Electronics®

Fastest emitter-coupled logic: page 124

Hybrid computers design controls: page 132

Seeing under water with lasers: page 140

October 14, 1968

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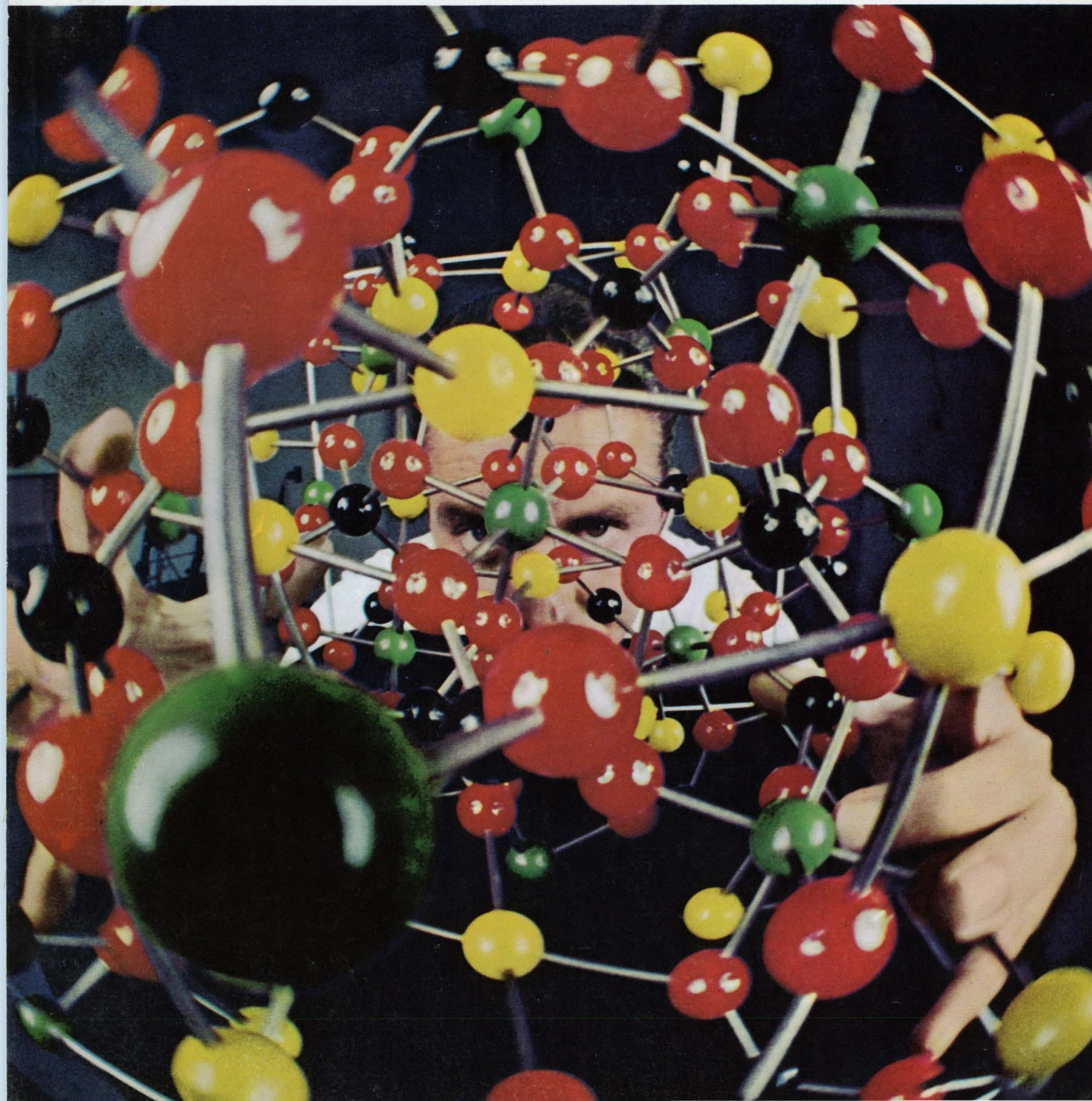
Below: Ferrites yield better microwave components, page 104



