A-5A 3000 film, single exposure of 50 Mhz damped sine wave.

Fast linear sweep

While the horizontal sweep is being expanded 10 times, the duty cycle is very low, so average power from the supply is low. Further, with a power supply of only 100 volts, the circuit will deliver a very linear swing from about 6 to 94 volts from either side. (The horizontal amplifier is differential to drive the crt). With a crt horizontal sensitivity of 9.5 volts per centimeter, the circuit delivers a linear sweep speed of 5 nsec/cm in the times-10 mode. This is twice the sweep speed previously obtained, and boosts the resolution with which nanosecond rise-time pulses may be presented.



The vertical amplifier input circuit uses high transconductance (12,000 μmhos) junction FET's. R_1, C_1, D_1, and D_2 constitute an overload protection network. R_2 sets the real part of input impedance. R_4 and R_5 set the d-c bias, and C_2 is a decoupling capacitor. Half the vertical input is shown; other side is similar but input is grounded.



Horizontal amplifier circuit has npn transistors for its operational amplifiers, Q_2 and Q_3, and complementary pnp transistors, Q_1 and Q_4, in place of load resistors. At high frequencies, capacitors C_1 and C_2 pass more of the signal to the complementary load transistors. When these are turned on they provide a low-impedance path to discharge the plate capacity.

As a result of using the new horizontal sweep circuit and of using FET's in the amplifier inputs, the power requirement for the oscilloscope is cut from 155 to 95 watts and no fan is needed.

Annoying shifts in carefully positioned waveforms are not uncommon when the sensitivity of the vertical amplifier (deflection factor) is switched. This is because gain is often varied through interstage attenuation. In the H-P Model 180A, the vertical amplifiers function at a single, stabilized gain. The deflection factor is selected by an attenuator at the input of each amplifier. The vertical input signal is attenuated to 5 millivolts/cm sensitivity before it is applied to the amplifier.

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The authors

Prior to directing the design of this 50-Mhz oscilloscope at Hewlett-Packard Co.'s Colorado Springs division, William Grein contributed to the basic design of the H-P Model 175A oscilloscope. He joined H-P shortly after receiving a BSEE from the University of Colorado in 1960.

Milton Russell is project engineer for cathode-ray tube development at Hewlett-Packard's Colorado Springs division. He designed industrial and military crt's at General Electric, Syracuse, N.Y., before joining Hewlett-Packard.

Johan Sverdrup was project engineer in charge of the development of the delay line for the new oscilloscope. Earlier, he helped design a high-sensitivity wide-band vertical amplifier for the H-P Model 175A oscilloscope.

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

Full-wave detector without transformer

By Colin Yarker

Marconi Instruments Ltd., St. Albans, England

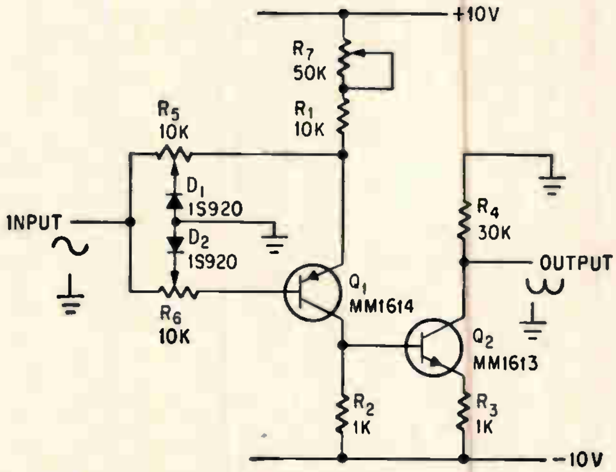
Full-wave detection of a signal with both input and output referenced to ground is provided without a transformer. Operation of the detector is from d-c to more than 10 kilohertz.

A half-wave rectifier with a diode or a transistor is normally used to detect an a-c signal for automatic gain control or a similar application. The a-c to d-c conversion efficiency of a half-wave detector is low, 0.318 volt peak reference to 1 volt peak, compared with the conversion efficiency of 0.636 volt peak for a full-wave detector. Furthermore, the circuit time constant of a half-wave circuit is much longer than that of the full-wave circuit for a given ripple content.

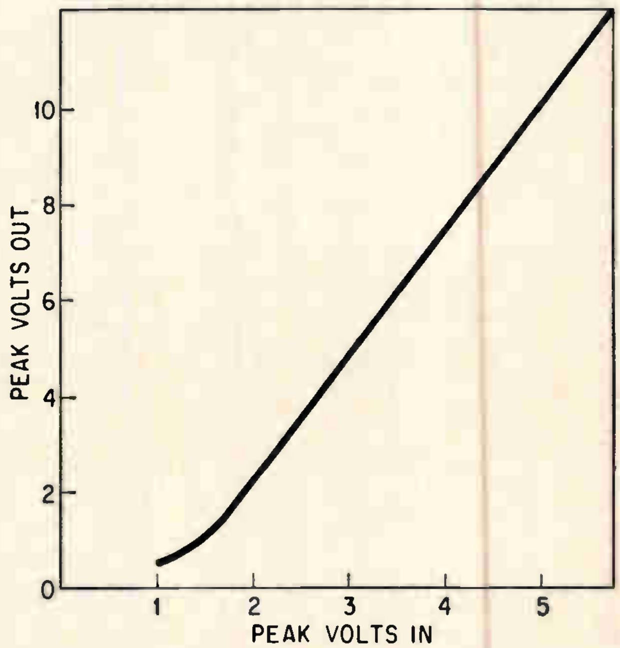
The main disadvantage of a full-wave detection circuit is that a transformer is necessary to reference the input and output to ground, which affects the circuit's low-frequency response and complicates the circuit.

With the positive half-cycle of a sine wave applied to the input, diode D_1 is backbiased and diode D_2 is clamped to ground when the emitter of Q_1 goes positive. With the negative half-cycle applied to the input, diode D_2 is backbiased while diode D_1 is clamped to ground when the base of Q_1 goes negative. Each half-cycle, positive or negative, causes a positive half-wave voltage to develop across resistor R_2 in the collector circuit of Q_1. Transistor Q_2 acts as a restorer to reference the output back to ground. Potentiometers R_5 and R_6 are adjusted to obtain equal amplitude of the two output half-wave voltages. These appear across R_4 in the collector circuit of Q_2. Potentiometer R_7 biases Q_2 to a minimum level of continuous conduction to form a sharp cusp-shaped wave form across R_4. This adjustment of R_7 causes a slight d-c offset across R_4, which is made negligible in proportion to the output-signal amplitude.

The curve shows the relationship between the peak input and output voltages.



Transformerless full-wave detector reference to ground. Each half-cycle of input sine wave causes negative half-cycle at the output.



Linear relationship exists between input and output peak voltage, except in 1.5-volt input region.

Nonlinearity occurs in the region of 1.5 volts peak at the input, because of the changing impedance of the diodes and the transistor Q_1. The upper level is limited by the negative supply voltage and can be extended if required.

If the circuit replaces a bridge-detector circuit with a 1:1 transformer, it would have a gain of 2 down to d-c. The ripple percentage would be the same using an equivalent load impedance and smoothing capacitor.

If the circuit replaces a half-wave detector, the improvement in gain would be 0.636/0.318 x 2 = 4, with an equal ripple level. Thus, reducing output levels to those of a half-wave circuit results in less ripple with the same time constant.

The circuit could also be used as a frequency doubler. In this mode, Q_2 may be omitted if the d-c level at the collector of Q_1 is not critical.

Multivibrator controls single-diode gate

By S. Hoi Tsao

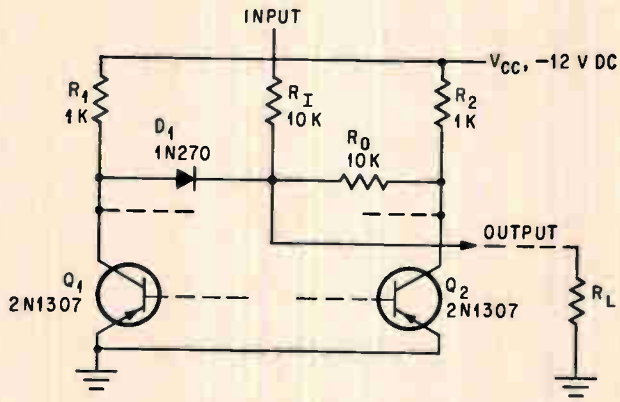
National Research Council, Ottawa, Canada

A simple bilateral gate is shown with part of the collector circuit of a typical saturated multivibrator which controls its gating action.

When Q_1 turns on and Q_2 turns off, the germanium diode D_1 is forward biased. The collector of Q_1 bottoms, and the output is thus held close to ground potential. As the state of the multivibrator changes, with Q_1 off and Q_2 on, D_1 becomes reverse biased, allowing an output to appear across R_o and Q_2 (now saturated) in parallel with R_L. With the input grounded, the change in output voltage amounts to about 0.2 volt.

For best results, both R_I and R_o must be comparable in magnitude to the geometric mean of the forward and reverse resistance of D_1, and considerably larger than R_1 and R_2. The gain of the gate can be approximated by

$$G = \frac{R}{R + R_I}, \text{ where } R = \frac{R_o R_L}{R_o + R_L}$$



Transistors Q_1 and Q_2 are part of a saturated multivibrator. The single-diode bilateral gate consists essentially of R_o and D_1. It permits an output when Q_2 turns on, blocking D_1. As Q_2 turns off, D_1 and Q_1 clamp output close to ground when Q_1 conducts heavily.

The maximum allowable input voltage should not exceed $\pm V_{cc}\ R_I/R_o$. Under these conditions, the gated signal has little effect on the switching action of the multivibrator and spurious triggering does not occur.

Complementary as well as a multiple number of gates can also be controlled by a single multivibrator. Capacitive coupling offers another modification for a-c signals.

Differential discriminator rejects common-mode noise

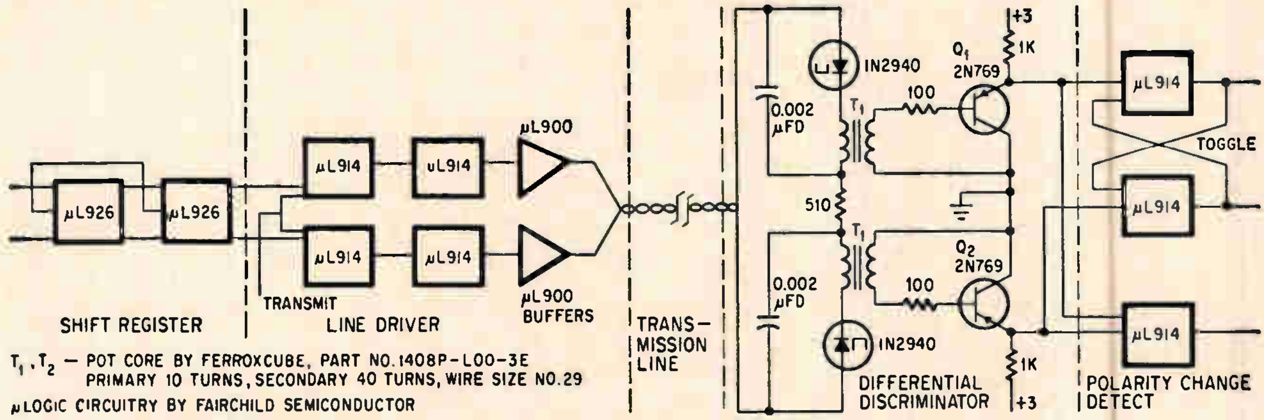
By Forrest Salter

Argonne National Laboratory, Argonne, Ill.

Tunnel diodes serve as current level detectors in the differential discriminator shown. Diodes allow detection wave-form restoration and storage of high speed serial binary information transmitted over long distances. This method of detecting serial bit information eliminates differential amplifiers and their power supplies, and still provides common-mode rejection of high and low-frequency noise.

The discriminator shown—designed to be compatible with low-cost RTL (resistor-transistor logic) integrated circuits —is part of a system for transmitting phase-modulated digital data over a 3-mile telephone line.

The system's transmitter consists of a shift register and line driver made from Fairchild Micrologic circuits. The line driver holds both sides of the line at ground for no transmission and polarizes the line in either direction during transmission, (positive for a logical one and negative for zero). This permits the receiver to detect the start



Attenuated binary bits—received at the termination of telephone transmission—trigger tunnel diodes and the original pulse wave form are restored. The toggle circuit restores the d-c level lost in the pulse transformer.

of transmission with either a leading one or zero, saving synchronization time.

The differential discriminator in the receiver includes two tunnel diodes and two high-frequency pulse transformers arranged back to back to sense current for logical bit detection.

Resistor R_1 in the receiver terminates the telephone line in its correct impedance. The two input capacitors to the discriminator form a low-pass filter for bypassing high-frequency noise. The values of resistance and capacitance are chosen to match the impedance of the telephone line and for frequency response.

The detector is differential because changes of state of the tunnel diodes depend on the current through them. This current in turn is a function of the difference of potential between the two input terminals.

As the forward peak current of either tunnel diode is exceeded, impedance changes abruptly, producing a pulse on the output of the transformer. Both are tied into a NOR gate to signal the control circuitry that information has been received in the toggle and can be gated out.

These high-speed pulses—coupled through the transformers—set the toggle, which reestablishes the d-c voltage level. The pulses are conducted through the emitter followers, Q_1 and Q_2, which provide the current gain and positive d-c shift to achieve stable triggering.

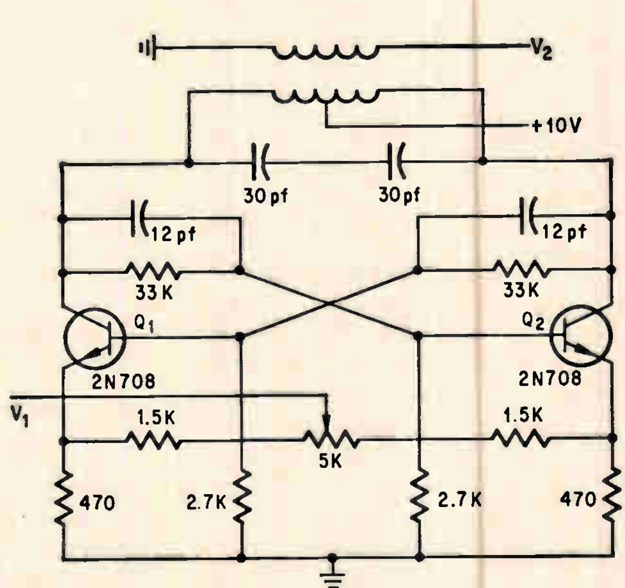
Multivibrator provides continuous phase control

By S. Tesic

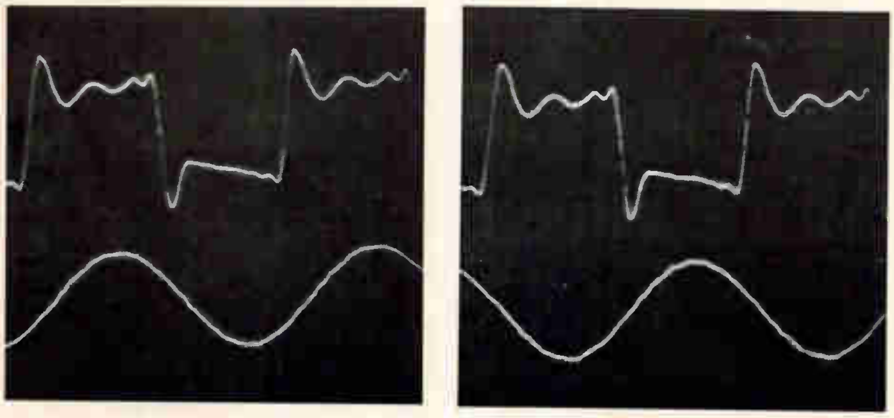
University of Belgrade, Yugoslavia

A single potentiometer provides smooth 180° phase control in the free running multivibrator at the right. With a synchronizing voltage, V_1, at the input, the phase of the output voltage, V_2, varies as the arm of the potentiometer is moved from transistor Q_1 toward Q_2. The circuit has the advantage of maintaining a constant output voltage over the phase-control range. The phase depends on the energy distribution ratio between the two active elements of the symmetrical generator.

Since the frequency of the circuit is controlled by the synchronizing voltage, the circuit may be



Moving the potentiometer arm changes the phase relationship between synchronizing voltage V_1 and output voltage V_2. Amplitude of V_2 remains constant.



Phase relationship between a 30-megahertz square-wave synchronizing voltage and the output sine wave at two different potentiometer settings.

operated over a large frequency range. In addition the synchronizing voltage may be either a sine wave or a square wave.

The minimum amplitude of V_1 is that value necessary to synchronize the circuit when the potentiometer is at its midrange. At this point the circuit is least sensitive. The voltage is about 2 volts peak-to-peak, about 10 times the amplitude necessary to synchronize the circuit directly at the emitter.

The photographs, taken at two different settings of the potentiometer, show how the phase of a sine-wave output at 30 megahertz varies in relationship to the square-wave synchronizing voltage.

Integrated circuits quickly assembled

By Forrest Salter

Argonne National Laboratory, Argonne, Ill.

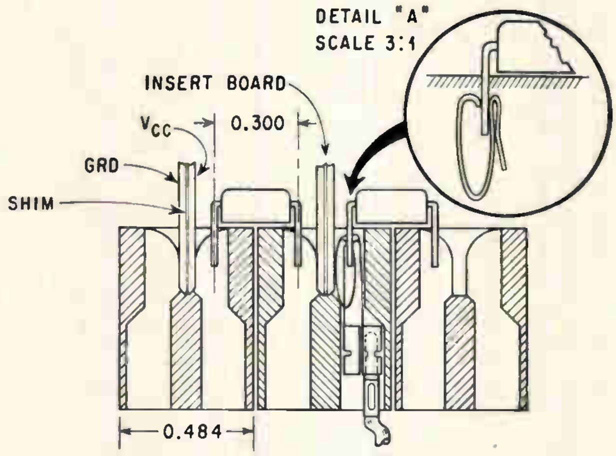
An easy way to breadboard integrated circuit assemblies is to use IC's in dual in-line packages (DIP's) and plug the DIP leads directly into the type of connector normally used as edge connectors for printed circuit boards.

This assembly offers fast turn-around, quick changes and the possibility of repeated re-use. By using this method a small control system was built in days rather than weeks.

A printed circuit edge connector (EMS048DJ000), made by Hughes Connecting Devices, a division of Hughes Aircraft Co., possesses the correct dimensions. The contact rows are the proper distance apart and the tenth-of-an-inch spacing matches the DIP lead spacing. To plug in the DIP's requires near-zero insertion force.

A cross-sectional view, at the right, shows the IC's in position. The insertion of blank insulating boards or etched circuit boards as shown applies pressure to pinch the leads into position, providing two-sided contact on each lead.

On the wiring side of the connector, two removable crimp-type pins with leads (Hughes's Jacpin EJ20N24C000) are provided for each integrated circuit terminal. This permits a wide variety of interconnections to the integrated circuits.

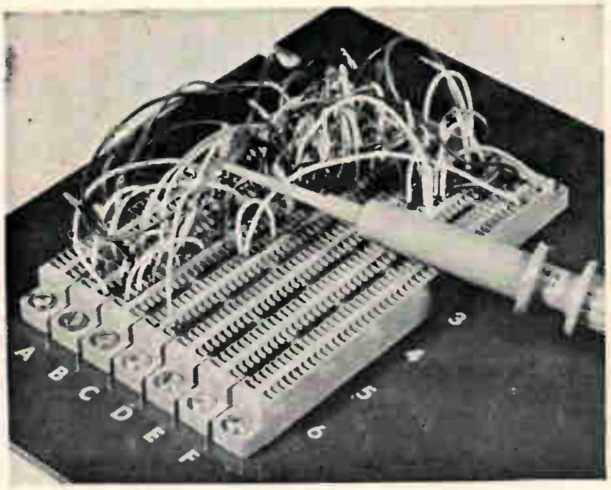


NOTE: CONNECTORS MOUNTED ON 1/2" CENTERS

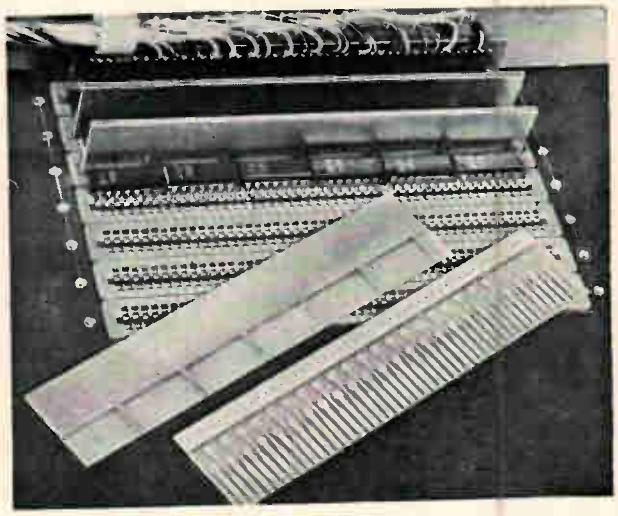
Cross section of three connectors placed side by side with integrated circuits in position.

Voltage and ground leads should be inserted first, keeping them on the bottom layer away from the logic wiring and any required changes. Partial insertion of the Jacpin allows easy removal for any necessary changes.

Additional etched cards can conveniently provide voltage and ground interconnections, besides locking the integrated circuits into position. Because the locations of ground and power terminals may differ from package to package, it is a good idea to make the one-sided 1/32"-thick etched cards longer than necessary. These cards can then be cut at the appropriate locations and placed back-to-back with



Etched boards pinch the leads of in-line integrated circuits mounted in the connectors. These boards are also arranged to interconnect common ground and power connections.



Pins inserted in the wiring side of the connectors allow the integrated circuits to be connected to each other and to external circuitry.

an insulating shim between them to provide proper pressure. The two extreme longitudinal rows of contacts on an assembly of connectors are not used for the integrated circuits because each circuit must straddle two connectors. If desired, these rows can connect external circuitry through an etched board.

The cost of the connectors and pins to accommodate 54 integrated circuits is about $120, or about $2.20 per dual in-line pack. The low cost makes this construction practical for prototypes.

Series regulator gives overload protection

By Michael A. Torla

Sylvania Electric Products Inc., Waltham, Mass.

The series voltage regulator at the right provides both overload and short-circuit protection. The circuit is characterized by low power dissipation and high speed, and the output voltage is automatically restored upon removal of the overload. Usually, a series regulator of this type exhibits high power dissipation in the pass transistor, or requires the manual restoration of the input power after fuses or circuit breakers trip.

Before the regulator turns on, resistor R_3 and the load resistor, R_L, form a voltage divider, such that some small fraction of the input voltage appears across the output terminals:

$$V_o = V_{in}\left(\frac{R_L}{R_L + R_3}\right) \qquad (1)$$

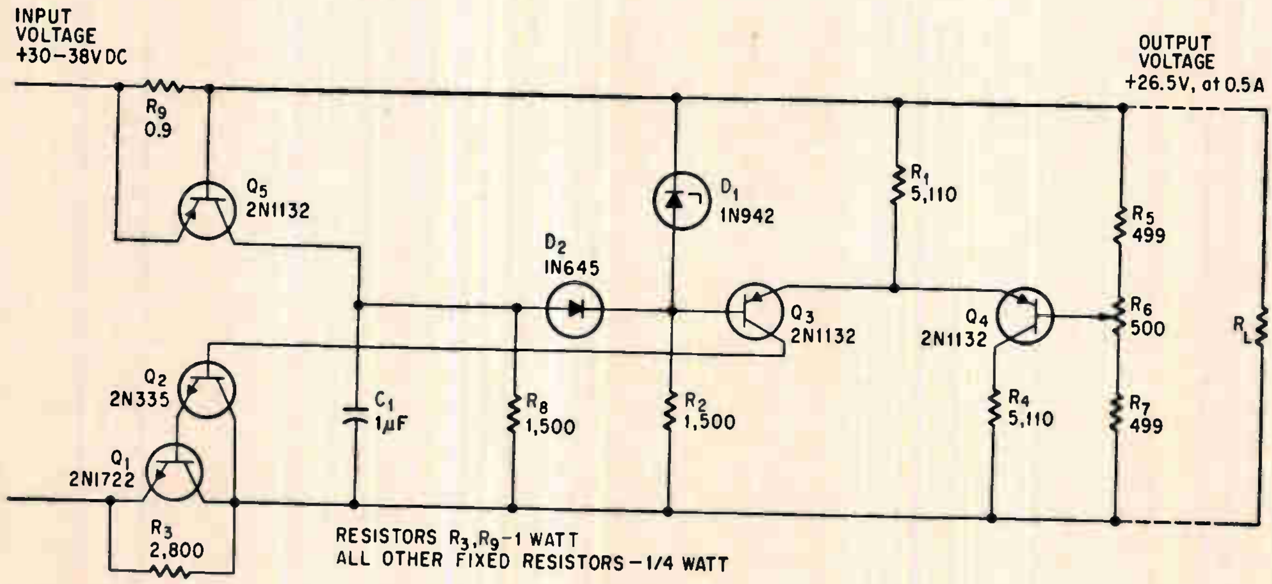
The combined resistance of the sensing and reference network is assumed to be large in comparison with the load resistance.

Since there is no current flow in R_1 and R_2 prior to turn-on, V_o appears across the base-emitter junction of Q_3. If the magnitude of this forward-bias voltage is sufficiently large, Q_3 will turn on, forcing Q_1 and Q_2 into conduction. There is, therefore, a critical value of R_L for each combination of V_{in} and R_3. If the load resistance is less than this critical value, the regulator cannot start. This critical value is the minimum load resistance.

If the load current is increased above maximum design limits with the regulator operating at some normal quiescent point, the voltage developed across R_9 becomes sufficiently large to forward bias the base-emitter junction of transistor Q_5. The resulting collector-current flow develops a voltage across R_8 and C_1 such that the reverse bias across diode D_2 is reduced. At some specific value of overload current, the collector current of Q_5 develops a sufficiently large voltage across C_1 and R_8 to forward bias the diode D_2. This "turn-off" voltage across C_1 and R_8 is a function of the output voltage V_o:

$$V_{TO} = V_o - V_{D1} + V_{fD2} \qquad (2)$$

where V_{D1} is the reference voltage across D_1 and V_{fD2} is the forward bias across D_2. The resulting current flow through D_2 reduces the current through



During overload, degenerative feedback reduces the voltage across the reference diode, D_1, and output voltage falls until Q_5 turns off, thus shutting off the regulator. Regulator cannot turn on unless the load current is decreased.

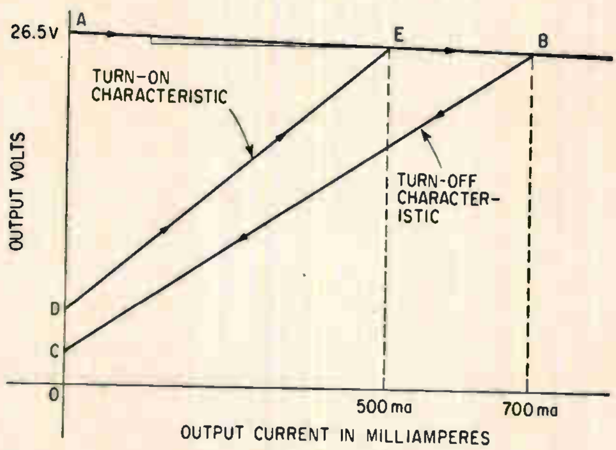
reference diode D_1, thus decreasing the reference voltage, V_{D1}. This change in the reference voltage is accompanied by a corresponding decrease in the output voltage, V_o. From equation 2, it is seen that the combined effect of these two voltage changes is to increase the forward bias across D_2.

As a result, capacitor C_1 discharges more current through D_2, further reducing the reference diode current. This degenerative type of feedback continues until the reference diode current and voltage, as well as the output voltage, drop to approximately zero. With no appreciable output voltage or load current, transistor Q_5 turns off. As soon as capacitor C_1 has fully discharged, the regulator returns to its normal operating mode.

In a typical output characteristic shown for this type of regulator, point A is the open-circuit voltage, while point E represents the maximum design load current. The slope of the line segment AB is the output impedance of the regulator. When there is an overload, the line segment BC represents the turn-off characteristic. Point C is the voltage seen at the output terminals when the regulator is in its short-circuit mode. This voltage may be any value between 0 volts and point D, which is the starting voltage as determined by equation 1.

The line segment DE represents the turn-on characteristic as the regulator returns to its operating condition at normal full load. The geometric figure, BCDE, represents a hysteresis-type effect which arises as a result of changing input voltage conditions, load resistance changes, and variations of component parameters within the regulator, preventing unstable system operation due to overload.

The circuit's maximum average power dissipa-



Output turn-on and turn-off characteristics of the series regulator represent a hysteresis-type effect, due to changing loads, component variations, and input voltage variations. Maximum average power dissipation of the pass transistor, Q_1, 5 watts, occurs at point B.

tion occurs at point B, which is the point of maximum dissipation of the pass transistor, Q_1. The time required for the quiescent point of Q_1 to shift from B to C or from D to E is in the order of microseconds.

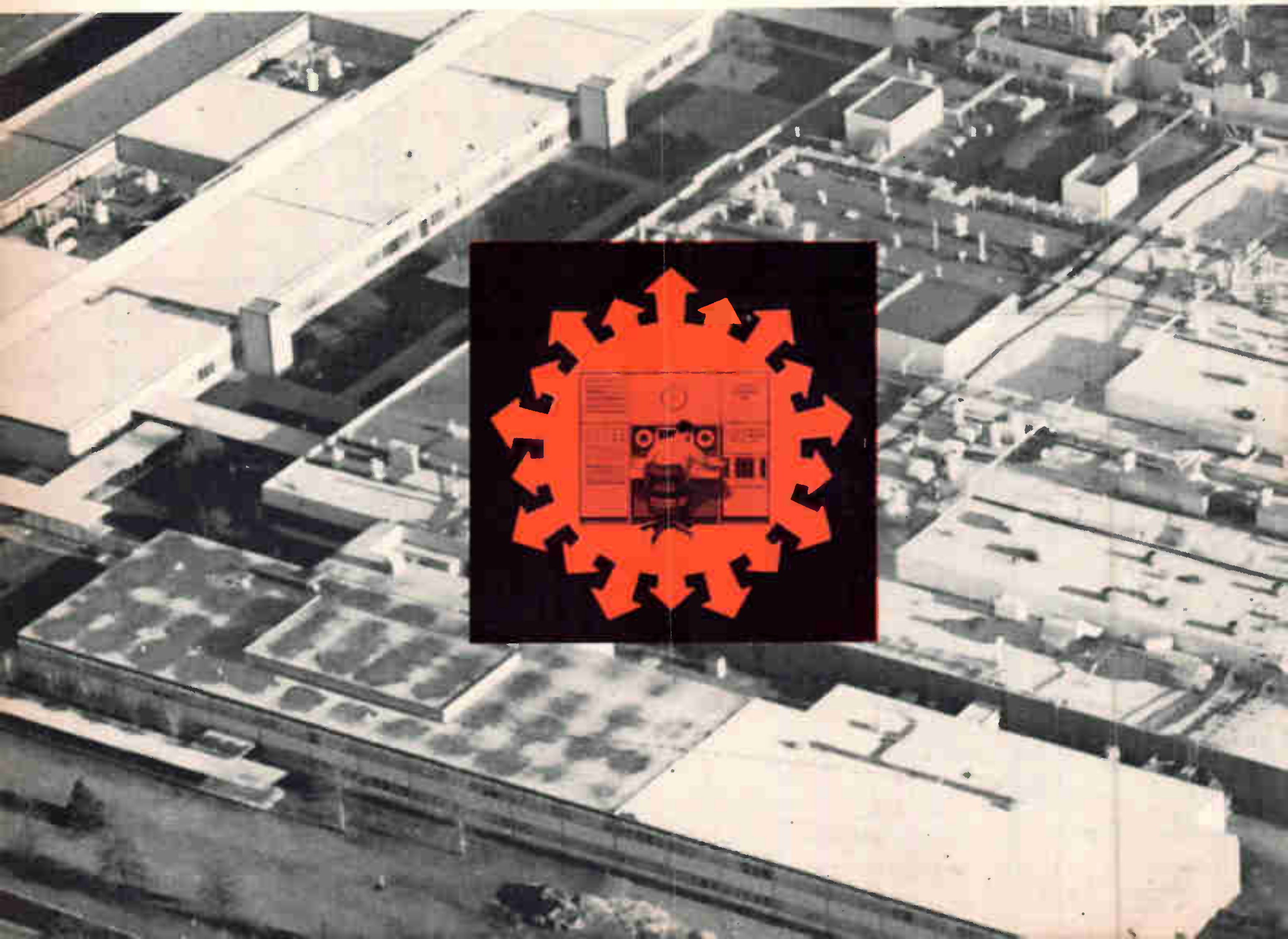
The series regulator can be used to supply power to capacitive loads. In this case, however, capacitor C_1 must be adjusted to provide immunity from surges of load current which occur during the starting cycle of the regulator.

A second effect of capacitive loads is the increase in turn-off time which this type of load causes. This increase in turn-off time, however, does not impair the operation of the circuit, since the switching times are still in the microsecond range.

Honeywell $\boxed{\text{1-man}}$ Control delivers perfect temperature and humidity at new RCA plant

(and it almost paid for itself before the plant even opened)

Here in RCA's advanced Conversion Tube plant the manufacture of intricate, space-age electronic assemblies requires a precisely controlled environment without excessive humidity, temperature variations and dust and dirt. Honeywell 1-man Control monitors all air-conditioning systems and fan systems, as well as the special equipment in RCA's unique, laminar-flow clean room called the "cleanest room on earth." Vincent G. Kling & Associates, Architects. Consulting Engineers: R. J. Sigel Inc.



Messages sent in symbols will link multilingual troops

Small enough for jungle warfare, an encoder-decoder permits soldiers of different nationalities to communicate through simple digital displays

By H.R. Gutsmuth

Communications Systems Division, Radio Corp. of America, Camden, N.J.

A military coder may soon allow troops of different nationalities to communicate with each other through the universal language of digital symbols. Military directives will be translated into the symbols and radioed to friendly troops—to be read out in their own language.

In Vietnam, for example, communication is difficult and subject to error. With the coder, South Vietnamese and American troops could signal one another in clear terms, overcoming both language and distance barriers.

The jungle message encoder-decoder (JMED) transmits in seconds, rather than in minutes as with audio equipment, cutting down on chances of jamming or interception.

Developed by the Radio Corp. of America's Communications Systems division, JMED is essentially a telemetering system with a transceiver-display unit. Its operation depends on several cards containing military messages in the user's language and a 5-bit digital code for each of 30 messages. By matching symbols on the card and display, the messages are exchanged.

The jungle coder works with the Army's AN/PRC-10 and AN/PRC-25 manpack radios. It can be modified, however, to work with almost any portable military communication set. Its nickel-cadmium batteries provide enough power for 200 transmissions or receptions and about 1,000 hours of standby operation.

Pluses and zeros

Coded messages are read on five modular displays, each 1 × 0.6 × 0.5-inch. Each module contains a magnet with a manual or electronically actuated armature and a movable slider mounted against a fixed lens on the module face. The five modules, each displaying either + or 0, are bracketed together. They are capable of indicating 30 coded military communications and two control messages. Adding a sixth display module and its circuitry would raise the message formats to 64.

The transmission system on page 110 sequentially frequency-modulates a 1.55-kilohertz carrier tone with two audio frequencies—70 hertz for the 0 data bit and 130 hz for the + bit.

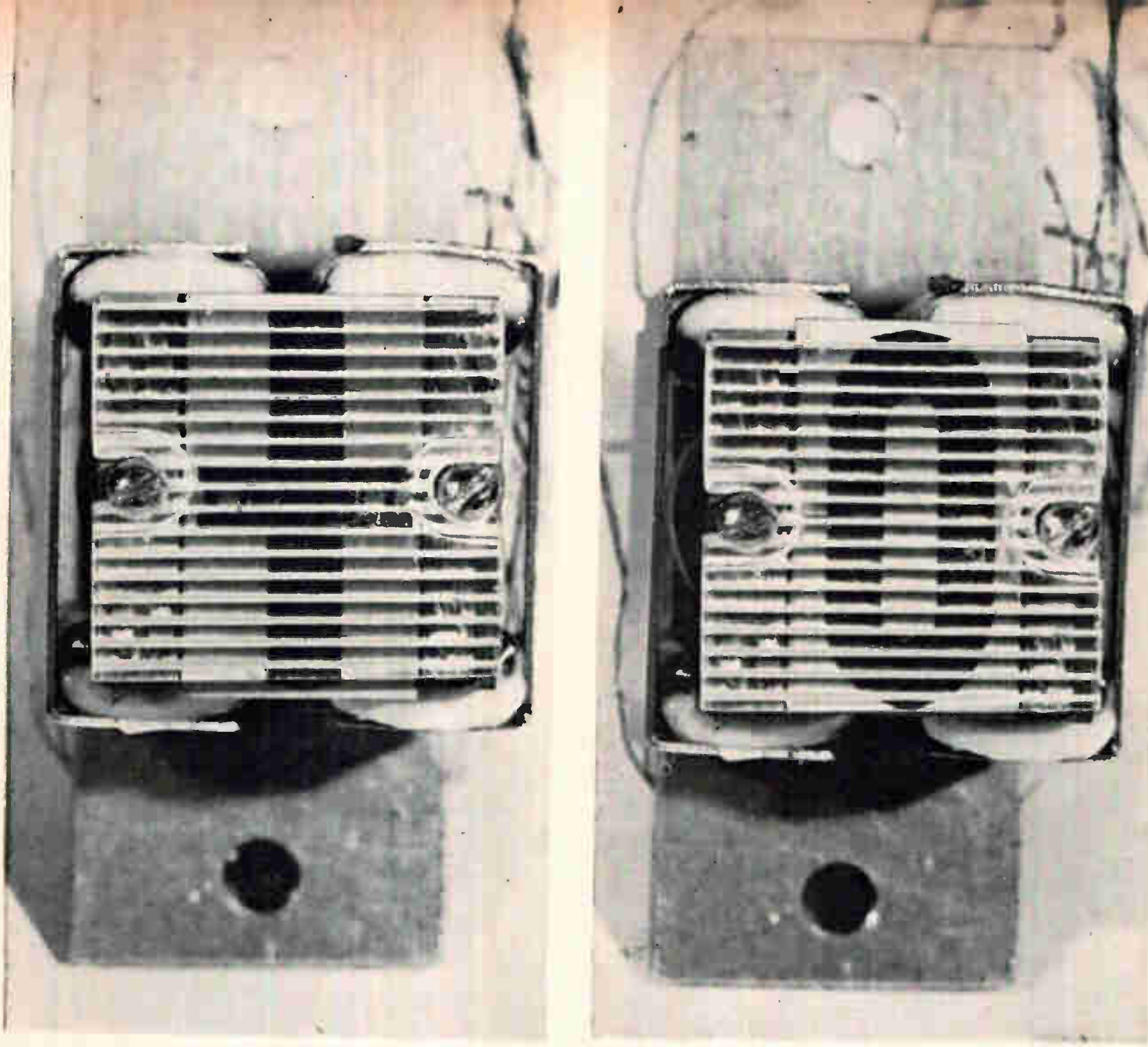
The operator selects the digital code representing the message he wants to transmit and inserts it into the coder by pressing the + buttons on the top of the unit or the 0 buttons on the bottom. He then moves the mode selector to the transmit position and depresses and holds the transmit switch momentarily. Power is turned on, starting the oscillators; but the system is inhibited from transmission while the stages switch to the proper state to begin generation of signals.

After a 500-millisecond period, a 5-hertz clock and a time-slot generator formed by the ring counters, AND gate and one-shot multivibrator, as illustrated, produce time-sequencing pulses for the encoder operation.

The first time slot—each slot is characterized by a 175-millisecond square-wave pulse at the beginning of the 200-millisecond period—turns on the

The author

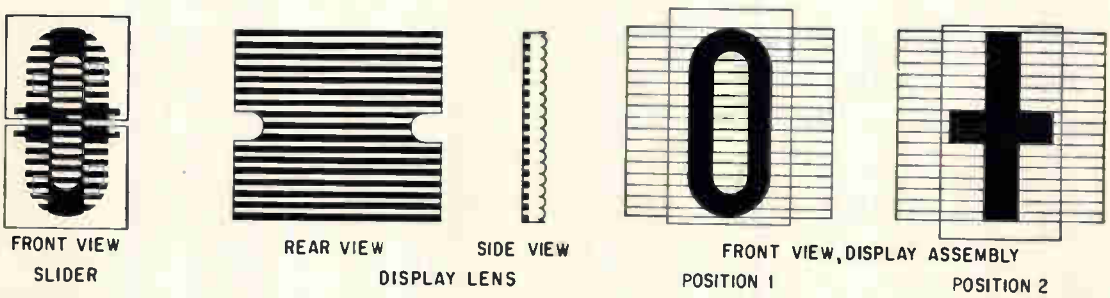
H.R. Gutsmuth, a design engineer with RCA, has been responsible for the development of several secure communications field sets. He has also been project engineer for the ballistic early warning system site in Thule, Greenland, and for RCA's Mark 1B satellite communications terminal.



Scribed movable slider and a fixed display lens work together to form + and 0 symbols for the encoder-decoder display. The slider is positioned manually or by an electronically energized armature.

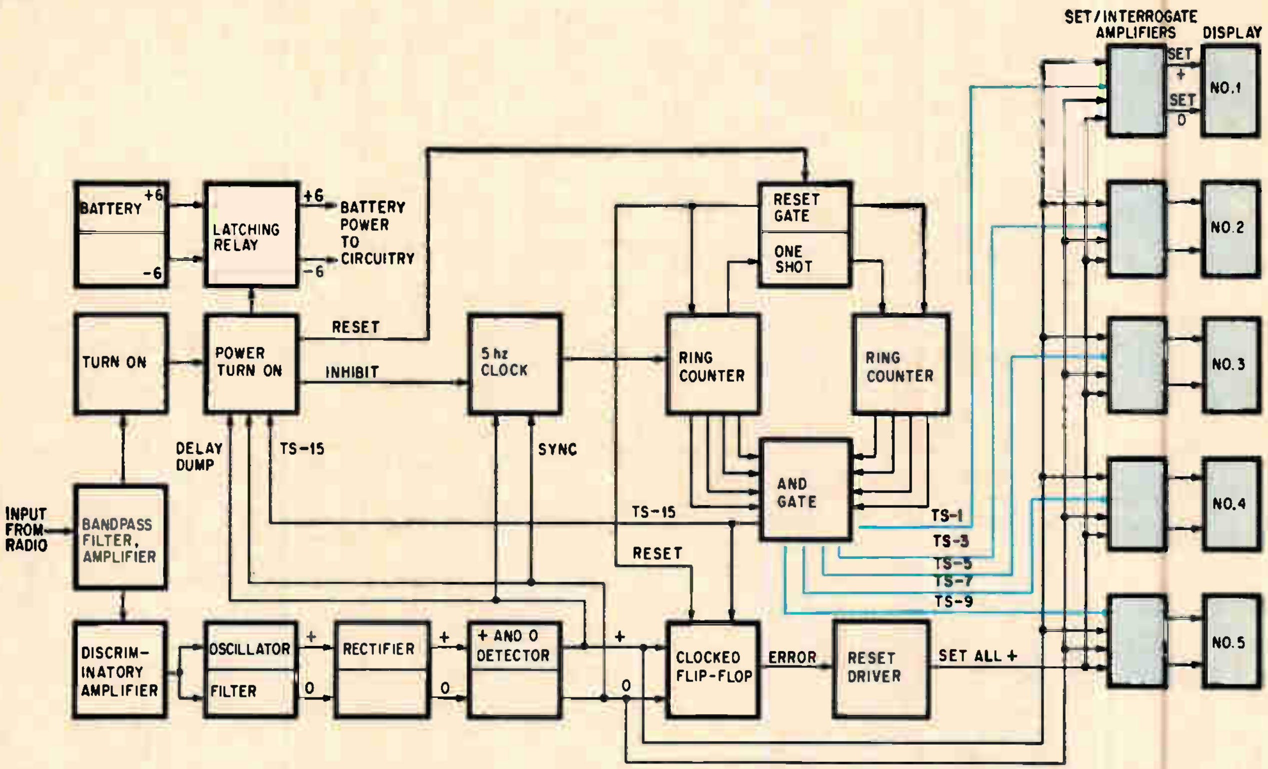
number 1 interrogate stage, which samples the state of display module 1. The display, with separate readout coils for the + and 0 states, emits a 1.5-volt pulse. Detected and amplified by a gate circuit, the pulse switches the tone gate's monostable multivibrator so that either the 70-hertz or 130-hertz tone signal frequency-modulates the 1.55-khz voltage-controlled oscillator. The tone signals are produced by an oscillator-filter.

The transmission of the data bit signal is based on a return-to-zero format. At the end of 175 msecs the time-slot generator shuts off the tone signal. The second time slot is used as dead time, during which only the subcarrier is transmitted. Time slots 3, 5, 7, and 9 interrogate the remaining display modules, for transmission of + or 0 data bits. Like time slot number 2, the even numbered slots, 4, 6, 8 and 10, are used for subcarrier transmission only. Time slot pulses 1, 3, 5, 7, 9 and 11, which are fed directly from the AND gate to the tone gate's amplifier, are reset pulses. Time slot 11 also samples the clocked flip-flop and triggers a 0 or

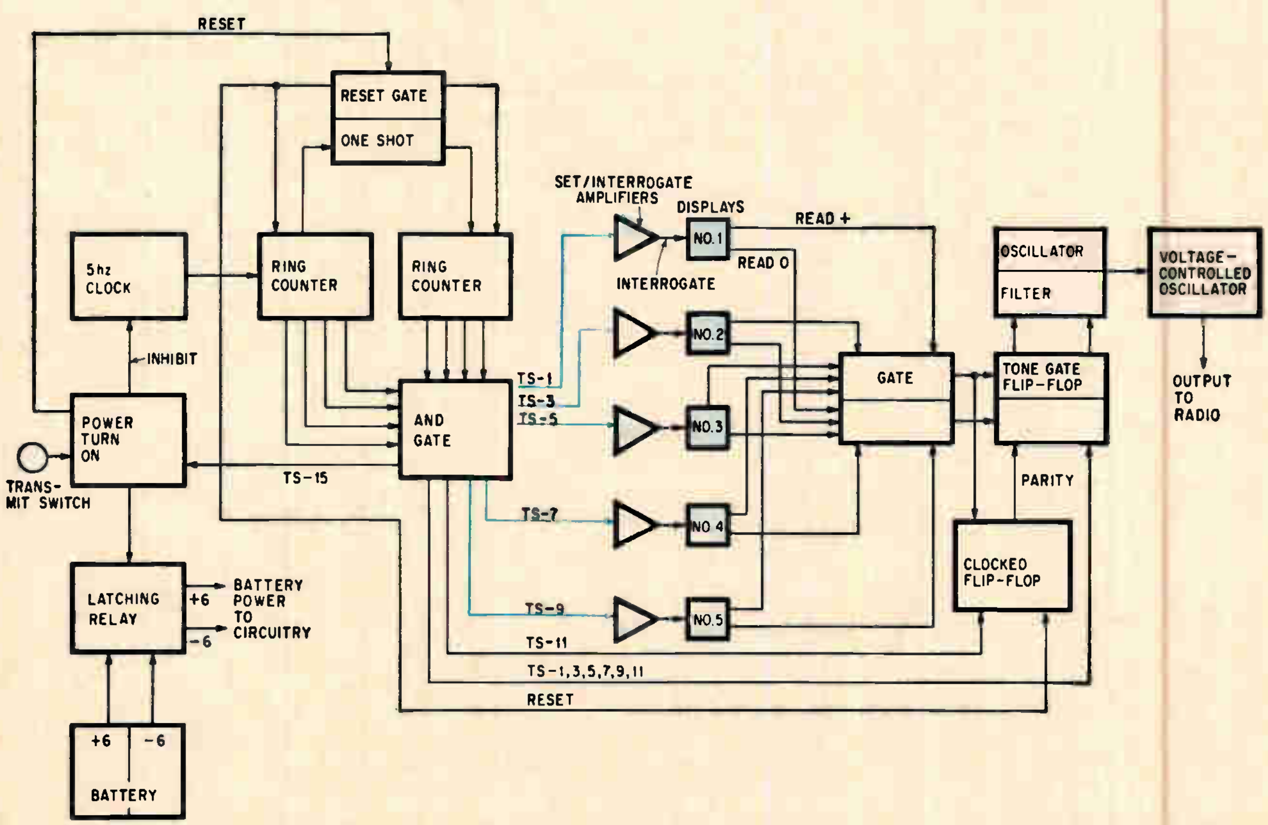


Display symbols are changed by the movement of the aluminum slider. Paint-filled scribed lines on the back of the outer lens piece cover and uncover the black lines of the movable inner slider, forming 0 or +.

Symbol encoder-coder



When the equipment is receiving, the modulated subcarrier is filtered, amplified and rectified. After passing through a 0 or + detector, the 70- or 130-hertz signal gates on the set/interrogate amplifiers. Amplifiers' output pulses set up the receiver display modules to indicate the same symbols as those in the transmitter.



When the transmitting switch is depressed, a latching relay applies battery power to the electronic circuits. It also operates a second relay which configures the JMED for transmission. Simultaneously, it turns on a voltage controlled oscillator which generates a 1.55-kilohertz subcarrier signal for 500 milliseconds. During this start-of-message signal, the transmitter is inhibited and the stages set for data-signal generation.

+ to generate an odd parity bit signal. The remaining cycles, to time slot 15, produce only subcarrier transmission.

Getting the message

During the first 500 msecs of operation, the transmitted subcarrier signal is received by the AN/PRC-25 or other communications set and is passed on to the JMED. In the decoder, the signal is passed through a bandpass filter, amplifier and integrator stage to the turn-on circuits, which are in standby condition. The receiver requires about 300 msecs of the 500-msec subcarrier transmission time to switch its turn-on stages from standby. After the 500-msec period, the leading edge of the first incoming data-bit pulse removes an inhibit signal from the power turn-on stage and power is applied through latching relays to the decoder circuits. Simultaneously, the clock is synchronized to the + and 0 detector's output pulse's leading edge. To assure synchronization, the clock period is made slightly longer during reception than during transmission although both cycles are nominally 5 hz. A capacitor is used to slow the clock slightly in the receive mode. Coincidence of time slot number 1 and the first detected data-bit pulse are used to gate-on the first display driver module.