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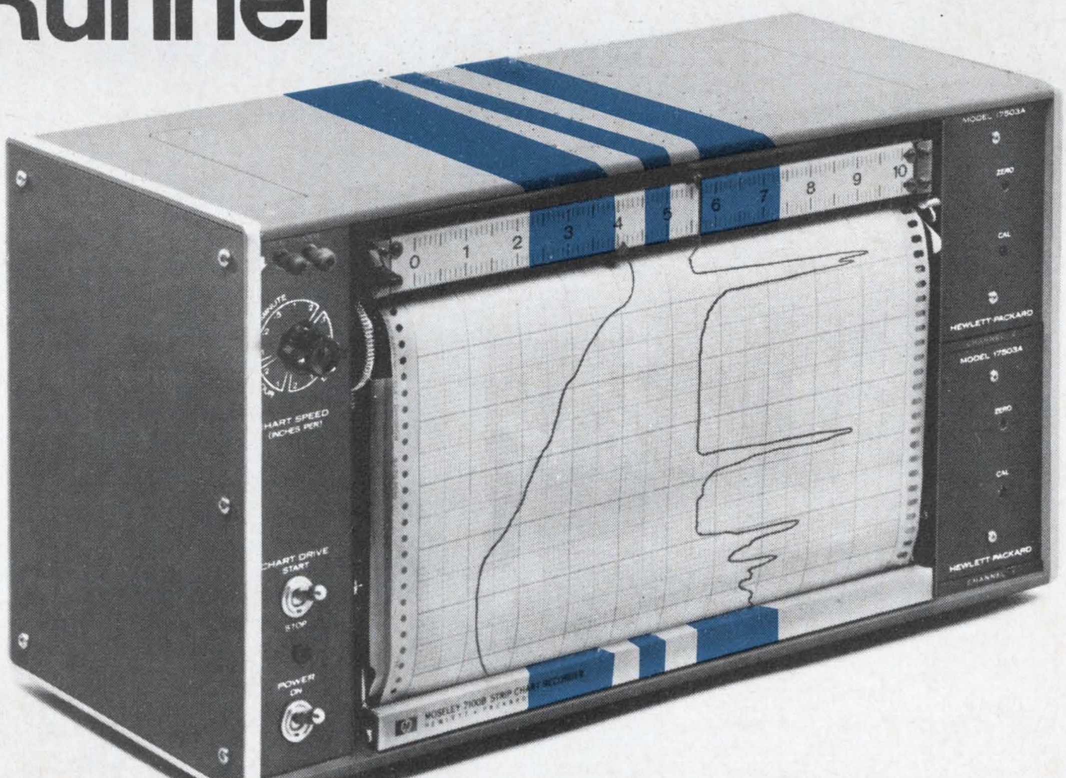

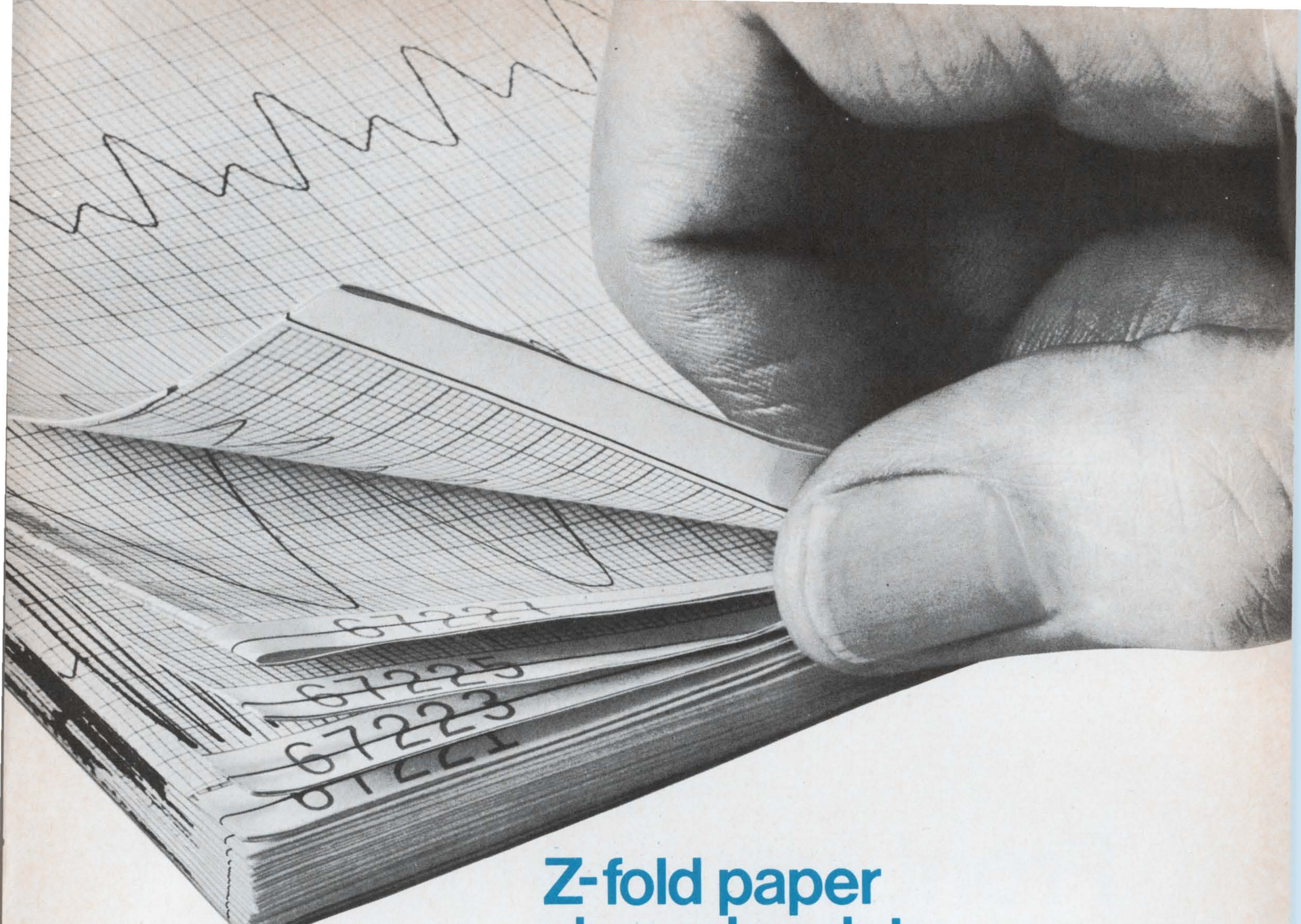

Z-fold paper zip codes data for quick retrieval

Data recorded on Z-fold paper by the Hewlett-Packard 7800 Series Rectilinear Recorder is instantly retrievable. Each page is numbered to simplify reference to recorded data. Z-fold chart packs store easily in their original cartons.

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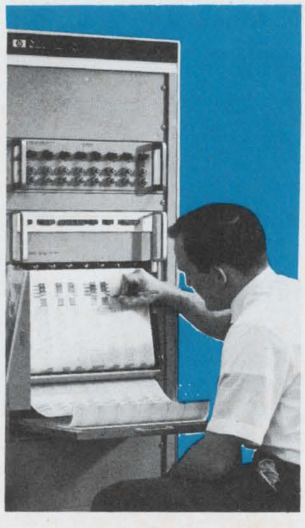

response of the recorder is 150 Hz for 10 div p-p deflection and 58 Hertz maximum for full scale deflection. Maximum ac or dc non-linearity is 0.5% full scale. Additional features include: choice of chart paper in Z-fold packs or rolls; 14 electrically-controlled chart speeds; built-in paper take-up; ink supply warning light; disposable plug-in ink supply cartridge that may be replaced while the recorder is in operation and modular construction for easy maintenance.