After the power is turned on, the incoming signal passed through the bandpass-filter amplifier stage is directed to the discriminator. Here the signal is demodulated, applied to selective (70-hz or 130-hz) filter amplifiers and passed on to the rectifiers. The output of the rectifier is a d-c level the amplitude of which depends on whether the subcarrier only, or a + or 0 is being transmitted. The detector output has the appearance of a square wave, since the rectifier subcarrier establishes a zero reference (d-c) level and the time between pulses is equal to the pulse-transmission period. The synchronization of the time slots and the return-to-zero mode of transmission assure that the transmitted signal actuates only the appropriate display module.

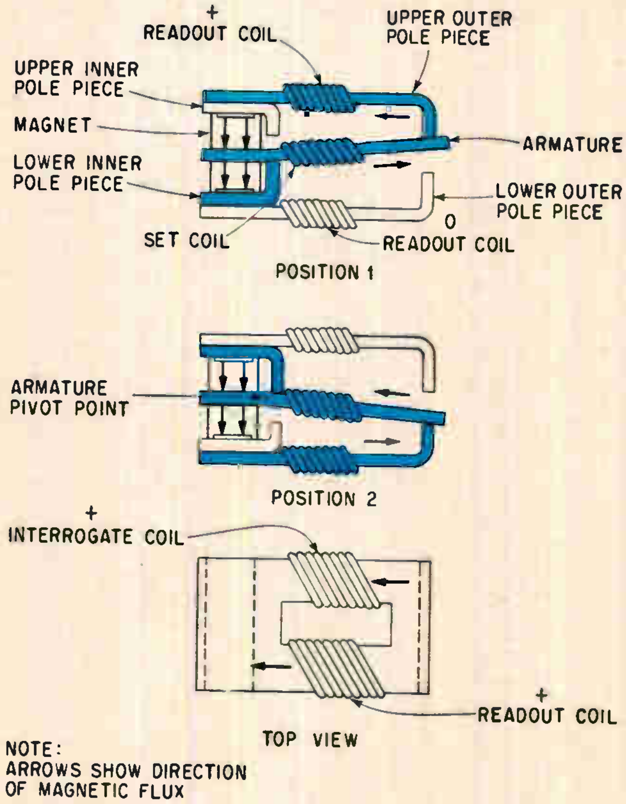
As each + or 0 detection is made, the error circuit of the clocked flip-flop counts the data bits and + odd parity. If the error circuit does not count a total of six data bits—five data bits plus a sixth for odd parity—error pulses are automatically sent to the display modules, placing all five of them in the + position. This indicates to the user that the correct message was not received. If the count is correct, the received message is set into the displays where it remains until a second message arrives, or until the operator changes the displays.

Two states

The + and 0 symbols are formed on the display module by a painted aluminum slider and a molded plastic lens piece, as shown in the diagrams and photographs on page 109.

The back of the lens has scribed lines filled with opaque paint and the front has a series of 2X magnifying lenses. The lenses double the apparent width of the clear area and shrink the lines to a tenth their actual width. The slider is scribed with a line pattern that forms both a + and 0.

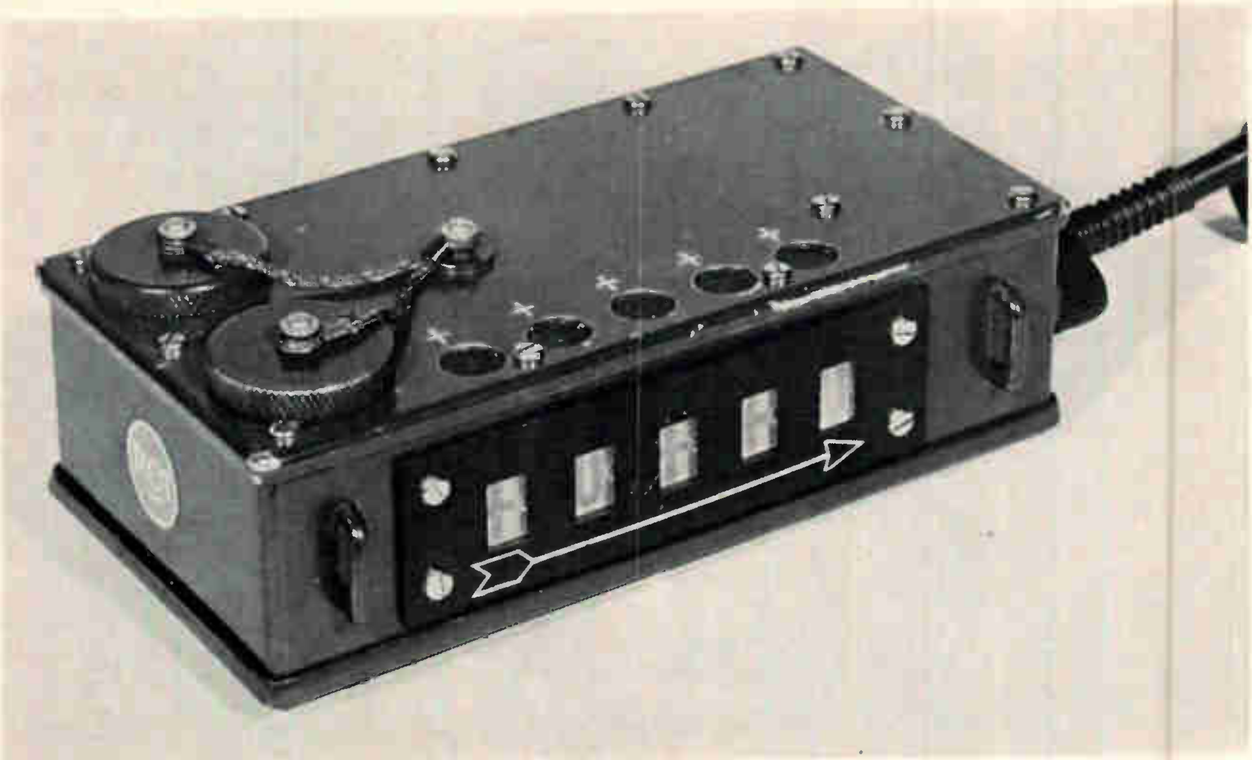
When the slider is in the 0 position under the lens, the lines forming the 0 are under the clear areas of the lenses and are magnified so they appear to fill the space between the lens lines, while the + pattern is hidden behind the lens lines and is not magnified. In the plus position the setup is reversed: the lines which form the + sign are



Magnetic flux passing through the pole piece retains the display module's armature in its set position. When the set coil is energized by a square-wave pulse, it rotates and changes the position of the slider. Arrows indicate flux path for two conditions.

Module coil characteristics

Set and reset coils	
Maximum set and reset power	300 mw
Minimum drive voltage	5 v
Approximate coil resistance	83 ohms
Interrogate coils	
Minimum drive voltage	5 v
Approximate resistance per coil	60 ohms
Both coils in series	120 ohms
Readout coils	
Minimum output voltage (nonsaturated state into 1-kilohm source impedance)	1 v peak
Maximum output voltage (saturated state into 1 kilohm)	0.45 v peak
Approximate coil resistance	115 ohms



Depression of + buttons on top and the 0 buttons on bottom of the jungle message encoder-decoder changes symbols to form special military messages. These could be transmitted to troops of many nationalities by manpack radios. Only 6¾ x 3½ x 2 inches in size, the JMED weighs about 3 pounds.

in the clear area and therefore are magnified.

The slider is moved back and forth by the pushbuttons when a message is to be transmitted, moving the position of the magnet armature about 0.014 inch. This position determines which readout coil is sensed by the transmitting system. When a message is received, the received signal energizes the appropriate coil, moving the armature and the slider.

The display module's magnetic structure, shown on page 111, is designed so that the armature has two stable positions. When the armature is rotated so that it is against the upper-outer and lower-inner pole pieces, 0 is displayed. If the armature is against the lower-outer and upper-inner magnetic pole pieces, + is displayed. Magnetic flux generated by built-in biasing magnets retains the armature in either of the two positions.

When the front of the armature is against the upper-outer pole piece, as indicated, the magnetic flux continuously flows through the two pole pieces and the armature is retained by the magnetic attraction between it and the pole piece once the slider is in the 0 position. If the front of the armature is manually forced from the upper pole piece to the lower pole piece by depressing the + button on top of the JMED, the flux direction in the armature reverses and the armature is held against the opposite pole piece.

In receiving, flux direction is reversed by a current pulse in the set coil. The armature rotates and magnetic repulsion moves the front of the armature from the upper to lower pole piece, setting a + in the display. A second flux reversal by the set coil will return the armature to the 0 position. The total electrical energy required to move the armature is very small, less than 1 milliwatt second.

When the armature front is against the upper pole piece, a pulse into the + interrogation coil produces little output voltage, because of the magnetic saturation of the pole pieces. However if the armature front is against the lower pole piece, the upper pole piece is unsaturated and a pulse at least 20 decibels greater than the saturated pole pulse can be read in the + output coil. A pulse into the 0 interrogate coil causes an output in the 0 readout coil that is also affected by the rest position of the armature. The armature and pole pieces are made of 4750 iron-nickel magnetic alloy (49% nickel).

Testing the circuit

To test the performance of the system's modules, RCA developed a unijunction-transistor oscillator with the output characteristics of an actual JMED. When its 5-volt peak, square-wave pulse was fed into the two 60-ohm interrogate coils, an output voltage of 0.45 volt or 1.5 volts was observed at the readout coils. The slider moved rapidly from position to position when a 5-volt pulse was injected into the set coil. Although the JMED specifications required a minimum set power of 300 mw, all of the first units tested operated with set powers of 200 mw and set voltages of 4 volts. The amplitude change ratio for the display module's + output was 21.5 db; the change ratio for the 0 output was 23 db.

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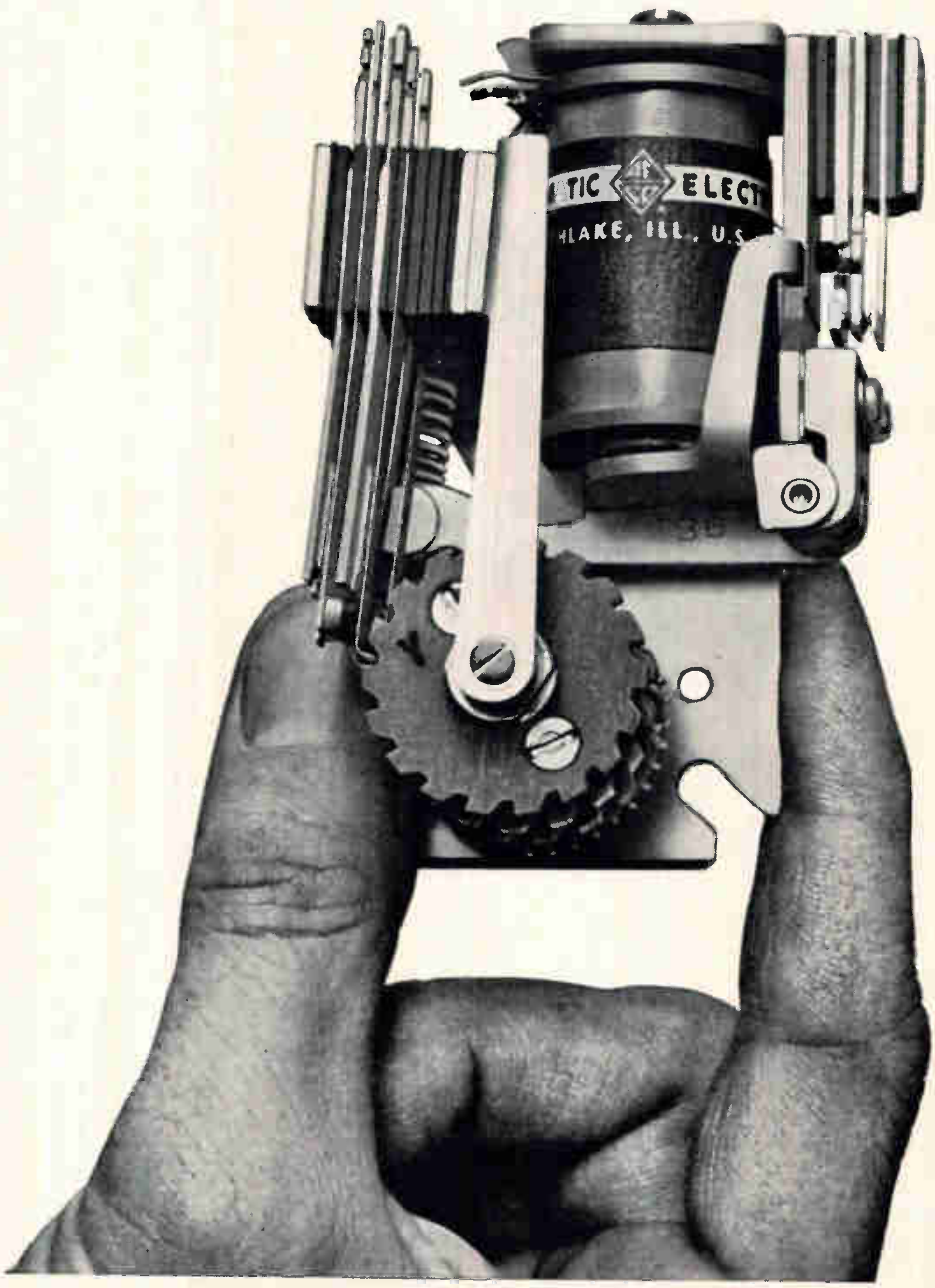


Gold-plated nickel wiring debugs parallel-gap welding of IC's

Better etching and plating processes for nickel, new layout rules and visual inspection criteria plus a few tricks of the trade make parallel-gap welding of integrated circuits a routine job

By Norman A. Jarosik and Harold Shapiro
Sylvania Electric Products Inc., Williamsville, N.Y.

Parallel-gap welding is, in principle, a superior way to bond integrated circuits to printed-circuit boards. Properly made bonds are very reliable and the new automatic welding machines work fast. But the many flaws that can be caused by seemingly minor inadequacies in materials and methods have limited practical applications in quantity production.

One by one, the shortcomings were overcome during production of microminiature test sets for the Air Force's Minuteman ground maintenance equipment program, now in its final production phase at the Electronic Systems division of Sylvania Electric Products Inc. Improvements in techniques have relaxed the constraints and precautions that were typical when the program began in 1964.

The basic change in material was adopting high-purity nickel for the printed wiring. Copper proved unweldable in production volume and special composite materials posed such problems as rusting and poor adhesion to the board substrate. However, nickel required development of a special process to tame violent chemical reactions which could destroy narrow nickel wiring traces as they were etched or plated with gold.

New wiring layout rules were developed; for example, to equalize heat sinking during welding. This offsets one cause of inconsistent weld strength —variations in welding temperature from joint to joint.

In 1964, there were no visual-inspection criteria that would allow weld quality to be monitored on the production line. Now, the appearance of the joint after welding and other signs are adequate backups for more rigorous destructive testing of sample welds.

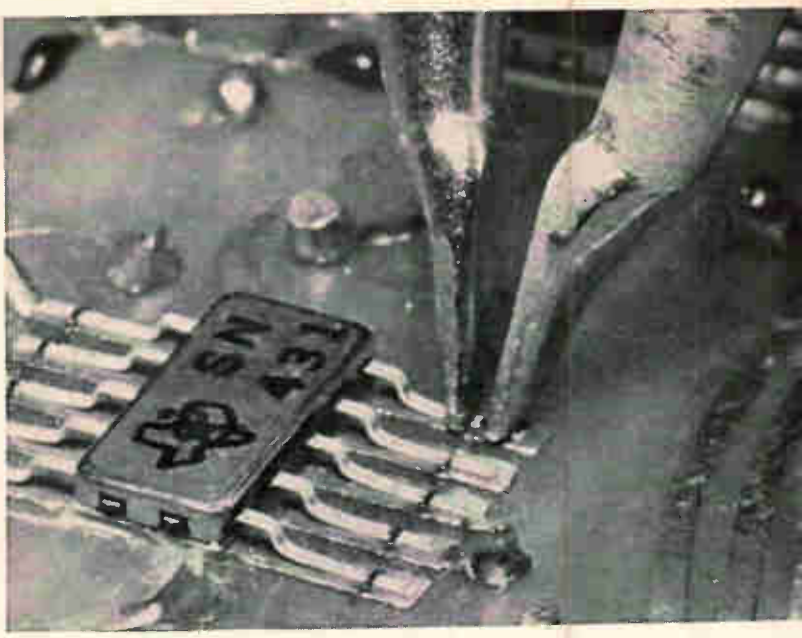
The Sylvania methods give consistently strong bonds. However, the bond between a flatpack lead and the printed wiring is not a true weld. The lead is not fused to the nickel, but is brazed to it by thin platings of gold on the lead and the wiring, visible in the weld cross section on page 117. Fears early in the program that gold braze could not withstand severe physical stress were soon dispelled. None of the more than 750,000 welds made to date has failed in the field.

Of course, soldering would avoid the welding problems, but the Minuteman program required a high density of circuits and connections on the boards. This meant a decrease in size and increase

The authors

Norman A. Jarosik began as a broadcast engineer in 1948, switched to radio-tv design in the 1950's and then to electronic countermeasures. This led to packaging and production of integrated circuit assemblies. He now works on military radios and hybrid IC's.

Harold Shapiro is chief chemist at the Sylvania plant. An expert in the chemistry of materials used in the electronics industry, he has taught metal finishing and electrochemistry at the near-by New York State college of Education at Buffalo.



Parallel-gap welding with an automatic welding machine takes about 30 seconds per flatpack. The view at right is through operator's stereoscopic magnifiers. The configuration of the electrodes gives the technique its name.

in reliability of the joints. Components on the underside of the board prevented the use of wave-soldering machines. Solder bridging between closely spaced conductors and thermal shock to the IC's were additional hazards. Components could be hand-soldered to both sides of the board, but the Achilles' heel of the operation was its dependence on operator skills. Thus, welded joints were preferable.

Welded joints are small and reliable; bridging can't occur; thermal stresses are negligible and the automatic process depends only slightly on operator skill—the operator looks through magnifiers and can see defects more readily. An additional welding advantage particularly important—because IC assemblies are expensive—is that repairs are less likely to damage the board. A component can be replaced by clipping its leads and welding another in its place. If a component is desoldered, too much heat may cause the printed wiring to be lifted accidentally from the board.

Board cladding materials

The decision to use nickel foil as the conductor material followed evaluation of a long list of available board claddings.

Copper was ruled out, despite its many desirable properties, because its high conductivity makes parallel-gap welding difficult. When the current flows between the electrodes atop the IC lead, the copper under the lead forms a high-conductance shunt that carries off too much of the weld current and heat. Further, variations in copper foil thickness on a board upset welding conditions. Welding-machine schedules (settings) must be juggled constantly.

Kovar board cladding welds well, but since it is an iron alloy it may corrode, and its conductivity is so low that the high resistance of narrow, etched wiring degrades circuit performance.

Some claddings are layers of different materials, such as one made by plating 1½ mils of nickel over a half ounce of copper and then plating the nickel with gold. This foil's conductivity is good —a restivity about twice that of copper. The foil doesn't corrode and the copper base bonds it strongly to the board. But it welds erratically; in every 300 welds, there are typically 30 to 50 cold welds or blowouts. The trouble, again, is variations in the copper's thickness. At present, there is no practical method of holding the copper thickness variations below the required tenths of a mil.

Another cladding is a sandwich of three foils: aluminum is the bottom 5% of the total thickness; steel, the middle 90% and nickel, the top 5%. The aluminum is the bonding layer, while the steel buffers the heat as the weld is made to the nickel surface. This laminate welds excellently, etches well and its resitivity is reasonable, five to six times that of copper; but humidity rusts the steel.

Encapsulation prevents rusting of the circuitry on the board. However, when a card-edge connector is used, the exposed steel in the contact area is difficult to protect. An immersion plating won't adequately seal the interface between the cladding and the glass-epoxy board substrate.

Another cladding tested falls off the board after humidity tests. The corrosion of the cladding, which also contains iron, sometimes can be seen underneath the wiring. Even when it can't be seen, the material still loses virtually all its bond strength.

Thick nickel platings are no solution. When the wiring is pulled, it cracks on each side of the weld, and that section of the wiring, plus the lead and weld joint, can be lifted off the board. The wiring may even crack before welding. The defect can be greatly reduced by plating with a nickel-sulfamate bath rather than the usual nickel-fluorobate bath.

High-purity nickel foil

The laminate now used is a 3-mil cladding of high-purity nickel on both sides of a 62-mil-thick epoxy-glass board (grade G-10). It welds well, resistivity is adequate—about five times that of copper—corrosion resistance is high and the material etches well.

At first, two different nickels were being used and etching ranged from poor to good. The poor results were traced to impurities in the standard "A" grades of nickel. A high-purity nickel was selected for which a representative analysis is given in the table at the right. Suitable nickel-clad boards are now available from the Mica Corp., the New England Laminate Co. and Fortin Plastics Inc. Sylvania buys its boards from the Mica Corp.

Since the nickel quality is critical, materials testing has continued throughout the program. Newer boards, made with electrodeposited foil instead of the earlier rolled foil, etch uniformly and consistently from lot to lot. Lines as narrow as 12 mils can be etched with little or no loss of definition. The "A" nickel on the boards tried at the beginning of the program dissolved so unevenly that a 12-mil line might have disappeared from the board.

The growing interest in weldable nickel cladding has prompted laminate suppliers to improve foil purity and bond strength. Bond strength has to be high because conductor widths are becoming narrower and welding heat and pressures soften and distort the epoxy under the joint. Some suppliers now use better adhesives; others plate the underside of the nickel with copper so proven bonding methods can be used. Bond strength is 15 pounds per inch, or more. Earlier claims of bond strengths of over 20 pounds were highly exaggerated, however.

Etching the nickel

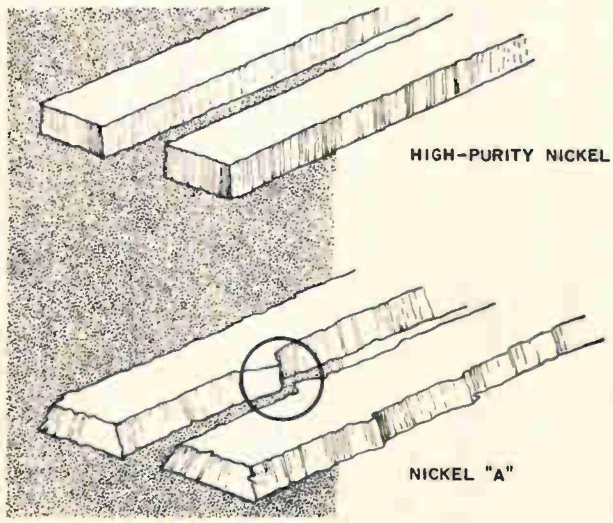
Good boards cannot be produced by etching the nickel with conventional copper-etching methods. The photoresist is undercut severely and trace lines are so uneven that weld strength suffers and the circuits can be shorted out between the wiring as in the sketch at the right.

Sylvania's nickel etchant is ferric chloride containing a dry-acid inhibitor to lower the exotherm —heat produced by the chemical reaction—approximately 10°C. The precaution is important because heat increases etching speed. Also, narrow lines etch faster than wider ones. The accepted theory is that wide lines etch more slowly because the larger areas can dissipate the exothermic heat. Consequently, the narrow lines remain completely exposed to the etchant for a longer time. Without an inhibitor, the narrow lines would etch to a pyramidal cross section and the board would be rejected as overetched. The wiring can vary in width on the Sylvania boards from 15 mils (0.015 inch) to over 45 mils.

Nickel analysis

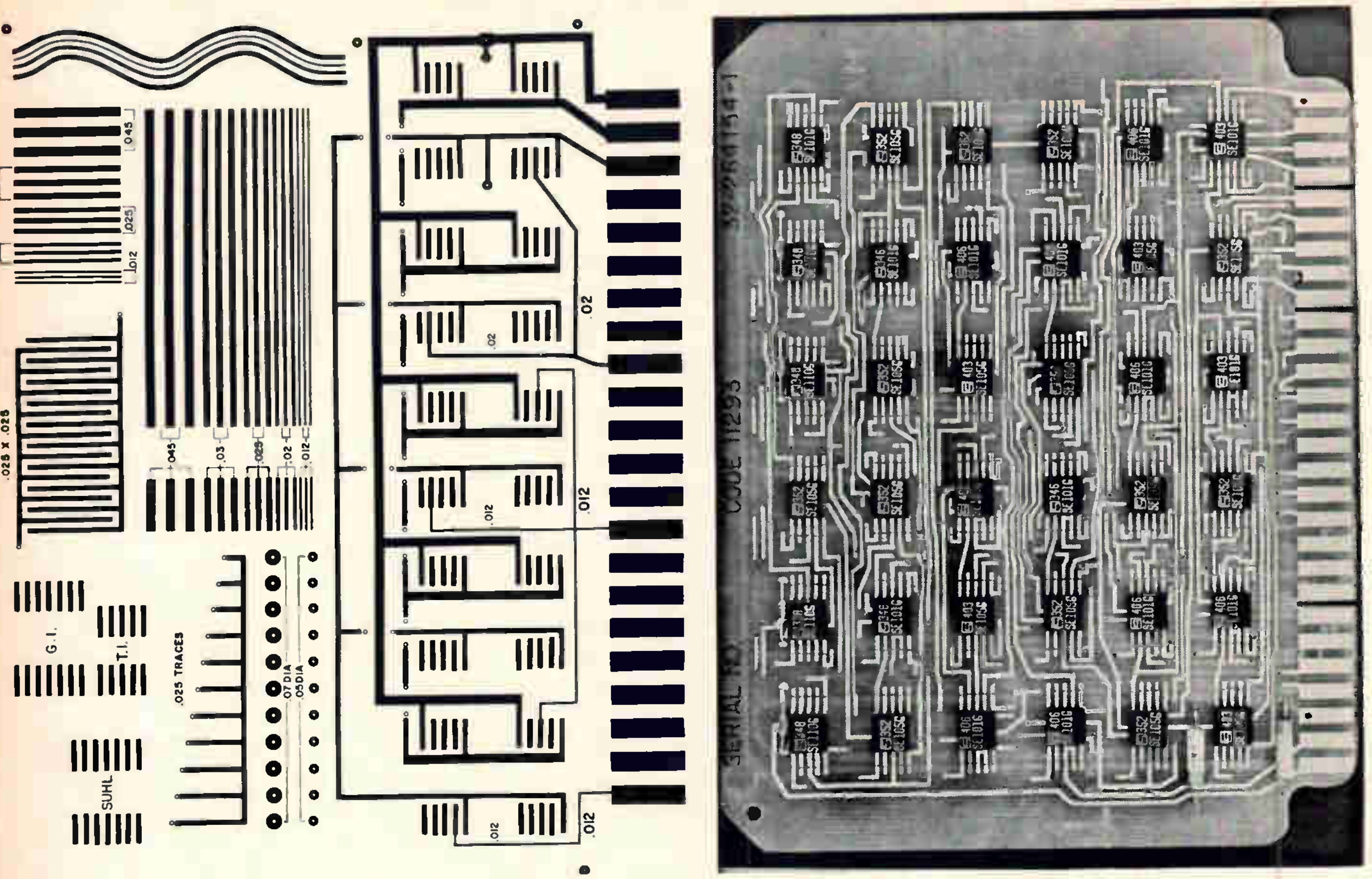
Material	Percentage
Nickel (including cobalt)	99.9
Copper	0.008
Carbon	0.002
Iron	0.014
Silicon (maximum)	0.003
Aluminum (maximum)	0.003
Chromium (maximum)	0.003
Titanium (maximum)	0.003
Magnesium (maximum)	0.003
Sulfur (maximum)	0.002

Cross section of a bond. The lead is bonded to the printed wiring by fusion of the gold plating on each, rather than fusion of the lead and wiring materials.



Standard "A" nickel wiring etches erratically, making short circuits possible between adjoining spurs (circle). High-purity nickel etches evenly (top).

Normally, the etchant attacks the nickel at the junction of the resist and the foil, undercutting the resist. As the resist flakes away, the nickel may etch until the top of the trace is a sharp edge. Photoresist adhesion is improved by dipping the bare nickel for 10 seconds in an etchant based on ferric chloride which microscopically roughens the surface. Increasing the photoresist's solids content and baking it for 10 minutes at 200°F after application makes it more adherant. Both processes help prevent the etchant from attacking the nickel under the resist during the first minute of the etching



Test pattern that monitors the etching process covers the full range of wiring widths and layouts. The lines are both horizontal and vertical to detect any preferential etching effects caused by etchant runoff. One of the boards in the Minuteman test equipment is shown at the right.

cycle, thus slowing down the undercutting action.

Retarding the undercutting causes the traces to etch to a cross section that is a pure trapezoid with an overhang of about 0.1 mil along the top edges of the trace. The overhang can be detected with a fingernail or seen under a microscope. It drops off when the board is cleaned.

The boards are mounted vertically in the etching machine and rotated 90° every 30 seconds. This rotation, plus oscillation of the etchant-spray heads, overcomes the tendency of nickel to etch preferentially in the direction of etchant runoff, which would cause extreme overetching of some lines. Etching is monitored with a test pattern of horizontal and vertical lines, as narrow as 12 mils, as shown above.

Gold-plating

The boards are gold-plated for several reasons:

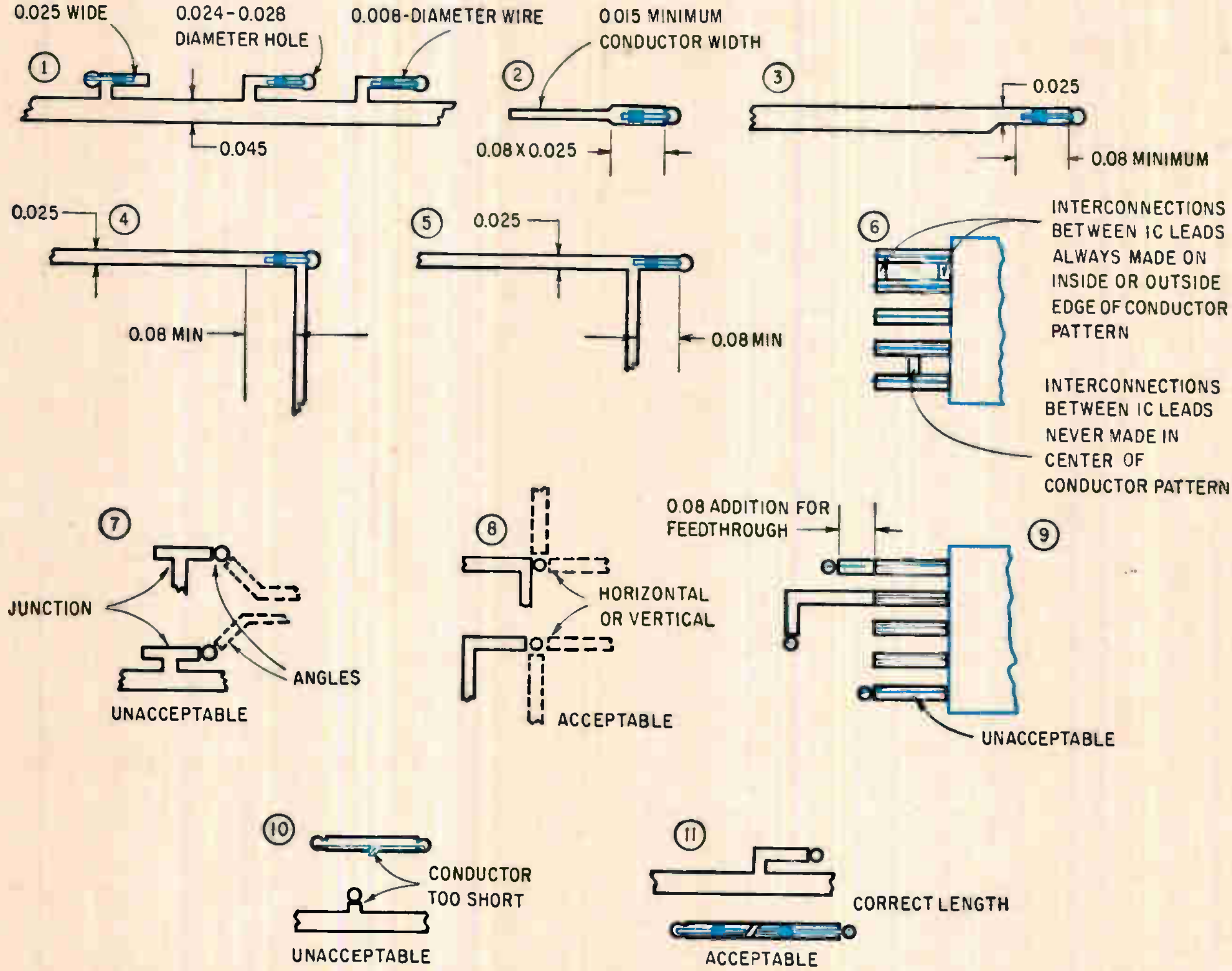
- It is more practical to hand solder the relatively few discrete components needed than to develop a large number of weld schedules to accommodate the differences in materials, dimensions and plating of the discrete-component leads. Gold is a more solderable surface than nickel.
- Gold is a more uniform welding surface. Bare nickel becomes passivated—a natural form of oxidation—while gold does not. The passivation may vary the nickel's conductivity, affecting weld consistency and weld schedules. The gold also helps produce a good brazing fillet.
- Gold is also an ideal background for visual inspection of the welds since its color contrasts sharply with nickel.

Four-to-six-millionths of an inch of gold is plated by chemical immersion after the nickel has been etched. The nickel cannot be electroplated before etching because trace lines would be virtually disintegrated by the secondary battery action of the gold, nickel and iron in the ferric chloride etchant. The chemical immersion process has to be carefully controlled because, among other things, the hot acid could degrade the foil's bond strength.

The rules for printed circuit design control variations in heat-sinking due to different wiring layouts and compensate for the difference between the electrical resistivity of copper and nickel. The layout designers tried their hands at welding to make sure that practical rules would be drafted.

Conductor width standards are: at least 45 mils for buses around the board perimeter; at least 25 mils for feeder conductors and positive supply-voltage branches of the buses; and 25 mils nominal for bias and signal conductors, which can be reduced to 15 mils for no longer than a half inch (15 mils on the artwork results in an etched line effectively 12 mils wide due to the trapezoidal shape of the cross section).

Wiring layout rules



Welding-pad dimensions for welding feedthrough wires to printed-wiring traces (1, 2 and 3), locations and dimensions for printed-wiring traces that branch off from other traces (4, 5 and 6), unacceptable and acceptable trace geometries on the underside of the board and at pads (7, 8 and 9), and trace design for jumpers (10 and 11).

Maximum trace length is 8 inches. A bus 45 mils wide, 3 mils thick and 8 inches long has a resistance of 0.19 ohm, the maximum acceptable value. The 15-mil width is acceptable only when the wiring has to be extremely dense and the higher resistance will not impair performance.

Welding-pad portions of a trace are 25 mils wide, as illustrated in the layout diagrams above. The first set of illustrations shows trace geometries for feedthrough connection. The minimum pad length of 80 mils gives the operator some leeway in weld positioning. The next set of diagrams shows how branch runs are located so as not to compromise the weld-pad's width. The remainder of the diagrams above indicate acceptable and unacceptable geometries for traces to which feedthroughs and jumper wires are welded.

Feedthroughs and crossovers

Feedthroughs—connections from one side of the board to another—are made by passing 8-mil, gold-plated Dumet wire through 25-mil holes in the board and welding the ends to pads on each surface. Crossovers—running a wiring path over an intervening path—were originally made with two feedthroughs, but are now made with jumper wires.

Some assemblies require about 400 feedthrough welds. Plated-through holes in the board would avoid the wire feedthroughs and cut welding time and cost substantially. However, the best hole size for IC assemblies is 25 mils, so a board thickness should be 25 mils for optimum through-hole plating. Boards that thin are a questionable bargain in costly assemblies since structural damage is likely. The 62-mil-thick board is far more rugged. The 62-mil boards could be successfully plated through if other metallurgical problems did not exist.

The through-hole plating process is itself a deterrent to the use of plated feedthroughs. Usually, copper is chemically reduced onto the hole walls and the plating is built up with electrodeposited copper. But to use nickel wiring, the buildup also should be nickel. The different platings and foil that form the plated feedthrough may not hold together. Trial boards were made, but wire feedthroughs were the production choice.

A wire feeder for the standard welding machine speeds up the formerly tedious and time-consuming feedthrough job. The feeder's step-by-step operation is shown in the figures below.

At first, crossovers were made by passing a feedthrough to a trace on the opposite side of the board that carried the signal path under the interfering trace. Then the path went back up to the original side of the board through another feedthrough. Crossovers were later simplified by applying a strip of Mylar tape to the interfering trace and welding a jumper wire across it. Now, epoxy insulation is screen-printed at every jumper location after the board is etched. The board encapsulant—applied after assembly—prevents snagging and damage to the jumpers. Jumper layout is given in the figures at the top right on page 121.

Welding procedures

The sequence of operations during welding is: welding and inspecting the feedthroughs; cementing ribbon-leaded components (flatpacks and diodes) in place with resilient adhesive; inspecting the card to make sure the component-loading is correct; and welding the leads to the etched wiring.

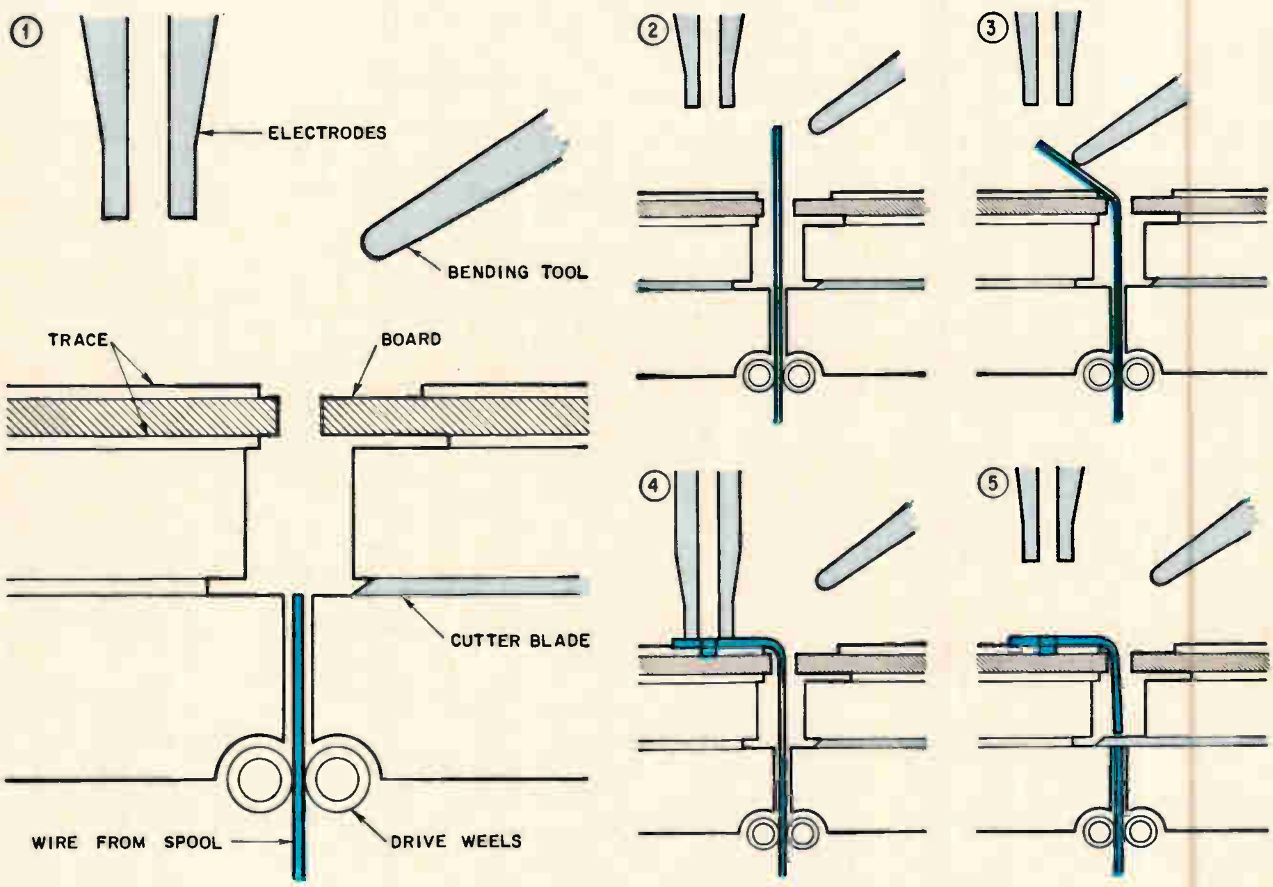
Under "race" conditions, the fastest operator welded a 10-lead flatpack in 15 seconds. Thirty seconds is a more realistic time, allowing for minor delays and occasional close examination of the welds. The operator checks the machine's performance during the process to avoid excessive rework if corrective action is required. The faults pictured on page 122 are readily seen under the machine's stereoscopic magnifiers.

The operator has to make sure that the leads and electrodes are aligned on the traces before the weld pulse is fired. The resilient adhesive allows minor corrections in package positions (the adhesive is Polystix 3719, made by Adhesive Products Corp.). Tweezers are used to move the flatpack body. The leads are not bent into position, since bending the leads would stress the package seal.

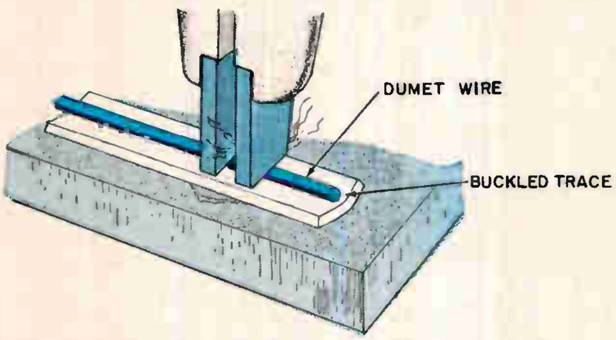
While the welding machine is automatic, the operator has to trigger it properly. If the operator kicks the foot pedal, the force at which the welder fires will not change, but the momentum of the electrodes will cause the follow-up force to exceed the pressure setting; excessive pressure on the Dumet wire drives the trace down into the heat-softened epoxy, diagram above right. The trace buckles and remains bonded only under the weld when the epoxy solidifies.

Keep it clean

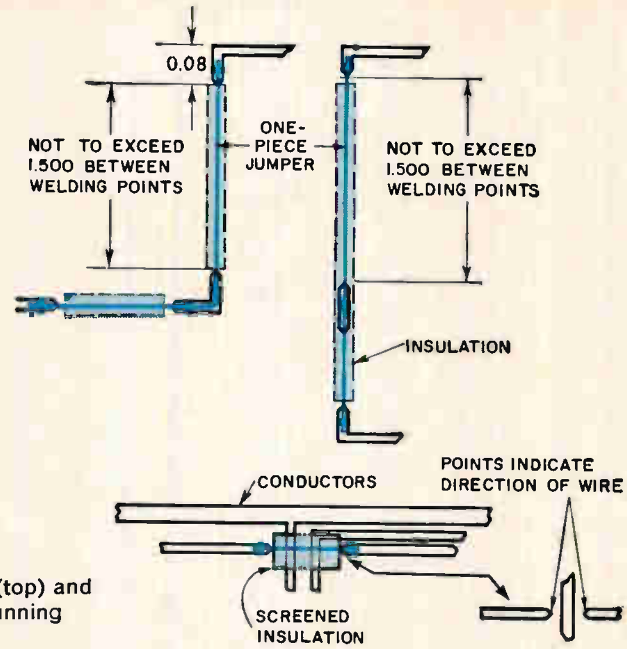
"Spitting"—the vapor given off by the momentary melting of the epoxy under the weld—fouls



Feedthrough feeding and forming mechanism. The figure at left (1) shows the start position. The small drawings at the right show the sequence of operations: feed (2) bend (3) weld (4) and cut (5).



Too much welding force, caused by operator kicking welding-machine pedal, buckles trace and causes bond between traces and board insulation to become weak through reduction in bond area under trace.



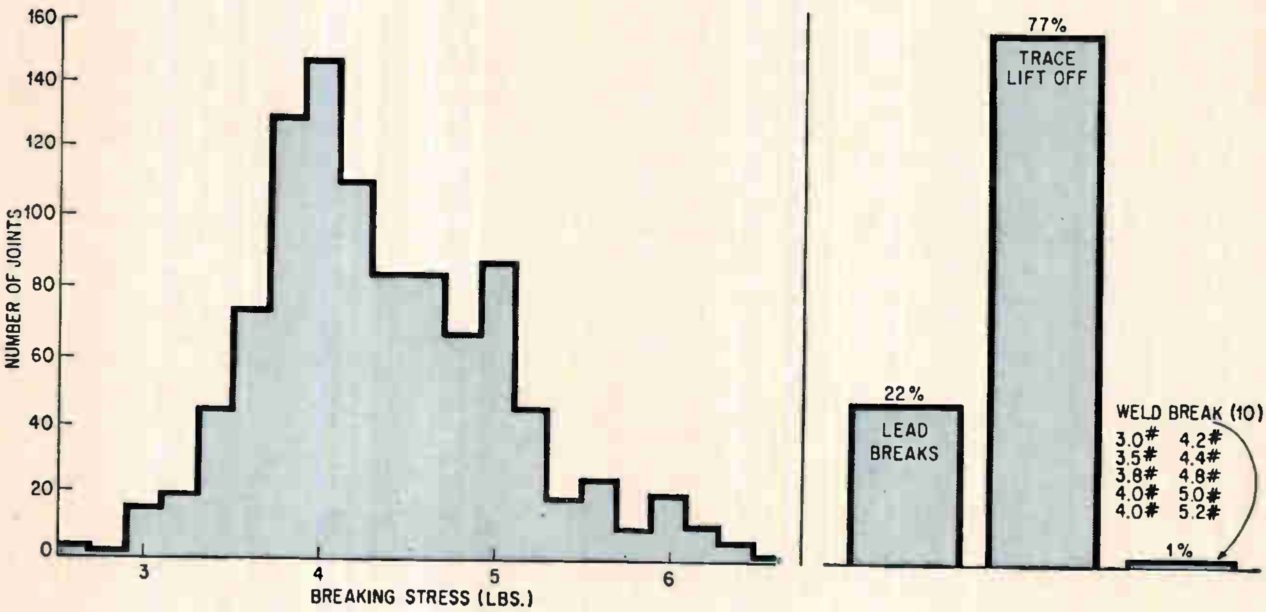
Jumper-wire layout and dimensional controls (top) and the layout when the jumpers are crossovers running over screen-printed insulation (bottom).

the welding electrodes. The adhesives of experimental laminates are particularly troublesome. Two ways to reduce the frequency of cleaning are directing a small jet of air at the electrodes and occasionally brushing them with alcohol. To clean the electrode tips, they are placed on a hard Arkansas stone, typically ¼ inch in cross section, on the table under the electrodes. The tips are lowered until they rest on the stone, a slight amount of pressure is applied and the stone is slid gently under the electrodes. This keeps the bottoms of the electrodes parallel to the table. The tips are inspected with a small dental mirror; there should be no pitting or irregular edges. Repeated cleanings wear away the tips, broadening them, and weld schedules must be changed to compensate for the lowering of weld-current density.

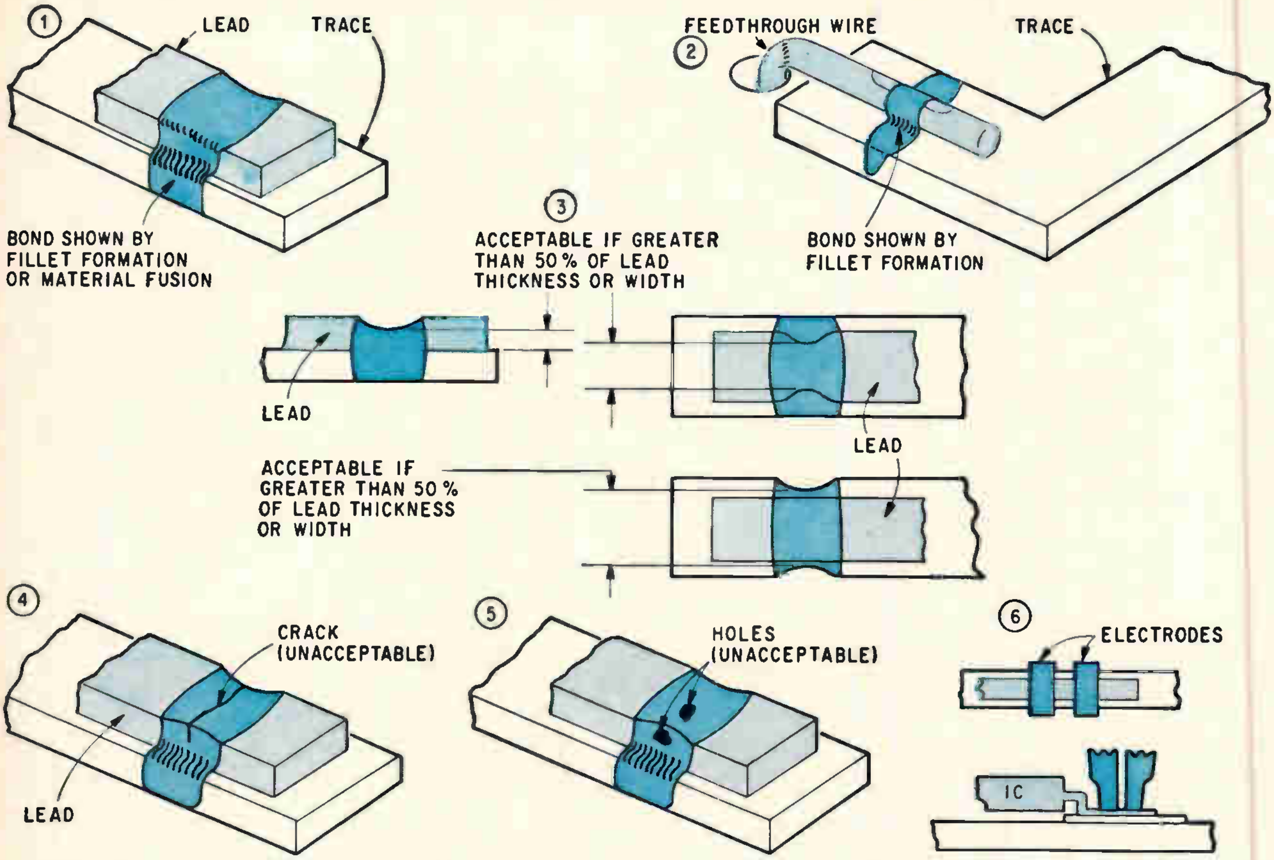
Scheduling and certification

The welding machines (Model CWPA-296, Texas Instruments Incorporated) have a fixed pulse length and electrode gap has been standardized at 15 mils, so the major variables in the schedule are the pulse voltage, capacitor voltage and electrode pressure.