For complete information on the 7800 Series, optional and related equipment, contact your local HP Field Office or write Hewlett-Packard, Waltham Div., 175 Wyman St., Waltham, Mass. 02154. In Europe: 54 Route des Acacias, Geneva.

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RECORDING SYSTEMS

Circle 2 on reader service card

17802A

Electronics

Volume 41, Number 21 October 14, 1968

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Probing the News

Electronics Review

Electronics International

New Products

Technical Articles

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Circulation: Isaaca Siegel

Publisher: Gordon Jones

Electronics: October 14, 1968, Vol. 41, No. 21

Published every other Monday by McGraw-Hill, Inc. Founder: James H. McGraw 1860-1948.

Publication office 99 North Broadway, Albany, N.Y. 12202: second class postage paid at Albany, N.Y.

Executive, editorial, circulation and advertising addresses: McGraw-Hill Building, 330 W. 42nd Street New York, N. Y. 10036. Telephone (212) 971-3333. Teletype TWX N.Y. 710-581-4235. Cable address: MCGRAWHILL N.Y.

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Readers Comment

A consumer reports

To the Editor:

The article on the Consumers Union seemed to lean against this organization [Aug. 5, p. 170]. I'm an avid hi-fi hobbiest and have never found fault with their ratings or comments on hi-fi equipment. As to their other product ratings, I have never been misled.

If you were to make a reader survey you'd find that a large number of people in the engineering community read and follow Consumer Reports.

Moreover, the article neglected to mention the repair-record data based on over 100,000 questionnaires returned by readers of Consumer Reports. A sample of this size gives an accurate account of who makes a reliable product.

Just as your publication has had critical editorials directed at the color television industry, so has Consumer Reports. I must say they are 100% correct about the sad state of the industry. I own a color set; 20 service calls and a new picture tube were required in the first year. I am very anxious to see Consumer Reports' repair records on this major item and will be especially interested in the company that manufactured my color set.

Max Wexler
Brooklyn, N. Y.

Dismayed

To the Editor:

I read with some dismay the discussion entitled "Mother of invention" [Aug. 5, p. 54]. The discussion implies that there is very little new in the Johns Hopkins' experiments with computer-assisted reporting of radiological examinations, and that a satisfactory answer has already been available in the Swedish "Medela" system for three years. Quite a few of us have been intensively interested in the potentialities of these developments for many years and among others I have personally visited Sweden and looked into the system available there. It is very far from being satisfactory.

The tone of the report in Elec-

Did You Know Sprague Makes 21 Types of Solid-electrolyte Tantalex® Capacitors?

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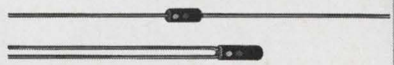

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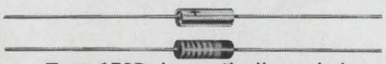

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Type 165D, sealed in polyester-film tubes
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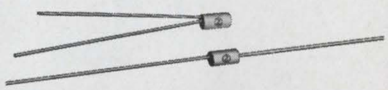

Type 162D, axial-lead, polarized
Type 163D, axial-lead, non-polarized
Type 169D, single-ended, polarized
Type 170D, single-ended, non-polarized
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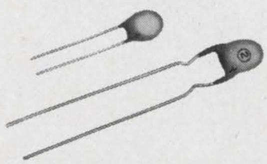

Type 196D, radial lead for printed wiring boards
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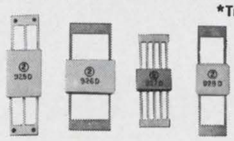

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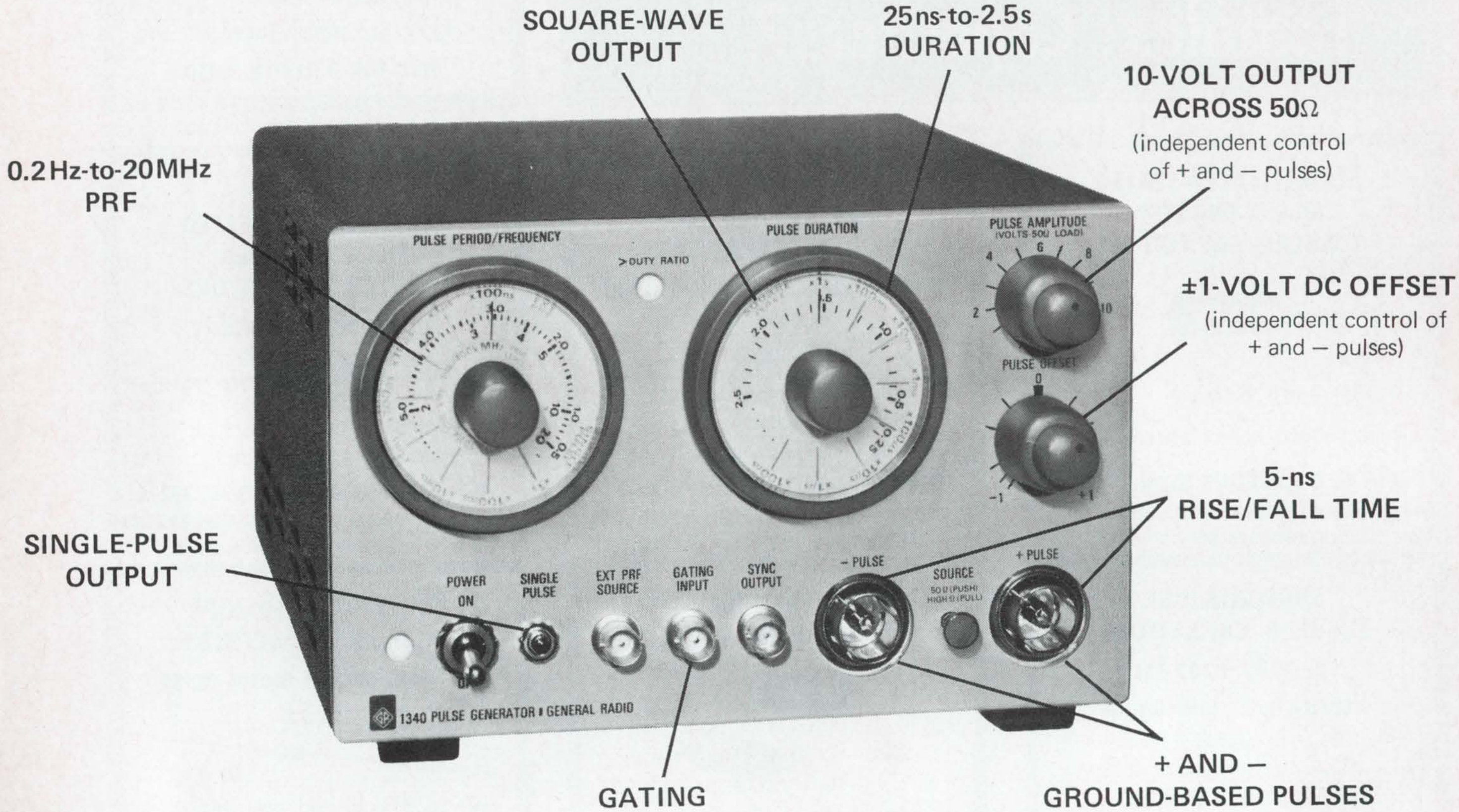

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GENERAL RADIO

tronics also does disservice to the great amount of imaginative development that has been taking place at Johns Hopkins and the great breadth of vision which their research program has shown with the sponsorship of the National Center for Radiological Health. The successful testing of its present capabilities are only the beginning, and the great needs for truly workable systems of this type in radiological medicine call for much more effort in its further development.

Richard H. Chamberlain, M.D.
Hospital of the
University of Pennsylvania
Philadelphia

Fast Fourier faulted

To the Editor:

Measurement software should be specified in functional terms in the same way as hardware instruments. Such equivalent specifications would open up the whole area of computerized approach to thousands of engineers analyzing signals from many sources.