Each machine is scheduled for the type of component lead it welds. Typically, there are six schedules, one each for the flatpacks from four major suppliers, a fifth for ribbon-leaded diodes and a sixth for the feedthrough and crossover wire. The



Distribution of weld strength, found by tensile-testing 1,000 sample welds (left). The failure modes found during 1,000 trials show that only 1% of the welds fail; most of the time, the lead breaks or pulls of the board (right).



Visual criteria for acceptable welds. Welds are unacceptable if the fillets are poor or off center (1, 2 and 3), or if cracks and holes are seen in the weld spot (4 and 5). Electrodes must be centered on the lead and trace (6).

table below gives schedules for 25-mil traces.

The operators are allowed to vary the weld-pulse voltage by one scale division (0.2 volt) to optimize weld appearance. All other settings are made and maintained by the welding supervisor. Calibrating and other operational settings are sealed to prevent misadjustment by the operator.

During prototype production, the engineering department established optimum schedules and verified weld repeatability by visual inspection, metallurgical inspection and destructive testing. The manufacturing department used the optimum values to validate and establish schedules for each production machine. The quality assurance department certifies that sample welds of all the materials withstand breaking loads of more than 2 pounds in tensile-strength tests. Air Force representatives helped draft the certification document that describes the machine, visual inspection requirements and destructive test results.

Welding-machine schedules

Pulse (volts)	Force (lbs)	Component type
0.62	2.0	Feedthrough
0.62	2.5	Signetics IC
0.52	2.5	Texas Instruments IC
0.62	2.5	Westinghouse IC
0.58	2.5	General Instruments IC
0.58	2.5	IN3206 Diode

Capacitor voltage is 120 volts

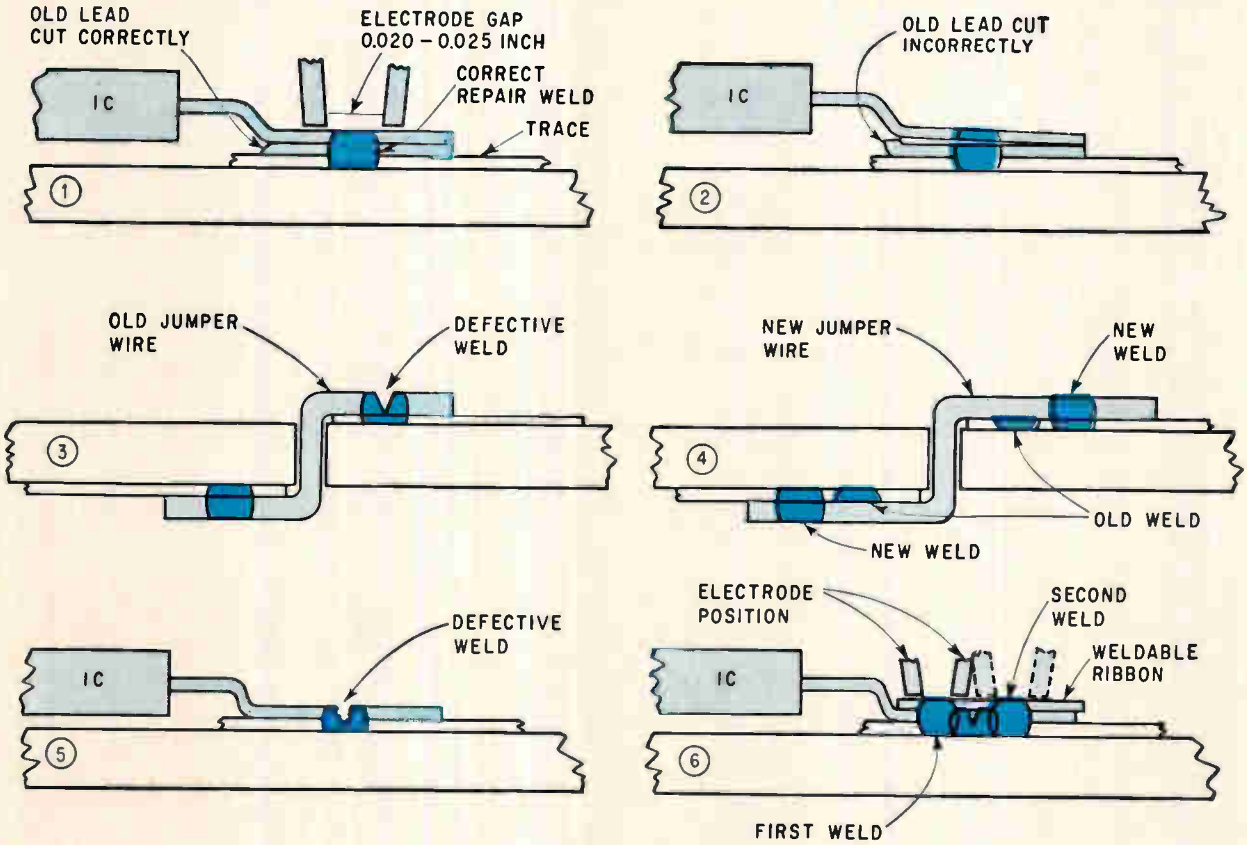
Visual inspection

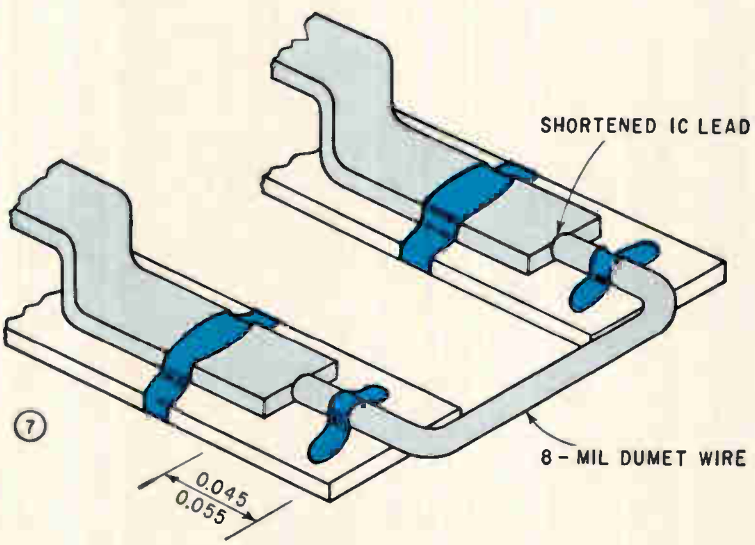
Valid visual inspection criteria are essential, if only to confirm that the process controls are adequate. The criteria shown above are used by the welding-machine operators and for 100% inspection at inspection stations. Quality control personnel also make sampling inspections. The criteria were established as part of the preproduction program.

The inspection criteria are based on results of destructive tensile-strength and peel-strength tests. Destructive tests were needed because non-destructive tests proved inadequate. Electrical-noise measurements did not correlate with the strength measurements. Welds that were obviously too hot or too cold were not discernible in the noise data. (A manufacturer of noise-measuring equipment made the tests.) Also rejected was resistance measurement because the contact resistance of the probes may mask variations in weld-joint resistance; besides, this electrical test might accidentally damage components.

Strength-test samples are printed circuit cards carrying welded strips of lead material that hang over the card edge. Tensile strength is typically 4 pounds. Peel strength, when the pull is perpendicu-

Repair and replacement procedures



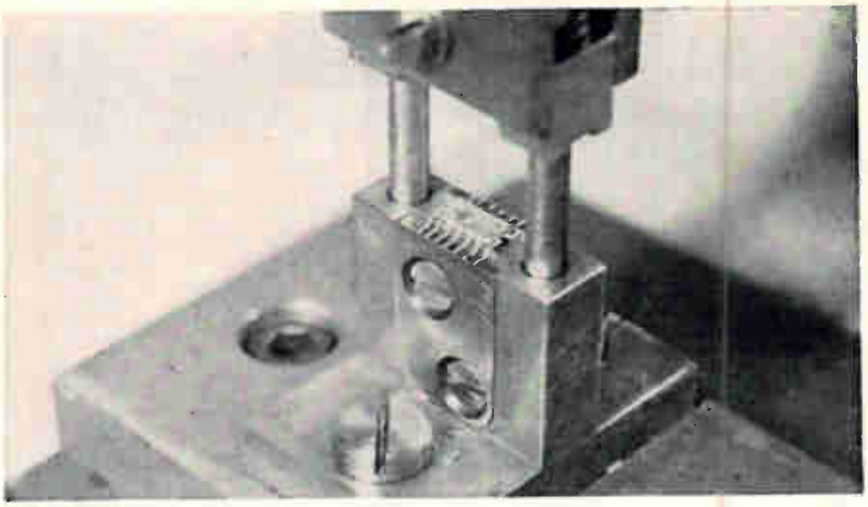


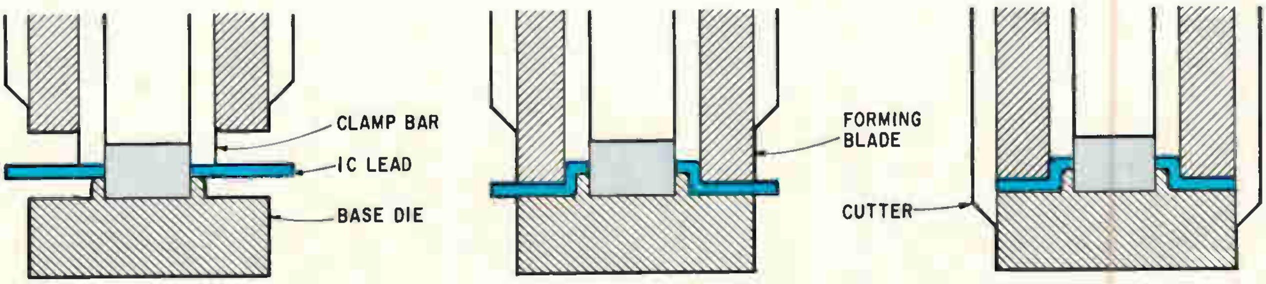
When a flatpack is replaced, the old leads have to be clipped flush with the trace (1). Otherwise, the new lead may not be welded securely to the old lead (2). Jumper wires are removed with a flush-ground nipper and the replacement wire welded at two new spots on the weld pad of the printed-wiring trace (3 and 4). Blowout or other weld defects in an otherwise good assembly are repaired by double-welding a piece of weldable ribbon on either side of the defective weld (5 and 6). Wiring modifications are made by shortening the flatpack leads and welding a piece of jumper wire to the welding pads on wiring traces (7).

lar to the board surface, is typically 1½ pounds. Tests are made with a tester made by the Hunter Spring division of Ametek, Inc.

Bond strength is indicated by the force needed to peel the conductor from the board, to break the weld, or to break the lead. If the trace is peeled or the lead breaks, the weld is satisfactory, since the weakening of the bond between the trace and the board during welding is negligible. The two graphs on page 121 show the proportion of failure modes and the distribution of pull stress at failure. The pull strengths are all completely adequate for 10-lead flatpacks.

During prototype production, sample coupons were cut from the board stock, etched with the boards and lead material was welded to the coupons on the same machine that would weld the assembly. The tensile tests provided a constant check on board materials, processing and welder performance. This procedure has been relaxed, but





Tool that forms and trims flatpack leads clamps the leads before they are formed and cut (diagram, left to right). The tool and a closeup of a flatpack on the forming die are shown in the photographs at the top.

weld sampling is still part of the production quality assurance procedure.

Peelable protection

Epoxy resin is often the first-choice encapsulant to protect printed circuit assemblies, but Sylvania chose urethane because it allows the IC assemblies to be repaired and meets or exceeds the ability of epoxy to prevent corrosion and contamination.

Removing an epoxy coating from a board is risky because the only practical method is heating the area to be removed. Too much heat can degrade the reliability of nearby IC's and destroy the bond that holds the narrow, etched-wiring traces to the board. Chemical solvents won't do because they would attack the epoxy-glass of the board.

So, after a board passes its electrical tests, Sylvania dips it in urethane and air dries it. If part of the urethane has to be removed later, it is cut with a small, razor-sharp modeling knife and peeled off like the skin of an orange.

Repairs and replacements are usually made before encapsulation. The recommended methods of replacing components, repairing welding blowouts and damaged leads and making wiring changes are shown in the drawings on page 123. Leads can be replaced several times and, if properly done, the repairs won't stress the board or lift the traces.

Flatpack preparation

The flatpack leads should not waste space on the board and they have to lie perfectly flat on the weld pads during welding. This requires forming and cutting, but it must be done without stressing the flatpack seal; if the seal is cracked, the IC will be unreliable.

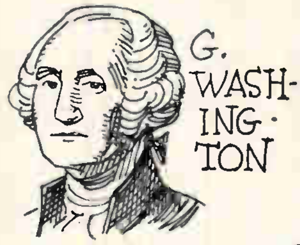
The tool shown above clamps, cuts and bends the leads. Clamping prevents lead deformations that would stress the seal during bending and cutting. Rounded edges on the forming blades don't nick or scratch the leads. The leads are bent slightly below the horizontal to allow for their springing back. The cutter trims off excess length.

Lubricants have to be kept clear of the leads because a lubricating film would affect weld quality. The cutter has to be sharp because burrs left under the lead would hold the lead end off the weld pad, causing erratic welds. This problem could be avoided by an upward cutting action, putting any burrs on the top of the lead.

Each manufacturer's flatpack goes into a special die. One die could handle several manufacturers' flatpacks, but the user would have to be wary of worst-case combinations of dimensions and pay particular attention to tolerances and uncontrolled dimensions. If, for example, one lead was out of line at the seal, clamping it down to the level of the other leads would stress the seal.

Leak tests checked out the method. Each IC manufacturer sent leak-tested sample IC's to Sylvania. These were put through the preparation and welding procedure, then the sample assemblies were sent back to the IC manufacturer. All of the samples passed another leak test.

Be a hero



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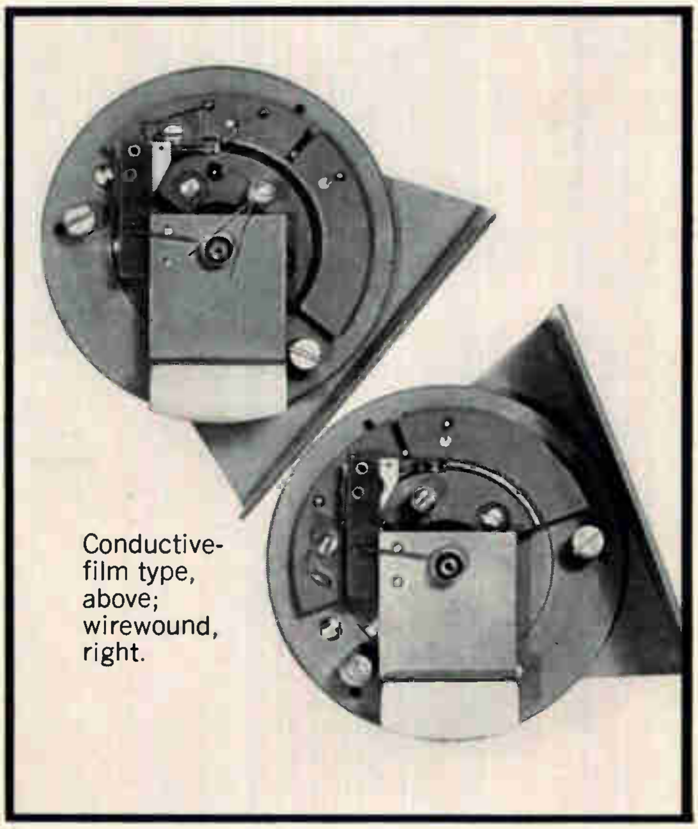
We've already thought of a few of the more obvious applications, but let's see what you can come up with. We'll send your certificate by return mail, and if yours is one of the 50 best ideas we'll publish it in our next IDEA BOOK.



Conductive-film type, above; wirewound, right.

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The great shmoo plot: testing memories automatically

Shmoo curves, which show computer memory performance under marginal drive currents, can be plotted automatically—and so can many other curves that depend on two variables

By John E. Gersbach
Systems Development Division, International Business Machines Corp., Poughkeepsie, N.Y.

A tester—with a unique, fast-recovery, single-shot circuit—automatically plots performance curves representing failure-free operation of a device in which two independent parameters vary. It was developed at the engineering laboratories of the International Business Machines Corp. to test ferrite core memories, but has other applications.

Plotting error-free performance of a ferrite core memory against drive-current amplitude produces a "shmoo" (or "schmoo") curve.[1] Two current amplitudes are measured independently along the x and y axes of a graph; the locus of points where failures occur form a closed curve that, in some cases, resembles a shmoo—a comic-strip character created by cartoonist Al Capp.

Points inside the curve represent error-free operation of the memory. Points outside the curve represent errors that occur because one or both of the current supplies went beyond allowable tolerances.

The setup could also test the operation of any circuit with two or more independent power supplies. Or, two variables in an integrated circuit manufacturing process could be checked simultaneously. Nonelectrical variables are easily converted into current analogs which can drive the tester. In fact the plotter can evaluate any device whose operation is a function of quantities convertible to voltage or current.

The author

John E. Gersbach is a senior associate engineer at IBM's Systems Development division laboratory in Poughkeepsie, N.Y. Since 1959 he has participated in several memory development programs using various technologies.

Plotting the shmoo

The currents that vary during shmoo plotting are the word current and the digit current [see panel on page 132]. In a two-dimensional memory, these are the only important currents. In a three-dimensional memory, there are two word currents and an inhibit current (the digit current); in some 3-D memories, the word currents flow from the same power supply and they cannot vary separately. Pulse widths, the stored data pattern, ambient conditions and other parameters that would affect the shmoo-curve area must be held constant while the currents are being varied; however, tests that include these parameters can be devised.

Two linear-ramp generators control the power supplies that provide word and digit currents for the memory being tested. A feedback control system varies the drive currents to maintain marginal operation of the memory. An x-y recorder monitors the currents and plots the shmoo curve.

At first, the x current increases slowly, starting from point A in the diagram on page 128, regardless of any error condition. The y current increases more rapidly, also from point A, until an error is detected. The y generator reverses, the current decreases and the error condition disappears; then the y current begins to increase again. Thus the y current tends to stay on the error boundary as the x current slowly rises. The x-y plotter draws a series of small peaks that approximate the upper part of the shmoo curve.

At point B the x generator passes the right-hand end of the shmoo curve. An error occurs and the y generator sweeps downward looking for a no-error condition, which it cannot find. Both generators reverse at point C, and the x-generator jumps to D to prevent the system from moving back up the broken line outside the error-free zone. The y generator then begins to rise from point D. When the error condition disappears, the y generator resumes its rapid alternation, and the plotter traces out the lower boundary of the shmoo curve.

At point E the x generator passes the left-hand end of the shmoo curve, and a similar sequence takes place. The operator stops the machine when the remainder of the shmoo curve has been drawn.

What the memory does

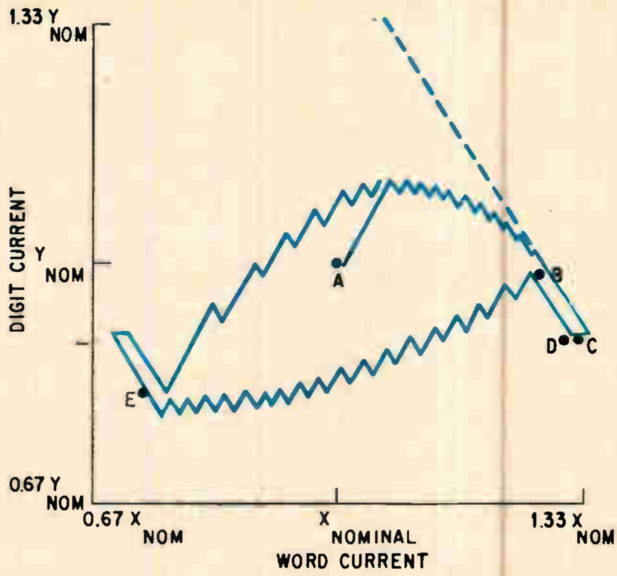
While the current generators vary slowly, the memory being tested rapidly cycles through all its data. For example, a 16,000-word memory may take two microseconds to read out a single word and replace it in its original location in the memory. Each word may have to be cycled four times during a test and there may be an error in any cycle. During the 128 milliseconds required to cycle every memory word four times, the y generator reverses once, so that the x-y plotter traces from a point where an error was detected, to a point within the shmoo curve and back again to an error condition. The details of timing and insuring that there is only one reversal are treated later.

The memory tester must produce an error pulse 100 nanoseconds long when an error is detected and continue to operate when errors occur. It should operate in a read-write mode, not a read-regenerate mode. Otherwise incorrect information would be regenerated in the memory every time an error cropped up. The error condition would recur every time that word was cycled again even though the drive currents possessed proper amplitude.

Noisy data

Data stored in the memory during the test is such that the worst possible noise voltage reaches the sense amplifiers during any particular cycle. The noise causes errors when it is large enough not to be rejected by the sense amplifiers. The exact data pattern producing this noise depends on the particular memory design. Partial switching of cores through which half-select current passes during a memory cycle generates errors, as do pulses above a specified maximum when a 0 is read, and pulses below a specified minimum when a 1 is read.

An error in the memory causes the single shot, or monostable multivibrator (diagram, top of page 129) to generate a pulse half as long as a complete pass through storage—64 msec in the previous example. This causes the system to track along the error boundary; if the boundary is approximately horizontal, the single shot operates at a 50% duty cycle. The exclusive-OR circuit inverts the single-shot signal to the y-ramp generator if



Generalized shmoo curve traced by IBM's tester. The drive currents are initially set at nominal values, represented by point A. The x-drive current gradually increases, while the y-drive increases more rapidly until an error is detected. The y-drive then oscillates about the error boundary until the x-drive current rises beyond allowable limits, at B. Then the x-drive current begins to decrease slowly, and the y-drive continues to oscillate. The operation continues until the entire shmoo curve has been drawn.

the binary trigger Y is on. This signal controls the sweep direction—positive or negative—of the y-ramp generator.

At point C in the diagram above, the integrator detects the increased duty cycle of the single shot and turns on binary triggers X and Y. Binary trigger X reverses the direction of the x-ramp generator; binary trigger Y, through the exclusive OR, inverts the signal from the single shot to the y-ramp generator.

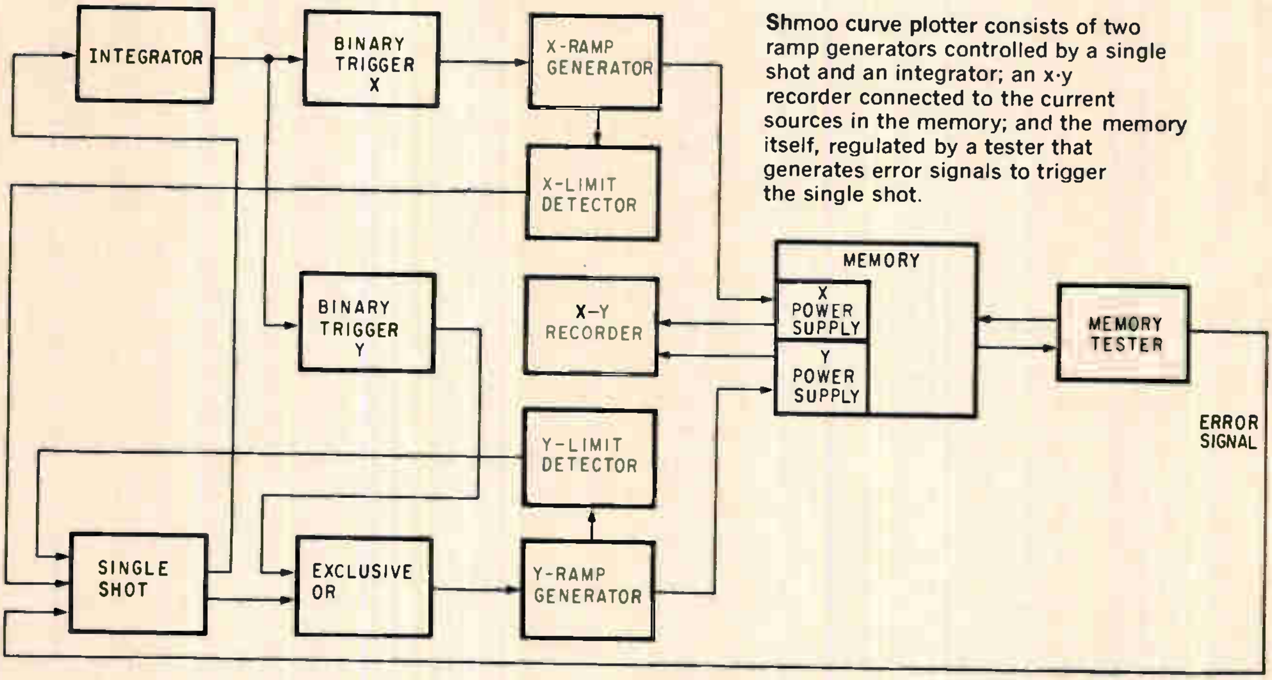
If either ramp generator attains a level above or below a set limit, the limit detectors turn on the single shot; and the system responds as it would to a memory error.

Circuit details

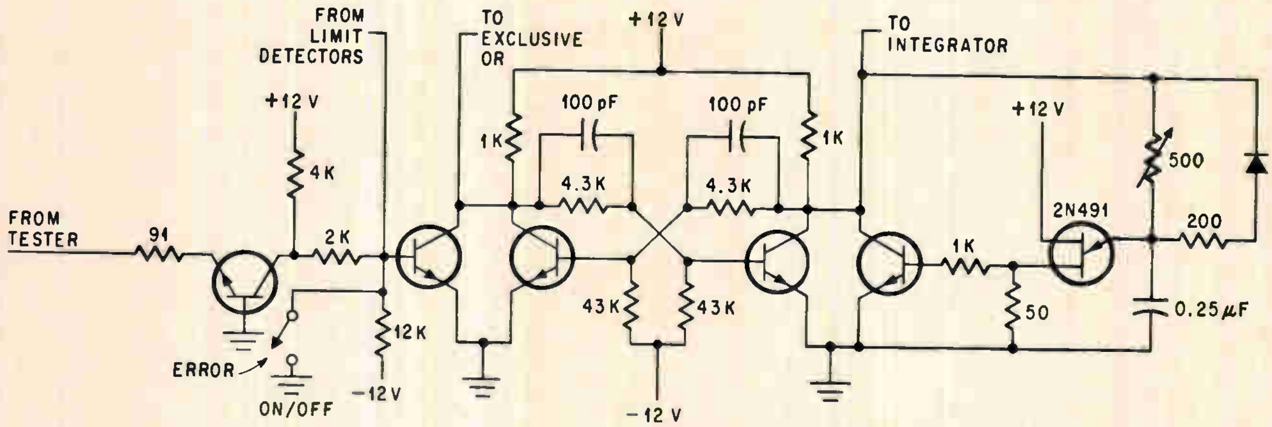
The single-shot circuit makes the shmoo plotter possible. The single shot must respond to short pulses and operate at duty cycles greater than 80%. The one designed for the shmoo plotter can have a duty cycle of 99%, or better, compared with 30% to 50% for many single-shot circuits. The diagram in the center of page 129 is of a high-speed latch with feedback to the reset input through a unijunction-transistor circuit[2] providing a long delay and a short recovery time. During recovery, the capacitor discharges through the resistor-diode network, since the unijunction transistor can discharge the capacitor only to a level equal to the valley voltage of the device. Output-pulse widths range up to 100 milliseconds with a constant recovery time of 0.2 milliseconds.

The integrator is another unijunction-transistor

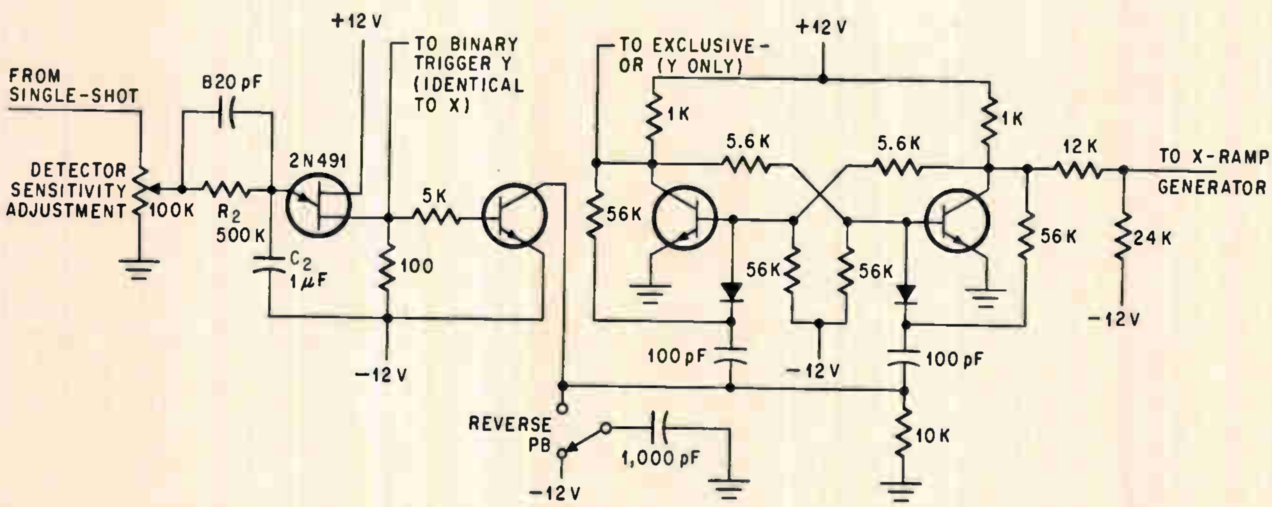
Shmoo plotter and two key circuits



Shmoo curve plotter consists of two ramp generators controlled by a single shot and an integrator; an x·y recorder connected to the current sources in the memory; and the memory itself, regulated by a tester that generates error signals to trigger the single shot.



Single shot, designed for the shmoo plotter, is capable of duty cycles of 99% or greater. In all circuit diagrams, the npn transistors are 2N706, the pnp's are 2N1132, and the diodes are 1N921.



Integrator and one of the two binary triggers in the plotter. The integrator detects the passage of the tester beyond either the right-hand or left-hand end of the shmoo curve, by measuring the duty cycle of the single shot. The binary triggers control the direction of the ramp generators and increase or decrease the memory drive current.

circuit (bottom, p. 129). The R_2C_2 combination averages the single-shot duty cycle so that the emitter voltage of the transistor is proportional to that cycle. The transistor fires when the duty cycle reaches 80%; the capacitor discharges from +3 to —12 volts and the two binary triggers change state. While the capacitor again charges up, the detector is desensitized for a few seconds after the system reverses (at point C). The small capacitor across R_2 supplies the peak current of the transistor.

A buffer amplifier following the detector improves the signal to the two binary triggers. Each trigger is a set-reset circuit with steering inputs. Push-button inputs can manually reverse the ramp generators.

The output of the exclusive-OR circuit below, right, is positive when the inputs are alike and negative when inputs are different.

In the ramp generators, diagram on the opposite page, a capacitor and two current switches generate a positive or negative charging current depending on the input voltage polarity. Since $dv/dt = i/c$, the voltage will be linear with respect to time if the current is constant. Resistor R_3 causes a small step in the x-voltage when the input changes. The circuit to the right of C_1 isolates that capacitor from the voltage-to-current converter supplying output for the storage power supply. The potentiometer permits manual voltage adjustment of power supplies.

For general use a pair of external decade boxes could replace R_4. C_1 is too large to be easily connected externally.

The limit detector, shown below, is two voltage dividers that set the levels between which the ramp generators should remain. If the voltage across the capacitor in the ramp generator exceeds either value by more than the voltage drop across two diodes, the capacitor charging current flows into the limit detector, through one of the two amplifier transistors, to the output line that triggers the single shot.

Memory power

The last stage in the chain of control maintained by these circuits is the memory-current power supply. Most memory-power supplies are one of the two electronically regulated types, shown at the top of page 133. During normal operation the amplifier, which has very high gain, produces an output with nearly zero input; to show the relation of percentage change of voltage-to-power supply parameters, the input is assumed to be exactly zero and the amplifier gain is assumed to be infinite.

In the regulating circuit at the top of the diagram R_2 sets the nominal voltage, and $V_1 = V_R$ when the amplifier input is zero. The currents flowing away from node V_1 are described by:

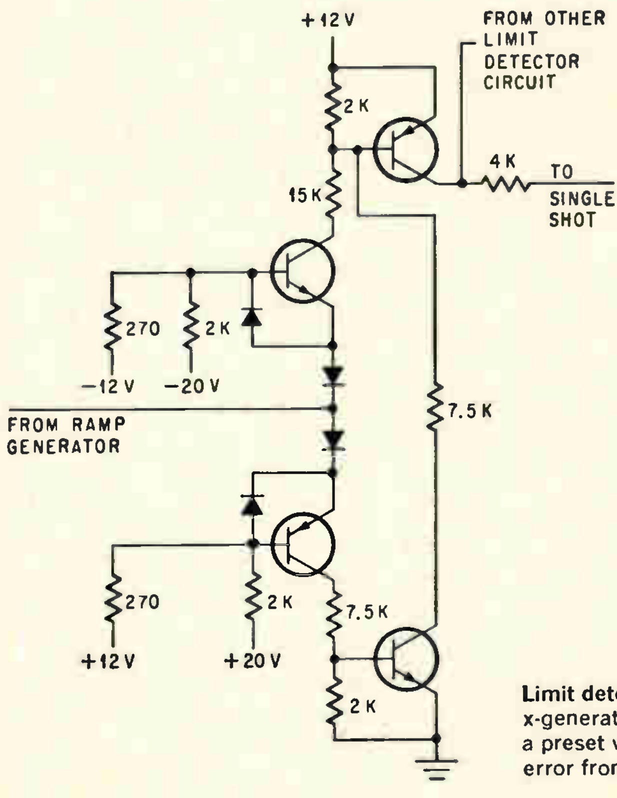
$$\frac{V_R - V_o}{R_1} + I_s + \frac{V_R}{R_2} = 0$$

Solving for V_o

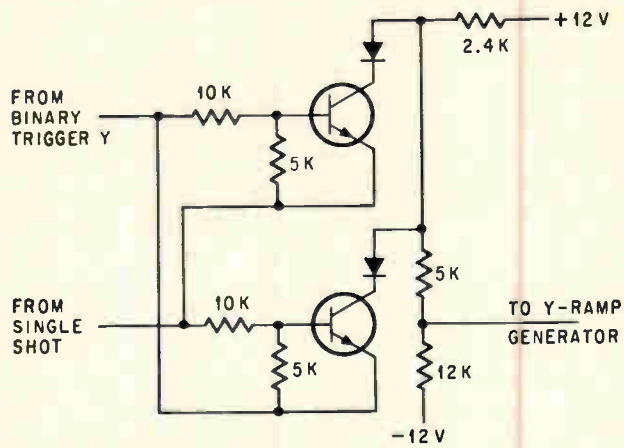
$$V_o = V_R\left(1 + \frac{R_1}{R_2}\right) + I_sR_1$$

shows that power supply output is a linear function of I_s, the control current from the ramp generator. The rate of change of V_o with respect to I_s is simply R_1.

Divide this by V_o, remembering that $\Delta I_s = I_s$

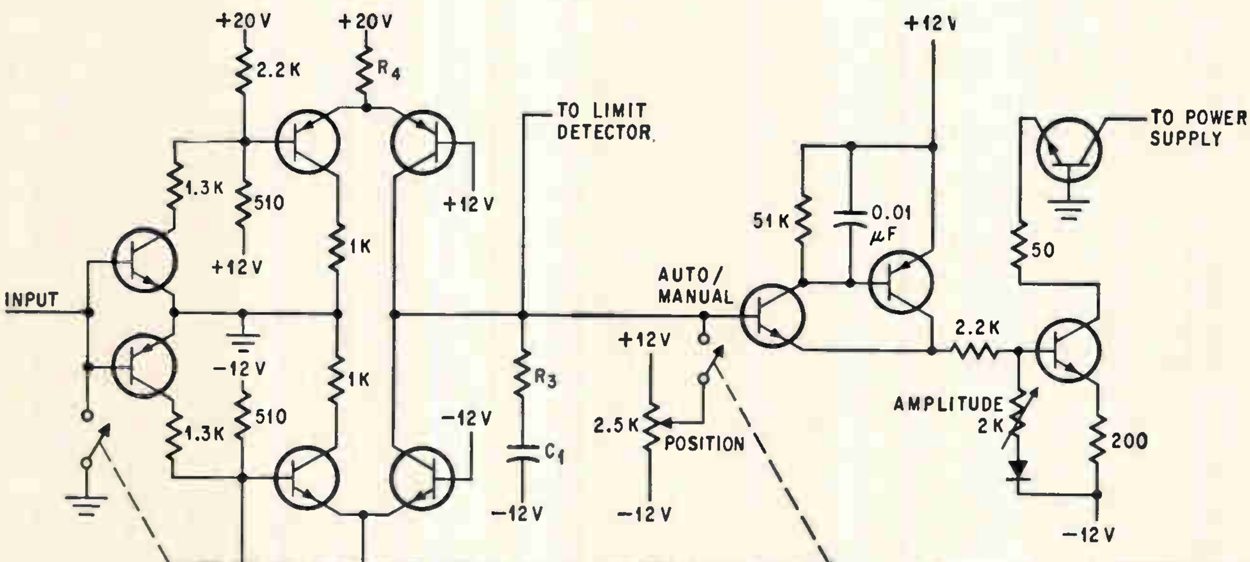


Limit detector forces a reversal if the x-generator or y-generator exceeds a preset value without detecting an error from the memory.



Exclusive-OR circuit combines the single shot and binary-trigger output. An error triggers the single shot and changes the direction of the y-generator from positive to negative along the top of the shmoo curve, and from negative to positive along the bottom.

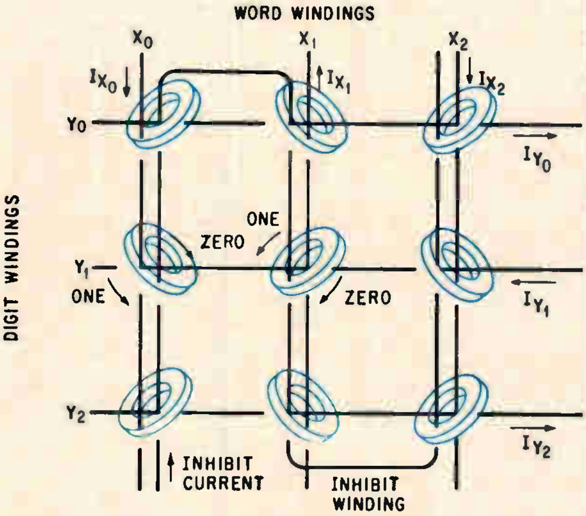
John Gersbach inspects a shmoo curve drawn by his automatic device. The circuitry of the plotter is entirely in the chassis at bottom; the x-y recorder is a commercial unit connected to the plotter. If an actual test were under way, wires would be connected to terminals at the far end of the plotter.



	X	Y
C_1	1,000 μF	100 μF
R_3	30	0
R_4	7.5 K	7.5 K

Linear ramp generator is one of two that differ only in the component values in the table. Resistor R_3 in the x-drive circuit causes the x-generator to jump when the capacitor stops charging and starts discharging.

Memory-core switching



Ferrite-core memory windings permit the storage and readout of binary data. A minimum current is required to switch an individual core from a 1 state to a 0 state, or vice versa.

To read data, approximately half the minimum current is driven through one word winding and one digit winding in a direction that tends to switch the core from 1 to 0. These currents together produce the required total at only one core in the plane. If that core is not already in the 0 state, it switches, generating a pulse in a sense winding (not shown) that passes through all the cores in the array.

To write data into the memory, currents equal in magnitude but opposite in direction to reading currents switch the core from 0 to 1. If a zero is to be stored, a current passes through the inhibit winding, not strong enough to switch any core but large enough to block the two write currents so that the selected core stays in the 0 state. Staggering the cores makes the routing of the inhibit winding efficient and also tends to cancel the half-select noise in the sense winding. This winding is routed along one diagonal for half the cores and along the other diagonal for the other half.

when I_s is zero, and:

$$\frac{\Delta V_o}{V_o} = \left[\frac{R_1 R_2}{V_R (R_1 + R_2)}\right] I_s$$

This expression gives the percentage change from nominal voltage that a given control current produces in a particular power supply. If the nominal voltage is changed, the plotter may require adjustment with the variable resistance at the ramp-generator output.

Electronically regulated power supplies, variable from 0 to some maximum, have the configuration shown at the bottom of the diagram. Again, assuming gain is infinite, the current at node V_1 is

$$-\frac{V_R}{R_1} + I_s + \frac{V_o}{R_2} = 0$$

As before, the output is a linear function of I_s. In this case, V_o's rate of change with respect to I_s is $-R_2$ and

$$\frac{\Delta V_o}{V_o} = \frac{-R_1}{V_R} I_s$$

Since the percentage change from nominal voltage is independent of the nominal voltage setting, this kind of power supply regulation allows the shmoo plotter to be connected without adjustment to different memories operating at different nominal voltages.

In either case the control-current input will not affect the power supply's characteristics because regulation is a function of amplifier gain and output wiring. However, care should be taken to prevent noise on the control input wiring.

If the power supply has a magnetic amplifier or some other nonelectronic form of regulation, or if another type of device is being tested, the shmoo plotter might need a special conversion circuit to control the power.

The automatic shmoo plotter can continuously indicate memory performance. The operator can watch the x-y recorder, busily tracing the same shmoo over and over, to detect malfunctions, parasitic loading conditions or power-line noise. Or the operator can set the x-generator manually to any desired value and let the error signals control the y-dimension of the plot; or the operator can disable the error check for particular bits or words to locate circuits operating marginally.

Related functions

The single shot's duty cycle and the plotter's accuracy make up two important parameters of the system. They are related to the timing of the single shot, the slope of the shmoo curve and to each other. The duty cycle is a function of the shmoo-curve slope and the x and y sweep rates.

The shmoo curve may be approximated over a limited range by the equation of a straight line passing through the origin of a Cartesian coordinate plane, $y = Cx$. Since the ramp-generation outputs are linear with time, they may be expressed in terms of time in the parametric form:

$$y = y_o + At$$
$$x = x_o + Bt$$

Coefficients A and B can be positive or negative, depending on the sweep direction. As diagramed on page 133, the x and y generators sweep positively and trace out the line WO. An error detected at O triggers the single shot and reverses the direction of the y sweep. During the single-shot period (half the time of one pass through the memory, or $\frac{1}{2}T_1$) the generators trace out the line OV. The coordinates of V are:

$$x = \tfrac{1}{2} T_1, \quad y = Y_1$$

At V the single shot turns off, the y sweep again reverses and the line VU is traced out until another error is detected at U. The duty cycle, d, of the single shot is its period $\frac{1}{2}T_1$ divided by the length of time T_e between successive triggering signals.

From the known points U and V and from the point where UV extended crosses the y-axis, the equation of the line UV is:

$$y = \frac{A}{B}x - 2Y_1$$

But, from the definition of the slope A

$$y_1 = \tfrac{1}{2}T_1 A$$

Therefore the equation of the line is

$$y = \frac{A}{B}x - AT_1$$

The value of T_e depends on the distance CU; to locate U in terms of t, Cx (from the shmoo equation) may be substituted for y and x found terms of T_1:

$$x = \frac{AT_1}{\frac{A}{B} - C}$$

In the previous expression for x in terms of t, $x = 0$ when $t = 0$, and therefore $x_o = 0$. At point U, $t = T_e$ and $x = BT_e$. Substituting again, then:

$$T_e = \frac{T_1}{1 - \frac{BC}{A}}$$

This is the time between successive error signals expressed in terms of the single-shot timing and the slopes of the shmoo and the ramp generators. The duty cycle becomes:

$$d = \tfrac{1}{2}\left(1 - \frac{BC}{A}\right)$$

Accuracy

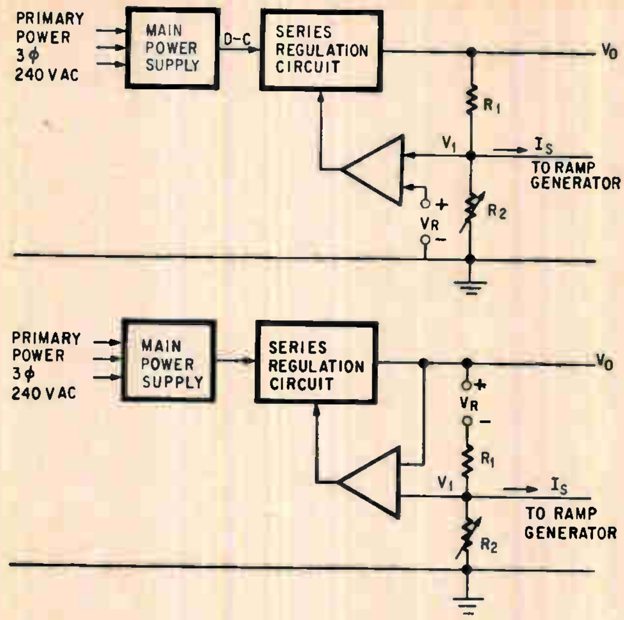
The system accuracy is a function of T_1 and the x and y sweep rates. The fractional error in each direction is the change in the respective voltage between reversals relative to the total range of voltage within which the shmoo is plotted. Symbolically:

$$E = \frac{\Delta V_y}{V_y} = k\frac{T_1}{T_y}$$

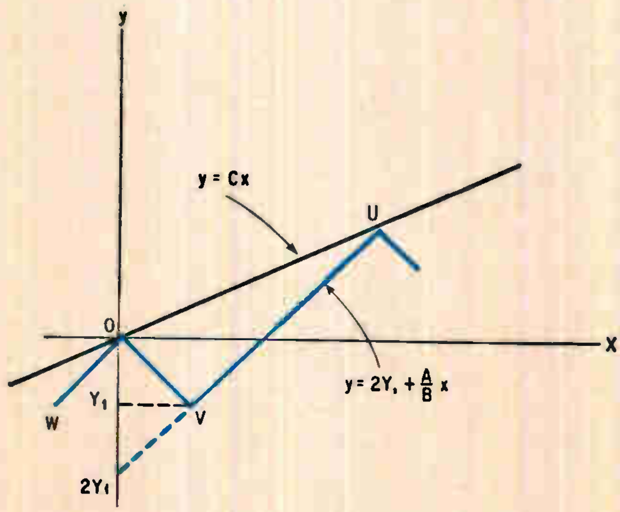
$$\frac{\Delta V_x}{V_x} = \frac{B}{A}\frac{\Delta V_y}{V_y}$$

where T_y is the sweep time through the entire y range and k is the y range expressed as a fraction of the nominal y voltage. Typically, $T_y = 20$ seconds, $k = 0.67$, and $A/B = 10$. Thus the error on y is always much larger than that on x.

Error E_y occurs because a memory error may not be detected at the instant the y-ramp generator crosses the shmoo. The generators continuously change the current supplied to the memory while a single pass is being made through the memory. Errors caused by marginal currents may be more pronounced at some memory locations than others. If the actual error boundary is crossed while a relatively noise-free portion of the memory is working, an error signal may not be generated until the y current reaches a point well outside the actual error boundary.



Two typical designs for electronically regulated power supplies. The bottom design is variable from 0 to an upper limit without plotter adjustment. The top design is variable over a smaller range and requires adjustment of the shmoo plotter.

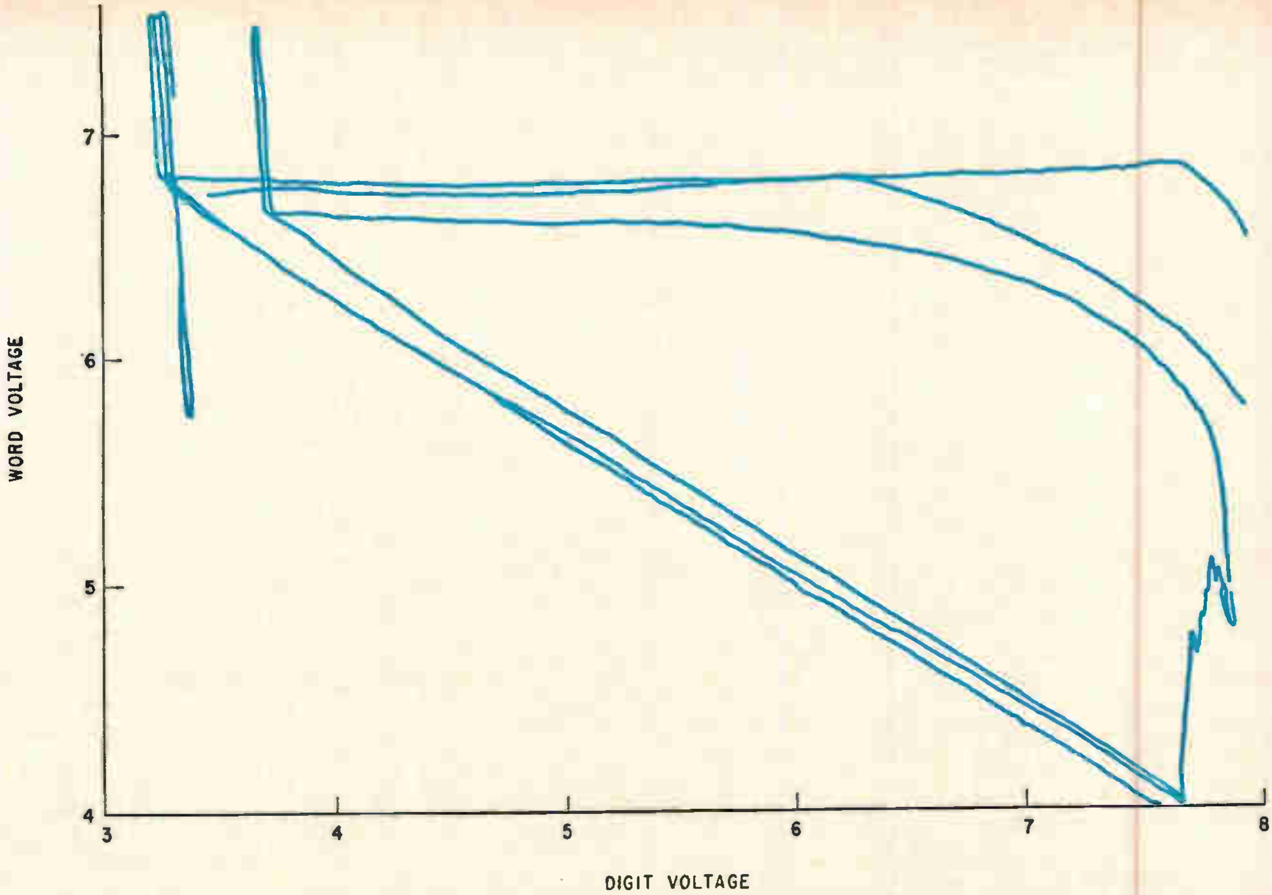


Relationship between the true shmoo curve and the line plotted by the IBM tester. Ideally the curve drawn by the plotter remains inside the true curve—but just barely—at all times.

The above equations give the maximum error in terms of the nominal V_y. The average error is much smaller. The error caused by the control-loop response time of a microsecond is negligible, because the 100 msec for a single pass is about 100,000 times longer.

The x-y recorder and the reference which calibrated it contribute the only remaining error. The accuracy of a typical commercial x-y recorder is 0.2%.

The width of the plotted curve—how much it oscillates about the true shmoo curve—is propor-



Specimen shmoo curve drawn by the IBM plotter represents a two-dimensional memory, in which error-free reading requires the sum of word and digit currents. Therefore, the lower half of the curve is nearly a straight line.

tional to the time of one complete pass through the memory, or

$$\Delta V_y = \frac{T_1}{2T_y} y$$

where y is the length of the y-axis.

System requirements

As a whole, the system must be able to plot a shmoo with a small maximum error, a rather steep slope and a narrow line width in a reasonable time. If the first two requirements are satisfied, the line width will be negligible.

Total plotting time amounts to twice the time it takes to sweep over the entire x range. This time can be determined from the equations for accuracy and for duty cycle, as follows:

$$\frac{k T_1}{T_x} = \frac{\Delta V_x}{V_x} = \frac{B}{A} \frac{\Delta V_y}{V_y} = \frac{k B T_1}{A T_y}$$

$$T_x = \frac{A}{B} T_y$$

$$\text{But } \frac{A}{B} = \frac{C}{1 - 2d} \quad \text{and } T_y = \frac{kT_1}{E}$$

$$\text{Then } T_x = \frac{C k T_1}{(1 - 2d) E}$$

The slope of the shmoo curve, C, may reach a maximum of 10. If the curve is a continuous closed curve, the slope at each end is infinite. A plotter that can handle a slope of 10 is doing well—that slope corresponds to an angle of 84° from the horizontal. A 0.5% error is tolerable. The duty cycle, d, of the single shot may reach 90% by the time the x-ramp generator reverses direction. Then, for typical values of k and T_1, 0.67 and 128 msec, T_x is about 208 seconds. Total plotting time is twice this, or about seven minutes. The shmoo curve is plotted clockwise; when the x-ramp is about to reverse, the factor (1—2d) and C are negative, so the time is positive.

The total plotting time is a function of the time for a single pass through the memory if C, k, E, and d are considered fixed:

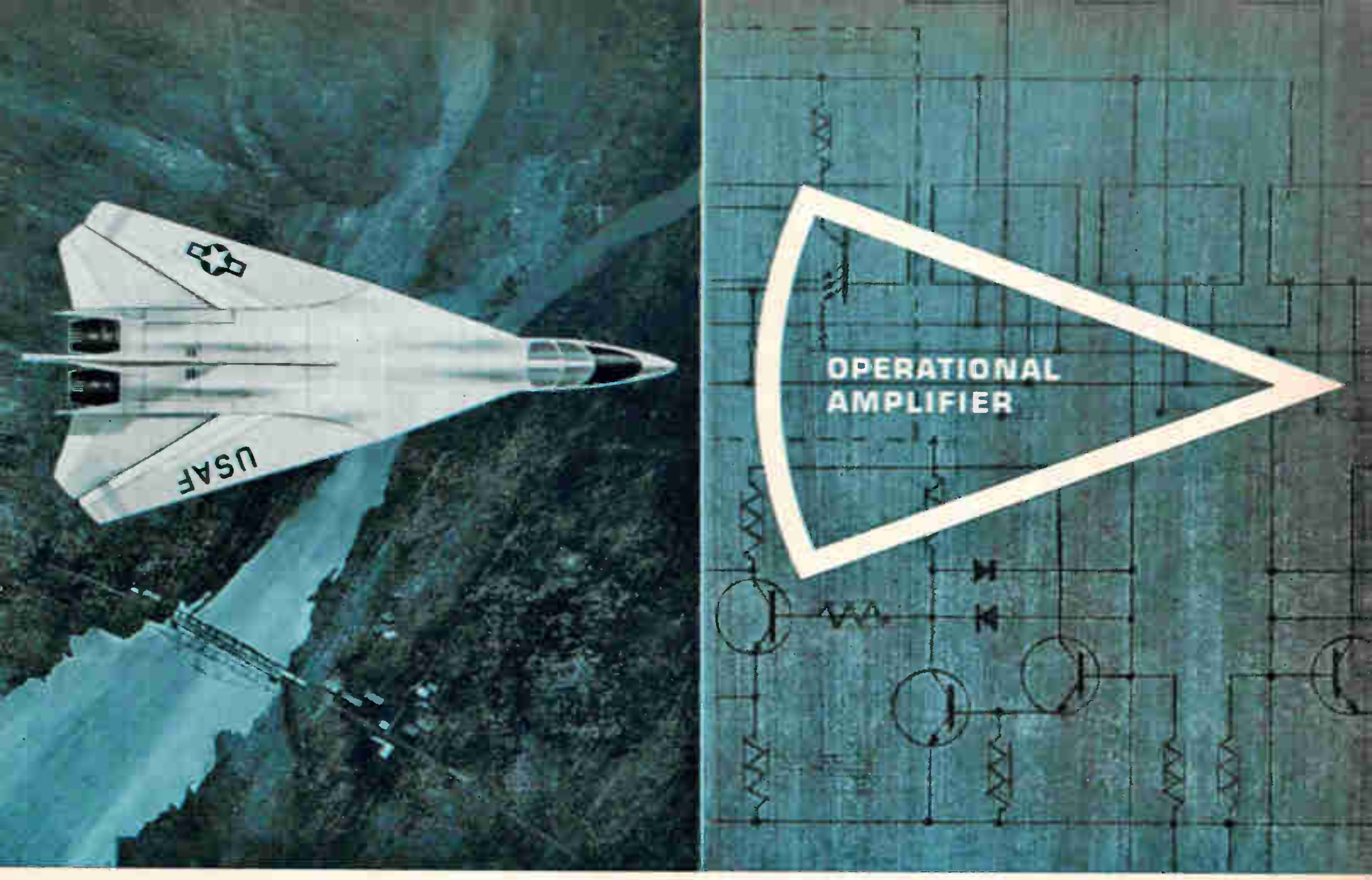
$$2T_x = (3.33 \times 10^3)T_1$$

This equation is not valid for extreme values of T_1. When T_1 is small, the response time of the x-y recorder limits the system. When T_1 is large, the design of the single shot is difficult because its timing depends on the time constant of a resistance/capacitance circuit, and these components are difficult to obtain with large values. Practical values for the total plotting time range from one to 30 minutes.

References

1. Charles P. Womack, "Schmoo plot analysis of coincident-current memory systems," IEEE Transactions on Electronic Computers, February, 1965, p. 36.
2. J.F. Cleary, ed., "G.E. Transistor Manual," chap. 13, General Electric Co., Syracuse, 1964.

Circle 135 on reader service card→



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Explain it to the fellows, Tom

Ask a lawyer about holographs. He will tell you that in Scotland, Quebec, Louisiana, and in most of continental Europe a holograph is valid without being attested by witnesses, being a document wholly in the handwriting of the maker. If he is a patent lawyer, however, he may only groan and launch into bitter complaint about overwork and a hopelessly lengthening backlog. This indicates that he understands all too well the new meaning of holography because he is working for one of the hundreds of organizations where implausible but nonetheless feasible ideas are popping fast on how to use the new lensless photography, or laser photography, or wavefront reconstruction, or whatever it's called in the latest article where some reporter strives valiantly to explain holograms.

(Yes, holography does permit making perfectly respectable photographs through ground glass. Yes, stereoscopic photographs. Stereoscopic singles, unpaired. Why not?)

As one might guess, we are finding the mail and the switchboard loaded with oh-by-the-way-type questions about materials on which to make holograms. Nobody can be blamed for wanting to sound casual about the subject. Maybe it *will* all blow over. Maybe nothing will come of it. Too bad so to conclude and then turn out to have been wrong.

Which leaves us, as a leading supplier of light-sensitive materials, in an interesting position. To advertise that we offer the perfect material for holography would seem timely but unfortunately would be sheer nonsense. Holography represents such an entirely different viewpoint on the nature of photography—such an entirely different collection of viewpoints, in fact—that even defining what you want the photographic material to do may be half or three-quarters of the battle. And useless to the next holographer on the phone.

If it would help to try talking it out with someone who understands photographic materials, try 716-325-2000, extension 2720, which connects you with Eastman Kodak Company, Special Applications, Rochester, N.Y. 14650. We begin each conversation with a clean sheet of the note pad and a certain type of carefully cultivated memory loss. Meanwhile, pity poor Tom Freeman. He has a tough assignment. Here he is trying to write an article for our men on the road that will tell them what to reply when a customer asks about holography.

Friends of physics in white overalls

The chemists who make and market EASTMAN Organic Chemicals have had to learn a little about present-day activities of physicists. When a chemist looks around for an economic base to support his game, he thinks traditionally of pharmaceuticals, dyes, agriculture, photography, preservatives, adhesives, fuels, finishes, and similarly broad areas for chemical reaction or resistance thereto. Now along come these physicist customers. They aren't interested in chemical change but in physical changes of a subtlety that strains the faith of hard-bitten veterans of the 20-liter flask. Two current examples:

• To the Quantum Electronics Conference of the American Institute of Physics and the Institute of Electronic and Electrical Engineers came word on April 13, 1966 from United Aircraft Research Laboratories by A. J. DeMaria and associates that EASTMAN 9740 Q-Switch Solution, fruit of our flasks, could do significantly more for 1.06μ neodymium lasers than just Q-switch them. It also mode-locks.

The Q-switches available before our dye-makers were called to the service of quantum electronics simply blocked light first and then opened up. Our product isn't just go or no-go. It attenuates low intensities preferentially. Furthermore, our dye recovers its opacity quicker than light takes to make a round trip between the laser mirrors. In consequence of these two points of distinction, the axial modes all come into phase at regular intervals.

Axial modes are the various discrete frequencies jointly permitted by the Nd^{+++} energy levels and by the necessity that inter-mirror distance divided by wavelength must be an integer, albeit a large one. The glassy environment of Nd^{+++} in KODAK Laser Glass unsharpens its transitions to the point that DeMaria is exciting some 30,000 axial modes (=frequencies). Every time they go into phase with each other, the interference effects work out to concentrate the radiation into a short pulse. The more modes the shorter the pulse, just as the more lines in a diffraction grating the better the resolution. EASTMAN 9740 thus turns the spectral breadth of KODAK Laser Glass emission into an asset by packing the energy into pulses calculated to be around 2×10^{-13} sec wide. Slugs of light like that are only 0.006 cm long, or 60 wavelengths. In a span of 30 optical cycles instantaneous power level rises from zero to several gigawatts. That's a lot of naked power to get out of a paltry thousandth of a joule of energy in each pulse. Interesting nonlinear optical effects may not be all that will come out of this.

• A coordination compound of sulfuric acid with that well-known and popular amino acid glycine is ferroelectric. Memory and switching devices employ it. The volume of solid-state discourse already in print about it alerts us to the possibility that solid-state physics will soon turn its thoughts in a big way to the wonderful world of organic molecules. We are ready with *Glycine Sulfate* as EASTMAN 9921.

One of the early lessons learned by serious newcomers to the wonderful world of organic molecules is that the great index of off-the-shelf availability is the catalog of EASTMAN *Organic Chemicals.* EASTMAN *9740 Q-Switch Solution and* EASTMAN *9921 are available from Distillation Products Industries, Rochester, N. Y. 14603 (Division of Eastman Kodak Company). Absence of a molecule from the catalog is no indication we couldn't be persuaded to make it.*

More informative electrons

KODAK Electron Image Plates are hereby announced. The wave-particle dualism that once troubled philosophers now arrives in yellow boxes for the stockroom shelves. As demand for resolving power goes up, down goes effective wavelength. Which young Einstein was kind enough to translate as higher kilovoltage. Which means that in the newer 75- and 100-KV electron microscopes, unless something were done about it, too many electrons would get through the emulsion too fast to touch off a silver halide crystal into developability.

What had to be done about it we have done. While we were at it, in the interests no less of performance than of user convenience, we adapted the new KODAK Electron Image Plate to a developer that comes as a liquid instantly ready for use: KODAK HRP Developer. A mnemonic by which to remember HRP is "high resolution plate," but the bottle delivers more than mnemonic.

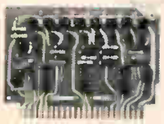
Should any communication difficulties develop on this subject with your local photographic supplier, please alert Eastman Kodak Company, Special Applications, Rochester, N.Y. 14650.

The hope of doing each other some good prompts these advertisements

Kodak

WHEN DO YOU USE INTEGRATED CIRCUIT LOGIC MODULES?

by Don Tothe, Product Manager



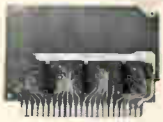
So why design, breadboard, test, de-bug, procure, produce, test, de-bug—well, you know the story. That's why you buy your logic module boards pre-engineered and mass-produced from, we hope, Wyle.

But which type of logic cards do you choose: our new Integrated Circuit or our old-faithful Discrete Component boards? Although the IC uses silicon semiconductors while the discrete usually uses the less-expensive germanium, they both offer the high-level reliability that goes with all-solid-state circuitry. Ninety percent of all logic card applications can be satisfied by Wyle's in-stock modules, and either type can be used in a number of ways.

Which is best for you? If you're already using Discrete Component logic modules—ours, we trust—and you aren't having any problems, why change? The discrete is still your least expensive route. So as long as your functions are being performed satisfactorily, and if your sales are increasing, stay with discretes!

But other considerations may lead you to IC's now. For one thing, our 20 varieties of IC cards can be arranged to carry out most of the functions fulfilled by almost 100 standard discrete types. For another, if you're being pushed for space, or lower power requirements, or faster response time, or performance at 70°C, or want the added prestige of incorporating the most recent development into your product—then the Integrated Circuit is your baby.

Maybe you can tell we're pretty excited about the new Wyle Integrated Circuit cards. The big point is that they're truly in the forefront of design. They incorporate the industry's design thinking you're becoming familiar with—plus some fresh thinking that, for instance, helps one board do the job for which you previously needed several. And Wyle will give you more engineering assistance than anyone else in the business.



There's quite an alphabet of uses for logic modules so while we're on the subject, let's review some of them.

Binary counting? We've got a 5-bit IC board for that.

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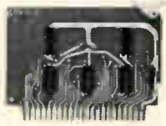

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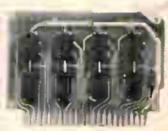

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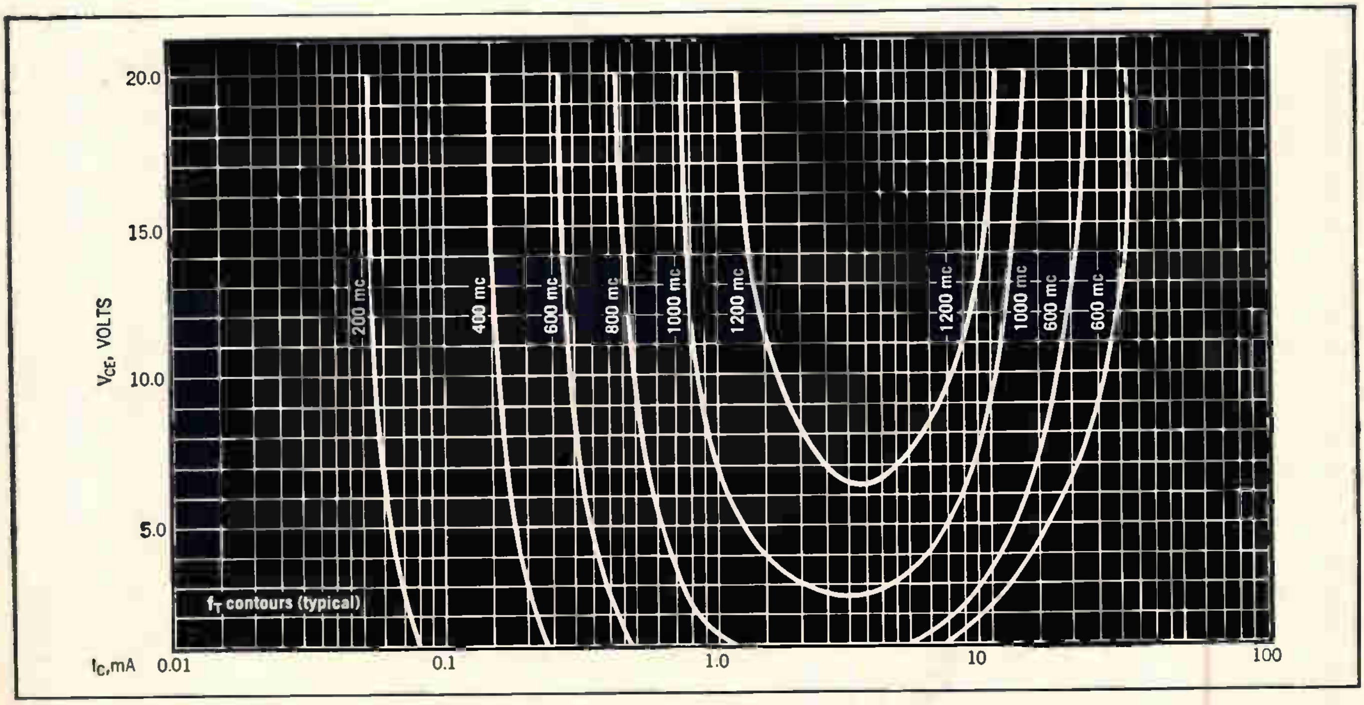

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*PLANEX—Raytheon's designation for planar epitaxial

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C_{ob}	V_{CB} = –10V		1.0	1.7	pf
G_{pE}	V_{CC} = –5V I_C = 1mA f = 200mc	15	18		db
C_{ib}	V_{EB} = –0.5V		1.3	2.0	pf
N_F	V_{CE} = –5V I_{CC} = 1.0mA R_g = 5Ω f = 200mc		4.5	6	db

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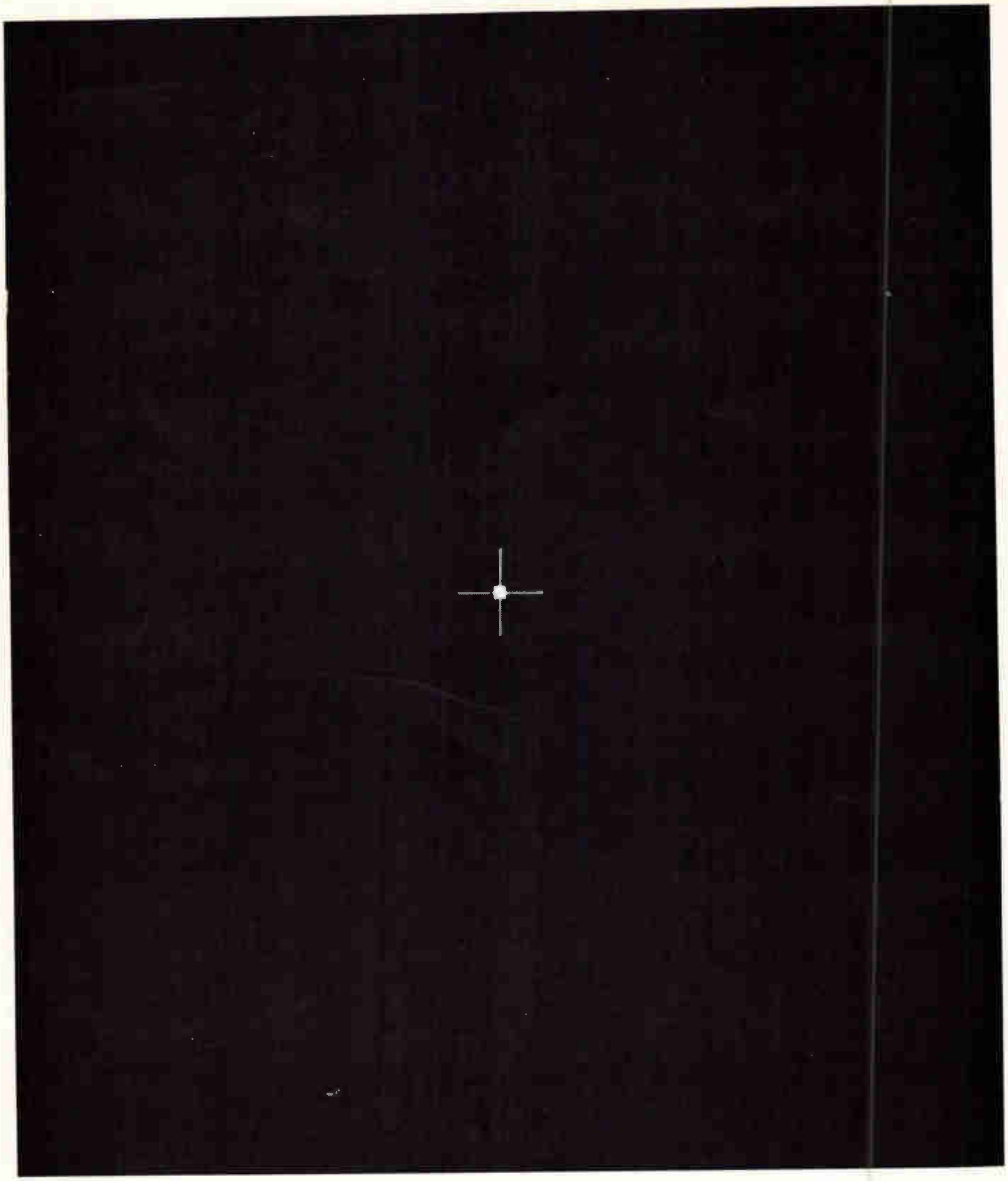


Probing the News

Instrumentation

Toward large color displays: eliminating film from the picture

Laser-projection and other electronic techniques may soon outmode older methods of display based on chemicals; new systems provide images in real time in ordinary room light

The need for wall-size displays presents the electronics industry with a big new market. Many companies are working on bright, multicolor displays that will exhibit data in stock exchanges, airline terminals and military installations.

Companies and the military look to electronics to replace the present methods of big display, many of them based on cumbersome photographic film techniques or requiring darkness to bring out the images.

The military, in particular, wants command and control displays that are bright enough for use in ordinary light. Adds Robert L. Dondero, chief of the electro-optics section of the Display Techniques Branch of the Air Force's Rome, N.Y., Air Development Center: "What is needed and wanted is all-electronic, large-screen displays for multiple viewing of fast-changing information."

Laser display from Texas Instruments Incorporated projects blue and green beams. TI has a prototype system that adds red.

To bypass film, with its chemicals and phalanx of maintenance men, electronics researchers are concentrating on three methods: light-valve displays, discrete-element systems and laser-generated displays.

Because of their concentrated light and versatility, many researchers believe lasers offer the greatest potential for projecting large multicolored displays.

Vernon J. Fowler, scientist in charge of the optical devices group at General Telephone & Electronics Laboratories, a subsidiary of the General Telephone & Electronics Corp., where an experimental model of a modulated three-color laser system is operating, points out that the laser is capable of tremendous brightness because it transmits coherent light. The entire source can be concentrated to one point on the screen, making that point brighter than the source. Incoherent light, used in most other displays, can never produce a point as bright as the source. Another advantage of the laser, Fowler says, is the purity of its color.

I. The crt principle

GT&E's experimental system uses lasers like a cathode-ray tube to form a raster scan of three colored beams, which are modulated by color video signals.

A laboratory model projects a picture 12 feet onto a display screen 10 inches by 40 inches with a brightness of 5 foot-lamberts. The lasers operate in the milliwatt level. The same lasers are expected to operate with power outputs two orders of magnitude greater when the system becomes operational. With more powerful lasers, the projected pictures will fill a theater movie screen, the developers say.

The image is projected by means of a deflection technique based on a method developed under contract with the National Aeronautics and Space Administration's Marshall Space Flight Center. Gas lasers generate red, blue and green light beams which are modulated separately by a system developed by Sylvania Electric Products, Inc., a subsidiary of GT&E.

The beams are combined in a common axis and passed through a single deflection system before being projected onto a conventional movie screen. Color video signals are generated in a closed-loop system and transmitted to the modulator.

The display operates now like a television camera. With further development of the deflection technique and the addition of an electronic package to generate video and deflection signals, it will be able to display information directly from a computer or a remote camera.

However, the system, and others under development at Texas Instruments Incorporated, are subject to the reliability problems that beset all laser systems right now.

At Rome Development Center, where laser display research is going forward, Dondero flatly states that none of today's lasers satisfies the requirements of command and control displays, adding that "no coherent light source operates in the red with sufficient power, stability, singleness of mode, efficiency and monochromaticity."

As a minimum requirement, Dondero says, command and control displays will need an output of 1 watt in the green, 5 watts in the blue and 5 in the red—operating not in the laboratory, but reliably, over a long period, in a military environment.

Charles E. Baker, manager of the optoelectronics system branch at Texas Instruments' Apparatus division, agrees. "Lasers just haven't been engineered enough. They have low efficiency, poor reliability — especially high-power lasers. A laser plasma tube is good for 500 hours. We don't want to put a laser display on the market until it's capable of at least 2,000 hours without maintenance."

Despite these handicaps, however, Baker predicts that full-color displays with a 12-square-foot area may be available by the end of this year. A year from now, Baker added, TI may be in a position to offer a commercial system 48 square feet in area, providing 50-foot-lambert brightness in full color, and costing less than $25,000.

However, Baker and others in the TI group qualify their prediction. They freely concede that problems with the lasers in systems they now have under development have to be solved first.

II. Instant data

TI's Baker says that coupling the laser display directly with computer data, instead of with tv signals, will open new markets, making possible stock market quotations, passenger information and interplant management data straight from computers.

TI is developing a 3- by 3-foot real-time multicolor display for the Navy Bureau of Ships. Laser techniques are among those being explored.

TI has delivered to Rome a helium-neon laser display system for research, which generates displays from tv signals, red taking the place of white in a black-and-white presentation. The system cost just under $100,000.

Two in one. In a few weeks TI is scheduled to deliver to Rome a multicolor system powered by two continuous-mode gas lasers: ionized argon for blue and green outputs and the helium-neon for red. The price for a prototype will be about $87,000.

The modulation and deflection systems will resemble those of the single-laser display. Outputs from the two lasers will be split by a dispersive prism so that each color can be amplitude-modulated independently by the correct video signal. Eventually, computer-generated information will modulate the light beams.

Passing the light through a second prism will combine the three beams into one that will vary in color to correspond with the threefold modulation. The composite beam will then be scanned into a 525-line television raster by horizontal and vertical deflectors while being projected onto a screen through a conventional lens.

The first multicolor model — an 18- by 24-inch display, about the size of a desk blotter — will be limited by the 100-milliwatt level available now from the helium-neon red light source — a third the power available in the blue-green laser output. Indications are that krypton-ion lasers may soon provide a more powerful source of red light.

Laser rainbow. As part of its job for Rome, TI will try to determine how well the primary colors can be mixed to produce subtle hues.

Under a separate program, TI is also developing a 945-line-per-second scan to get better resolution.

The electro-optics group at Rome is also looking at the possibility of creating a laser display with selective beam-writing, instead of sequential scanning. Under contract with Rome, the Hughes Aircraft Co. is exploring electro-optical approaches.

"If it can be done," says Dondero, "it can mean increased brightness and reduced complexity." For command and control, he points out, it is desirable to send a writing device directly to a point on a map or graph. Selective access could mean less buffering between computer and display.

The International Business Machines Corp. has developed for the Army an electro-optical switch that allows several colors to be selected from the beam of a single laser [Electronics, July 11, p. 84].

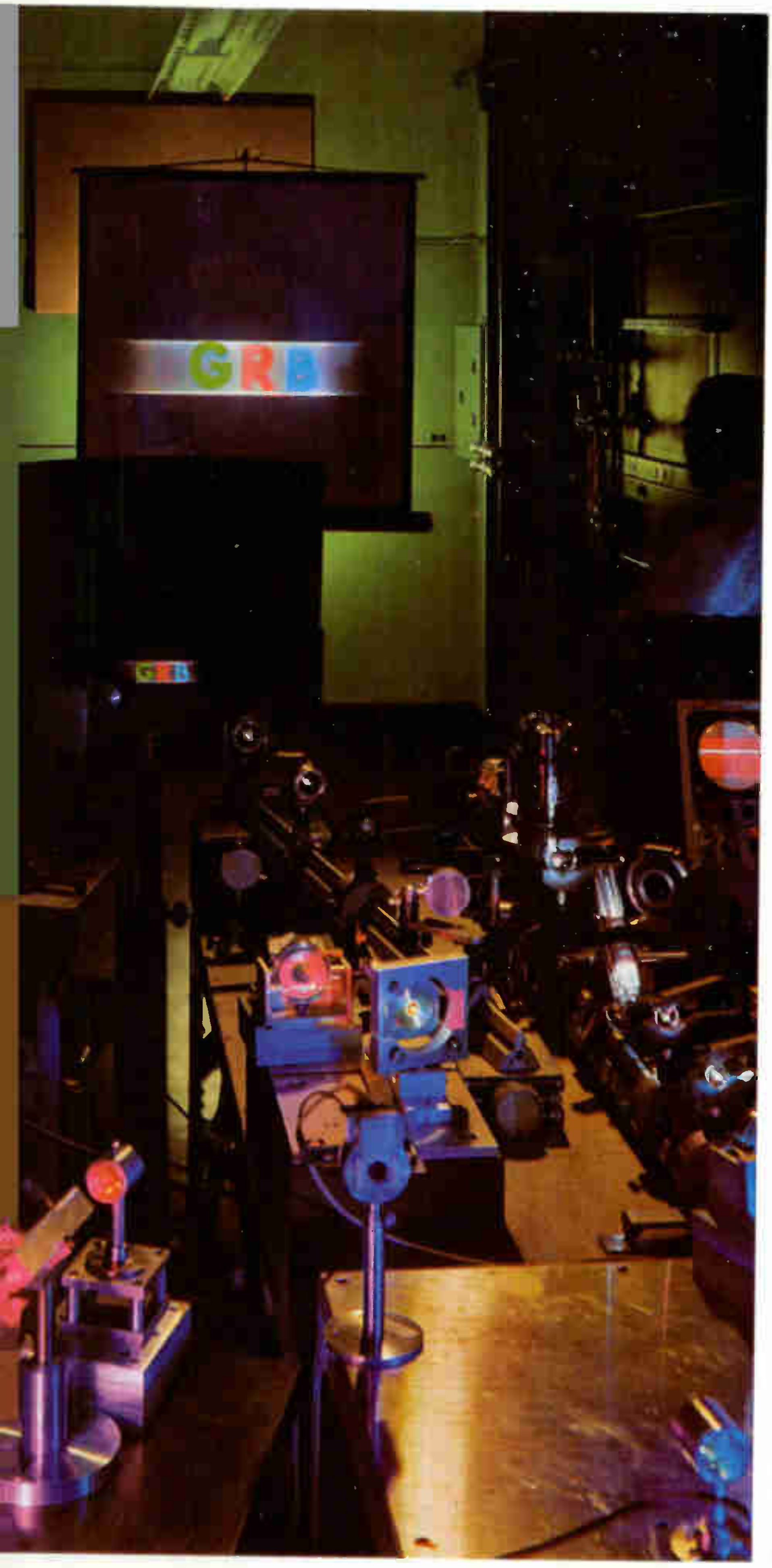
Dondero says that a fully electronic laser display which meets most command and control requirements could be in the field by 1971 or 1972.

III. Dot by dot

The Air Force is putting development money into discrete-element displays, where one component produces one dot of light. Work has branched out into monostable and bistable approaches. Sylvania Electric Products, Inc., is developing bistable displays in which each dot of phosphor has its own switch, which performs a memory as well as a control function [Electronics, Jan. 11, 1965, p. 36]. Rome engineers are working on monostable displays, seeking higher contrast and other methods of achieving gains in panel brightness and symbol intelligibility.

The bistable approach, though presenting a problem in manufacturing and brightness, offers the advantage of eliminating the need to recycle information from the computer to refresh the display.

In working toward a manufacturing technique, Sylvania is developing silicon controlled rectifiers in



integrated-circuit form, but the packaging and interconnections problems are severe. The IC's must be so cheap that millions can be laid down. In the small devices being made, the IC's are put into flat-packs, but eventually a technique that is less expensive and more compact will be necessary. Beam leads are being considered for interconnections.

Probe economics. The Sylvania group at Needham Heights, Mass., under Joseph L. Hallett, is working on a 100-element display of 1¼ square inches. The contract for the little module requires study of the economics of electroluminescent techniques for wall-size command and control displays, with an eye to the practicality of automated production methods. "The feasibility of electroluminescent displays has been proved; it's now a question of cost," says Dondero.

The displays could be compact, rugged enough for a military environment and provide high-speed, real-time displays with the precision inherent in a digital technique.

A second approach to bistable switching lies in the use of bulk cadmium selenide. To take advantage of the hysteresis effect of the material as the controlling element or switch, the CdSe is matched to an electroluminescent material. On a single-cell basis, it works, says Dondero. Radio Corp. of America has a contract with Rome to investigate the problem of uniformity over large-area screens and the practicality of batch fabrication.

International Telephone & Telegraph Corp. in Nutley, N.J., is working on a proprietary electroluminescent material. The Air Force Flight Dynamics Laboratory at Dayton, Ohio, has awarded ITT a contract to apply the material to a cockpit display.

Contracts for color. Two contracts have recently been awarded for work on multicolor electroluminescent techniques. Canadian Westinghouse International Co., Ontario, is using a triad approach, three dots side by side. The three primary colors are emitted by these dots, producing secondary hues to a human

Laser-generated display demonstrated by the General Telephone & Electronics Corp. The light is projected 12 feet and creates an image in three colors approximately 10 by 40 inches.

A light-valve system of display based on the Eidophor. An oil film on a rotating mirror allows projection of bright, true colors on the screen.

observer at a certain distance from the display.

Huyck Systems Co., a division of Huyck Corp., will build a 1- by 1-inch model of a display panel, made up of 100 discrete elements, 10 per line, in six colors. In this approach also, the initial colors are mixed in the eye of the observer to create the appropriate colors; but the colors are produced by a multilayer array of electroluminescent layers, excited by digitally controlled solid state circuitry. The technique is in a very early stage, says Dondero, and it remains to be determined if the design can be packaged to take full advantage of the concept.

IV. The image bearer

Closest to actual operation in the military is a system based on a light-valve display, the Eidophor. It's a Swiss system distributed in the United States by Theatre Network Television, Inc., for projection of closed-circuit television onto movie screens. NASA and promoters of championship sporting events use Eidophor.

The military won't use it in its present form because it won't take information from a computer. Also, though it works well for short periods, the military seeks a system that will operate 24 hours a day.

A number of projects are under way to adapt Eidophor for the military. Rome is working on a technique to permit the system to receive information from a computer. To increase the information density of the projected picture and to get higher resolution for full color, Rome is developing a 945-line scan to replace its 525-line picture.

Also, Theatre Network Television in a cooperative effort with CBS-Laboratories, a division of the Columbia Broadcasting System, Inc., is trying to develop for Rome a beam-writing mode for command and control displays. The Eidophor now operates in a raster or sequential mode only.

In addition, the Air Force has under consideration a proposal submitted by Theatre Network for a failure-rate study of all components of the Eidophor system, aimed particularly at the cathode. The cathode, a basic component, fails too often, according to Anthony De Minco, supervisory physical scientist at Rome. "It also costs $120." As one solution, Theatre Network is completing development of an automatic turret, which will replace a defective cathode during a 3-second interruption of the display. The first will be installed at New York International Airport for projection of images from air-traffic-control radar scopes.

Removed from vacuum. Studies at Rome indicated that contaminants in the evacuated envelope were degrading the cathode. The Air Force gave the Stromberg-Carlson division of General Dynamics Corp. a contract to build a display with the cathode removed from the vacuum, isolating the writing surface. In this device, known as a pin matrix light valve, the matrix of pins is on the face of the cathode-ray tube, but outside the vacuum. When a pin is energized by the crt's electron gun, the electrostatic field produced distorts the reflective oil film on the surface of the matrix. Instead of bouncing back to the source, the light at that point enters and is projected by the optics onto the display screen.

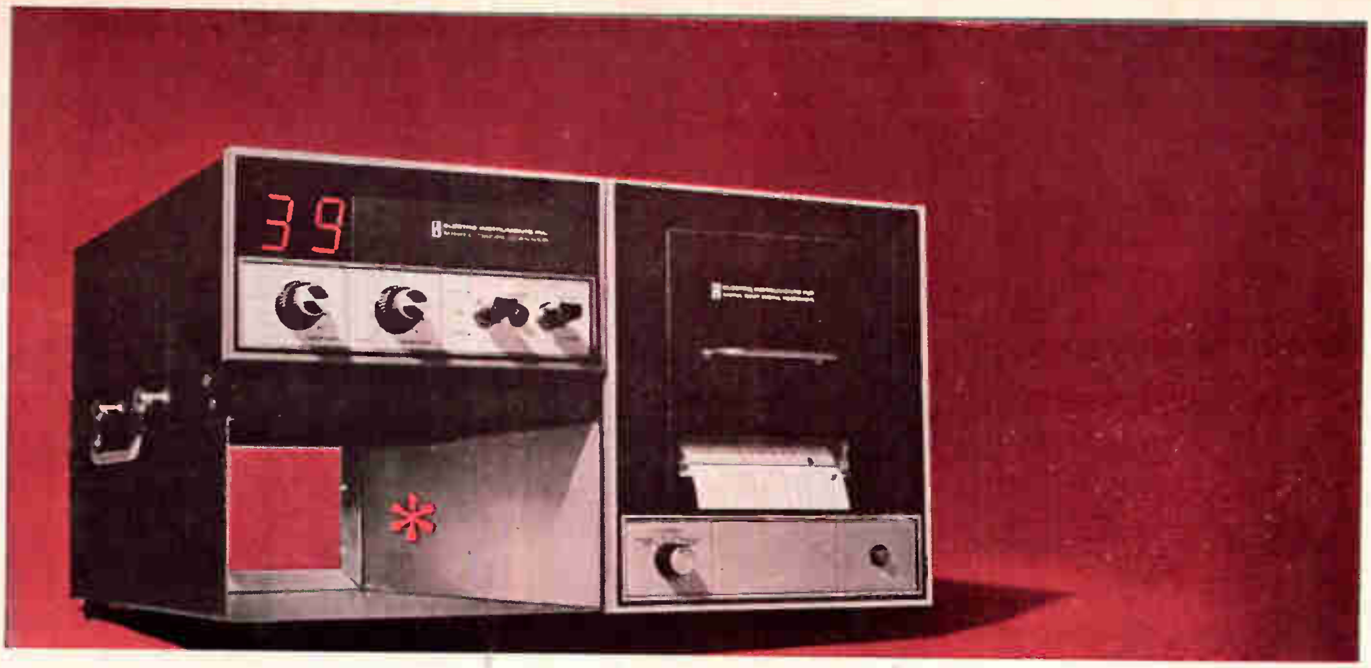
Although the next generation light valve will probably be solid state, command and control needs cannot be met by the solid state light valve as it exists. For example, it provides resolution of 250 television lines. "We want at least the conventional 525," says Dondero. "We want full color, and today you can get only black and white. We would also like to be able to address the display selectively rather than sequentially."

Autonetics division of North American Aviation, Inc., has completed a study contract for Rome and is continuing the work under a Navy contract to clear one road block to using solid state.

At present, the Eidophor uses an oil film on a rotating mirror — in a vacuum — as the modulated surface for control of light to the screen. The signals picked off the front end of a tv receiver modulate an electron gun. The stream of electrons produces tiny depressions in the control layer of oil, distorting the normal path of the light at those points, creating the pictures seen on the screen.

Autonetics is working to replace the oil film with an electro-optical crystal.

The display branch at Rome is "dabbling" in a fourth possible display technique — holography; but no holography work is being sponsored as yet for displays. "My initial judgment," says Dondero, "is that holograms are not needed for command and control displays. Most military users require computer output in alphanumeric and vector form, not large-screen pictures. "Military commanders," he adds, "have no use for the three-dimensional illusion characteristic of holograms."



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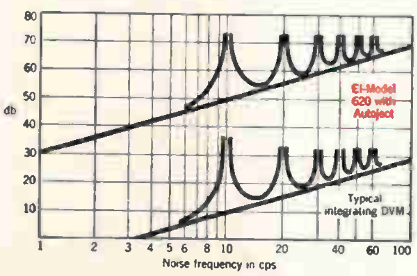

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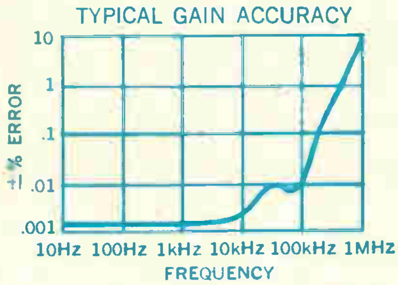

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Control theory: burgeoning but baffling

Even control theorists concede that supersophisticated mathematics is outdistancing hardware-oriented engineers

By Derek Barlow
European Editor

By and large, hardware-designing practitioners manage to keep abreast of the theorists working in their field. But in automatic controls, a frightening gap has opened up between theory and practice.

During the last decade, control theory has burgeoned. To the dismay of many a working engineer, though, the theorists have soared into the rarified atmosphere of higher mathematics. When engineers turn to the literature on theory they find it studded with Euler equations, Lagrange multipliers, nonlinear partial differential equations and Liapunov functions. All too often, a venture into the realm of advanced control theory leaves the hardware-oriented engineer feeling that he's in a strange country with a new language.

Even the theorists recognize they've lost touch with the people who translate concepts into hardware. At the recent Third Congress of the International Federation of Automatic Control held in London, Cambridge University professor John Coales summed up the sentiment. Said Coales, president of the congress, "Theory has outstripped its application and it almost always takes one or more decades to learn to apply new mathematical techniques."

As a result, theoreticians tend to mark time right now. On hand for the IFAC congress and a worldwide report on control theory, industry engineers found the theorists had come up with little that was startlingly new. Rather, the emphasis in the IFAC sessions tended toward stripping the frills from theoretical concepts in an effort to make them useful to engineers. Even so, the gap seems destined to plague system designers for many years to come.

Around the world, researchers are trying to work out practical techniques for the design of optimal control systems. Optimizing these systems has always been an attractive idea and the underlying concept is deceptively simple. It boils down to generating a signal that will vary control settings for a process in a way that a selected performance index stays at an optimum value despite random variations in raw materials and other factors that affect the process. The performance index for a catalytic cracker gas reforming unit, for example, would be lowest cost for the gas produced. Alternatively, the optimal control signal might be set up so that a process would always turn out a maximum quantity of the product.

I. Optimal Control

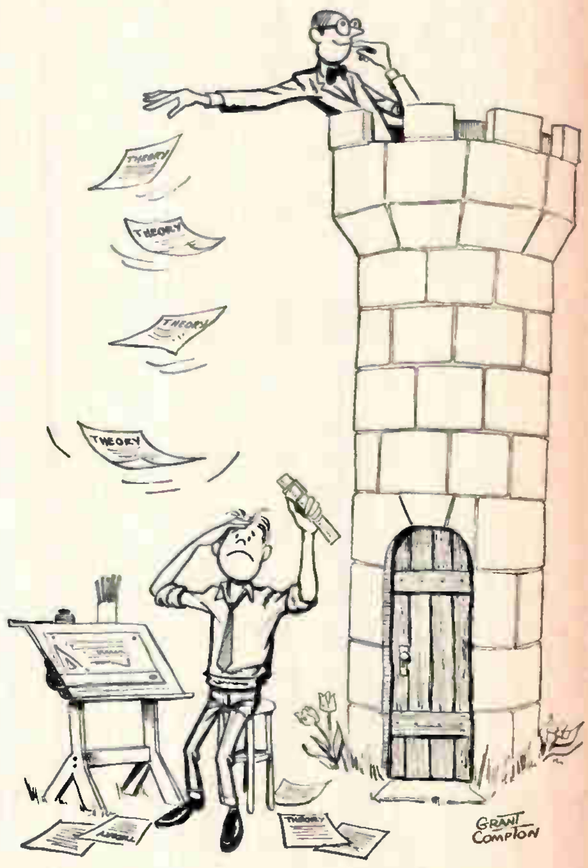
Many theoretical methods have been suggested to generate the complex control signal needed to make this simple concept work. One of the most promising is the dynamic programing approach developed at the Rand Corp. largely by Richard Bellman. Bellman's method generates the control signal in terms of first-order partial differential equations. However, the method requires a computer with an elephant-like memory even for a small process-control system.

On the other side of the world, a group of Soviet scientists have developed a method based on the calculus of variations. Known as Pontryagin's maximum principle, it defines the control signal in partial differential equations, but they are difficult to interpret. What's more, the boundary conditions for the equations have to be applied at two points.

Summing. Still a third approach, devised in the United States, develops the control signal by summing a sequence of signals that progressively drive the process toward the optimum value for the chosen performance index. Unfortunately, this gradient approach produces only an open-loop control input when closed loops are what are wanted.

All in all, the consensus at the IFAC congress was that all three approaches—despite their promise—needed a lot of refinement before they would come into everyday use.

Even when optimal control theory finally gets pared down to manageable form, systems de-



signers still will have to cope with another bugaboo—building up mathematical models for complex, nonlinear processes.

So far, even for the impressive large-computer installations tied into the control systems of steel mills, the programing techniques have been linear. This is adequate to "schedule" a process, that is, set it up so that a satisfactory product comes off the line at the lowest cost. But the linear programing really amounts to a half-solution. It assumes there are no random fluctuations in processes when actually there are. The ultimate computer control system would keep the whole plant running at the optimum as each parameter in the process changed, even at random.

Hard climb. At present, the complete mathematical models crucial to continuous dynamic control of complex processes can't be devised. Often, what goes on in the process itself isn't known well enough to formulate the equations. Then, too, the 100 or more differential equations needed to describe what goes on, say, in a steel mill are unmanageable mathematically.

Up against a theoretical impossibility, systems designers are turning to a more empirical approach called "hill-climbing." Here, a rough mathematical model is set up and programed on a large digital computer to obtain the best coefficients for the equations. The model is then checked against masses of real values of input and output variables recorded on a data logger. Repeated revisions and rechecks of the rough models make them better each time—the coefficients climb closer to optimum values.

An attack like this, though, has to be carried out off-line. The new values of coefficients for the equations of the mathematical model cannot be calculated fast enough, except in very simple cases, to generate control signals for on-line adaptive controls.

Pared down. The theorists have started to tackle the problem of reducing mathematical models for dynamic control. For optimal control in real time, using digital computers, the number of main control variables has to be held to 10 or fewer. Even then, the rate of change in parameters cannot be too fast; if it is, the control system won't react in time to compute new control settings to counteract the variations.

One promising technique, aimed at cutting down the number of variables and reported at the IFAC congress, is modal analysis. In this method, the roots of the mathematical expression representing the dynamic model are calculated and then arranged in ascending order of their negative real parts. By ignoring the larger values, a good approximation of the real model for a plant can be had.

Speedy. IFAC congress-goers also perked up as the United Kingdom Atomic Energy Authority's control and instrumentation division described a digital technique it has used to speed the task of building mathematical models. The agency claims that the method is fully competitive with analog simulation and can handle models involving large sets of equations.

The atomic energy group uses the digital technique to assess dynamic performance of reactor plants. For example, equations for a boiling-water reactor—16 linearized differential equations and 20 algebraic equations — were programed straight as inputs for an IBM 7090 computer. The programing took three days and the computation on the computer three hours. Out of it came an analysis and plot of 60 transients in the system under different test conditions. This technique costs roughly half as much as an analog simulation.

II. Bang-bang

The overwhelming difficulties involved in continuous, dynamic optimal control system points to an opening for sophisticated bang-bang systems. Instead of continuous control, bang-bang systems change control settings only when the error signal runs outside a preset range. Then the system switches in maximum power to drive the process back toward optimum conditions. The use of maximum control power every time settings are changed is an advantage over normal continuous control where the power applied to valves and actuators is proportional to the amplitude of the error signal.

Bang-bang systems aren't new, but their use has been limited because of two major drawbacks. One is that they have a tendency to hunt around the zero-signal level; the other is that in large systems with time constants it's hard to predict the right moment to switch off the correction signal in order to prevent overshoot.

Iterative programs. Researchers at Cambridge University have developed an approach that could make bang-bang systems the kingpin control technique in the future. The approach uses simple iterative procedures to calculate, by computer, control-signal switching times for a fast mathematical model for the plant. Up to three system variables, along with their velocity and acceleration terms, can be handled by iterative computer programs developed so far. To be sure, there's hunting around the zero-signal level as always. But since the mathematical model is many times faster than the actual plant, the fluctuations are outside the bandwidth of the plant control system and there's consequently no loss of performance.