In my job I must continually analyze complex signals, and I want the best information for the least cost. I want to look at long periods of indescribably wiggly lines, and I want an answer to "what's there" in nonmathematical terms. And my measurement problems are surely just the same as thousands of others. What is analysis cost per data point? Is there a software package for an autocorrelation algorithm that acquires statistical validity by integration instead of iteration? Can't we get a tradeoff among accuracy, signal duration, frequency, random versus continuous signals, and cost? Where is the linear-digital crossover point?

These questions are easily answered when the usual laboratory instruments are applied to problems in signal analysis, because instrument manufacturers supply pages of good hard specifications with their products. General-purpose computers can provide the same measurements on the same signals—yet the tradeoffs cannot be made, because the specifications on the software are not available.

This is where the Cooley-Tukey fast Fourier transform fails us. It was originally reported in an obscure journal that most programers never heard of. Now that it's been more widely reported, in Electronics and elsewhere, it's generating a good deal of interest.

How about hard-nosed analysis of true-to-life sloppy nonstationary discontinuous signals? These can be processed neither by Bell Labs' fast Fourier transform processor [June 24, p. 92], nor by any of its cousins that have recently appeared on the market; yet the machines all have rows of pushbuttons whose functions are rigorously specified.

Software specifications should be just as rigorous.

Henry Stude Jr.
Edgewood Arsenal, Md.

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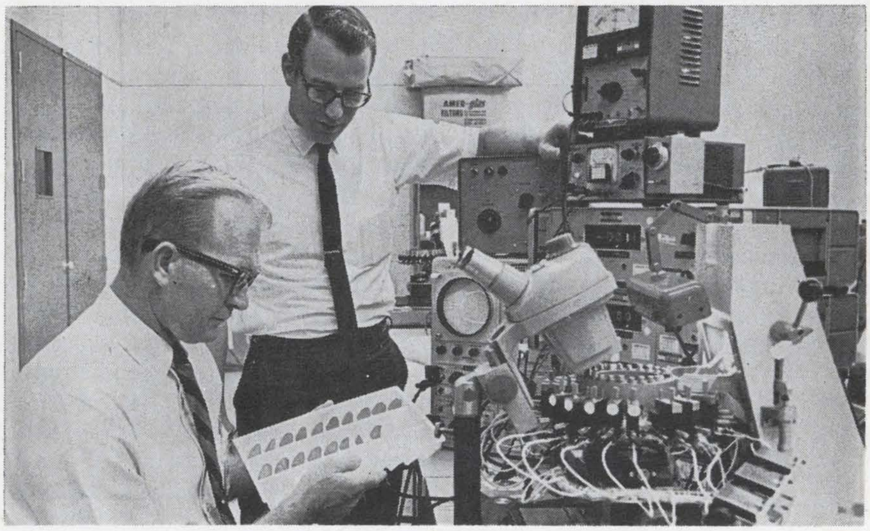
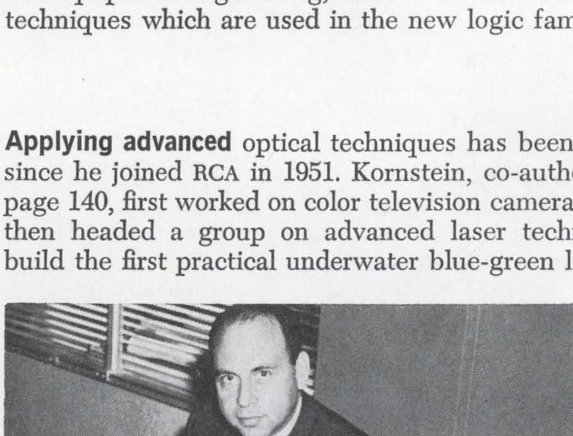


Phillips **Byrd**

Speed—a highly desirable property in integrated circuits—can create problems for the IC designer and the user. In describing the fastest IC yet, the authors of the article on page 124 outline these problems and offer suggestions for their solution.