III. No need to know

Because most engineers can't wait for the hardware to catch up to the theory, they have started to explore down-to-earth methods of obtaining optimal control. A technique that seems to do away with the need to know precisely the dynamics of a system has been tried out both in Britain and Japan to optimize efficiency of a boiler.

The technique establishes boiler efficiency by comparing the energy inputs and outputs. Volumetric flowmeters fitted with pulse generators measure the input of fuel. Similar flowmeters in the feedwater flow measure the output energy, since the boiler converts feed water into steam. The efficiency is varied by computer control of the ratio of air flow to fuel.

Japanese engineers at a ship research institute in Tokyo checked this method of optimal control on the working plant against its theoretical equivalent—a capacitance lag with a time constant of 10 minutes. Over a period of four hours, the actual efficiency of the boiler under varying conditions was optimized at 68% to 70%. That worked out to within 2% of the calculated theoretical response.

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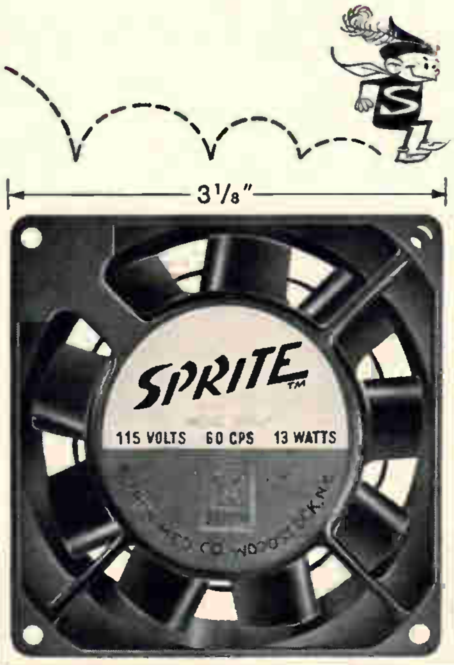

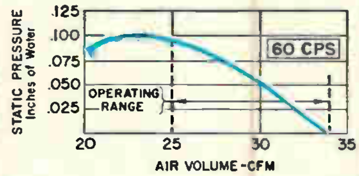

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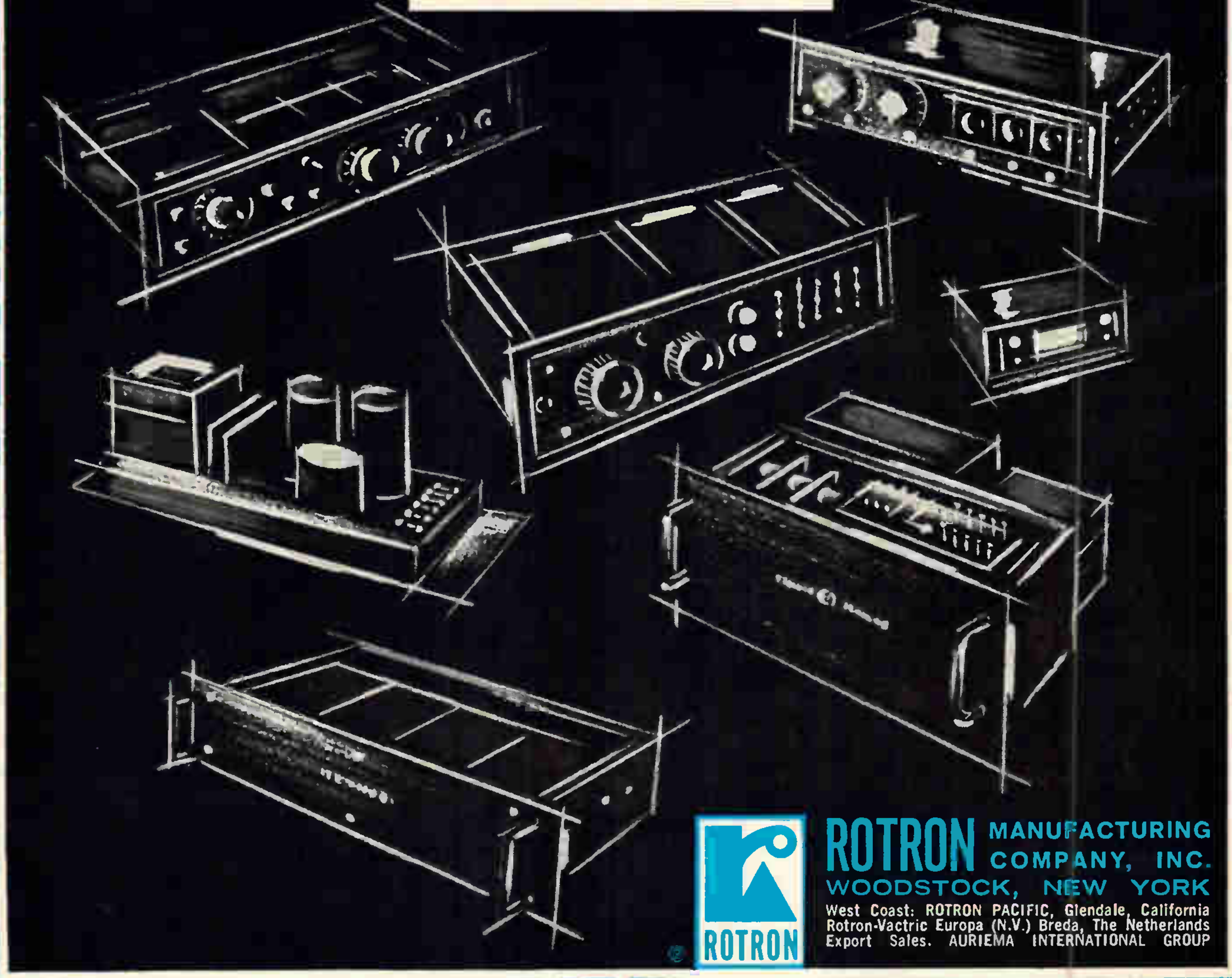

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Defense savings stir debate

Defense Secretary McNamara claims a saving of $4.5 billion in his program of cost reduction, but Congress is skeptical of the bookkeeping

By Robert Henkel and William Hickman

Electronics Washington Bureau

It was that time of year again and Defense Secretary Robert S. McNamara trotted out the fiscal 1966 edition of his cost reduction program. The annual statistical show triggered the traditional skepticism from such places as the Congress and the press. But whether one believes McNamara's figures or not, there's no doubt that what he is doing is having a significant impact on how the electronics industry produces and sells its wares to its biggest single customer.

The Defense Secretary's bookkeeping on the program makes it nearly impossible to tell how much of the reported savings is related to electronic equipment, but the electronics industry's share is sizable.

Electronics manufacturers are feeling the cost-cutting efforts in several different ways:

- The Pentagon is maintaining much lower inventories of multiyear procurements (items bought for years under one contract).
- There is an increasing tendency on the part of the government to supply components to prime contractors.
- The Pentagon is awarding more and more competitive and incentive contracts.
- And the Defense Department is renewing efforts to use less sophisticated equipment wherever possible.

McNamara got as much political mileage as he could out of his report to President Johnson. In an announcement earlier this month before a national television audience, McNamara claimed that the cost reduction program in fiscal 1966 resulted in savings of about $4.5 billion.

He heaped praise on government employees who, for example, conceived such ideas as modifying a signal converter instead of doubling its size, thus saving $95,000. And he didn't hesitate to credit his own ideas, such as the component breakout technique—a process by which various subsystems are furnished to the prime contractor by the government. He said this saved the government more than $200,000 last year on the purchase of one series of magnetron tubes.

I. Ready for battle

After hearing skeptics attack the credibility of his cost reduction figures in the past three annual reports, the Defense Secretary was ready for their attacks this year. He hired Touche, Ross, Bailey and Smart, public accountants, to verify his bookkeeping. Touche and group duly performed their task, agreeing that the Pentagon's accounting methods and savings reports are "logical and reasonable."

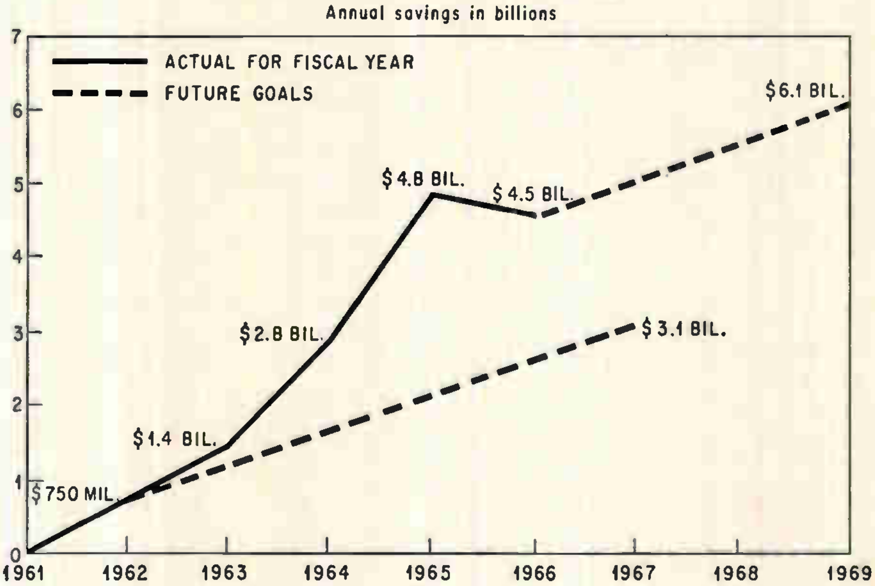
McNamara had barely put his triumphant report on the record, however, when there was a volley of adverse reaction on Capitol Hill. The battle charge was led by Representative Porter Hardy (D.-Va.) and his special investigations subcommittee of the House Armed Services committee, which held a three-day probe of the program. Hardy had plenty of ammunition—he "borrowed" 10 auditors from the General Accounting Office last October to augment his own staff and to look into the validity of McNamara claims of cost savings.

Statistics can lie. The resulting staff report ticked off a long list of instances where it maintained the "cost reductions" were not valid or, in some cases, had even cost the government money.

One reported "cost reduction" idea, which had been rewarded by a cash stipend, was in fact a routine action to correct a much larger error in judgment made earlier by the same agency, according to the

Progress of cost reduction program

Annual savings in billions



staff report.

The subcommittee researchers said another "saving" was in reality an action that ultimately will cost the government more than if it had not been taken.

The congressional auditors took a close look at 53 cost reductions claimed in previous fiscal years. They didn't try to evaluate military judgments in the decisions or to take issue with the guidelines set by McNamara's staff to measure savings. They were concerned only with whether the Defense Department lived up to its own rules.

McNamara had previously reported that the 53 cost savings amounted to about $1.25 billion, but the subcommittee's auditors disagreed. They said that $449.3 million of the savings did not meet the Pentagon's criteria for cost savings and that "some undeterminable part" of another $415.4 million also did not qualify.

II. Vitamins for defense

Generally, the Defense Department's criteria limits the savings that can be reported to "those which result from the application of new, improved or intensified management practices and actions initiated after June 31, 1961."

Following the staff report at the hearings, Hardy worried that the cost reduction program may begin "depriving our military of the vitamins that would give the added punches needed for an extra edge over the enemy." If that happens, Hardy said, Congress should be alerted. He went even further by suggesting that "someone over at the Pentagon may be bragging just to make himself look good"—an apparent reference to McNamara.

Another question in some people's minds has been whether the savings would have resulted even without a formal cost reduction program, which in itself is expensive. Some 200 man-years of audit time are devoted annually to validating the savings by the Defense Department—the cost in salaries alone is in the millions of dollars.

Savings drop. The $4.5 billion McNamara reported in fiscal 1966 was lower than the $4.8 billion in 1965—a dip he attributed to the war in Vietnam. He pointed out, however, that in the five years he has been in office the cost reduction program has saved the taxpayer some $14 billion. The Defense Secretary is optimistic about reaching his long-range goal of $6.1 billion annually by 1969. The original goal of $3.1 billion by 1967 was exceeded in 1965.

One of the ways the Pentagon says it is saving money is by shifting more of its contracts from noncompetitive to competitive bidding. McNamara said experience has shown that an average of at least 25 cents is saved on each dollar's worth of contract that goes competitive. He estimates that $1.3 billion was saved by this technique in fiscal 1966 alone and that 46.4% of all defense contract dollars are now being awarded in a competitive marketplace.

III. From pennies, millions grow

An example of how money is saved by going competitive is an indicator pulse analyzer (1P471), an instrument that displays video signals from any standard countermeasures receiver. Its previous cost was $3,212 from an unnamed sole-source contractor. When competitive bids were sought, the price fell to $2,142—a savings of more than $1,000 on each unit and a total 1966 savings of $88,890.

In another case, the government was buying a gyroscope to stabilize a radar antenna for $11,000 from the prime contractor for the radar on a sole-source basis. When the government went directly to the vendor that built the gyro, the cost dropped to $4,956, a per unit savings of $6,044. Total savings in fiscal 1966 on this instrument alone were reported as $84,616.

Cost-plus. Getting away from cost-plus-fixed-fee contracts is another tried and true method McNamara has for cost reduction. He calculates that cost-plus contracts are at least 10% more expensive than other contracts, particularly when the other contracts have incentive clauses.

An outstanding example of how the Pentagon would like incentives to work is the Vela nuclear blast detection satellites which were built by TRW, Inc.'s Systems Group in Redondo Beach, Calif., under one of the earliest incentive contracts. The first three launches came off so well that the Pentagon decided there was no need for the last two launches and canceled the rest of the contract. Although TRW Systems didn't build all the satellite hardware it originally planned, it received an 11.9% profit, rather than the planned 8.3%.

Another way of reducing costs is to go to multiyear procurements. Here all requirements for a needed item are contracted for a number of years and the government usually obtains lower prices since unit quantities are larger and production runs are longer. McNamara reported that $80 million was saved in the last fiscal year using this approach instead of one year procurements.

Lower inventories of electronic equipment can reduce the government's capital investment. In one case, the Army maintained a 5% replacement stock on hand for a radio relay set. When field experience showed that the replacement ratio of 2% was more reasonable, the Army saved $2,114,073 by not buying the sets needed to keep replacements at the 5% level.

Another $1,386,000 was saved when the Marine Corps assumed ownership of 10 radar sets from Army rather than buying new units from the manufacturer. The radar sets, used in the guidance system for the Hawk missile, were no longer needed by the Army.

Wholesale. Eliminating the middleman can save money. In one case, a magnetron tube (QKH-942), that amplifies power in radar warning systems was being supplied by the prime contractor of the system for $12,094 each. By going directly to the tube manufacturer, the government found it could buy them for $7,630, furnish the magnetrons to the prime contractor and pocket the difference.

The Pentagon also believes its cost reduction program increases the cost consciousness on the part of government employees and has the examples to prove it. For example, an alert Eighth Army engineer found a way to double the capacity of an existing 32-bay communications signal converter, a device which converts dial signals in long-distance dialing between exchanges connected by microwave radio channels. His idea for modifying the converter instead of procuring a duplicate 32-bay system saved the government $95,600.

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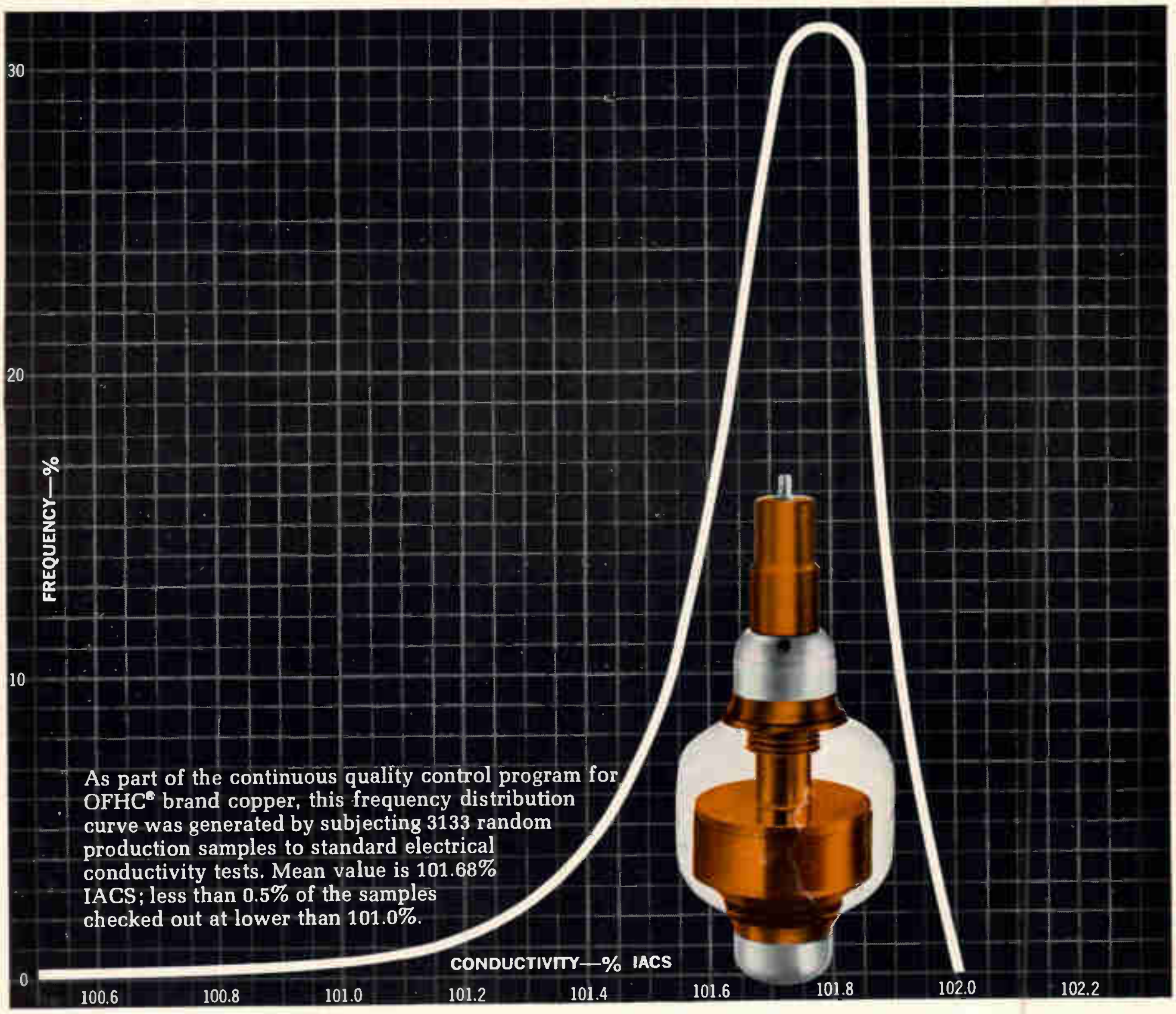

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Radar warns of low-level missiles

Design modifications make new tracker in Alaska '25% better' than predecessors at other early warning sites

By Ray Bloomberg
Seattle News Bureau

The new radar tracker at the Ballistic Missile Early Warning System site at Clear, Alaska, moves the capability of radar trackers a step forward and gives the site a defense against the potential threat of missiles at low altitudes.

The three detection radars at Clear, which are neither as fast nor as maneuverable as the tracker, have been considered adequate to detect a ballistic missile coming in at high altitude and to calculate its destination. But now that improved propulsion makes it possible to send ballistic missiles in at lower altitude, a more versatile sensor has been added to fill this gap.

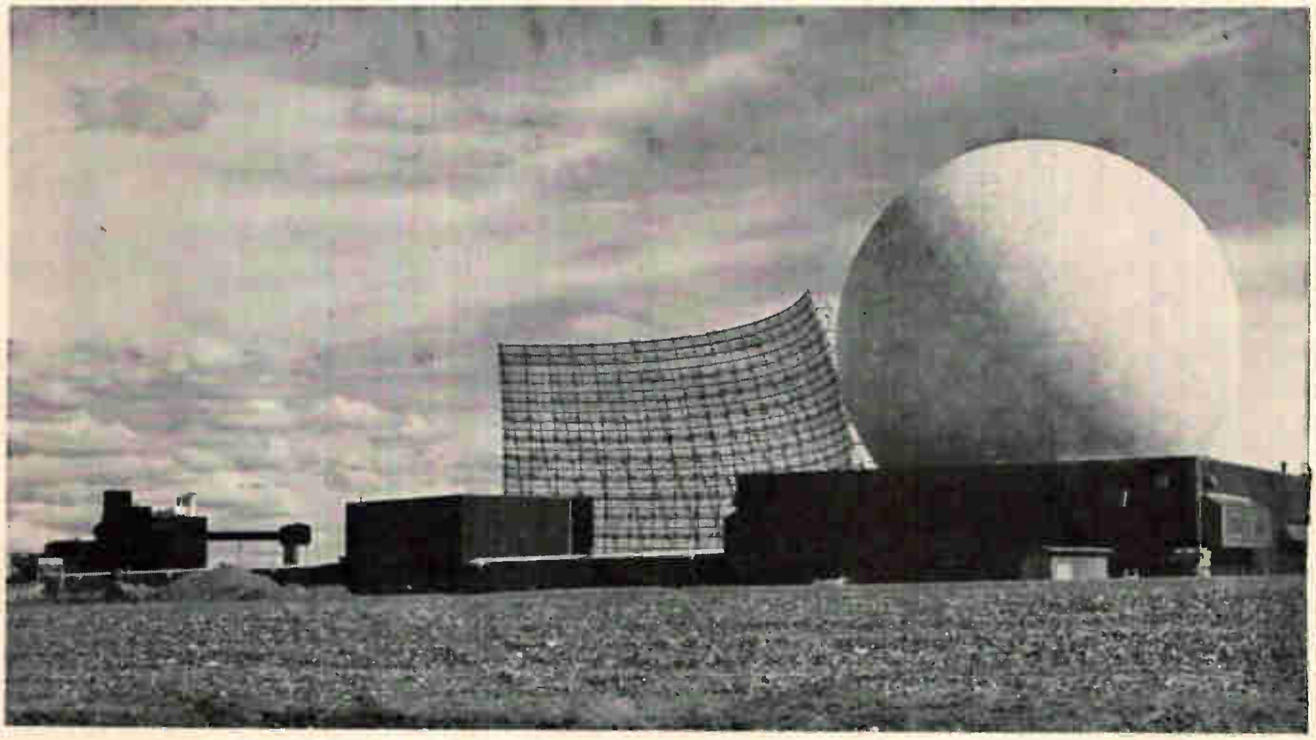
I. A sharper search

Although the trackers at the other two early warning sites are not considered outdated, the radar at Clear represents such an improvement over them that it has a different designation, AN/FPS-92; the trackers at Thule, Greenland, and Fylingsdales Moor, England, are known as AN/FPS-49.

The new tracker is "25% better" than its predecessors, the Air Force says.

- It's more reliable because it uses 5% more solid state circuits, including a number of hybrid integrated circuits; and it is equipped with a more comprehensive electronic monitor to keep tabs on the whole system, particularly on the mechanical parts. Indicators will warn of weaknesses developing in such places as the hydraulic pumps and motors so that they can be replaced before a breakdown.
- It can track satellites better. By using a hydrostatic bearing in place of the giant, often-troublesome, ball bearings, the pedestal antenna can scan at extremely slow rates without jerking or introducing noise. This enables the tracker to hang onto distant satellites with low angular velocities.

The slow-scanning antenna will give angular measurements that are accurate to within 3 seconds of



New radar tracker, inside the radome, can detect and track missiles launched at low angles while the billboard-like detection radars pick up missiles entering at higher altitudes. The new tracker has a number of advantages over trackers at other sites; its hydrostatic bearing permits it to scan slowly enough to track distant satellites.

arc. This precision represents a tradeoff between the precision necessary to give accurate missile-impact prediction and the beam-width necessary to acquire targets easily.

The hydrostatic bearing is much more reliable than ball bearings. It has an infinite predicted life because it is without moving parts or friction. It is supported by a 0.004-inch film of silicon fluid under pressure of 1,100 pounds per square inch.

The bearing is about 9 feet in diameter.

- An aurora "fix" quiets disturbances caused by the nearby aurora borealis. This fix device, which permits operators to "see through" the aurora, will also be installed at the early warning site at Flyingsdales Moor, where noise from the aurora is also a problem.
- The receiver system has a low-noise front end (2 decibels), achieved by using a d-c pumped, electron-beam parametric amplifier.
- Extensive electronic counter-countermeasures have been put in the tracker and the scanner to provide a highly sophisticated means of identifying and coping with electronic countermeasures that enemy missiles might use.
- Other advantages include the use of advanced high-power isolators in the transmission lines, and the ability to obtain more target data during a single scan than can the FPS-49.

The hardware. The antenna and its pedestal weigh 200 tons. It is equipped with an 84-foot parabolic antenna enclosed in a radome 140 feet in diameter. It stands 15 stories high. The radome is made up of more than 1,600 pieces of 6-inch-thick dielectric sandwich honeycomb plastic. The radome protects the radar from Alaskan winters where the temperature has reached a low of —75°F. The tracker cost $16 million.

Both the new and the older trackers were built by the Radio Corp. of America's Missile and Surface Radar division at Moorestown, N.J. The General Electric Co. built the detection radars. The Air Force Systems Command's Electronic System division is responsible for developing the early warning radars with engineering control provided by the Rome, N.Y., Air Development Center. The facility is operated and maintained by the RCA Service Co. for the Air Defense Command.

The 84-foot parabolic antenna is protected from the severe Alaskan winters by a radome 140 feet in diameter. The antenna and pedestal weigh 200 tons.

II. Trackers and detectors

The tracker's job is much more complicated than the detector's. The tracker sends out a single radar beam which indicates the presence of a target by hitting it and bouncing back. The tracker then locks onto the target, follows it and obtains quick, detailed information, not only about its origin, velocity and destination, but its size and other characteristics. The tracker's excellent discrimination techniques also help distinguish warheads from decoys.

The detector notes with one stationary beam the presence of a moving object and with a second beam determines the object's origin, velocity and destination. It cannot discriminate between decoys and warheads and it cannot specifically identify the object.

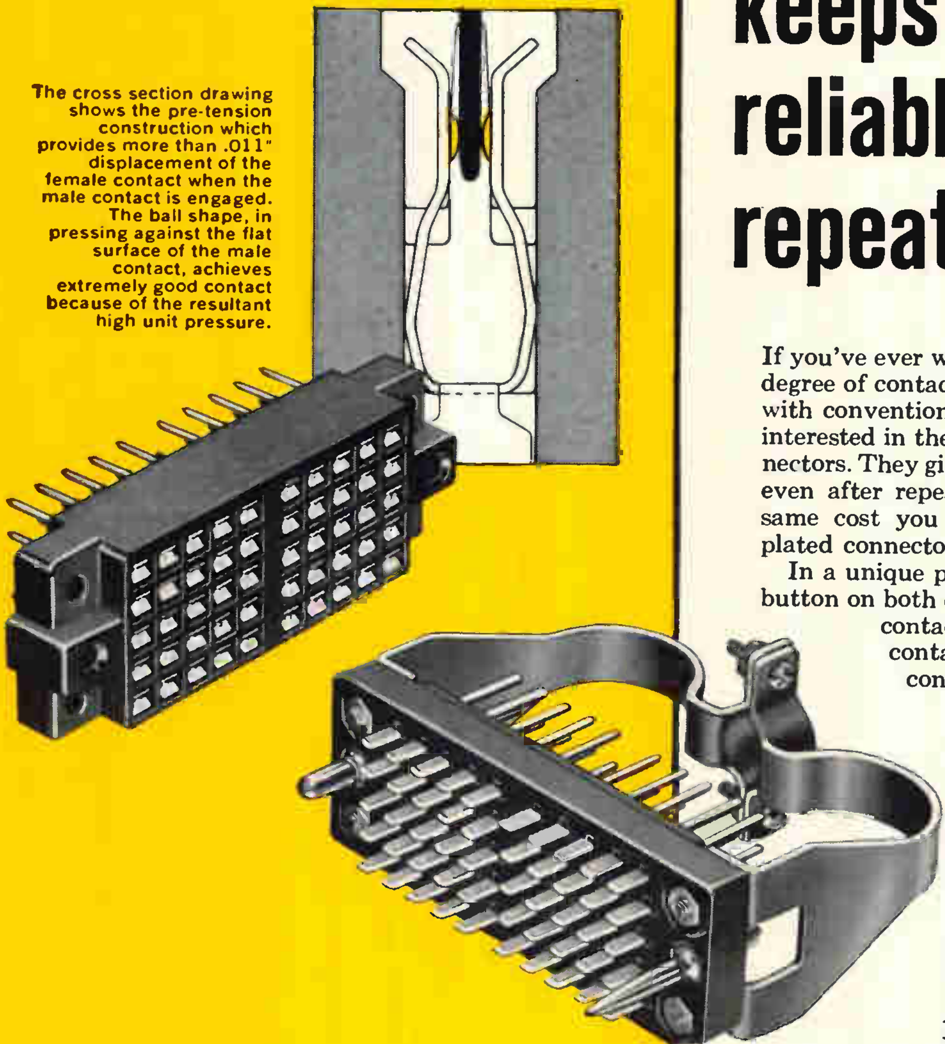
III. The mission

Tracking and cataloging satellites is increasingly important as well as difficult. There are now 2,257 objects in orbit. When a satellite, or debris from a satellite, is first detected, the tracker determines the object's velocity, range and cross-sectional measurement.

The cross-section measurement capability of the equipment makes it possible to determine target characteristics such as size, shape and rotational dynamics. The data is obtained in real time and stored on chart recorders, printer outputs and computer tapes for post-flight analysis. Data recorded includes target cross-section (horizontal, vertical and total), fine-line spectrums, automatic gain control, noise biases, doppler error signals, polarization-phase angles and time of day.

Signal returns are converted into data for computers which predict the place and time the objects will appear again. On future appearances, any change in data is compared with earlier data. The extreme range of the radar permits a daily cataloging of almost all satellites traveling in high-inclination orbits. While the exact range of the tracker is classified, it can easily track 1-square-meter targets at ranges beyond 2,000 miles.

Information, processed and displayed at the early warning site in Alaska, is transmitted automatically, via redundant systems, to the North American Air Defense Command in Colorado Springs, as well as to the Strategic Air Command headquarters near Omaha, Neb., and to the Pentagon. A computer at Colorado Springs evaluates the threat and the degree of confidence in the incoming information.



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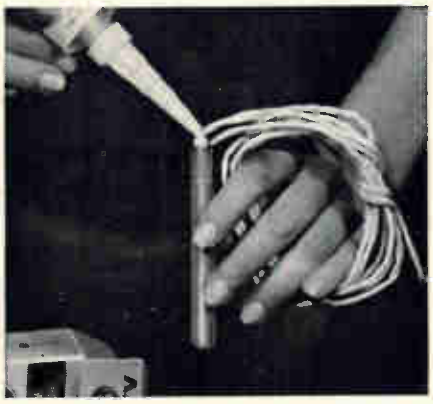

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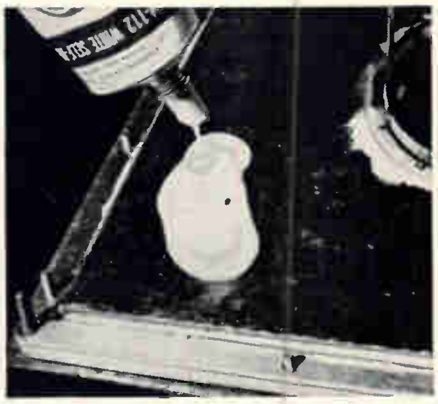

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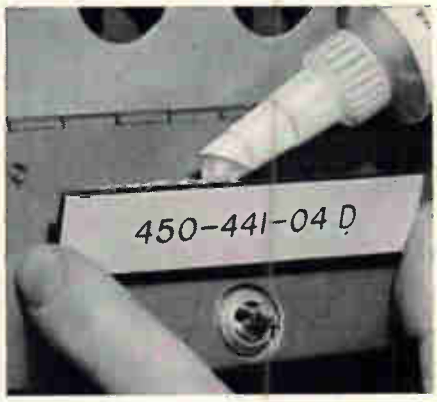

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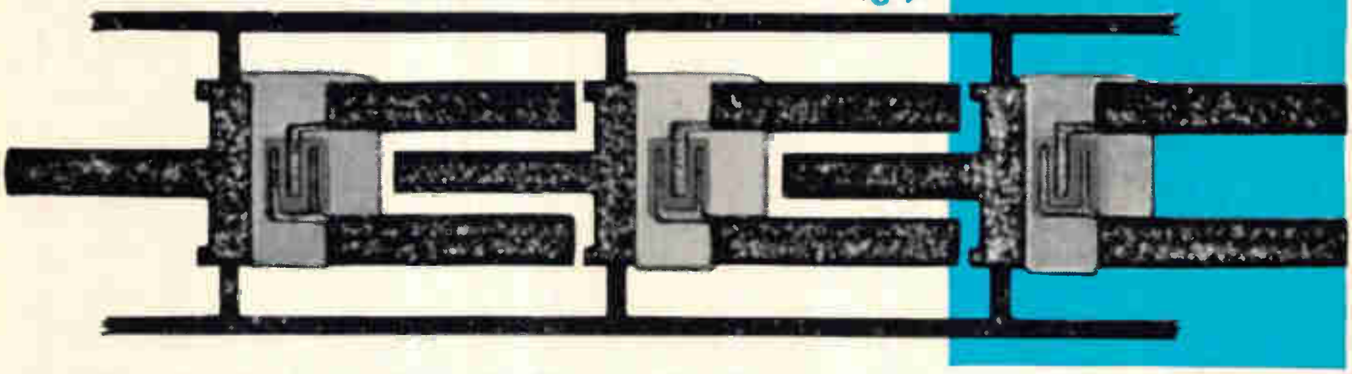
Report from
BELL LABORATORIES

"Beam lead" technique for fabricating solid-state devices

Magnification: 125X (color square is period at end of this sentence, to same scale).



Row or "ladder" of beam-lead transistors fabricated experimentally at Bell Laboratories has a transistor every 16 mils along its length. Each transistor (on light-gray areas) has three beam leads (dark-gray rectangular areas) for electrical and mechanical connection. The side rails at top and bottom of photo are used only for support and ease of handling.

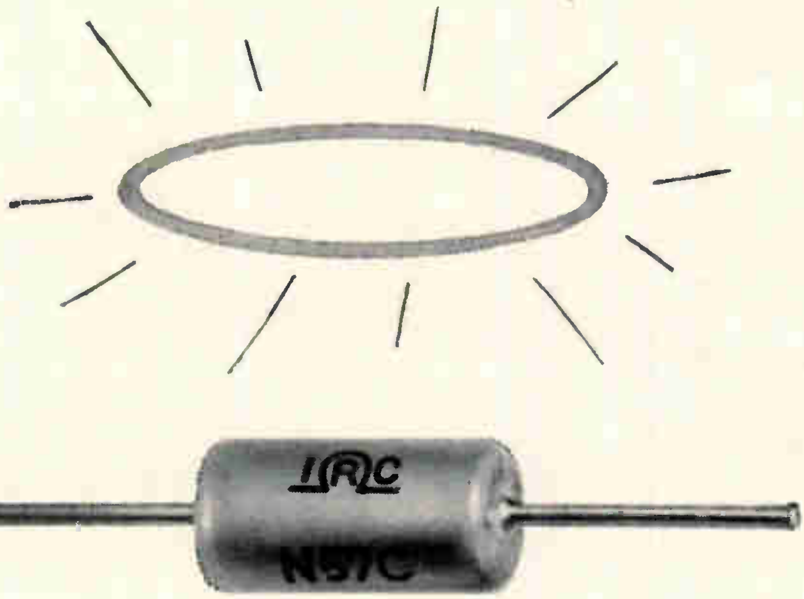
To make tiny solid-state devices and circuits, groups of elements are generally formed on a single semiconductor slice or substrate. Then the slice is "diced" (physically separated) into pieces as either individual units or groups of units for integrated circuits. If used individually, they are connected to terminals or to other devices with short segments of extremely fine wire—a difficult and time-consuming operation. If used as groups of devices, they often need special processing to electrically isolate those making up each circuit.

Bell Laboratories' M. P. Lepselter has developed a promising solution to both of these problems. After the device elements are formed, mechanically strong electrical leads are deposited onto them. These electrically and mechanically intraconnect the devices and circuits. Unwanted semiconductor material between the individual devices in a circuit is then removed . . . isolating them electrically, yet leaving them mechanically joined. This permits batch processing of electrical leads, eliminating many individual connections and requiring only connection to external terminals.

Thus, handling tiny devices and circuits is simplified. The leads, precisely positioned with respect to each other, are easily connected to a circuit board or other support, perhaps eventually by automated techniques. They are strong enough so that the semiconductor wafer or chip needs no further attachment to the substrate. Entire circuits joined by beam intraconnections can be handled as one unit.

M. P. Lepselter examines beam-lead model (enlarged about 300 times). Beams were thermally aged in 360° C steam for 1000 hours, centrifuged to 130,000 G, bent 90° twenty times without failure. Beams can be tapered for smooth impedance matching, widened to act as heat sinks.

Bell Telephone Laboratories
Research and Development Unit of the Bell System



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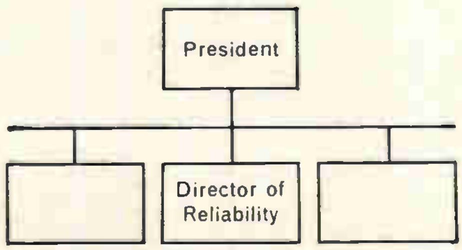

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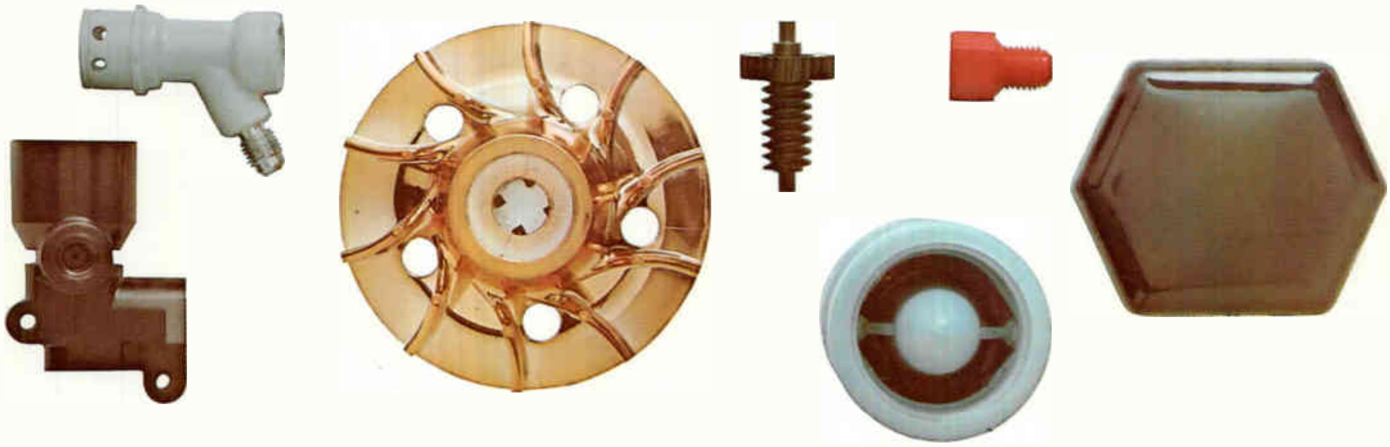

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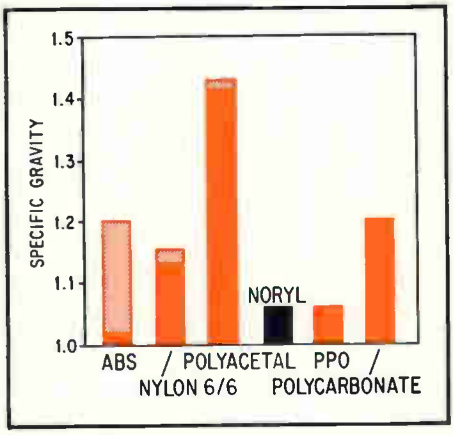
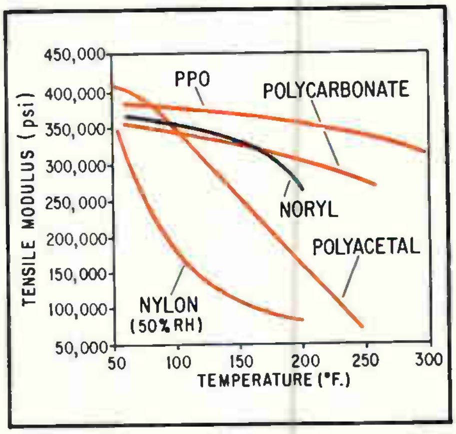


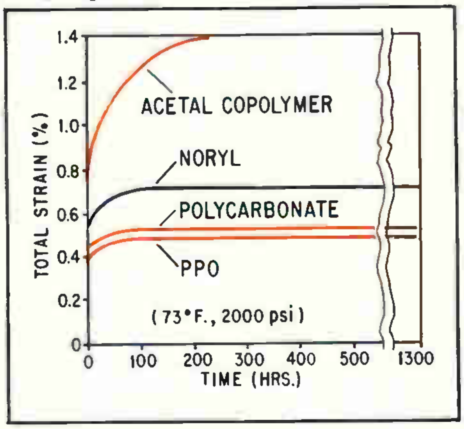
Low specific gravity. The specific gravity of Noryl is only 1.06 (one of the lowest of the engineering thermoplastics). As a result, you get more parts-per-pound when molding Noryl resin. Range of usage is wide, including water, automotive and medical uses.

Self-extinguishing. Noryl is self-extinguishing and non-dripping according to ASTM D635. This property, combined with high dielectric strength and low dissipation factor over a wide temperature, frequency, and humidity range, qualify Noryl for electrical use.



High strength and stiffness. Noryl maintains its strength and stiffness over 200°F. As a structural material, Noryl competes with metals and out-performs many engineering thermoplastics which have, at best, marginal properties at elevated temperatures.

Low, predictable mold shrinkage. The mold shrinkage of Noryl is .005-.007 in/in. This provides precision molding to close tolerances. Combined with excellent melt flow behavior, Noryl offers easy processing and precision molding for low production costs.



Dimensional stability. In addition to *maintaining* its mechanical properties at elevated temperatures, Noryl is superior to most other thermoplastics in dimensional stability. With extremely low creep, Noryl also offers high heat deflection (265°F @ 264 psi).

Hydrolytic stability. Noryl has the lowest water absorption of any engineering thermoplastic except PPO. It is unaffected by aqueous media including hot and cold water, detergents and many acids and bases. Ideal for many uses like these pump parts.

LOOK INTO NORYL TODAY, the new molding and extruding resin combining an overall balance of properties with value and easy processing. Designed for use where the ultra-high performance of PPO polyphenylene oxide is not demanded, Noryl is an excellent material for water distribution parts, electrical components, appliances, automotive fixtures and many others.

FOR MORE INFORMATION, call your local Chemical Materials Sales Representative or write Section CDX, Polymer Products Operation, General Electric Company, One Plastics Avenue, Pittsfield, Mass.

GENERAL ELECTRIC

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CDX-21

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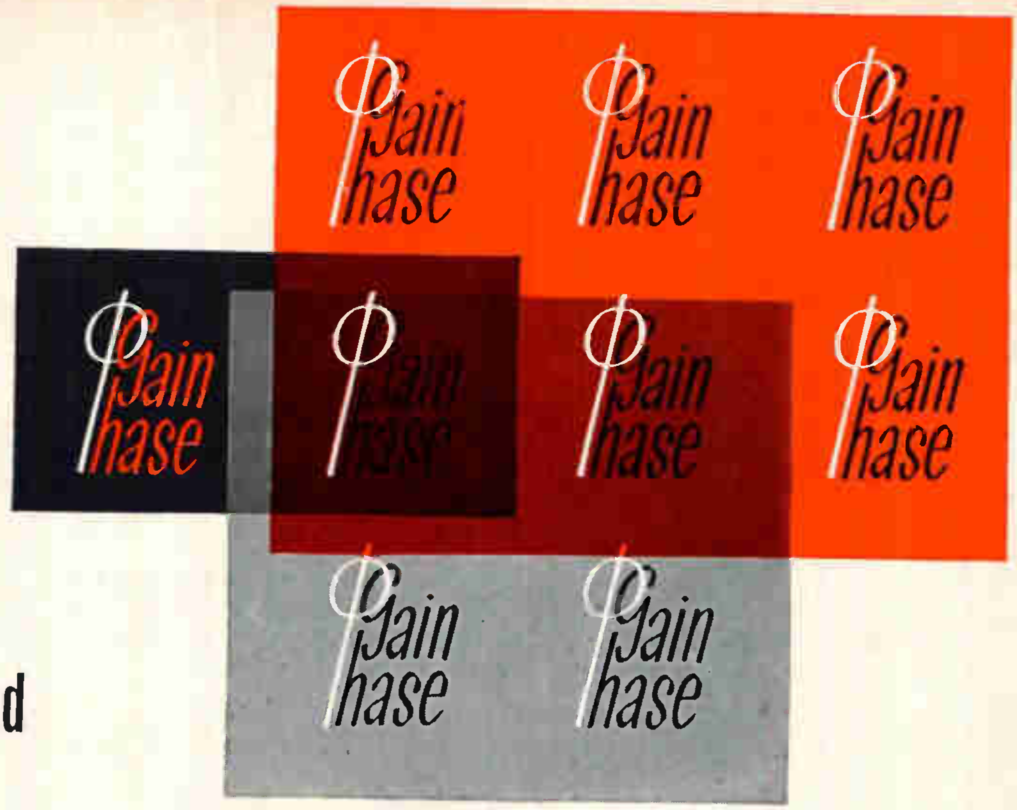
How many MATCHED radar channels?

Build all you need with



LEL Gain and Phase Matched Amplifiers and Mating Mixer-Preamplifiers

LEL 2- or 3-Channel matched post amplifier units offer superior performance over the widest range of gain control. They're ideal for use in monopulse radar applications. In such an application you can also build with LEL's monopulse comparators, matched mixer-preamplifiers and appropriate LEL-LINE strip components now available up through Ku Band. Send for LEL's new catalog now.

Mixer-Preamplifiers UMK-11†

Signal Input	0.2 to 1.0 Ghz†
IF Center Frequency	30, 60 or 70 Mhz
Bandwidth (3 db)	25 Mhz
Gain (RF to IF)	20 db
Gain Reduction	20 db
Maximum RF Input Signal for Linear Output	−20 dbm
Output Impedance	50 ohms
Noise Figure	as low as 7.5 db
Power Required	−20 VDC
Phase Tracking (as compared to another similar unit operated off a common AGC bias)	2° (max)
Gain Tracking (as compared to another similar unit operated off a common AGC bias)	1 db (max)
Chassis Adjustments	Phase Trim and Gain Trim

†Other models available covering 35 ranges between 0.1 and 40 Ghz.

Dual Channel Amplifier ITA-8 2

Center Frequency	30, 60 or 70 Mhz
Bandwidth (3 db)	10 Mhz
Gain (IF)	65 db
Gain Reduction	40 db (min)
Max. Output Signal for Linear Operation	+10 dbm
Max. Input Signal for Linear Operation	−15 dbm
Input Impedance	50 ohms
Output Impedance	50 ohms
Power Required	160 ma @ −20 VDC AGC: 0 to +10 VDC
Phase Match	2.5° (max)*
Gain Match	1.0 db (max)*
Dimensions	7" L x 1½" H x 2½" W
Weight	1¼ lb. max
Chassis Adjustments	Gain and Phase Trim

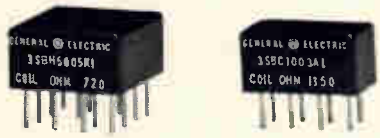
Triple Channel Amplifier ITA-8 3

Center Frequency	30, 60 or 70 Mhz
Bandwidth (3 db)	10 Mhz
Gain (IF)	65 db
Gain Reduction	40 db (min)
Max. Output Signal for Linear Operation	+10 dbm
Max. Input Signal for Linear Operation	−15 dbm
Input Impedance	50 ohms
Output Impedance	50 ohms
Power Required	240 ma @ −20 VDC AGC: 0 to +10 VDC
Phase Match	3.5° (max)*
Gain Match	1.5 db (max)*
Dimensions	7" L x 1½" H x 3¾" W
Weight	2 lb. max
Chassis Adjustments	Gain and Phase Trim

*These data are maximum variations within temperature range of −50°C to +75°C and over the full specified gain control range, for a signal spectrum greater than 60% of the IF bandwidth.

LEL DIVISION
varian / akron street / copiague / new york 11726 / 516 AM4-2200 / 516 PY9-8200 / TWX 516-691-5085

We expect these 150-grid relays to be copied



4-pole 2-pole

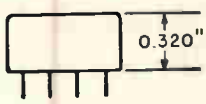
And by 1967 they'll be a standard of the industry

Right now, these General Electric 2- and 4-pole relays are years ahead of the field. Their low, low profile—just 0.32 inch high—lets you stack more circuit boards in the same space.

They're not just cut-down versions, either. These 150-grid relays can perform right up with microminiature relays four times their size.

For example, closing force is about the same to provide snap-action, positive contact mating. In addition, General Electric 150-grid relays meet or exceed environmental and mechanical specs of much larger microminiature relays.

And compared to relays of comparable size, G-E 150-grid space relays have three times the magnetic force and over twice the contact force of their nearest competitor. What's more, they're the only relays in this size range that are all welded to eliminate flux contamination.



ACTUAL SIZE

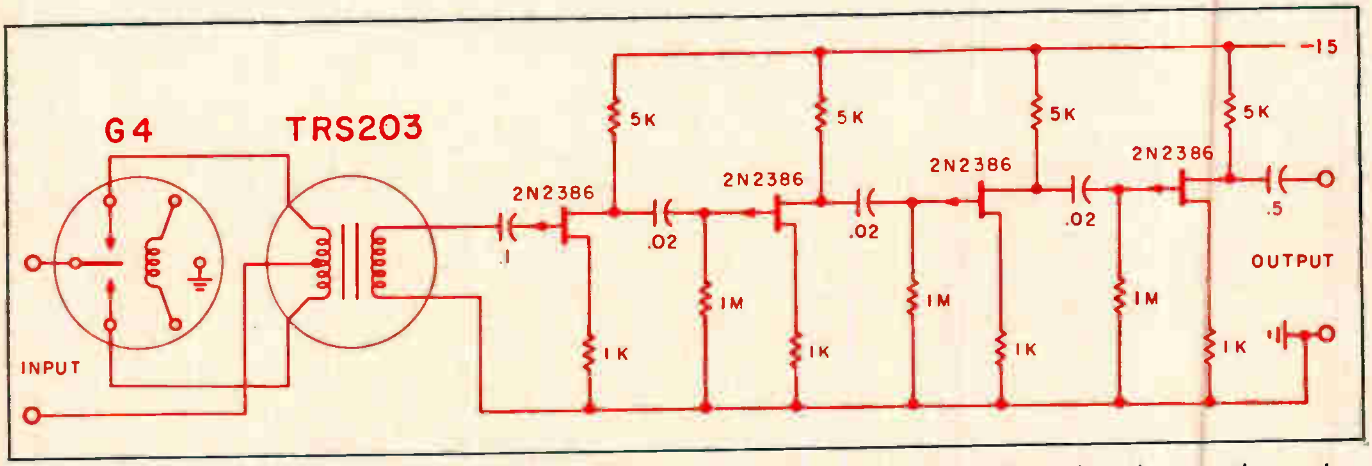
Your G-E Electronic Components Sales Engineer can tell you more about 150-grid space relays and help with your individual applications. Contact him. Or write for bulletin GEA-8042B, Section 792-38, General Electric Co., Schenectady, N. Y. 12305.

Specialty Control Department, Waynesboro, Va.

GENERAL ELECTRIC

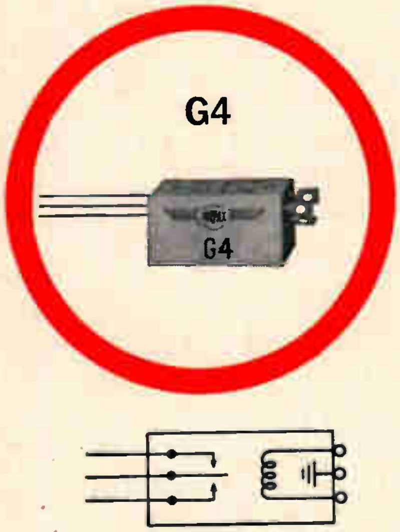
TEN YEARS TOO LATE

Part TEN in a series on THE STATE OF THE CHOPPER ART

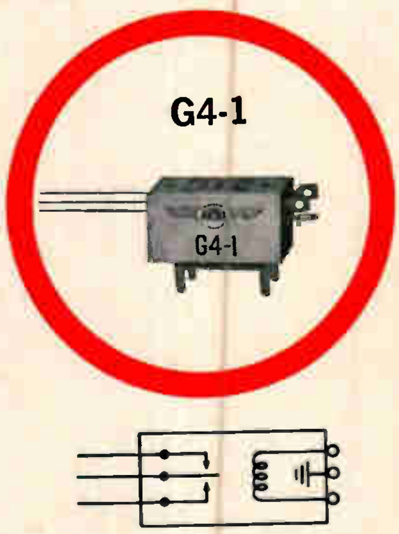


The FET amplifier has remarkable low noise performance. Tubes — and transistor junctions — have at least one thing in common — the noise power increases as the frequency goes down. This means a lot of jitter near DC, making readings at less than 100 nanovolts about impossible, unless the amplifier bandwidth is severely restricted. You can read 10 nanovolts with this circuit with wide band response.

THE VERY REMARKABLE G4 MECHANICAL CHOPPER – BORN 10 YEARS TOO LATE



TRANSFORMERS DON'T SEEM TO GET ANY SMALLER



Boy oh boy. If only we had this thing 10 years ago when mechanical choppers were real fashionable. It would have made all those nasty competitors look sick. (Sigh!)

We don't really expect you to care much about a mechanical chopper nowadays. Even if the offset is below 50 nanovolts, even if it buzzes away docilely at most any frequency up to some 1500 cycles. Even when it's almost transistor size. (You can get by without the input transformer — we're just trying to sell you that too. Profit is our motive.)

Could be, of course, you haven't time to horse around — you need something working the first time. Or you'll sacrifice reliability — 25,000 hours life is good enough. You might like the bifurcated contacts isolated completely from contamination. Try one. This G4 chopper is practically perfect.

We maybe ought to ignore the low cost, it not being Solid State. The G4 is a lot smaller and lighter than a solid state chopper. Honest. Just add up the contrivances you need for solid state drive.

It sure would have been nice 10 years ago.

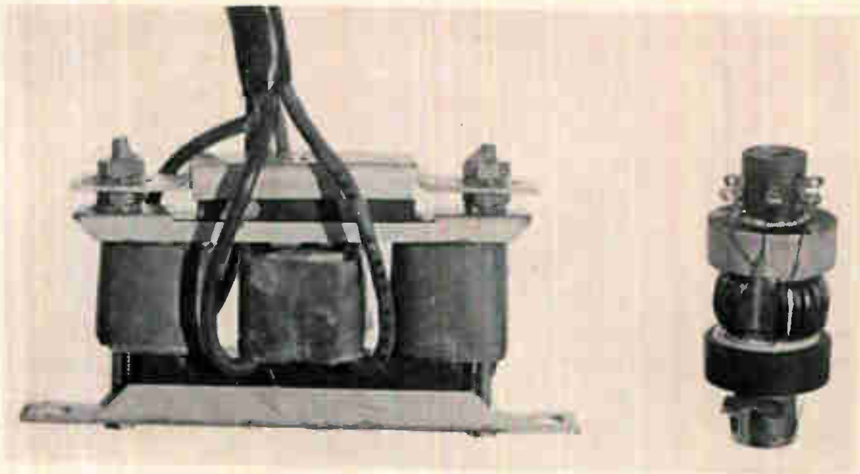
AIRPAX ELECTRONICS incorporated **Cambridge Division, Cambridge, Maryland**

Two magnets shrink saturable reactor

Simpler design will make color-television deflection circuitry and appliance controls cheaper and smaller

A saturable reactor the size of a man's thumb has been developed by applying the basic physics principle that magnetic fields at right angles do not affect each other. The reactor, a coil whose inductance is changed by varying the magnetic field of its core, will be a part of some color television sets this fall.

The concept applied by engineers at Coilcraft reduces the reactor to a quarter of its former size and cuts the cost from $1.35 to 85 cents—important factors in consumer applications.



Saturable reactor on the right replaces the larger, more expensive unit in the pincushion-correction circuitry of a color tv set.

The unit is constructed by winding a toroidal output coil around a ferrite-core solenoid. Since the two coils and their magnetic fields are at right angles, there is no direct magnetic coupling. The solenoid assembly is slipped on a cardboard tube and sandwiched between two ceramic permanent magnets in the configuration shown. The two ceramic devices magnetically bias the ferrite core to a point near saturation so that small changes in the input signal to the solenoid drive the ferrite core into saturation, substantially reducing its permeability. Since the toroidal output coil is wound on the same core as the solenoid, changes in the core's permeability directly affect the toroid's inductance even though the coils are magnetically isolated.

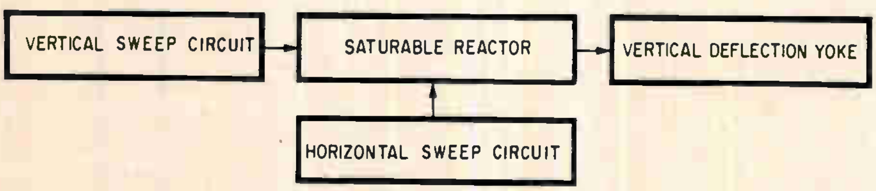
In the conventional reactor design, isolation is accomplished by placing the signal and control windings on three separate legs of an E-shaped core. This provides isolation for the output winding on the middle leg while allowing the flux created by the input signals to control the permeability of the rest of the core.

The new reactor functions as a magnetic modulator in the color tv's beam-deflection circuitry to correct the pincushion effect—a bowing-in of the raster or trace on the top and bottom of the picture tube. It occurs because the beam is a point source scanning a nonspherical target. In black-and-white sets, the distortion caused by the squeezing in of the horizontal lines can be corrected with permanent magnets in the deflection yoke, since only one electron gun is involved. The three-gun geometry of the color tube makes this sort of correction impossible because the guns are spaced far enough apart to require individual correction, yet close enough so that permanent-magnet correction of one gun interferes with the correction field of the other two guns.

To overcome this in a color set, the vertical scanning signal is modulated by the horizontal sweep signal in the saturable reactor before being applied to the deflection yoke, as shown in the diagram. Thus, the corrected vertical sweep signal has an equal and opposite barrelling distortion which exactly compensates for the pincushion effect, resulting in a straight-line horizontal scan. The isolation provided by the saturable reactor is important, since it preserves the horizontal signal while allowing it to modulate the vertical signal in the correction circuit.

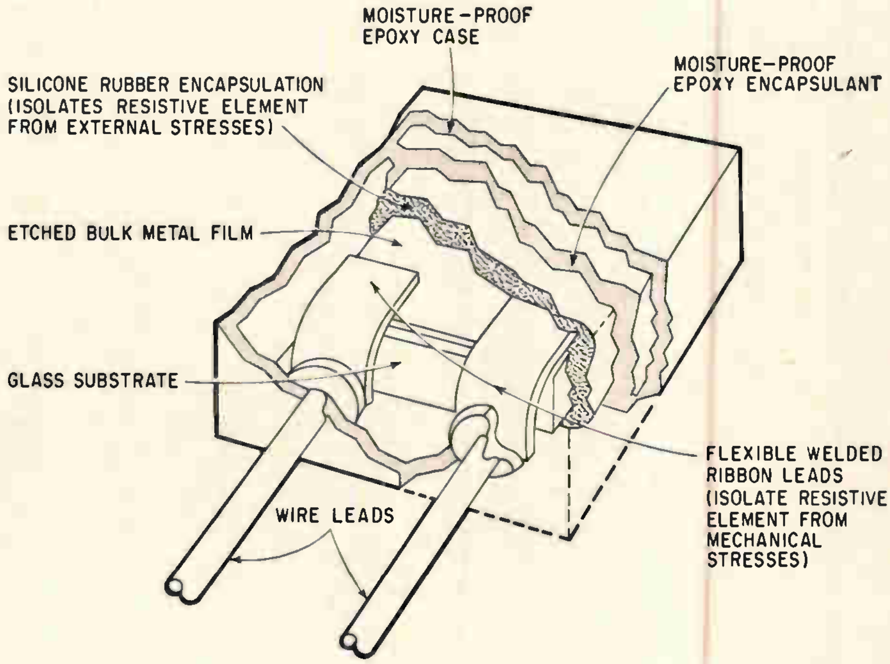
The small saturable reactors may also be used in the speed controls of small motors for tools and household appliances, as magnetic switches in silicon-controlled-rectifier trigger generators, as electrically variable inductors in swept-frequency devices and as modulators in magnetic amplifiers.

Coilcraft, Inc., Cary, Ill., 60013.
Circle 350 on reader service card



Functioning as a magnetic modulator, the reactor corrects the vertical sweep signal by mixing it with the output of the horizontal circuit.

With less stress, a more precise resistor



Resistors with values to within 0.01% and a temperature coefficient of one part in a million per degree centigrade are being manufactured by Vishay Instruments, Inc., by a process that eliminates the effect of all mechanical stresses on the resistive element. Mechanical stress, the company says, had limited the precision attainable with resistors.

Ordinarily, precision resistors are made with materials whose electrical and mechanical characteristics are strongly affected by temperature. As a current passes through the material, its temperature increases, its resistance changes and its physical dimensions change. The heat also affects the nonelectrical parts of the component such as the substrate or insulation, which in turn can affect the resistance.

For instance, if a wirewound resistor is made of wire with a positive temperature coefficient, its resistance tends to increase as it gets hot. As the wire heats up, its length increases, and its tension on the spool decreases. As the wire heats further, the spool gets hot, and expands, increasing the wire tension again. This fluctuating mechanical stress affects the electrical resistivity of the wire—and the total resistance of the component. What's more, the resistance does not vary uniformly over a specified temperature range.

Vishay's approach is to use a material of well-known electrical and mechanical properties and a structure that eliminates some of the mechanical stresses that occur during manufacture and operation, and to compensate for other stresses. The material, a nickel-chromium alloy, is of proprietary composition. Its mechanical and electrical temperature coefficients are nearly equal in magnitude but opposite in sign. The manufacturing technique protects the resistive element from mechanical stress caused by pressure, tension on the leads, or other external effects, and compensates for the mechanical stresses that occur when the resistive element heats up.

A film of the nickel-chromium alloy, 10 times thicker than conventional films, is deposited on a glass substrate in a pattern whose resistance can be adjusted to 0.01% (0.005% on special order) by cutting away part of the pattern. Flexible ribbons are welded to the resistive element and wire leads are welded to the ribbons. The assembly is encapsulated in silicone rubber and then in moisture-proof epoxy.

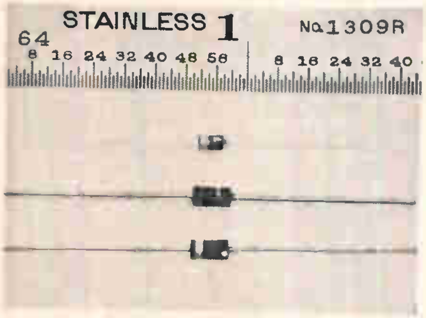
Vishay also sells resistive networks. The networks, as precise as the component resistors, have a very fast rise time (1 nanosecond or less), made possible by the negligible inductance of the resistors. (Some customers can't check the specifications because their test instruments aren't fast enough.)

Specifications

Resistance range	30 ohms to 120 kilohms, depending on style Some styles also 10 to 30 ohms, 0.1% tolerance
Styles available	6
Dimensions	Height 0.200 to 0.520 in. Length 0.295 to 1.190 in. Width 0.100 to 0.245 in. also 0.275 diameter by 0.510 in. long
Wattage	0.30 to 1.00
Tolerances	0.01% to 1.00%
Shelf stability	25 ppm (1 year)
Load life	0.030% (125° C, 2,000 hrs)
Temperature coefficient	±1 ppm (0° C to 60° C)
Noise	Nonmeasurable
Inductance, resistor	Nonmeasurable
leads	0.08 μh
Shunt capacitance	0.5 pf

Vishay Instruments, Inc., 63 Lincoln Highway, Malvern, Pa. [351]

Silicon stabistors meet military standards



Microminiature silicon stabistors of high-speed or minimum-recovery types are available for general purpose and computer applications.

The devices consist of 1, 2 or 3 passivated glass pellets mounted in a whiskerless package with a double heat sink. This construction makes for more uniformly controlled forward conductance which is desirable in clamping circuits, bias regulators, clippers, d-c coupling circuits and other circuitry demanding close tolerances on forward voltage levels.

Body sizes range from 0.075-in. diameter by 0.170-in. length to 0.050-in. diameter by 0.100-in. length. Units meet or exceed MIL-S-19500C specifications. Price in quantities of 100 are $1.25 each. Delivery can be made from stock to two weeks after receipt of order.

Micro Semiconductor Corp., 11250 Playa Court, Culver City, Calif. [352]

Miniature 6pdt relay exceeds MIL-R5757/1

A new line of Mark II 6pdt relays are 50% smaller than the company's conventional 6pdt relays with the same reliability. Weighing 2.2 oz, the units are 1 in. high and 1 in. in diameter.

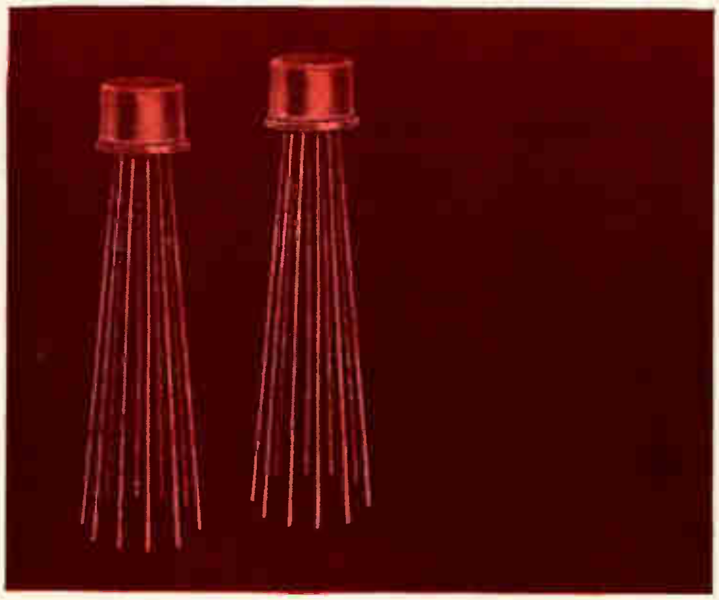
The series 300 relays provide highly dependable operation for dry-circuit (low-level) to 2-amp applications, according to the manufacturer. They incorporate the patented wedge-action contact mechanism, which results in extremely low contact resistance, large wiping action and high contact pressure that increases during overtravel. The wedge-action design has attained a dry-circuit confidence level of 90% based on a failure rate of only 0.001% per 10,000 operations.

The relays exceed all requirements of MIL-R-5757/1 and are interchangeable with most other relays. They operate over the temperature range of $-65°$ to $+125°C$ and withstand vibration of 30 g up to 3,000 hz as well as shock of 100 g for 11 msec. They are available with solder hook or plug-in terminals.

The wedge-action design in the series 300 relay employs the sole-

Is your problem summing amplifiers, differentiators, integrators, programmable supplies, inverters, unity gain amplifiers?

Here are two new NSC integrated operational amplifiers available for off-the-shelf delivery



Features: • low input currents • low differential input currents • high output current capability • low standby power • TO-5 package.

Check the specifications at the right —and then get in touch with us.

Other integrated linear amplifiers. Also available from NSC are: a versatile *audio amplifier*—with efficient operation from 1 mW to over 50 mW output . . . a two-stage, wide band *video amplifier,* with extremely constant gain characteristics . . . and a line of *integrated choppers.*

SPECIFICATIONS	NS 7560	NS 7560 A
High Open Loop Voltage Gain (Typical)	2000	5000
High Loaded Output Voltage Swing (RL equal 100 Ω)	−5 to +5 v	−5 to +5 v
Low Input Offset Voltage (Maximum)	10 mv	3 mv
Low Input Offset Voltage Temperature Coefficient (Maximum)	20 μ v/°C	10 μ v/°C
Low Input Bias Current (Maximum)	100 na	25 na
Low Differential Input Current (Maximum)	50 na	2 na
Low Input Temperature Coefficient (Max.)	2 na/°C	1 na/°C
Low Standby Power (Typical)	60 mw	60 mw

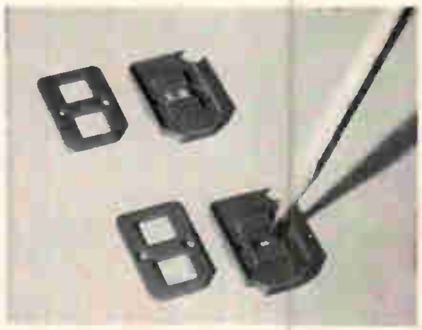
NSC

NATIONAL SEMICONDUCTOR CORPORATION, DANBURY, CONN.
(203) 744-0060

noid principle to actuate the moving contacts. Each of the fully supported movable contacts is positioned between two rigidly mounted stationary contacts. Movement of the actuator in either the energizing or de-energizing direction is translated into a wedging action of the moving contact against the fixed contact ramp. All contact surfaces are electrodeposited 24-k gold over electrodeposited fine silver.

Electro-Tec Corp., P.O. Box 667, Ormond Beach, Fla., 32075. [353]

IC carrier applies no stress on leads

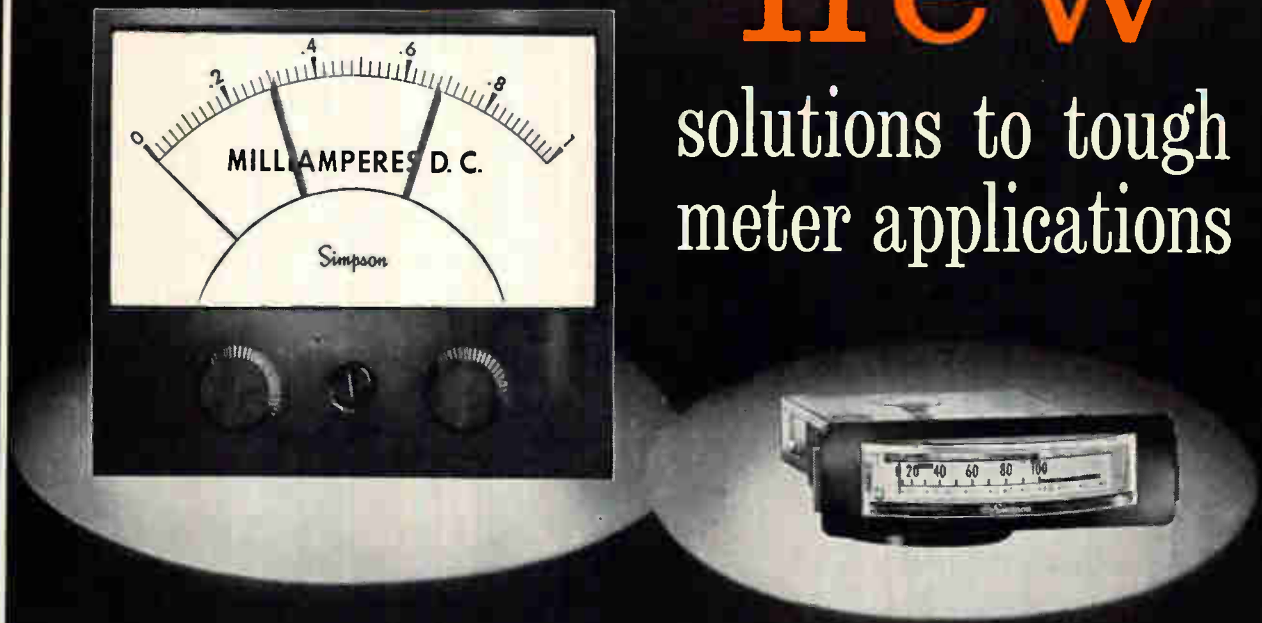


An integrated-circuit carrier securely holds flatpacks for testing and shipping without stress of any kind on the delicate leads. Called the Auto-Pak carrier, the two-piece device positions the flatpack within a boss molded into the base. A snap-in cover locks the flatpack in place. The leads, entirely accessible for electrical testing, are neither twisted around supports nor clamped as in other devices.

Made of Union Carbide's new plastic, polysulfone, the carriers have an operating temperature range of −100°C to +150°C (−148°F to +302°F). Storage temperature range is −180°C to +175°C (−292°F to +347°F). Polysulfone was selected because, in addition to excellent strength and dielectric properties, it is said to offer the highest temperature capability of available injection-moldable plastics.

The Auto-Pak carriers are produced in four designs to accept a variety of the Electronics Industries Association registered types

new
solutions to tough meter applications



Simpson
INSTRUMENTS THAT STAY ACCURATE

NEW *contactless* meter relays (4½″)

Utter reliability . . . utter simplicity. Completely fail-safe circuitry insures 100% reliability. No limitation on pointer travel due to mechanical contacts. Model 3324XA meter relays are CONTACTLESS. An infinite life lamp and solid state photo-conductors do the sensing. Solid state switching circuit and relay (10 amp, DPDT, 115VAC) are contained internally on single and double control point units. Set point accuracy rate ±1% of full scale. Available through distributors in ranges shown. For specials in 3½″ and 4x6″ models and other ranges contact factory.

RANGE	Approx. Ohms	Single Control Cat. No.	Single Control Price	Double Control Cat. No.	Double Control Price
DC Microammeters					
0-50	3000	16451	$99.00	16470	$136.35
0-100	1300	16452	96.15	16471	133.65
0-200	570	16453	96.15	16472	133.50
0-500	220	16454	96.15	16473	133.50
DC Milliammeter					
0-1	80	16455	95.10	16474	132.45
DC Millivoltmeter					
0-50	10	16460	95.40	16480	137.25

NEW miniature edgewise meters (1½″)

Takes only *half the space* of a 2½″ Edgewise meter with little sacrifice in scale length. Movement is *self-shielded*. DC accuracy is ± 2% (F.S.); AC (rectifier type), ± 3% (F.S.) at 25°, 60 cycle sine wave. Dustproof case. Meter comes complete with bezel and mounting hardware. 20 Ranges are STOCKED (see sampling below). Contact your ELECTRONIC DISTRIBUTOR about Model 1521.

RANGE	Approx. Ohms	Cat. No.	Price
DC Voltmeters 0-150	1000 o/v	10358	$15.45
DC Milliammeters 0-100	1.35	6817	15.90
DC Millivoltmeters 0-50	10	7013	16.20
DC Microammeters 0-25	3150	4552	23.40
AC Voltmeters 0-150	1000 o/v	10415	20.10

For Complete Details, Request Bulletin 2073 and Meter Relay Reprint Article.

SIMPSON ELECTRIC COMPANY

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Export Dept.: 400 W. Madison Street, Chicago, Ill. 60606 • Cable, Amergaco
In Canada: Bach-Simpson Ltd., London, Ontario
In India: Ruttonsha-Simpson Private Ltd., International House, Bombay-Agra Road, Vikhroli, Bombay

of flatpacks. They support the flatpacks through all phases of environmental and electrical testing by the manufacturer, during shipment and through incoming testing and inspection by the user. They provide indexing and orientation in every direction, and can be loaded and unloaded in automated production line equipment.

Molecular Electronics division, Westinghouse Electric Corp., Elkridge, Md. [354]

Time totalizers have lock reset

The HK200 series time totalizers are now available with a new key lock reset to prevent unauthorized count changes. Units with the key lock will be designated as model HK300.

Units in both series give an accurate and continuous record or running time as long as they are energized. A synchronous motor drives a set of digit high-visibility readout wheels, indicating the total time the unit has been energized. Six digit wheels, including a $^1/_{10}$ digit, provide a wide range of accurate measurement.

All units are said to be suitable for use with electronic equipment, computers and office machines, nuclear-control systems, and radio transmitters. They also can be used in connection with production control, maintenance programs and industrial cost analysis programs.

The Eagle Signal division, the E.W. Bliss Co., 736 Federal St., Davenport, Iowa. [355]

ETC® has them . . . already developed . . . already de-bugged

Designing and fabricating cathode ray tubes for out-of-the-ordinary requirements is a specialty at ETC. We thrive on challenges.

Each of the different tube types that make up our "standard" line was designed to answer a specific customer need. They range from small electrostatic CRT's to a twelve-gun multiple-display model, from fibre optic screens to distortionless rear windows. And they're all deliverable, saving you the expense of prototype development and de-bugging.

The same design ingenuity that turned these custom-engineered tubes into standard items can be applied to the modification of an existing tube, or the development of an entirely new one, if a stock answer doesn't fill the bill. Whatever it takes, we've got the know-how and skills to do it . . . including over three decades of experience in multi-layer phosphors, multi-gun structure, non-linear spiral bandings, hybrid deflection, shielding and potting.

Whether your needs involve data display, radar, mapping, or any other exacting application, you can be certain that an ETC tube will give you light output, deflection sensitivity and spot size criteria equaling or exceeding those available elsewhere. And you'll find our service to be prompt, efficient, courteous—no matter how simple or complex the assignment.

We can't promise you a scientific breakthrough. But we *will* provide you with the right tube for the job . . . even if we have to stretch the current art boundaries to do it. Find out why this kind of "total CRT capability" is your assurance of the greatest value in display. Write today for our latest catalog.

GENERAL ATRONICS
ELECTRONIC TUBE DIVISION
PHILADELPHIA • PENNSYLVANIA 19118

GENERAL ATRONICS®

New Semiconductors

Silicon rectifier handles high voltages

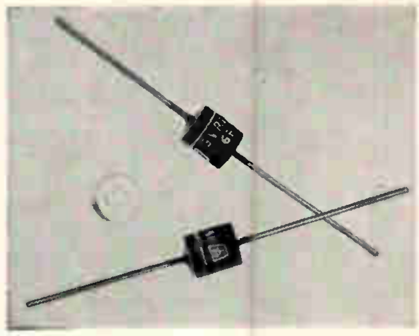
A 240-amp silicon rectifier offers improved reliability and efficiency for 1,000- to 2,400-v applications. The type 790 rectifier with compression-bonded encapsulation can withstand a one-cycle surge of 4,500 amps. It features internal contacts made by compression bonding which eliminate brazing and soldering, making the device thermal fatigue free.

The rectifiers are characterized by a high efficiency and even though they handle very high voltages, the voltage drop across them is only slightly above that expected across rectifiers of lower voltage ratings.

Reliability is improved by a rugged ceramic seal which effectively lengthens the path for any leakage current across the rectifier.

Westinghouse Semiconductor division, Westinghouse Electric Corp., Youngwood, Pa. **[361]**

Miniature zener diode encased in plastic



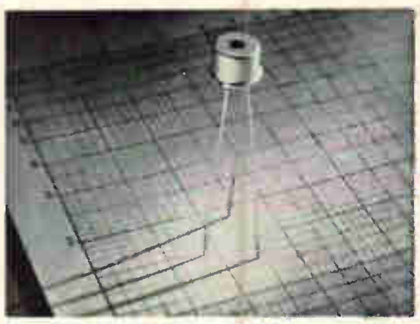
A plastic-cased zener voltage regulating diode has a dissipation rating of 3 w, rated at 25°C. The unit measures 0.375 in. in diameter and 0.425 in. in length (plus wire leads).

The manufacturer says the new diodes are available with breakdown voltages from 6 to 200, in 13 steps, with a standard voltage tolerance of 10%; 5% and 20% tolerance units are also available for all voltage ratings. Dynamic impedance of the diodes is as low as 1.0 ohm (for the 6-volt unit).

Prices are as low as $1.05 each in quantities of 1,000.

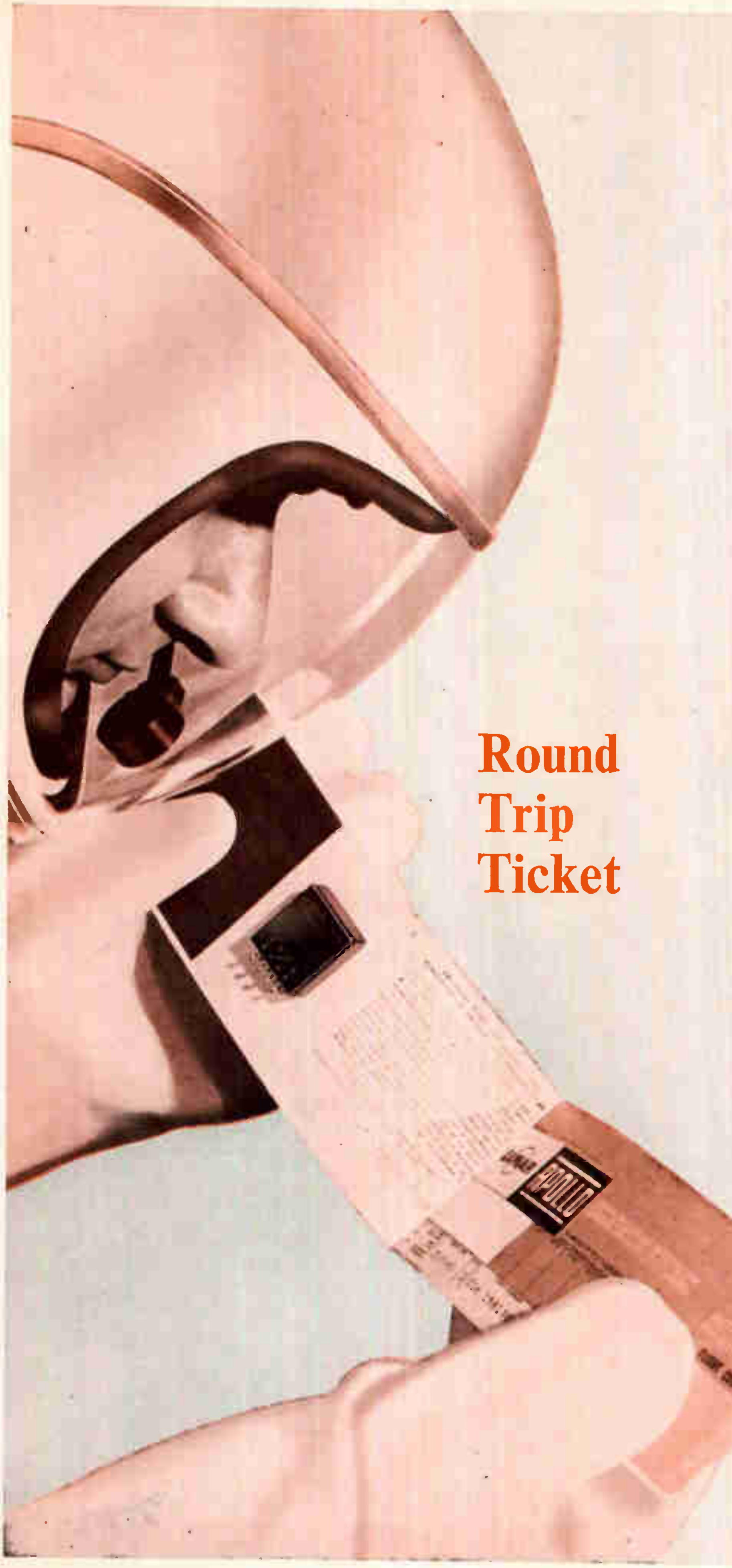
Semiconductor division of Sarkes Tarzian, Inc., 415 North College Ave., Bloomington, Ind. **[362]**

Silicon photodiode is unusually sensitive



The SGD-100 silicon photodiode is directly interchangeable with the SD-100 both mechanically and electrically; however, it offers substantial improvements in sensitivity, noise and capacitance.

The new device uses the manufacturer's special diffused guard ring construction, which features a wide spectral range of 0.35 to 1.13 microns and an unusually high response in the blue region, according to the company. Sensitivity values of 0.5 μa per μw at 0.9 micron (70% quantum efficiency) are typical. Leakage currents at 90 v bias are typically less than 0.1 μa. The SGD-100 has a rise time of 4 nsec and will operate up to 100 Mhz. Linearity of response has been demonstrated over a 7-decade range



Round Trip Ticket

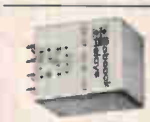
What more can we say about relay reliability. In the strange environs of space, warranty can be a pretty empty word. We like "integrity" better...a projectable promise backed by the relay industry's most comprehensive quality assurance program.

Babcock's tenure in space began with the earliest satellites under mission-critical conditions, progressed through the life-critical missions of Mercury and Gemini, and continues now with Apollo. This is not only experience and capability...this is responsibility.

To illustrate, let's look at Apollo – from the ground up.

Transistor Can, SATURN IC stage

10 amp., Crystal Can, Latching & Non-Latching SATURN II & IV B stages



10 amp., 4 PDT Latching & Non-Latching APOLLO service module

½-Size, Latching and Non-Latching, APOLLO command module

Each of these units has its own pedigree, and is produced on our own "TLC" line with Tender Loving Care. Each is the result of close customer liaison and application assistance. Each is the finest, most reliable relay of its type in the world.

Get acquainted with Babcock ...our service and the complete Babcock line of high reliability and general purpose relays. Write Babcock Relays, Division of Babcock Electronics Corp., 3501 Harbor Blvd., Costa Mesa, Calif.; (714) 540-1234.

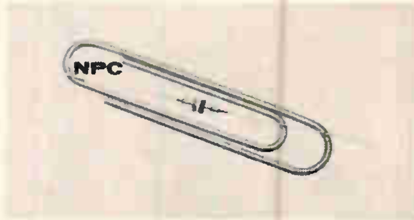
BR

New Semiconductors

of incident power levels.

Applications include detection and measurement of c-w and pulsed light sources and laser systems; star tracking and range finding systems; and optical navigation, guidance and communication systems. EG&G, Inc., 160 Brookline Ave., Boston, Mass., 02215. [363]

Germanium diodes wrapped in glass



Gold-bonded germanium diodes, for computer and switching circuit applications, are packaged in a miniature DO-7 glass case. Types available include 1N270, 1N276, 1N277, 1N281 and JAN versions.

The diodes feature high current (200 ma at 1 v forward voltage), low leakage (100 ma at 50 v), high voltage (125 piv), and low capacitance (1 pf).

Other specifications include: maximum temperature, 90°C; power dissipation, 80 mw; and peak surge current for one cycle, 0.5 amp.

Nucleonic Products Co., Inc., 3133 E. 12th St., Los Angeles, Calif. [364]

Bridge rectifier has 2-amp output

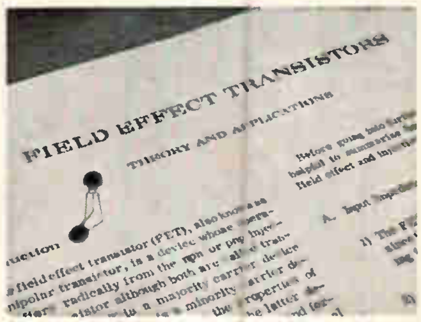
The EBR (epoxy bridge rectifier) is a 2-amp, full wave bridge designed

for rectifier applications in high-fidelity sets, phonographs, stereo amplifiers, television, radio, sound systems and many other low-current applications. Its small size reduces space requirements to a minimum. Output current is 2 amps at 25°C.

The devices are available with 200-v, 400-v, and 600-v prv ratings for 140-v, 280-v and 420-v rms operation. Peak one-cycle surge current is 100 amps maximum. A controlled avalanche series features 250-v, 450-v and 650-v minimum avalanche voltages. A noncontrolled avalanche series also is available.

All EBR devices have 2,000-v d-c minimum circuit-to-case insulation, and are available with silver leads or Faston 110 terminals. Cost is less than $1 each in quantity.
Varo Inc., 2201 Walnut St., Garland, Tex., 75041. [365]

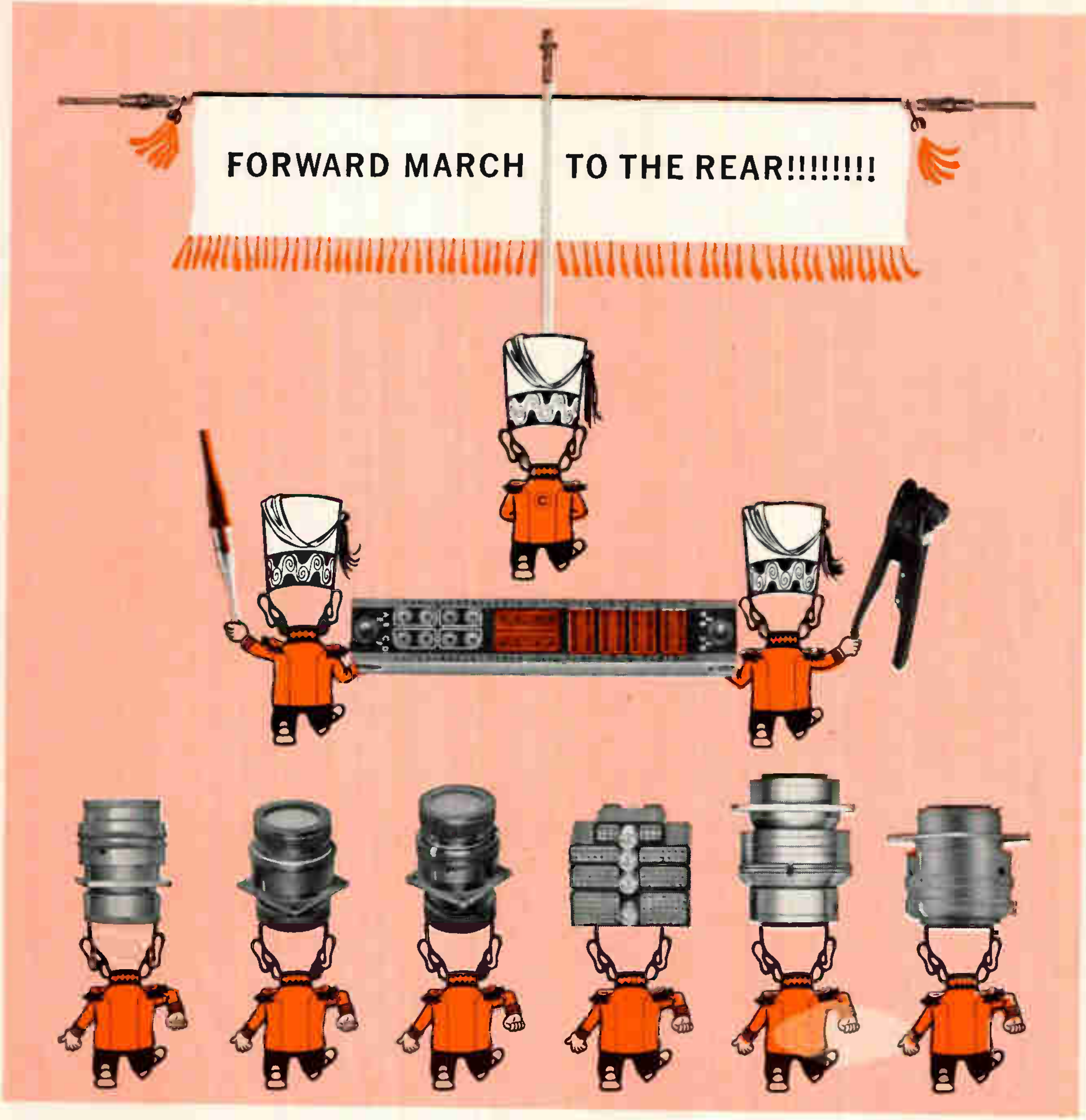
Low-cost FET's in epoxy package



Field effect transistors are now available assembled in moisture-resistant epoxy packages that, although not designed for military applications, will meet all requirements of MIL-S-19500, according to the manufacturer.

Initially three types are being offered in the new package and more will be added as interest develops. Prices range from $1.15 to $1.75 in quantities of 1,000.

Typical values for transconductance are 2,000 to 3,000 μmhos, drain-to-gate capacitance is 2 pf, and pinch-off voltage is 4 to 10 v.
Amelco Semiconductor, P.O. Box 1030, Mountain View, Calif. [366]



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Break away from the rank and file! Head for the rear release connectors using uniform standards and tooling to meet the toughest service requirements. The leader in this battalion of total performers is the Deutsch rear release contact system needing one standard crimp tool, one assembly procedure, and one fail-safe, expendable insertion/removal tool. Use this system to march away from logistics problems and simplify field maintenance and repair.

Be prepared! On land, sea, in the air or outer space, there is a squad of Deutsch rear release products to perform beyond the call of duty; environmental series for aerospace, and non-environmental versions for support equipment.

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- *Miniature cylindricals with bayonet, push-pull-quick-disconnect, or thread coupling.*
- *Subminiature cylindricals with bayonet or push-pull-quick-disconnect coupling.*
- *Subminiature, high density rectangular types.*
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ADVANCED SPECIFICATION REAR RELEASE ELECTRICAL CONNECTORS

New Instruments

Pressure transducers offered in 4 models

A line of pressure transducers has been developed to measure gage, absolute and differential pressures over a sensing range from vacuum to 20,000 psi. Complete pressure measurement and control systems as well as individual transducers are available for measuring a wide variety of corrosive or noncorrosive gases and liquids.

High reliability is achieved by the elimination of linkages, bearings and other friction producing elements. The pressure transducers measure directly the movement of a Bourdon tube tip or a diaphragm by means of a linear variable differential transformer.

Basically the line is composed of four models. The PT-1 covers the range of 0 to 10 in. of water to 0 to 400 in. of water. It is a general-purpose, industrial transducer to measure gage or differential pressures (absolute reference on special order) of noncorrosive liquids and gases.

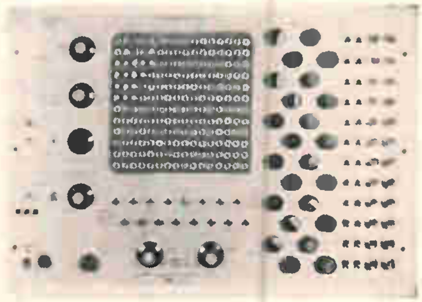
The PT-2 extends the pressure range from 0 to 15 psi to 0 to 500 psi. When used with special O-rings, the PT-2 meets the requirements for many corrosive liquid and gas applications for gage, differential, or absolute measurements.

The PT-3 is for low-range measurements (0 to 10 in. of water to 0-400 in. of water). Its primary application is for measuring small variations either above or below atmospheric datum. The PT-4 is a heavy-duty, industrial class gage in a range of units from 0 to 25 psi to 0 to 10,000 psi.

The pressure transducers are suitable for a wide variety of measurements for missile and aircraft applications, for process industry measurements, for oil and gas processes and transmission and for utility requirements. Prices begin at $90. Delivery is from stock.

Schaevitz Engineering, U.S. Route 130 & Schaevitz Blvd., Pennsauken, N.J. [371]

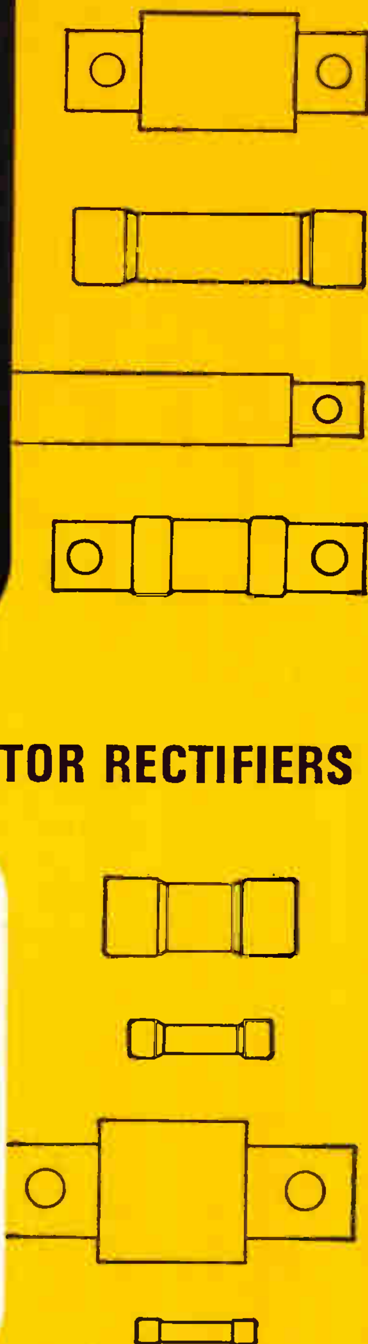
Pulse generator has 12 parallel outputs



The SQ-260 is a multiple-pulse generator that operates at stepping rates from 10 Mhz to 1 khz and has 12 parallel output channels. Programing is accomplished by inserting diode pins into a program matrix board that has 12 channels and 16 steps in each channel. The 16 time steps constitute a single pass through the program and the program may be repeated a given number of times under the control of a variable delay prior to being initiated again. The number of program repeats depends on the program, the stepping rate and the duration of the variable delay. The cycle may be started again either by an external control pulse or by a built-in slow (1 Mhz to 10 hz) cycle initiate clock.

Step and pair repeats are controlled by toggle switches associated with each time step and two variable analog delays with a range from 1 μsec to 100 msec. An "endless" position on the step repeat switch allows for a very long step or pair repeat period under control of the operator. When the switch is manually moved, the next time step is generated.

Each channel output will contain a variable delay in step starting



FOR THE PROTECTION OF SEMI-CONDUCTOR RECTIFIERS

LIMITRON Fast-Acting fuses provide extremely fast opening on overload and fault currents, with a high degree of restriction of the let-thru current.

If each SCR and individual diode is protected by a proper size Limitron fuse, the fuse will open to protect the unit when the current drawn exceeds the rating of the unit. Thus the SCR or individual diode is taken out of the circuit before damage can be done to other diodes in the rectifier.

LIMITRON fuses are available in a wide range of ampere sizes in voltages up to 600.

For full information and opening time charts ask for BUSS Bulletin HLS.

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

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for every protection need, *insist on*

BUSS QUALITY

Circle 187 on reader service card

time and a variable duration of the pulse level output. The output amplitude may be varied from 0 to +7 v and 0 to −7 v under open conditions. The output stages may be run at very high duty cycles (100%) and perfectly match a 51-ohm line in both the on and off condition. Plus and minus outputs are simultaneously available.

The pulse generator is well suited for acting as the clock and controller for any system that requires sequencing, such as memory testers. It is also said to be ideal for testing for hazards in logic networks and effects of irregular duty cycles. Price is $5,600; delivery, 30 days after receipt of order.

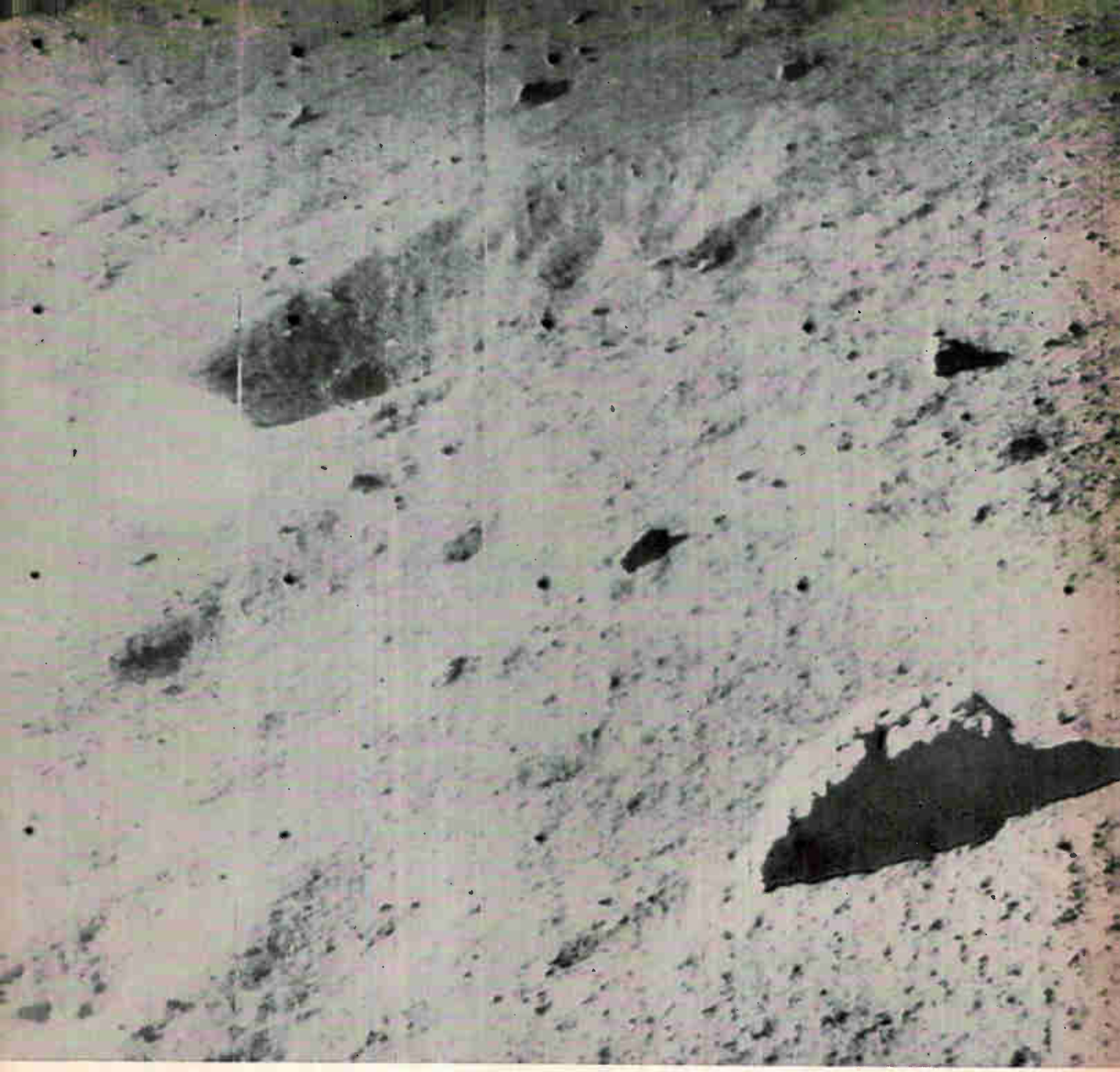
Adar Associates Inc., P.O. Box 27, Lincoln, Mass. [372]

Oscillograph combines versatility, economy

A direct-recording, light-beam oscillograph, model 801, is a general-purpose, industrial-laboratory type of recorder. It costs up to $705 less than comparable competitive models without compromising instrument performance, according to the manufacturer.

The model has the modular design features of other instruments in the company's line and the instrument's configuration can be changed in the field by adding optional accessories. Standard replacements and adjustments can be made on the spot.

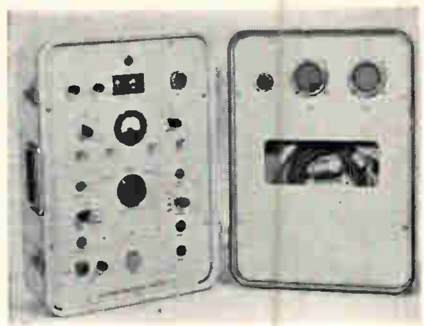
Principal features of the 801 include: 8-inch chart width; 200-foot record; 8, 14, 18, 25 or 36 active data recording channels; 10 speeds selected by push button and two push-button range multipliers; mercury arc or xenon lamp illumina-



tion, and galvanometer response from d-c to 15 khz. Optional features include electronic flash timing, margin trace numbering, and rear-mounted individual galvanometer inputs.

The instrument may be ordered in bench or rack mount.
Midwestern Instruments, Inc., 41st and Sheridan Rd., Tulsa, Okla. [373]

Portable cable-tester designed for field use



A hand-carried, automatic cable tester emphasizes field testing to NASA specifications. Model QC275 has capability of testing for continuity resistance and leakage resistance over a range of conditions. Resistance testing is performed with simulated load currents from 40 ma to 1 amp.

Leakage resistance is measurable to 5,000 megohms with go, no-go settings at 50, 100, 150 and 200 megohms at 500-v d-c test voltage. In automatic mode the instrument sequences and stops on faults. A numerical readout displays the circuit under test and a direct-reading panel meter indicates the measured values.

The instrument has a total capacity of 75 circuits with adjustable dwell time from 0.5 to 15 sec. Two decade switches permit autostop for cables with any lesser number of conductors.

Designed for field use, the molded fiberglass case houses mating connectors and the 115-v a-c power cord. High reliability is achieved by use of preferred components per MIL-STD-242 and hermetically sealed relays per MIL-R-5757 and MIL-R-6106. The in-

In less time than it takes to read this page, you could learn to use this new Universal Impedance Bridge.

Ready? One, two, three, go.

2. Adjust the range switch for an on-scale reading.

3. Obtain a null with the CRL dial. Now, read your measurement.

1. Select the function you want.

Nothing to it. No interacting controls to adjust and readjust. No multipliers. No non-linear dials. AUTO-BALANCE eliminates all that.

This new Hewlett-Packard Bridge is the first one that takes human beings into account as well as impedance. It's made for engineers who don't have time for a half-hour refresher course every time they want to use it.

You get direct digital readout of all C, R, and L values. Indicator lights show up-scale or down-scale unbalance. Decimal point and an equivalent circuit are automatically indicated. No problem with false or sliding nulls either: unique electronic AUTO-BALANCE takes care of that.

For a D or Q measurement, just switch from AUTO to low or high D or Q and turn the DQ control until you obtain another null. Simple. Particularly for low Q and high D cases.

So if you're the kind of engineer who's tired of complicated impedance bridges, Hewlett-Packard has your number: Model 4620A. $550.

Ask your Hewlett-Packard field engineer for a demonstration. Or write us for complete specs: Palo Alto, California 94304. Tel. (415) 326-7000. Europe: 54 Route des Acacias, Geneva.

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

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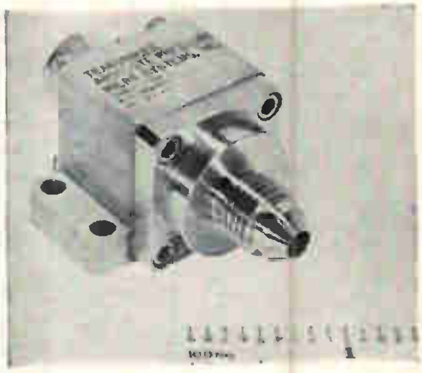
An extra measure of quality.

1844

strument conforms to NASA wiring specifications NPC-200-4. Price is $12,040.

Automation Dynamics Corp., Industrial Parkway, Northvale, N.J., 07647. **[374]**

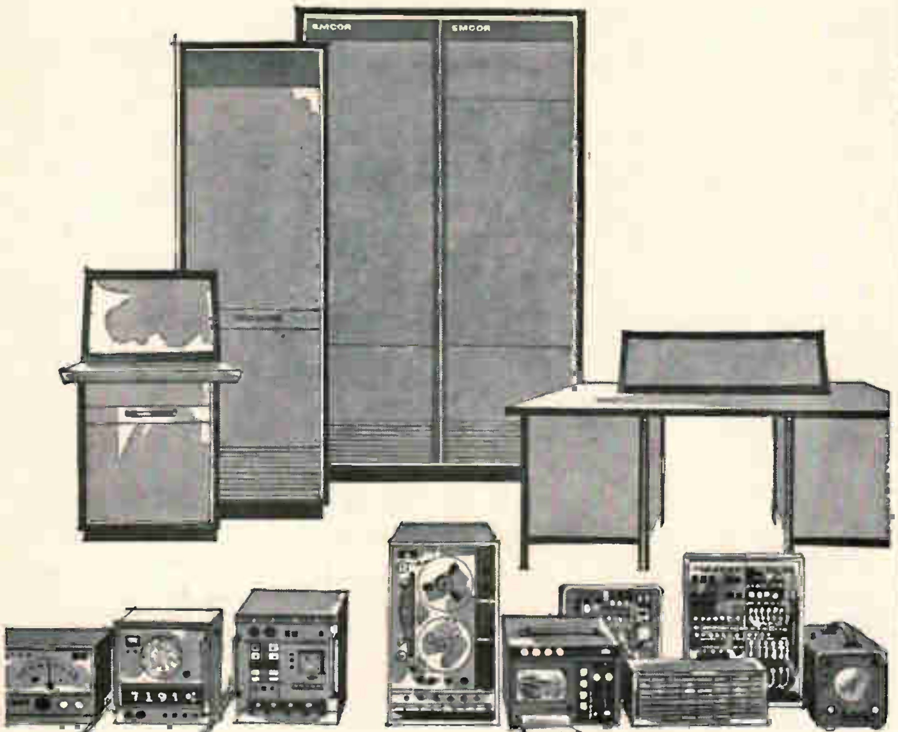
Pressure transducer for aerospace jobs



A transducer has been developed to measure low pressures and deliver high unamplified output under conditions of extreme vibration and acceleration. The 3-oz unit, offered in pressure ranges as low as 0 to 2 psia is expected to have widespread missile and aerospace applications where information on pressure profile and altitude measurements is required. These applications include compartment pressurization and evacuation and attitude compensation systems.

Model 1028 transducer utilizes four semiconductor strain gages bonded to a miniature cantilever beam which is driven by a push rod welded to a thin, stretched, pressure-sensing diaphragm. This system results in a high natural frequency (no less than 4,000 hz in the 2 psi range), fast response (1 msec maximum to achieve 63% rise time) and 0.02% full scale/g maximum vibration and acceleration sensitivity.

The transducer operates at temperatures from —65°F to +300°F in deep space vacuum conditions and is temperature compensated from 0 to 250°F. It has performed successfully under accelerations up to 1,000 g. With up to 30-v d-c excitation, the unit produces a minimum output of 300 mv with a combined accuracy (non-



linearity, hysteresis and nonrepeatability) of ±0.5% full scale.
Micro-Systems, Inc., 255 N. Halstead St., Pasadena, Calif., 91107. **[375]**

Memory voltmeter includes recorder

A memory voltmeter has been designed to provide a wide range of measurements and operating modes. Model 5201BR voltmeter is combined with a strip chart recorder into one integral unit. It measures and records the peak voltage of a single or repetitive pulse, and displays this reading indefinitely on the front panel meter until the voltmeter is reset.

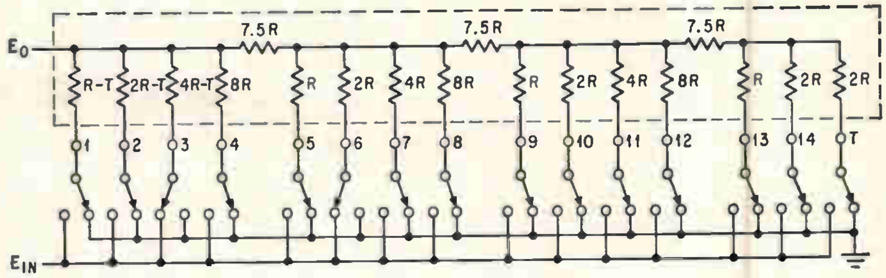
The voltmeter features a provision for resetting between readings with the reset interval adjustable from 10 msec to 5 sec after the input signal ceases. This feature allows a recorder with very low-frequency response to record amplitude peaks as fast as 50 nsec, and, in effect, transforms the strip chart recorder into a wideband instrument.

Other features include a 50-nsec acquisition time; automatic reset that permits use as a peak-reading voltmeter to 50 Mhz; no dead time or loss of transients, even during reset; input impedance to 10 megohms; and a-c or d-c coupling.

Voltage range of the model 5201BR is from 0 to 1,000 v (expandable to 30 kv with optional probes) in six steps. The voltmeter may be used to read peak positive, peak negative, or maximum peak of positive and negative.

Priced at $995, the model 5201BR can be delivered within 30 days from receipt of order.
The Micro Instrument Co., 13100 Crenshaw Blvd., Gardena, Calif. **[376]**

Ladder networks decode accurately



Precision film-resistor ladder networks that can serve as decoding and summing networks in analog-to-digital and digital-to-analog conversion systems are available in compact standard packages. Custom produced, the networks measure 1½ x 1 x 3/16 in. Packages shrunk to half the size—with the same number of components but with lower rating—will be made in the near future.

The standard package, manufactured by Angstrohm Precision, Inc., contains up to 28 film resistors (14 bits) molded by vacuum transfer, into high-density epoxy. The ladder network can have up to 28 leads; 14 on each side of the package made of 22-gauge, 0.025-in. gold-plated Dumet material. Gold plating permits soldering and the Dumet allows welding.

From four to 14 output bits on each ladder plus additional resistive components in any desired circuit configuration are available, provided there are no more than 28 resistors in any one standard package. Two basic ladder configurations can be supplied, the basic LN (ladder network) and the HLN (hybrid ladder network). A hybrid ladder network is shown with switches connected externally to the package. If less than 28 resistors are needed in a package (under 14 bits), then the size of the package can be reduced.

Resistor values, R, vary with the supplied input voltage to the network. The bit rise time is less than 20 nanoseconds when R varies from 500 ohms to 50 kilohms.

The cost of ladder modules differs with the customer's requirements—the greater the required output accuracy, the greater the temperature range, and the more complex the circuit, the higher the price. Typical specifications are listed below.

A package can be cut in half, and if a double decker is desired, folded in two, each half containing seven bits.

The size of future precision ladder networks containing 28 resistors will be cut to ¾ x 1 x 3/16 in. Components will be smaller; voltage ratings from 0 to 50 volts, and resistances to 50 kilohms. The price will be 10% to 15% above the present units.

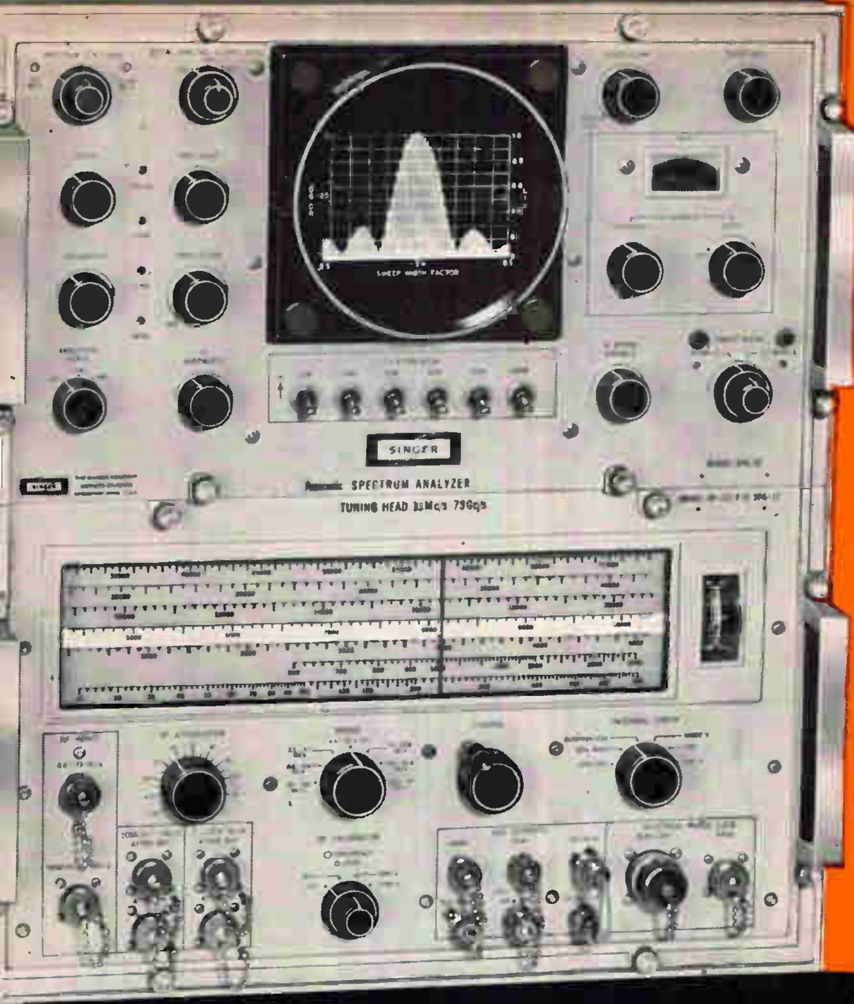
Specifications

Excitation voltage	7.5 to 75 v
Power	0.100 watt/resistor at 125°C
Output ratio accuracy	± 0.01%
Temperature stability	± ppm/°C
Package configuration	LN, HLN
Temperature range	−55° to +175°C
Price	$13 to $82 a unit; depending upon accuracy, temperature span and circuit complexity
Delivery	3 weeks

Angstrohm Precision, Inc., 7811 Lemona Ave., Van Nuys, Calif. [381]

Operational amplifier in a tiny package

Model A505 operational amplifier performs such functions as inversion, summation, integration, dif-



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10 Mc to 43 Gc — includes most of SPA-12 features, with somewhat less sensitivity. Lower priced.

Model SPA-12 features:

☐ 10 Mc to 73 Gc range, all in one compact tuning unit. All mixers built in. ☐ Band scale in use is illuminated on new easy-to-read electro-luminescent frequency calibrations. ☐ Wide dispersion range to 80 Mc (100 Mc optional) plus a stabilized narrow band 0-5 Mc sweep width range. ☐ Low internal residual FM means exceptional usable resolution: 1 kc resolution from 10 Mc to 10.3 Gc without the optional phase lock addition. ☐ Carefully shielded to minimize radiated and conducted RFI. ☐ CW sensitivity at least −105 dbm at 5 Gc; −100 dbm at 10 Gc; −90 dbm at 20 Gc; −60 dbm at 40 Gc.

☐ 3 Level Scales: linear, 40 db log, and power; all directly-calibrated on CRT graticule. ☐ Bright, well-focused readouts. Intensifier control brightens fast pulsed displays. ☐ Standard SPA-12 includes crystal-controlled RF frequency markers, marker modulation input, 160 Mc I-F input-output terminals, and an adjustable smoothing filter for noise analysis. ☐ Guaranteed reliability: MIL-Q-9858A QC includes 100% checkout of all performance specifications. Each SPA-12 is vibrated and drop-tested. Fully proven in environmental type tests. ☐ **Write for 16-page Microwave Spectrum Analyzer Handbook.**

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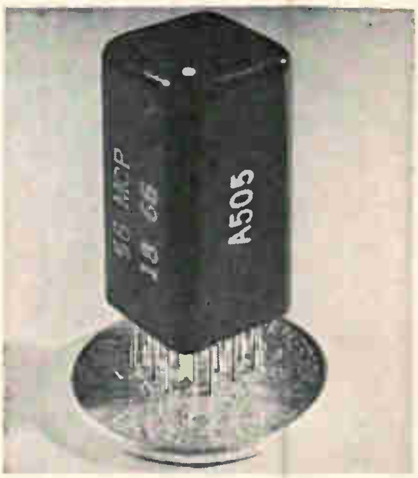


ferentiation or a combination of these. The hybrid solid state silicon amplifier has a long-term drift of 100 μv or less for 60 days. The high open loop voltage gain is typically 1,000,000 or 120 db. The operating temperature range is $-55°C$ to 125°C.

The differential d-c amplifier has a $\pm$10-v input range, and a typical unity gain bandwidth of 1 Mhz without external compensation. The output is $\pm$10 v at 5 ma with protection against short circuit. Stability is maintained, regardless of the closed-loop d-c gain needed for a system application, because the open loop gain-bandwidth curve never exceeds a slope greater than -6 db per octave.

The microelectronic amplifier is packaged in the welded hermetically sealed 0.12-oz, 0.12-cu-in. MicroCircuit Pack. The high-density MCP contains 12 transistors, including a matched pair; four diodes; two capacitors and 23 resistors, including one pair that tracks to within 20 ppm°C.

Price is $95 for small quantities. Availability is stock to 30 days.
Hamilton Standard division of United Aircraft Corp., Broad Brook, Conn., 06016. [382]

Differential-input operational amplifier

Model 115C is a 20-ma output current, differential-input operational amplifier in a miniature module package. The high driving power

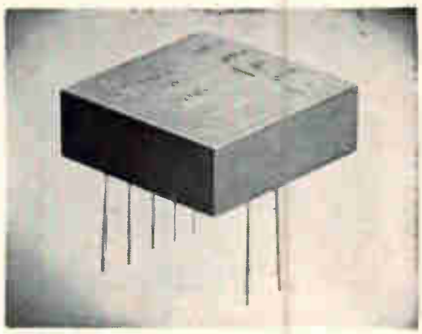
Within this temperature range Indiana General TC-7 has the most linear temperature coefficient of inductance of any standard ferrite material available. It also has the highest "Q", lowest loss, and the greatest stability over a long period of time. TC-7 is the perfect material for use in filters, oscillators, and tuned circuits using fixed or adjustable inductors and transformers at frequencies ranging from audio through the high frequency range (500 KC).

TC-7 is not just another laboratory ferrite. It is available in sample quantity orders and production runs in a wide range of cup core sizes including the International Series. TC-7 cup cores are also available with complete trimmer assemblies, bobbins, and bracket assemblies.

If you'd like sample cores to test yourself, or technical bulletins listing standard core sizes and assemblies, write Mr. Ken Talbot, Manager of Sales, Indiana General Corporation, Electronics Division/Ferrites, Keasbey, New Jersey.

INDIANA GENERAL

You can tempt it from −40°c to +60°c but our TC-7 ferrite won't stray from the straight and narrow

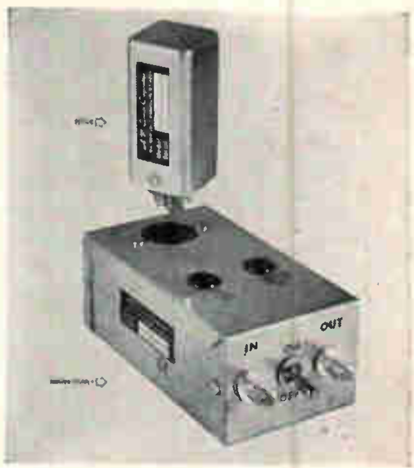


reduces varying load problems and can eliminate a buffer stage, saving space.

Output voltage is ±10 v at 20 ma; d-c gain, 10^4; slew rate, 6 v/μsec; voltage drift, 4 ma/°C. The package of model 115C is 1.125 in. x 1.125 in. x 0.625 in. of moisture-resistant molded epoxy. It is also available in a 0.4-in.-high flat package. P-c card type pins fit standard 0.1-in. hole spacing.

Price is $70 in quantities from one to nine; available immediately. Zeltex, Inc., 1000 Chalomar Rd., Concord, Calif. [383]

Active notch filter for wide range of uses



Model APN60 is a 60-hz active notch filter designed for applications in such diversified areas as medical electronics, controls, telemetry and analog computers. The unit is fully transistorized and enclosed in an aluminum can measuring 1¼ x 1¼ x 3 in., with a standard octal base.

Comparable frequency response curves of several passive filters

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We don't know what *your* recollection of Diehl's delivery is. But with small motors in short supply we think you'll want to hear about delivery from the *new* Diehl. We are now supplying motors much faster than the industry average. Some of our current accounts tell us we move *three to four times faster* than other well known motor suppliers. Diehl has been building motors since 1888. But now we're building them faster! Try us again, East Coast or West, at the numbers below. THE SINGER COMPANY, Diehl Division, *East:* Finderne Plant, Somerville, N. J. 08876 (201) 725-2200; *West:* LA Plant, 2221 Barry Ave., Los Angeles, Cal. 90064 (213) 478-0896. Also, representatives in all major cities.

Cidcle 423 on reader service card

Audio Amplifier? AC Power Supply?

the Compact NA Series gives you both!

The NA Series of AC Power Supplies are exceptionally flexible sources of audio power. Each power supply consists of a Regulated Audio Power Amplifier with interchangeable fixed or variable Plug-In Oscillators for a wide range of precision AC power applications. The Amplifier has a full power range of 45-6,000 cycles. With the incorporation of a CML Plug-In Oscillator precise fixed or adjustable output frequencies are available anywhere within this range. For complete information, write today.

CML, Inc.
A subsidiary of Tenney Engineering, Inc.
350 Leland Avenue · Plainfield, New Jersey
(201) 754-5502 · TWX: 201-756-2064

60

Circle 424 on reader service card

MODEL	6 db BANDWIDTH
TL-2D5A	2 kc
TL-4D8A	4 kc
TL-6D11A	6 kc
TL-8D14A	8 kc
TL-10D16A	10 kc
TL-16D25A	16 kc
TL-20D32A	20 kc
TL-30D45A	30 kc
TL-40D55A	40 kc
TL-45D65A	45 kc
TL-32E48C	32 kc
TL-50D75C	50 kc

Clevite Ceramic Ladder Filters 80 db rejection in 0.1 cu. in.

- **50% lower insertion loss**
- **Increased skirt selectivity**
- **Less insertion loss change with temperature**

Clevite ceramic ladder filters provide more selectivity for their size than any conventional i-f filter. They are fixed tuned and need no alignment—are non-magnetic and non-microphonic. Leading manufacturers now specify Clevite ladder filters for their modern communications equipment. Improve your newest design with these unique filters. Write now for complete specifications—Bulletin 94017 or request selectivity curves for each stock model. ■ Dimensions: 5-1/6″ diameter x 1-1/2″ long ■ Selectivity: 60 db/6db shape factor from 1.4:1 to 2.5:1 ■ Center Frequency Stability: within 0.2% for 5 years, and within 0.2% from −40°C to +85°C ■ Impedance: 1200-2500 ohms ■ Designed for military and space environment. ■ Clevite Corp., Piezoelectric Division, 232 Forbes Road, Bedford, Ohio 44014.

See it at WESCON—Booth 420

CLEVITE

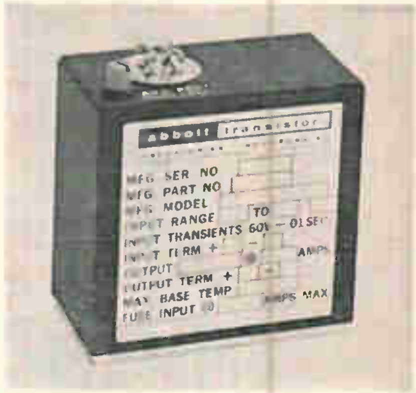
Circle 201 on reader service card

show that only the APN60 eliminates 60 hz without signal distortion, according to the manufacturer. The rejection bandwidth of this filter can be narrowed to 2 hz without a phase shift in the passband.

Other features are a very low d-c drain and an easily variable Q. Price for single quantities is $155; power supply including batteries, $58.

A.P. Circuit Corp., 865 West End Ave., New York, N.Y., 10025. [384]

D-c/d-c converter's design is modular



Model BO5D d-c to d-c converter can sustain full load operation at 100°C. It converts 28 v d-c to any required output voltage from 5 to 1,040 v d-c at 5 watts. Latest modular design techniques are used to provide a small-size package 1½ x 2¾ x 2¾ in. which weighs less than 0.9 lb.

Hermetic sealing and full encapsulation enables the unit to meet the environment of MIL-E-5272C at 100°C. These converters are especially designed for use in today's airborne and missile applications where small size and minimum weight are prime considerations. All semiconductor devices are silicon.

Units feature complete isolation of inputs and outputs and an output voltage adjustment range of 12% from the nominal output voltage. Regulation is 0.2% for input variations of 24 to 30 v d-c. In addition, the converters are protected against short-circuit conditions, in-

put voltage transients and reverse polarity damage.

Price is as low as $355; delivery, 4 to 6 weeks.

Abbott Transistor Laboratories, Inc., 3055 Buckingham Road, Los Angeles, Calif., 90016. [385]

Laboratory amplifier covers wide band

A low-pass, solid state laboratory amplifier, model 4375, features a bandwidth of 100 khz to 225 Mhz and an output of 15 v peak to peak across 75 ohms. Gain is selectable at 20, 40 or 60 db with an additional 6-db continuous adjustment.

Input and output are 75 ohms. However, the unit can be operated at 50 ohms with internal matching transformers. Noise is low with 30 μv equivalent input noise.

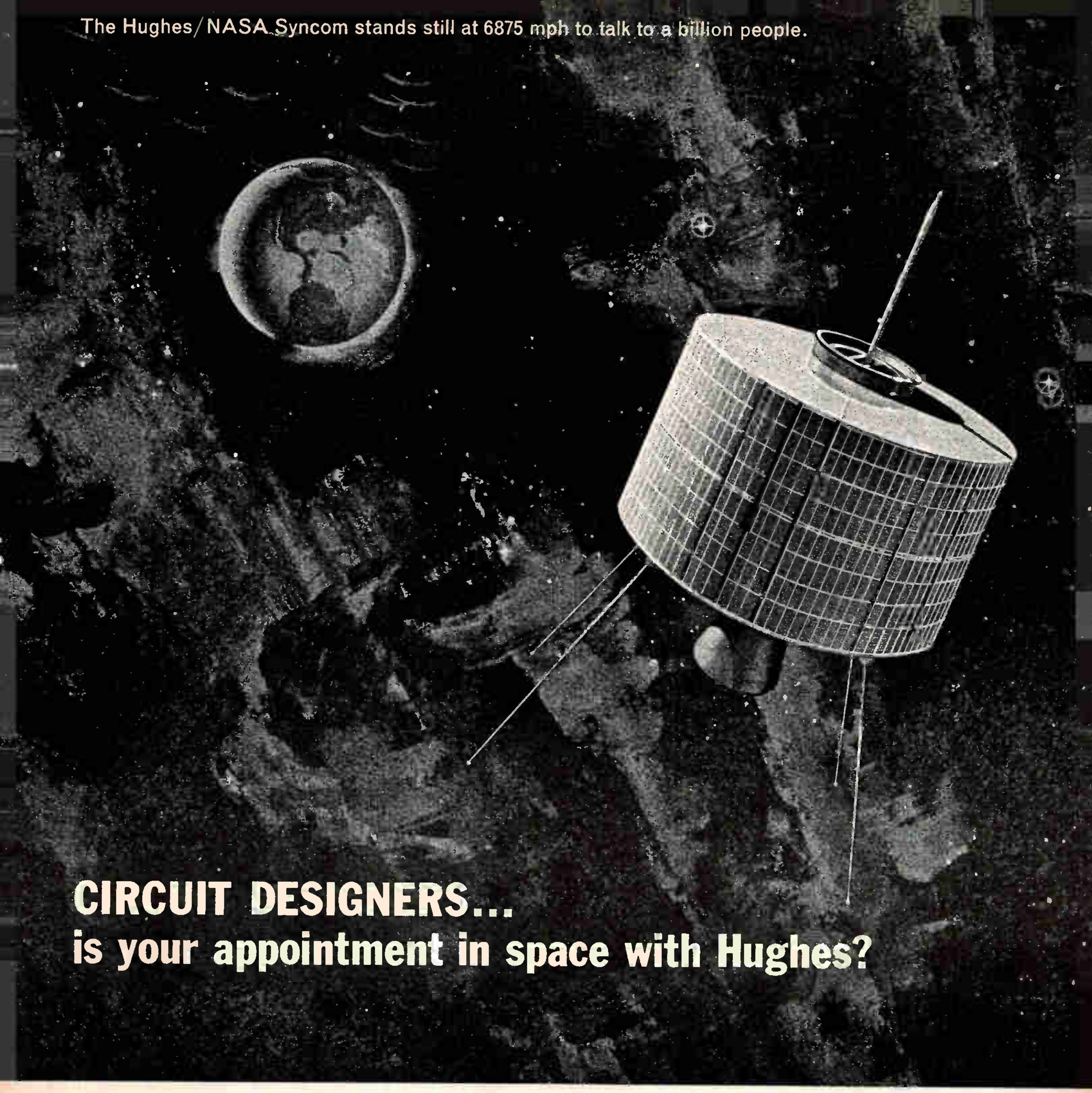
C-Cor Electronics, Inc., 60 Decibel Road, State College, Pa. [386]

Switching regulators come in 70 models

A line of d-c to d-c switching regulators is designed to meet the increasing need of high-efficiency, regulated power supplies for integrated-circuit applications. Designated the C-95 and CA-95 series, the regulators provide zero-up voltages from 10 to 250 v d-c, with power capabilities from 15 to 1,500 w. More than 70 standard models are available, permitting great flexibility in systems power designs.

Special packaging can be provided, in addition to many other options. One unit, for example, that was built to special shape and volume requirements, delivers 5 v d-c at 4 amps. Overvoltage protection is built in; efficiency is 65%.

Technipower, Inc., 18 Marshall St., Norwalk, Conn., 06856. [387]



Today, Hughes is one of the nation's most active aerospace/electronics firms: Projects include: F-111B PHOENIX Guided Missile System, TOW Anti-Tank Missile, SURVEYOR Lunar Spacecraft, SYNCOM, POLARIS, VATE, Hard Point Defense and others.

This vigor will assist the qualified engineers and scientists towards more and better opportunities for both professional and personal growth.

Many immediate openings exist. The engineers selected for these positions will be assigned to the following design tasks: the development of high power airborne radar transmitters, the design of which involves use of the most advanced components; the design of low noise radar receivers using parametric amplifiers; solid state masers and other advanced microwave components; radar data processing circuit design, including range and speed trackers, crystal filter circuitry and a variety of display circuits; high efficiency power supplies for airborne and space electronic systems; telemetering and command circuits for space vehicles, timing, control and display circuits for the Hughes COLIDAR (Coherent Light Detection and Ranging).

If you are interested and believe that you can contribute, make your appointment today.

For immediate consideration, please airmail your resume to:

Mr. Robert A. Martin
Head of Employment
Hughes Aerospace Divisions
11940 W. Jefferson Blvd.
Culver City 45, California

Creating a new world with electronics

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HUGHES AIRCRAFT COMPANY
AEROSPACE DIVISIONS
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New Microwave

Attenuator extends power meters, ranges

Model 20 is a d-c to 12.4 Ghz precision attenuator with a 5-watt average, 2-kw peak power rating. The units can extend the ranges of power meters and similar instruments. The attenuators also can be used in the calibration of directional couplers and antenna characteristics and in the simulation of path losses. They have a small insertion length (2.85 in.) and are lightweight (2 oz).

The resistive film on the attenuating card provides long-term stability, the ability to withstand temporary overloads of either c-w or pulse power damage and a low temperature coefficient of attenuation.

The model 20 has an anodized aluminum body and semiprecision stainless steel type N male and female connectors; other connector configurations can be ordered.

Calibration data is marked on the permanently affixed nameplate. The attenuator is color coded in accordance with the RETMA color coding table. Model 20's cost $60 each.

Weinschel Engineering, Gaithersburg, Md. **[391]**

Precision waveguide dial attenuator

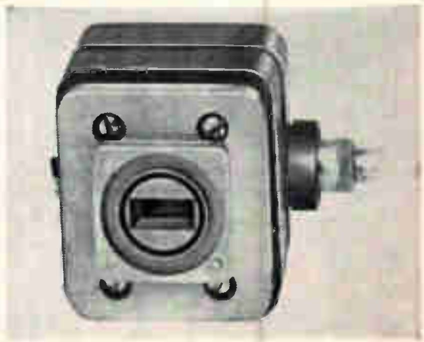
Type 196-DS10 is a precision waveguide attenuator designed to give highly accurate and stable control of attenuation, coupled with the ease of a single knob adjustment. The attenuating element, a Fotoceram plate, gives greater shock resistance. Insertion loss into the waveguide is varied by a precision screw-nut combination.

Attenuation range is 70 db over a frequency range of 8.5 to 9.6 Ghz, waveguide size 1 x 1/2 in., waveguide type RG-52/U, waveguide flange UG-39/U.

On special order, the 196-DS10 can be calibrated at any frequency in the band, or be provided with a variety of flanges, or designed for panel mounting.

PRD Electronics, Inc., a subsidiary of Harris-Intertype Corp., 1200 Prospect Ave., Westbury, N.Y., 11590. **[392]**

Beacon magnetron operates in Ku-band



A positively pulsed, 1-kw, Ku-band beacon magnetron has been developed. The MA-260 is a rugged, compact unit designed to tune over the 16 to 16.5 Ghz range with a 0.5-μsec pulse width and a 0.001 duty ratio. Peak anode voltage is 3 kv and peak anode current is 1.6 amps.

Input connections are made through flexible leads or solder lugs, and the output connector mates with a UG-541/U choke flange.

The MA-260 maintains the same basic positive-pulse design as the company's previous magnetrons now being used in beacon and navigation systems, lightweight radar systems, missile ground support equipment, transponders, and airborne radar. Better spectrum

performance and improved reliability are achieved with this magnetron design, according to the manufacturer.
Microwave Associates, Inc., Burlington, Mass. [393]

Directional coupler is flat and low priced

A series of extremely flat, highly directional and physically compact coaxial couplers is said by the manufacturers to be priced below units with inferior specifications. It is designed to provide maximally flat coupling over full octave frequency ranges; and frequency variation is only 0.2 db per octave. Directivity is 25 db minimum. The unit measures as small as 4 x 5.6 in. and is potted to withstand shock, vibration and temperature extremes.

Designated series CC, the 3-terminal devices are available with 10, 20 and 30 db coupling values. All are calibrated at five frequencies, which are clearly marked on the nameplates. Priced at $180 and $190, depending on bands, they are available on six weeks delivery.
Microlab/FXR, Livingston, N.J. [394]

Manually operated r-f coaxial switch

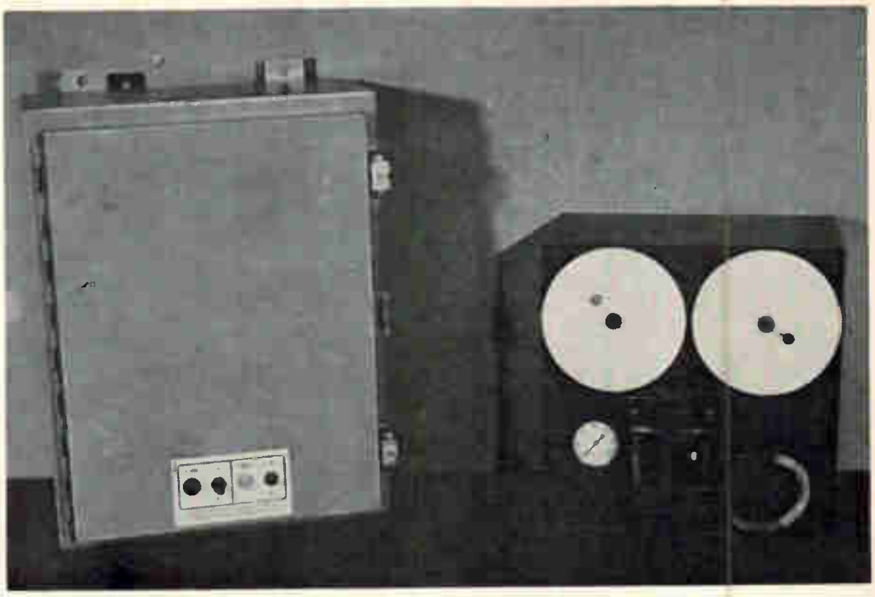
An r-f coaxial switch, model SW-20, is a two-pole, two-throw manually operated device covering the frequency range of d-c to 2 Ghz. Use of a coaxial switch permits time savings both on the production line and in quality control test positions, eliminating the changing of cable connections.

The characteristic impedance is 50 ohms; insertion loss is 0.05 db at 1 Ghz and 0.1 db at 2 Ghz; vswr is held to less than 1:1, and isolation is greater than 80 db at 1 Ghz.

Two or more switches can be stacked to add additional r-f poles and d-c wafer switches can be added as an option so that d-c and low-frequency circuits can be switched simultaneously.

Price of the SW-20 is $55. Delivery is from stock.
Texscan Corp., 51 South Koweba Lane, Indianapolis, Ind. [395]

Etchant times etching machine



Etching of printed circuits moves a step closer to full automation with a control that adjusts etching time while circuit boards or flexible printed circuits run through the etching machine. The control continuously monitors the strength of the etching solution and adjusts the time that the boards are exposed to the etchant.

Etchants become depleted as copper removed from the board goes into the etching solution. As depletion increases, the etching time must be lengthened. Normally, the degree of depletion is monitored by observing the condition of the boards being etched or by etching sample boards.

Chemcut Corp.'s automatic control diverts some of the etching solution into a small sampling chamber where it etches a test tape of copper foil laminated to Mylar plastic. The time it takes the etchant to eat through a segment of the foil is fed to a control box. The control adjusts the d-c voltage for the variable-speed motor that drives the conveyor carrying the boards through the etching machine.

Etch-through of the tape is detected by passing a test current through probes on either side of the tape segment exposed to the etchant. When the foil has dissolved, the current is interrupted. After each reading, the tape is advanced by the tape transport. If the etch-through time does not increase, no change is made in the conveyor speed.

Specifications

Time between samples	1 to 20 minutes
Depletion range	0 to 14 ounces per gallon of ferric chloride
	0 to 5 ounces per gallon of ammonium persulfate
Size	14 x 14 x 10 in. each for sampling chamber and control

The advantage of the technique, Chemcut points out, is that the etchant can be used until depletion for process economy; circuit boards are not lost because of over-etching or underetching, and the machine operator can concentrate on activities other than monitoring etching rate.

The foil on the tape does not have to be the same thickness as the foil on the boards. Since etching time at a given depletion is a function of foil thickness, the control can be adjusted for thickness differences. The sampling chamber is made of etchant-resistant materials (titanium and polyvinyl chloride).

The control is available as optional equipment on Chemcut mod-

telephone quality handsets

There is no higher standard for handsets. Specify famous Stromberg-Carlson . . . known to telephony since 1894.

Both models shown incorporate push-to-talk switches and high-gain receivers and transmitters.

No. 33 lightweight handset is furnished with a rocker bar switch.

No. 35 comes with a button switch, or with both the button and rocker bar switches.

Write for complete technical data.

STROMBERG-CARLSON

A Subsidiary of General Dynamics

114 Carlson Road • Rochester, N. Y. 14603

Circle 228 on reader service card

1/4" Mechatrim® Trimmer Pot

The only one like it on the market . . . Electro-Techniques' 1.5 gr. ¼" Type HT-250 Mechatrim® Metal Film Trimmer Pot in a TO-5 can; also panel and side adjustment mounts. It takes superlatives to describe its features and functions, which meet or exceed existing mil-specs. ▪ +30 PPM/°C temperature coefficient ▪ Non-wirewound reliability ▪ Infinite resolution ▪ Resistance maintained well into 150 MC ▪ Humidity proof ▪ Setting stability unaffected by acceleration, shock and vibration ▪ Long life ▪ Low cost ▪ Immediate delivery.

ELECTRO TECHNIQUES

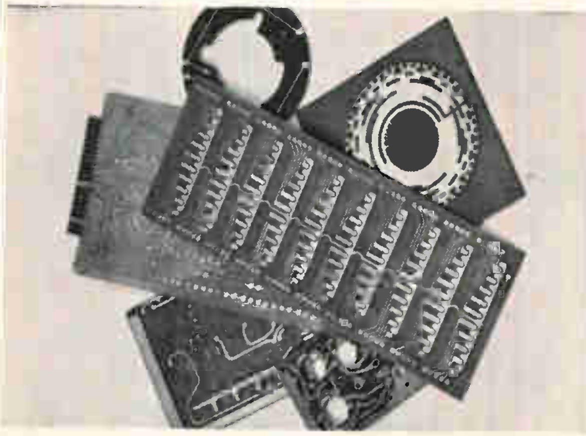
Write or phone for Technical Bulletin 109 or HT250 Test Report, or both

11301 E. Ocean Ave., La Habra, Calif. 90631/(213) 691-0741

MFRS. OF LINEAR AND NON-LINEAR PRECISION POTENTIOMETERS SINCE 1959

Circle 229 on reader service card

NEW lower-cost, epoxy flame-retardant copper-clad laminate



In response to the demand for a more economical epoxy grade of laminated plastic, Synthane now offers new grade FR-16.

FR-16 is reinforced with a random-oriented glass fiber mat which, because it can be produced on a modified paper machine, costs less than fabric reinforcements used in other flame-retardant grades.

FR-16 is excellent for printed circuits. It is mechanically strong, moisture-resistant, has a low dielectric loss and a high dielectric breakdown. Write Synthane Corporation, 36 River Road, Oaks, Pa. for the FR-16 Engineering Data Bulletin.

Laminated Plastic Sheets, Rods, Tubes and Fabricated Parts

SYNTHANE CORPORATION OAKS, PENNA.

Circle 209 on reader service card

els 502 and 1000 horizontal spray-etching machines for $6,500. For a small additional cost, the company says, it will put them on machines previously supplied. Operating voltages are obtained from the existing controls on the Models 502 and 1000. Delivery is 5 weeks.

Chemcut Corp., 500 Science Park, State College, Pa. 16801 [401]

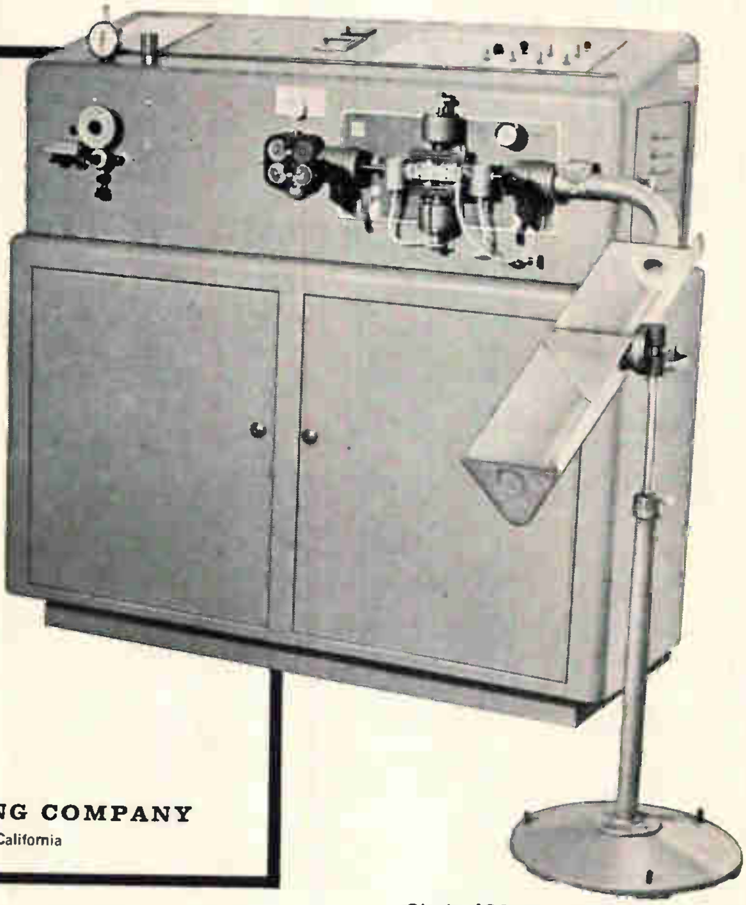
Air injection fixes plastic foam density

Rigid control of the cell structure and density of plastic foam is provided by the Blendmaster 27 PDM by injecting air where the mixture of resin and catalyst is discharged. By adding air at this stage, the manufacturer claims, more uniform structures can be provided and electronics firms seeking to encapsulate delicate circuits can mix the type of foam best suited for their purposes.

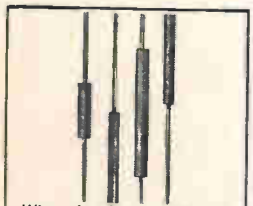
The mixing-dispensing machine can mix all types of foam, even those containing resins with a pot life as short as four seconds. Earlier models were limited to resins with a 10- to 15-second pot life. In addition, the machine can be run by unskilled operators and can be cleaned in less than a minute.

Resin and catalyst are stored in separate cylinders. A moving platen pushes the materials up into the mixing head, displacing the materials in direct proportion to the cross-sectional area of the cylin-

For solderless wrapped connections, a new automatic wire stripper



The Model 841 Solderless-Wrap Wire Stripper offers high speed preparation of 20-30 AWG solid conductor wire for insertion in a wrapping tool. It cuts wire to lengths of 1" to 50' and fully strips 1/8" to 1 9/16" from each end without nicking or scraping, whether the insulation be PVC or something as tough as Mil-Ene, Teflon or Kynar. With optional assemblies, you can also use it for shorter stripping of 10-32 AWG stranded wire. Write for information on this and other Eubanks wire strippers.



Wire is fully stripped, ready for wrapping tool.

Remaining insulation can be short as ½".

Eubanks ENGINEERING COMPANY
225 West Duarte Road • Monrovia, California

Circle 430 on reader service card

Openings for Graduate Engineers in ADVANCED ELECTRICAL MACHINERY

Pratt & Whitney Aircraft has attractive career positions available in a group engaged in the design of advanced electrical machinery for space power devises and fuel cells. For engineers with BS or MS degrees in Electrical Engineering, there are openings in:

SOLID STATE ELECTRICAL POWER CONVERSION

To qualify, you must have 3 to 5 years experience in the analysis and development of advanced circuits using the latest solid state components for DC-DC, DC-AC, and AC-AC power conversion.

ELECTRICAL POWER SYSTEMS ANALYSIS

Requirements include 5 to 10 years experience in the analysis and design of advanced power systems in one or more of the following areas: aerospace, military ground power, electric propulsion, emergency and auxiliary power.

These are positions that offer a high degree of technical challenge, considerable responsibility and excellent advancement potential. At P&WA, you will also find good starting salaries, outstanding company benefits, fully reimbursed engineering graduate study, and engineering department stability that is unusual in the aerospace industry.

For further details, please send your complete resume, including salary history, to Mr. P. Smith, Pratt & Whitney Aircraft, East Hartford, Connecticut 06108. We are an equal opportunity employer.

Pratt & Whitney Aircraft — DIVISION OF UNITED AIRCRAFT CORPORATION

ULTIMATE IN PERFORMANCE

TOHOKU METAL'S NEFERRITE POT CORES

NEFERRITE—developed by Nippon Electric Co., Ltd., and exclusively produced and sold by Tohoku Metal—a new type magnetic ferrite material which offers higher magnetic permeability and a low core loss coefficient even at high frequency. Highly suitable for tele-communications and electronic equipment. NEFERRITE CORE—utilized for coils and transformers over a wide frequency range, it tremendously improves functional characteristics and helps reduce their size and weight.

SPECIFICATIONS:

Item		Grade 1	Grade 2
μ		2000	2000
B Gauss		4200	4200
Br Gauss		1000	1000
Hc Oersted		0.3	0.3
$\tan\delta / \mu_0$	10 kc	0.7 × 10 [illegible]	0.7 × 10 [illegible]
	100 kc	2 × 10 [illegible]	2 × 10 [illegible]
	500 kc	15 × 10 [illegible]	15 × 10 [illegible]

Item		Grade 1	Grade 2
h cm A	10 kc	15	15
	100 kc	20	20
T. F	0 40°C	+ 0.5 × 10 [illegible]	0.8 ~ 0.5 × 10 [illegible]
T. c (°C)		180	180
D.F		3 × 10 [illegible]	3 × 10 [illegible]
ρ (Ω·cm)		700	700

U S PAT. No. 3106534

Further information, please write to:

Tohoku Metal Industries, Ltd.
7·4, GINZA-HIGASHI, CHUO-KU, TOKYO, JAPAN
Tel. Tokyo (542) 6171 Cable Address: "TOHOKUMATAL TOKYO"

Circle 211 on reader service card

ders. Stagnant areas in the mixing head have been eliminated, so all the mixed material is dispensed and none remains to clog any parts.

With all attachments, the 27 PDM sells for slightly under $3,000. Delivery time is four weeks.
Hull Corp., Hatboro, Pa. 19040 [402]

Manually operated wafer-probe machine

A compact, manually operated wafer-probe machine is said to be practical in both laboratory and limited production usage. Called Waferprobe Class I, the unit is offered to users and manufacturers of semiconductor devices, as an alternate to the company's larger, semiautomatic Waferprobe Mk III.

Like the Mk III, the manually operated probe machine Class I probes up to 18 bonding pads simultaneously and sequentially records both good and defective devices on corresponding counters. Rejected devices are automatically marked with a 9-mil ink dot. Design features include a 360° rotational gold-plated vacuum chuck, individually mounted probe point assemblies that are fully adjustable in x- y-, and z-axes, and an x-y mechanical stage that is controlled by two ungraduated rack and pinion guide knobs. An array of lens-shaped lamps are mounted on probe head to provide shadow-free illumination of devices under test.

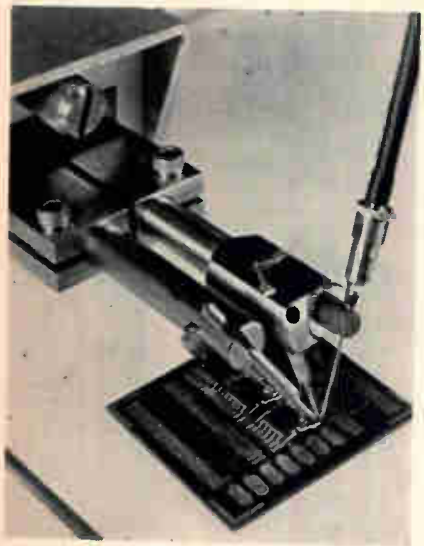
Although the machine is ideal for laboratory and quality control use, the manufacturer claims experienced operators can achieve an 800 probe per hour rate in full production environments.

Advance design provides a

unique method of penetrating outer oxide surfaces of semiconductor devices. Probe points displace surface oxide horizontally, and in direct proportion to the probe force applied, without skidding or whipping. Reliability of probe action assures valid test results, a vital necessity for increasing total yield while maintaining outstanding quality. Price is under $2,000; delivery, 10 days.

The Weldmatic division of Unitek Corp., 950 Royal Oaks Drive, Monrovia, Calif. **[403]**

Soldering system uses three probes



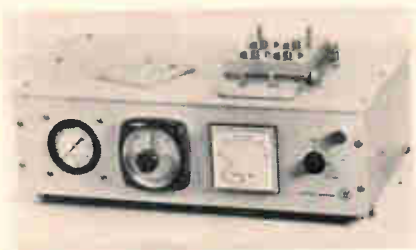
Model 3080 three-probe soldering system allows single schedule soldering of multilayer and other circuit boards with variable heat sink masses. The three-probe kit, adaptable to a standard variable-temperature-control soldering system, provides extremely accurate soldering temperature control.

Single connection pads and plated-through or built-up multiple pads may be soldered without rescheduling. Soldering heat is created by passing a-c current between two tungsten electrodes placed on the first pack lead. The third probe, a small and extremely fast thermocouple, is placed on the pad to sense the temperature of the interface plane. Heating current is limited by feedback from the sensor to the controller.

The system allows fast and accurate sensing of pad temperatures and provides variable heating energy according to the demand of the connection. Rate of current rise and fall is also controlled by the system, and the manufacturer says there are no temperature averaging errors as encountered with infrared systems. Timed-pulse control limitations also are eliminated.

Maximum reliability, elimination of schedule problems or judgment errors, as well as fast and economical operation are prime factors in application of this equipment.
Development Associates Controls, Santa Barbara, Calif. [404]

Semiconductor spinner applies photoresists



An improved semiconductor spinning machine is available for applying a thin, uniform coating to four substrates simultaneously, with a great reduction in cobwebbing (the undesirable textural effect associated with the spinning process). Features of the redesign include new vacuum chucks which produce a special airflow pattern that reduces cobwebbing; a tachometer with magnetic pickup from the output shaft; and a remote-mounted control panel.

The spinner, capable of spinning substrates as large as 1½ in. in diameter at any speed up to 10,000 rpm, can be used to apply any of the usual photoresists. The four spindles are loaded from an easily positioned stainless steel loading tray—a combination carrier and baking tray—which makes it unnecessary to touch the substrates throughout the spinning and baking operations.

The interchangeable vacuum chucks hold the substrates securely during the spin cycle. All four substrates are loaded from the carrier tray which is used to lower them onto the chucks. Then the tray is withdrawn and a shield is raised into position around the substrates.

Once the coating has been applied to each substrate and the spin cycle is initiated, the rapid acceleration of the spindles spreads the coating uniformly by centrifugal force. All excess material is retained in the recesses of the shield. At the completion of the spin cycle, the automatic reset interval timer turns off the motor; the shield is lowered manually; vacuum to the chucks is cut off; and the loading tray is used to remove the substrates from the chucks. At this point in the process, the substrates are ready for baking.

Westinghouse Scientific Equipment Dept., Westinghouse Electric Corp., Box 868, Pittsburgh, Pa., 15230. [405]

Meter with syringe dispenses materials

Potting compounds, sealants, adhesives, and other materials with consistencies varying from liquids to pastes are dispensed automatically in predetermined volumes by the impact Vari-Meter dispenser. Applications vary from the injection of measured amounts of acid during battery cell manufacture to the dispensing of dots, lines or volumes of epoxies, silicones, urethanes, and other materials in electronic or mechanical assembly. Most compounds can be fed with a repeatability of $\pm 0.1\%$ in less than 0.1 gram to over 1 oz per cycle.

Virtually no operator training is required. Once the single control is adjusted, the set quantity is dispensed with a foot switch. The dispenser regulates itself and shuts off on completion. Vari-Meter dispensers have also been designed for continuous operation. A complete potting station can be provided in a single assembly, with the principal controls housed in a chassis that fits on a standard work bench. Material is dispensed from disposable MicroAir syringes, available in 2½, 6 and 30 cc sizes. Technon Systems, Inc., 13206 South Western Ave., Gardena, Calif. [406]

Four-point probes test semiconductors

A series of four-point probes is designed to provide optimum dimensional and electrical accuracy in the measurement of thin semiconductor slices or raw crystals. The units feature continuously adjustable probe point pressure of from 70 to 180 grams and optional point spacing ranging from 0.025 in. to 0.625 in.

Adjustable probe point pressure results from a new design utilizing coil springs coupled to an adjustment screw, making each probe adaptable to the measurement of thin slices or raw crystals as opposed to fixed or preset pressures that limit the usefulness of probes to specific tests.

To assure precision accuracy and reproducibility of measurements over a long life, probe pins are held in a precision casting made of material chosen for its minimum friction-bearing characteristics and high abrasion resistance.

Probes are available in four standard point spacings and can be obtained in custom spacings to order.

Units are housed in rugged castings designed to fit any manipulating system, and are equipped with 12-inch, red, black, green and white color-coded leads for point reference during connection to the power supply and measuring instruments.

Price is from $45 each in quantity; delivery, 3 to 5 days after receipt of order.

Alessi Associates, 8710 Pershing Drive, Playa Del Rey, Calif. [407]

Assembly machine for semiconductor industry

Model 350 flatpack lead-frame and die attaching machine consists of a movable stage (on which selected dies are placed), heated holding fixture and die transfer arm.

In operation, the movable stage is positioned so the selected die is located in microscope cross hairs, the preglazed ceramic part is placed in the heated fixture and lead-frame placed on top. Depressing the operate switch causes the transfer arm to pick up the selected die and deposit it in the center of the ceramic lead-frame assembly where it and the lead-frame are pressed into molten glaze. The transfer arm remains in position for a predetermined period then lifts out the entire assembly, moving to the discharge point. The machine can be adapted for eutectic bonding.

Typical production rates are 6 to 10 assemblies per minute. Price is $3,500; delivery, 6 to 8 weeks.

D. P. Veen Co., 1737 Kimberly Drive, Sunnyvale, Calif. [408]

New Books

Troposcatter

Tropospheric Radiowave Propagation Beyond the Horizon
Francois Du Castel
Pergamon Press, 236 pp., $11.50

Tropospheric scatter communication has enjoyed more than a decade of use and generous endowment without the dignity of a concise theory explaining the phenomenon. Practitioners of the art have had to rely on papers—usually very narrow in scope—unpublished reports at informal meetings, and personal investigation and conversation for available intelligence. The bulk of the literature relates almost entirely to empirical data which is the best available approach to path-loss prediction.

The author, in the face of all this, has done a workmanlike job of assembling an orderly presentation of some of the concepts of the scatter propagation mechanism, after acknowledging the embarrassment of the scientific community over the elusiveness of a concise theory. The introduction traces the history of beyond-the-horizon propagation and establishes the theoretical basis for relating propagation to the meteorology of a path.

Du Castel reviews the known and readily measureable properties of propagation above 50 megahertz in the familiar line-of-sight and diffraction situations. The attention given to the structure of the atmosphere and troposphere will be useful to those not well versed in meteorology.

This is followed by a section on experimental data on transhorizon propagation. Although quite brief, the examples selected to theorize on the nature of the mechanism highlight those areas most open to question.

The author divides theoretical interpretations of the observed phenomena into two sections: influence of the earth and influence of the troposphere. Observers of attempts to ascribe major significance to diffraction, turbulent blobs and partial reflections will note the author's separate consideration and evaluation of all three factors. In the final chapter, practical examples are given of path attenuation determination by combining the influence of all three. The weight given each factor is the author's own, and he makes no claims for high accuracy.

The European work on tropospheric scatter has been almost entirely theoretical. In contrast, the American theory has been empirically derived. In spite of these differences and the tendency toward geographic clannishness in scientific pursuits, this reviewer was unable to detect any major discrepancies between the European theory presented by Du Castel and the American view, recently published in National Bureau of Standards Technical Note 101. Du Castel's book, of course, does not have all the empirical information upon which the technical note is based.

This book has many good features that will be appreciated by the working engineer and scientist. Foremost is brevity; this work could easily have run to 1,000 pages and yet have said very little more. Each chapter has its own appendixes, contributing to the leanness without loss of depth. The bibliography is of great value as it contains many European references not frequently used or known in the U.S. Finally, tucked into a pocket in the rear cover, there are 18 graphs of the major factors.

Although the writer assumes graduate-level knowledge of mathematics and electromagnetic theory, he thoroughly derives or explains the details of his particular usage. His work will be equally valuable for undergraduates as for readers long removed from the academic world.

William E. Yost Jr.
Consultant
Bethesda, Md.

Recently published

Oscilloscope Measuring Technique, J. Czech, translated from the German by A. Smith Hardy, Philips Technical Library, Springer-Verlag New York Inc., 620 pp., $15.80

Microelectronic Design, edited by Howard Bierman, Hayden Book Co., 312 pp., $11.50

A Fortran IV Primer, E.I. Organick, Addison-Wesley Publishing Co., 263 pp., $4.95

Roger Smullen is a 30-year-old malcontent. He came to Fairchild six years ago in Quality Assurance. Then, he became a Production Foreman. Then, Production Engineer Supervisor. Now, he's Product Manager in the Custom Integrated Circuits department at Fairchild. He can never leave well enough alone.

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Technical Abstracts

Cool filters

Superconducting ultrahigh Q tunable r-f preselector
F. Arams, J. Fradkin, E. Sard and K. Siegel, Airborne Instrument Laboratory, division of Cutler-Hammer, Inc., Deer Park, N.Y.

Use of superconductive materials and cryogenic cooling significantly reduce conductor losses and result in very high Q microwave filters with narrow bandwidths. As a preselector in communications receivers, the tunable superconducting filter provides greater rejection to nearby interfering signals and a reduction in cross-modulation and intermodulation interference.

Operating at a liquid-helium temperature of 4.2° Kelvin, a single-section superconducting filter exhibits unloaded Q's of 300,000 to 600,000 at frequencies from 6.3 to 21 megahertz. Bandwidth can be varied from less than 60 hertz to over 16 kilohertz.

Cooling can increase the Q of any filter but unless the material is superconducting, the Q is not as large. For example, at 10 Mhz a low-loss filter element such as a 4-inch diameter helical resonator made with ultrapure copper would have a room temperature Q of 7,500. Reducing the temperature to 25° K would increase the Q about 13 times to 96,500; further cooling would have a negligible effect.

Losses in dielectric materials used for mechanical supports limit the obtainable values of Q. A developmental filter employing fewer dielectric supports had Q's ranging from about 700,000 to 800,000 over a frequency range extending from 8.5 to 27.4 Mhz.

Lead is chosen as the superconducting material because it has a critical temperature of 7.2° K and is therefore superconducting at liquid-helium temperature. Furthermore, since lead can be electroplated, the filter's resonators are easily fabricated. In addition, lead-tin solders are available that are superconducting and cause only a slight reduction in critical temperature. Soft soldering techniques can connect terminals.

The filter minimizes changes in the resonant frequency due to load mismatch and bandwidth adjustment. Over a 30-minute period with the filter operating at 19.3 Mhz and a 500-hz bandwidth, the amplitude stability of a 100-hz square-wave modulated signal was better than 0.2 db.

The resonance curve follows the theoretical tuning curve to —60 decibels below the resonant frequency. Insertion loss is 1 db at a 500-hz bandwidth and 0.2 db at the 16-khz bandwidth.

Presented at the 1966 IEEE International Communications Conference, Philadelphia, June 15-17

Simulating troposcatter paths

Wideband troposcatter radio channel simulator
R.C. Fitting
Bell Telephone Laboratories, Inc., division of American Telephone and Telegraph Co., Whippany, N.J.

A device that simulates atmospheric fading characteristics of a troposcatter link can be used to evaluate troposcatter equipment in the laboratory. It has been tested against an existing 340-mile arctic link, and was found to produce very good agreement between the simulated and the actual-channel's signal-to-noise characteristic. The equipment has been used to evaluate an improved diversity-combining technique. Future experiments with the simulator include testing wideband-data transmission and measuring correlation-bandwidth.

Two or more diversity channels are simulated by summing the outputs of networks that are randomly phase-modulated by independent low-frequency noise sources. Each network contains a variable 0-to-1-microsecond delay line and a 0-to-100-decibel attenuator.

Different delays and attenuation in the networks result in simulating three different types of fading. Fading rate is changed by band-limiting the noise spectrum, which changes the phase variation.

The equipment can simulate time-varying radio channels with flat Rayleigh fading, frequency selective non-Rayleigh fading and frequency selective Rayleigh fading. The term Rayleigh fading specifies a particular statistical variation of the amplitude with time. It differs from the Gaussian distribution in that the curve is not symmetrical and the median value is always a positive voltage.

A radio channel with flat Rayleigh fading has a flat frequency response and the envelope of any spectral component in the channel is Rayleigh distributed. It is accurately simulated by summing a large number of equal-amplitude, random-phase sinusoidal voltages. However, as an approximation, only four simulator networks need be summed. For 90% of the time, this produces a distribution that departs from Rayleigh by less than 1 decibel. This type of channel is used in testing gain control circuits and threshold effects in frequency modulated receivers.

Selective non-Rayleigh fading channels have a frequency response in which the amplitude varies with time. The envelope of any spectral component in the channel has a statistical distribution that differs from the Rayleigh. The channel is simulated by summing the outputs of two or more networks that have unequal delays and losses. Because the minimum signal level can be held above some predetermined value, this type of channel allows multipath effects to be evaluated separately from deep fading effects.

Selective Rayleigh fading channels also have a time varying frequency response, but the amplitude of any spectral component in the channel is Rayleigh distributed. It is simulated by summing the outputs of four equal-magnitude, undelayed networks and the output of at least three networks that have delay and greater losses. This type of channel, combining the features of the other two, simulates the arctic troposcatter path. The undelayed channels represent the direct-path transmission which is Rayleigh distributed. The delay (echo) paths simulate multipath propagation. Although the magnitudes of each echo signal are constant, the ratio of the magnitudes of the direct-path signal to the echo-path signal is Rayleigh distributed. The echo path parameters needed for modeling a particular troposcatter link, may be computed from the link's geometry.

Presented at the 1966 IEEE International Communications Conference, Philadelphia, June 15-17

New Literature

Phase-lock-loop discriminator. Defense Electronics, Inc., Rockville, Md. Bulletin SCD-1 describes new and exclusive engineering features, performance specifications and block diagram for a solid state phase-lock-loop discriminator.
Circle 420 on reader service card.

Indicating temperature controllers. West Instrument Corp., 3860 N. River Road, Schiller Park, Ill., 60176. Indicating temperature controllers—on-off and combination high limit and on-off—are covered in bulletin JJL. [421]

Instrumentation tape recorder. Ampex Corp., Mail Stop 7-14, 401 Broadway, Redwood City, Calif. Description, specifications and applications of the model SP-600 1.5-Mhz instrumentation tape recorder are contained in brochure No. D046. [422]

Solder powder. Alpha Metals, Inc., 56 Water St., Jersey City, N.J., 07304. Bulletin No. 6a-18 describes Vaculoy solder powder, a specially processed high-purity powdered solder containing a low metal-to-oxide ratio. [423]

Photoconductive cells. Clairex Corp., 1239 Broadway, New York, N.Y., 10001. Photoconductive cells with maximum power as high as 10 watts when heat-sinked are described in data sheet 108. [424]

Automatic soldering systems. Hollis Engineering, Inc., Nashua, N.H. 03060, has published catalog No. 166 with emphasis on new improvements on series SS and TT wave soldering machines. [425]

Pcm decommutator. Monitor Systems Inc., Fort Washington, Pa., has released a two-page bulletin on its model 1000 stored program pcm decommutator for telemetry ground-station applications. [426]

Zener reliability program. Motorola Semiconductor Products Inc., Box 955, Phoenix, Ariz., 85001. Detailed information on the company's Meg-A-Life II high-reliability assurance program for zener and reference diodes is now available in brochure form. [427]

Wedge-action relays. Electro-Tec Corp., P.O. Box 667, Ormond Beach, Fla., 32075. A preliminary catalog describes two new 1-in. diameter, 1-in. high, 6 pdt and 4 pdt wedge-action relays. [428]

Tunable bandpass filter. Spectrum Instruments, Inc., Box 474, Tuckahoe, N.Y., 10707, has published a technical data sheet on the type BB4-1 spectrum analog electronic filter, a portable, all solid state, active tunable bandpass filter only 7¼ in. high. [429]

Beacon magnetron. Microwave Associates, Inc., Northwest Industrial Park, Burlington, Mass., has released bulletin 1259 describing the MA-212T beacon magnetron which utilizes a new tuning technique to provide very low cost mechanical tuning of 50 Mhz in the 8.8 to 9.6 Ghz range. [430]

P-m motors. Globe Industries, Inc., 2275 Stanley Ave., Dayton, Ohio, 45404. Bulletin A-3600 gives dimensional and performance data on 2¼-in.-diameter, permanent magnet d-c motors rated to 1/12 h-p, 6,000 to 10,000 rpm continuous duty. [431]

Deflection yokes. Syntronic Instruments, Inc., 100 Industrial Road, Addison, Ill., 60101, has issued technical bulletin 66-4 on two new stator type deflection yokes designed for standard 1½-in. neck diameter scan converter storage tubes. [432]

Subminiature lamps. Industrial Electronic Engineers, Inc., 7720 Lemona Ave., Van Nuys, Calif., 91405, offers a catalog including price lists of its new line of subminiature incandescent lamps. [433]

Low-pressure transducers. Robinson-Halpern Corp., 5 Union Hill Road, West Conshohocken, Pa., 19428. Bulletin P102-65 deals with the company's complete line of P20 series low-pressure transducers with both standard and high-accuracy ratings. [434]

Transistor choppers. Airpax Electronics Inc., Cambridge, Md., 21613. Bulletin C-117R2 provides complete information on the parameters of transistor chopper types now available from the company. [435]

Microwave system. Farinon Electric, 935 Washington St., San Carlos, Calif. A four-page brochure describes the PT/SS2000 microwave system for the 1710- to 2300-Mhz band. [436]

Pressure transducers. ElectroSyn Technology Laboratories, Inc., 480 Neponset St., Canton, Mass., 02021. Ten miniature pressure transducer designs utilizing a 3-fluted straight Bourdon tube as the sensor are shown in bulletin No. 102. [437]

Microwave materials. Trans-Tech, Inc., 12 Meem Ave., Gaithersburg, Md. Complete technical specifications relating to the properties of two new garnet materials and two new dielectric materials for microwave use are given in four bulletins. [438]

Production machinery. Heller Industries Inc., 30 N. 15th St., East Orange, N.J., 07017, offers its 1966 eight-page catalog of production machines for the electronics industry. [439]

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FAIRCHILD SEMICONDUCTOR Div. of Fairchild Camera & Instr. Corp. Mountain View, Calif.	219	4
GENERAL DYNAMICS Fort Worth, Div. Fort Worth, Texas	166	5
GENERAL ELECTRIC Heavy Military Electronics Dept. Syracuse, N. Y.	224	6
HEWLETT-PACKARD Palo Alto, Calif.	226	7
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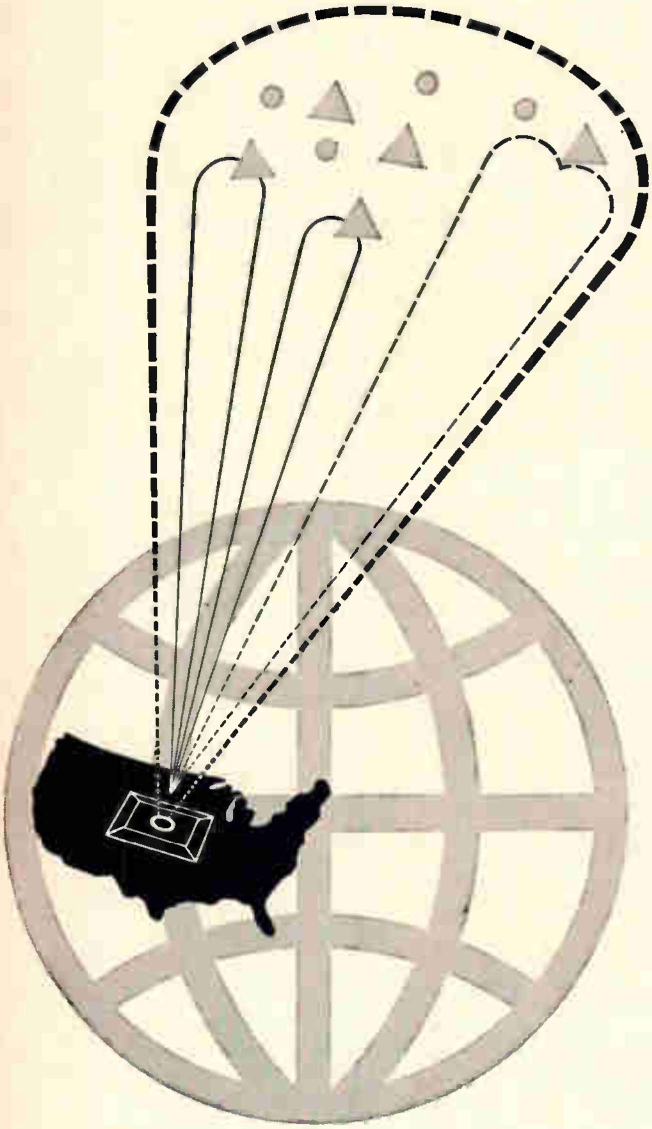

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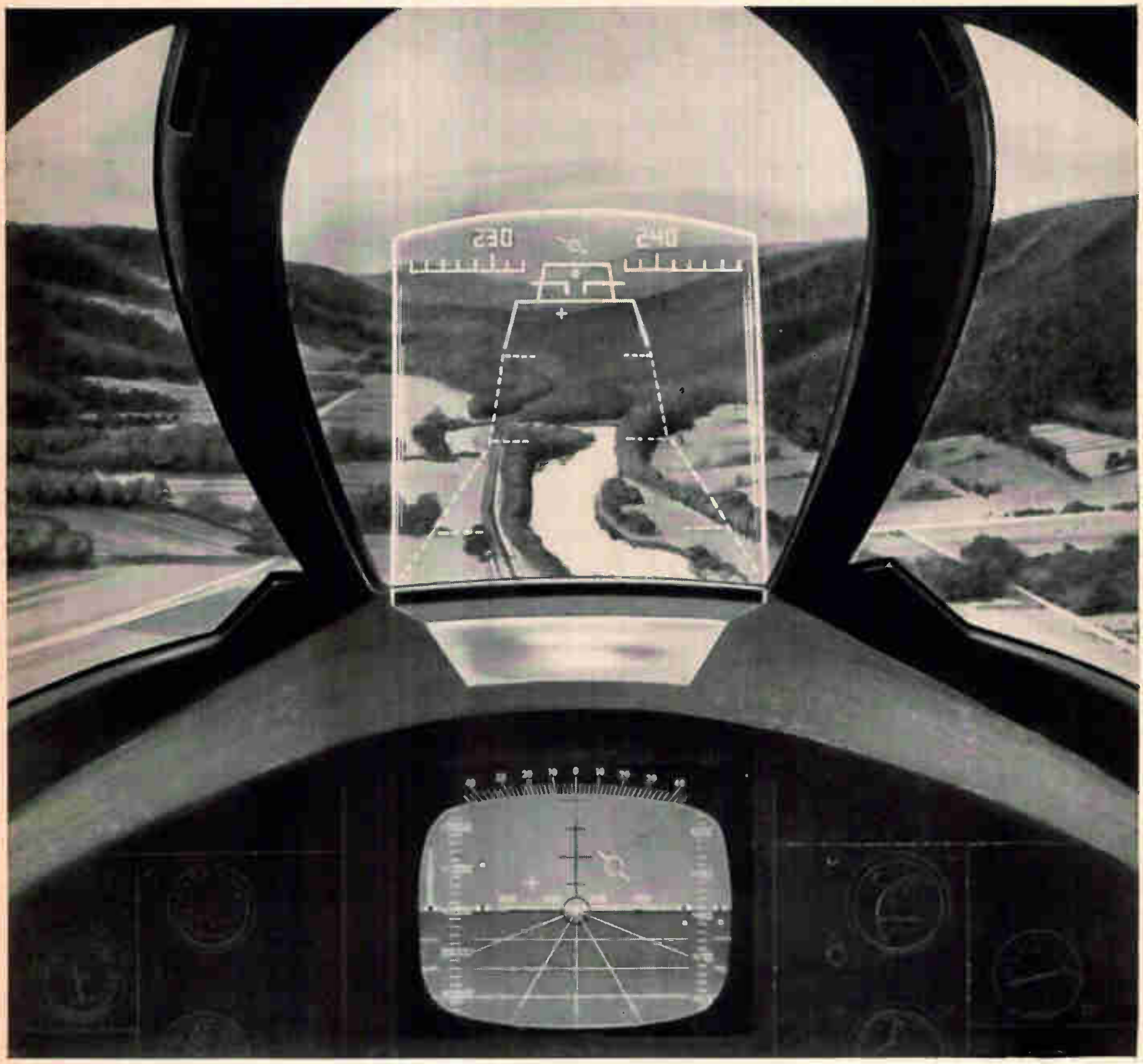

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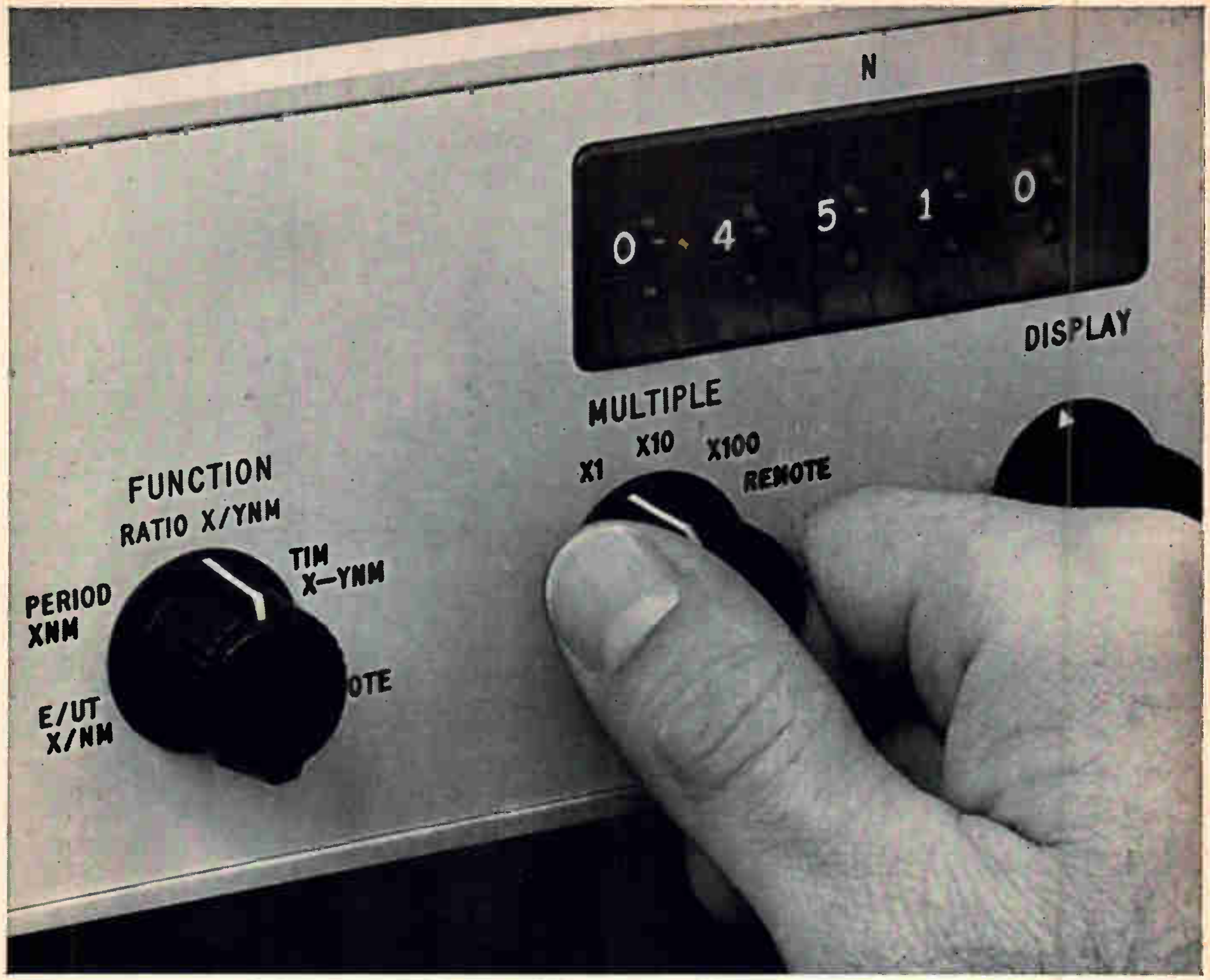

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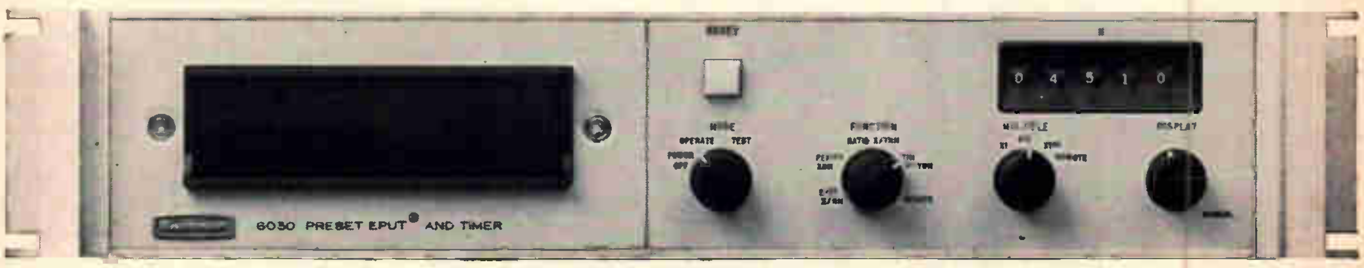


July 25, 1966

Electronics Abroad

Volume 39
Number 15

International

The equalizer

Last spring, United States semiconductor manufacturers thought they were ready to move in on the lucrative market in Western Europe for industrial and consumer-electronics transistors. Their not-so-secret weapon: low-cost transistors packaged in plastic by automatic molding machines rather than assembled in metal cans.

But European semiconductor makers moved fast to quell the threat. They, too, have begun to produce plastic transistors. And, again following the lead of their American competitors, European companies are starting to put integrated circuits into the large plug-in packages that are called DIP's—for dual-inline packages—in the U.S.

On both sides of the Atlantic, the equalizer is automatic molding, according to Lawrence L. Plummer. Plummer is sales manager of the electrical and electronics division of the Hull Corp., which makes automatic transfer-molding machines and has developed several of the key molding processes.

"It took American producers three to four years to get into mass production of plastic transistors," Plummer remarks. "The Europeans have done it in several months." Besides the incentive to hold on to their domestic markets, European companies are turning to molding because it makes silicon planar transistors competitive with the germanium types that have been staples in radio and tv sets.

Some Japanese companies, too, may adopt machine molding. The Japanese have been hand-molding plastic transistors for years, a method too costly for American and European producers.

Transistors galore. In England, Ferranti Ltd. and Mullard Ltd. are on the verge of going into production with automatic molding machines incorporated into automatic transistor-assembly lines. Most other British semiconductor makers plan to follow suit—when they see a big enough market in the offing to justify the investment in redesign as well as tooling.

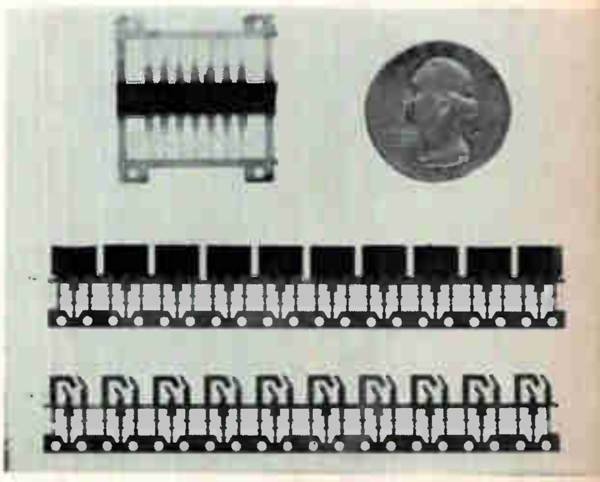
In the Netherlands, Philips Gloeilampenfabrieken has transistors pouring off automatic encapsulating machines. So have two top semiconductor manufacturers in France, Société Européenne des Semiconducteurs and La Radiotechnique, a subsidiary of Philips. And in Germany, Siemens and Halske AG; AEG-Telefunken AG; Valvo GmbH, the Philips' subsidiary, and a pair of affiliate companies of the International Telephone and Telegraph Corp. are in production with plastic transistors or about to start.

With labor costs climbing in Japan, semiconductor makers there have started to think about switching to automatic molding. Two already have firm plans to start: Kyodo Electronic Laboratories Inc. and Mitsubishi Electric Corp. Kyodo will use a machine it developed jointly with a Japanese equipment maker; Mitsubishi has bought a U.S. machine. About the only company not contemplating jumping on the bandwagon is the Nippon Electric Co., which figures its "Microdisk" package will keep its transistors competitive.

Framed. The process Philips uses incorporates most of the latest wrinkles in transfer molding. Starting point is a nickel-foil lead frame. On each frame, the transistor chip mounts directly on the collector lead; bonded wires connect the chip to the base lead and the emitter lead. Two lead-frame strips are slipped side-by-side into a multicavity mold for the automatic encapsulation. They come out joined by a runner of excess plastic and are then trimmed into individual transistors. The base lead at the center of the frame, longer than the other two leads, is bent up under the plastic to form the third leg of a "pin circle".

Most transfer-molded transistors start with a similar lead-frame strip or with one formed from round wires. However, molding has been tricky because it is difficult to obtain a tight seal around individual leads. The bar running along the center of the Philips strip solves the problem. The plastic flashes down to the bar, thus sealing around the leads. The bar is removed when the transistor is cut out of the molded strip.

Integrated circuits. Automatic molding of integrated circuits also is on tap for some European semiconductor manufacturers. Ferranti, Philips and La Radiotechnique all are producing them or about to



Transfer-molding process begins with lead-frame strip made of nickel foil (bottom). In each frame transistor chip mounts on collector lead, which extends into gap between other two leads. Bonded wires connect chip to emitter and base leads. Transistors encapsulated in plastic come out in long strips (center) and are separated by trimming lead frames. Unit at top is molded integrated circuit, untrimmed.

start. However there are companies, especially producers of IC's for computer use, which are holding back because they're worried that the plastic encapsulation will leak.

Plummer, of course, considers this needless worrying. He points out that tight seals are obtained by letting plastic flash out of the mold and around the lead. This technique was developed jointy by Hull and Texas Instruments Incorporated for TI's new line of IC's [Electronics, April 4, 1966, p. 44].

For this technique, the lead frame is a long strip running lengthwise through the package body. Instead of molding plastic around individual IC chips, the plastic is molded on as a long runner. This produces a strip of packaged IC's looking like a centipede. The strip is cut up into single IC segments and the leads are trimmed and formed to complete the packaging.

Place in space

Unwilling to let the potentially lucrative space communications business wind up monopolized by the United States and Soviet Russia, the seven-nation European Launcher Development Organization this month patched up its squabble over payments and payloads.

ELDO solved the payments problem by hacking down Great Britain's share of the cost of the program. Earlier this summer, Britain had threatened to pull out of the organization unless her financial load was lightened [Electronics, June 13, p. 25]. Instead of 39% of the tab, Britain henceforth will pay 27%. The difference will be made up by the other European member countries—Belgium, France, West Germany, Italy, and the Netherlands. At Britain's insistence, too, a ceiling of $331 million was set for ELDO spending over the five-year period ending in 1971.

The problem of payloads was settled with an agreement to build by 1971 a rocket that can put a 440-pound satellite into a stationary equatorial orbit. At the same time, ELDO will continue to go ahead with its original Europa 1 vehicle, a three-stage launcher with a British Blue Streak as the first stage, a French-built second stage and a German third-stage.

Upgraded. To get a launch vehicle capable of putting a communications satellite into stationary orbit, ELDO will boost the thrust of the first and third Europa stages so the rocket can put a 440-pound satellite into parking orbit at an altitude of 250 miles. Then a perigee motor would carry it on up to 24,000 miles, where an apogee motor would cut in to put the satellite into a stationary orbit. Upgrading the ELDO rocket will add an estimated $125 million to $180 million to the $443 million budgeted for the ELDO program.

Launch site for the upgraded ELDO booster will be the French complex now under construction in Guiana [Electronics, Nov. 1, 1965, p. 159]. For Europa test shots, ELDO will continue to use the Woomera test range of Australia, the seventh member of the organization.

Customers. If ELDO manages to develop its upgraded booster on schedule, it will have some customers ready and waiting.

France, especially, wants to loosen the stranglehold the U.S. and Soviet Russia now have on space communications. The De Gaulle government has two communications satellites under consideration. One is Safran (for satellite français), a medium-altitude telephone link serving France, French Africa and the Middle East [Electronics, April 4, p. 235]. The other is Saros (for satellite de radiodiffusion en orbite stationaire), a 330-pound satellite for tv broadcasts. Not counting exclusively on ELDO, France has a strictly national program aimed at developing satellite launchers by the early 1970's.

Olympics. Another potential customer is West Germany. Boelkow Gmbh, one of the country's leading aerospace companies, has completed preliminary design studies on a 330-pound satellite that would be placed in a stationary orbit to cover Europe and Africa. The aim is to use the satellite for live broadcasts of the 1972 Olympic Games from Munich. Cost of developing and testing the satellite is pegged between $25 million and $30 million. The West German ministry for scientific research will decide in the next few months whether Germany should go it alone with the satellite or to try to make it a joint project.

Still another natural client for an upgraded Europa rocket is ELDO's sister organization, the 12-nation European Space Research Organization. ESRO so far is committed to a program of research satellites but could become the nucleus for a communications satellite program.

Great Britain

New man at the ministry

So far, swinging Britain has barely noticed the Labor Government's effort to bolster the country's position in export markets through automation and advanced technology. But now the government agency that directs the effort—the Ministry of Technology—has a new chief who should be able to get it into the public eye and keep it there.

The new man in charge is 41-year-old Anthony Wedgwood Benn, who moved up from Postmaster-General to the sensitive post of technology chief. Wedgwood Benn has a flair for hitting the front pages. Three years ago, he became a national figure when he renounced his title, Viscount Stansgate, so he could run for a Labor seat in the House of Commons. Wedgwood Benn also did a stint as a producer of talk programs for the British Broadcasting Company, so he's no stranger to the art of mass communications. It's a safe bet that he will correct what most industry people felt was a major shortcoming—failure by his predecessor to win strong public support for the ministry.

Wedgwood Benn took over from 62-year-old Frank Cousins, a union leader who started the technology ministry up from scratch when Harold Wilson's Labor party came into power 21 months ago. Cousins resigned in a squabble over the government's prices and incomes policies that limited across-the-board wage rises to 3½% yearly—not enough for the workers in Cousin's view.

Computers. Initially, the ministry was involved only in computers, electronics, machine tools, telecommunications, atomic energy and scientific instruments. Throughout the emphasis was on automation—to make British products more competitive in world markets and thereby cut down the gap between imports and exports which has plagued the British economy for years.

Perhaps the most noteworthy achievement of Cousins' stewardship was the strengthening of the computer industry. One of the first major moves the ministry made was a $15 million loan to International Computers and Tabulators Ltd. to support long-range development. As a result, ICT has been transformed from a money-loser to a money-maker. Other computer-oriented projects funded by the ministry include standard compiler programs, a national computing center, software for process control, automatic typesetting, and numerical controls for machine tools.

Anthony Wedgwood Benn now heads Great Britain's technology ministry.

Broader range. Wedgwood Benn will have a wider field to cover than Cousins. Right now, the 5,700-man Ministry of Technology spans the whole of electrical and mechanical engineering, together with chemical plants. Prime Minister Harold Wilson intends to add to these the Ministry of Aviation. That will make Wedgwood Benn the head of the largest group of engineering and scientific talent anywhere in Western Europe.

West Germany

Sun struck

Astronomers still have a lot to learn about solar granules, lighter in color than sun spots and apparently caused by streams of hot gases rising vertically from the sun's photosphere. To get a better understanding of the phenomena, the Fraunhofer Institute of Freiburg will send an electronically controlled, balloon-borne solar observatory high into the sky for photographs and spectrographs.

The unmanned observatory, called Spektrostratoskop 1, will carry a 3,000-pound optical instrument package stabilized to an accuracy of 0.1 second of arc. With its 0.1-second stabilization, the West German observatory matches the pointing accuracy of Stratoscope 2, the United States' high-altitude platform that has been taking night-time observations for slightly over three years now. (But Spektrostratoskop 1 outstrips by far the performance of the solar observatory, Stratoscope 1.)

The Perkin-Elmer Corp. built the U.S. Stratoscopes. Carl Zeiss of Oberkochen is readying Spektrostratoskop 1, which will be launched from Palestine, Texas, since West Germany doesn't have the wide open spaces needed for balloon flights.

Closer and closer. Spektrostratoskop 1 packs a telescope with an aperture of 300 millimeters and focal length of 2,440 mm together with a high-resolution spectograph, a Lyot filter and a pair of cameras. To keep the telescope accurately locked on a single sun granule for as long as half a minute, there's a three-stage stabilizing system.

The coarse control stage orients the telescope mounting frame in azimuth and elevation with an accuracy of a half-degree. Photocells pick up the light from the sun and generate error signals proportional to the displacement of the mounting frame's axes from the line-of-sight to the solar disc. The error signals are fed to control motors in the coarse servo loop to correct the frame orientation.

The intermediate control stage uses an auxiliary telescope to spot the outer edge of the sun. The objective of the telescope puts an image of the sun in the base plane of a four-sided, pyramid-shaped prism. Diffused onto the image plane is a circle of light-absorbing material smaller than the sun image. In that way, four limb images are obtained and the prism reflects each one onto a photocell. The difference in the output from opposite photocells yields error signals for pitch and yaw motors in the intermediate servo loop. The accuracy of this stage is about 1 second of arc.

Final tilt. The fine control stage locks on a single granule that serves as a "guide star." The image of the granule is magnified and split into four partial images by a four-sided prism and beamed onto four photocells. Error signals are developed by comparing outputs of opposite cells and the signals are fed to a fine control loop that shifts the image with two tilting plates. This keeps the system locked on the granule to an accuracy of 0.1 second of arc.

Along with the guide-star granule, the fine control loop also locks on a second granule on the opposite side of the sun's surface. This enables the stabilization system to correct for rotation of the telescope about its own axis.

Telemetering. The solar observatory will also carry a 100-channel telemetry system with an up frequency of 150 megahertz and down frequency of 250 Mhz. Sixty channels are assigned to the command link and 40 channels to data transmission. Zeiss is aiming for daily balloon flights of 10 hours and so has powered the observatory electronics with silver-cadmium batteries that have a total output of 4 kilowatt-hours.

France

Phantom black gang

Like the coal-stokers they supplanted, the oilers and wipers who man the engine rooms of ships at sea are destined to see their jobs wiped out by the advance of technology.

The bleak long-term outlook for below-deck sailors unable or unwilling to upgrade their skills is reflected in the shiny new engine compartment of the 65,000-ton tanker Dolabella, recently put into service by Société Maritime Shell, a tanker-operating subsidiary of Royal Dutch/Shell. Except for the rounds of maintenance personnel, Dolabella's propulsion plant runs with a phantom black gang of instruments and controls, commanded from a central engineering station below deck or a console on the bridge.

In addition to fully automated engine-room control, Dolabella carries a $150,000 real-time computer developed by Philips Gloeilampenfabrieken of the Netherlands. At present, the computer works only as a data logger; later, it will also handle automatic cargo loading and unloading.

Electronic watch. At the central engineering station, six closed-circuit tv cameras monitor engine-room operations. A complex of consoles gives the engineer in charge immediate control of all valves and auxiliaries, plus displays of key temperatures and pressures. The computer rides herd on propulsion plant performance—it calculates boiler, turbine and propeller efficiency and also checks fuel consumption. Printouts record temperatures and pressures. In addition, 108 alarm points are scanned and compared to preset limits.

On the bridge, a second control console enables the deck watch officer to change speed simply by moving a lever alongside a graduated engine-telegraph scale. An electrical signal proportional to the lever position controls the turbine valves directly. This signal is applied to a closed loop so that the valves are positioned to match the propeller speed set on the telegraph scale.

Cargo control. Dolabella also has a central station that handles all cargo loading and discharging. Levels of all cargo tanks in the ship are indicated at the station and all cargo operations are carried out by remote hydraulic control. Maritime Shell anticipates programing the computer to automate cargo-handling.

The automation systems cost some $500,000, about one-twentieth of Dolabella's $10 million total cost. But Shell considers the automation money well spent. Dolabella will have a crew of 30 at the outset and perhaps fewer later. Conventional tankers of her size carry crews of at least 40 men.

Fast clocking

For millions of Frenchmen, the day begins and ends with a frustrating lineup at a classic time clock. Not so for about 500 employees of La Populaire-Vie S.A., a Paris-based insurance company. They clock in and clock out electronically in a matter of seconds.

Instead of riffing through a rack of time cards, the workers at La Populaire-Vie slip plastic ID cards they carry with them into a shoebox-size reading unit. A central processor for the eight units installed at the company's new headquarters stores the badge data and the time on punched tape.

For the management, the $26,000 system has slashed the time needed to transcribe payroll data from time cards. Although the tape could be used as computer input to prepare the payroll, La Populaire-Vie presently reads the tape with an electric typewriter. For employees, waiting is rare—if all eight units are punched at once the readout cycle takes about 300 milliseconds. For a single card, readout time is 36 milliseconds.

Coded. Compagnie Française Thomson-Houston developed the fully transistorized equipment. Its central processor interrogates the reading units sequentially. In addition, the processor gets a time input every minute from a clock whenever at least one badge has been read during the previous minute.

Badges are coded with punched holes that indicate the cardholder's payroll number and department. When a badge goes into a reader it blocks the light of a pilot lamp that illuminates a photodiode. Absence of an output signal from the diode triggers a circuit that powers an electronic flash in the reading unit when it's interrogated. Light from the flash passes through holes in the badge onto a matrix of photodiodes. The matrix output is applied to flip-flop circuits in the central processor that control the tape puncher.

Although La Populaire-Vie codes only payroll and department numbers on its badges, Thomson-Houston designed the system to handle up to five 8-bit words (including a parity bit) per badge.

Around the world

Norway. Two antennas for very low frequency operation will be built north of the Arctic Circle. One, for submarine communications, will operate at frequencies from 15 to 20 kilohertz and outputs to 100 kilowatts. Continental Electronics Inc., a subsidiary of Ling-Temco-Vought Inc., has the contract for this $15 million antenna. Norwegian authorities will build the other, for use in the Omega navigation system [Electronics, Aug. 9, 1965, p. 27].

Iran. A $1.4 million electronic system will control flow of crude oil by pipeline from the Abadan refinery to a new tanker port at Bandar Mah-Shahr.

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