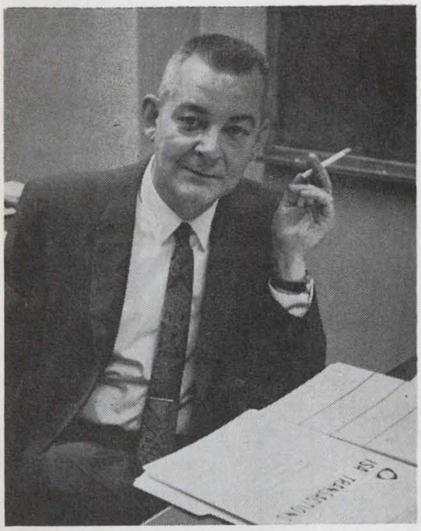
Paul M. Lee is the applications man; for six years he has advised Motorola's customers on the proper use of IC's. Before that, he designed logic for computer peripheral equipment at IBM. William H. Julitz and Marvin R. Byrd are processing specialists. Jultiz is Motorola's project manager for IC process R&D; Byrd is engineering section head in charge of the super-ECL pilot line. Curtis D. Phillips is responsible for IC pilot line equipment engineering; he has worked on the multilayer metalization techniques which are used in the new logic family.

Applying advanced optical techniques has been Edward Kornstein's job since he joined RCA in 1951. Kornstein, co-author of the laser article on page 140, first worked on color television cameras and optical processing, then headed a group on advanced laser technology. He helped RCA build the first practical underwater blue-green laser and develop a laser range finder for field use by the Army. Kornstein holds a master's degree in physics from the Drexel Institute of Technology.



Kornstein **Wetzstein**

Hanns Wetzstein, with RCA for more than six years, has concentrated in recent years on measurement and detection problems connected with finding submarines in the ocean. He holds a D.Sc. degree in electrical engineering from Harvard University.



Ross

Thoroughly immersed in control schemes in his position as director of the systems analysis department of the Leeds & Northrup Co., Charles W. Ross works on and guides advanced simulation, measurement, and control projects. He is the author of the article on the use of hybrid computers in the design of industrial control systems, page 132. In the past, Ross developed supercritical-boiler, electric-power, and cement-plant control systems. These projects required theoretical and applied studies, and included nonlinear, adaptive, optimizing, and all-digital control techniques.

Gundlach

What started out as a short article on yttrium iron garnet has ended up as a series on ferrites, beginning with the 15-page special report by Richard Gundlach on page 104. Gundlach, the military electronics editor of this magazine and the holder of a B.S. in applied physics from Adelphi University, is aiming these articles at the engineer who wants to know more about ferrites. He also did all of the drawings and cartoons for the article.

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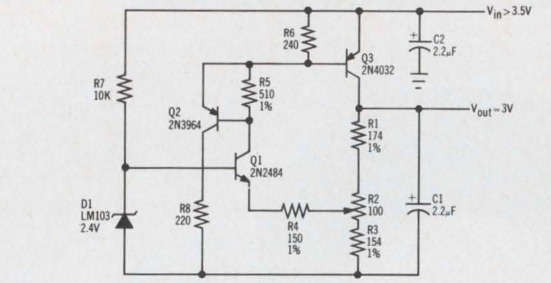
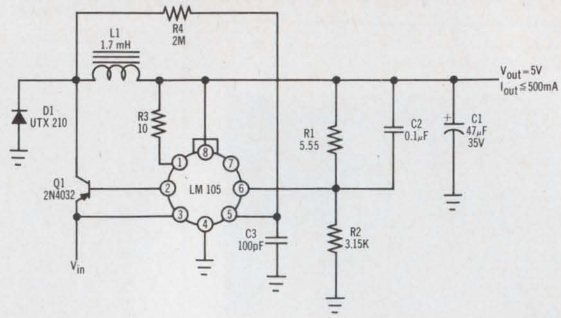
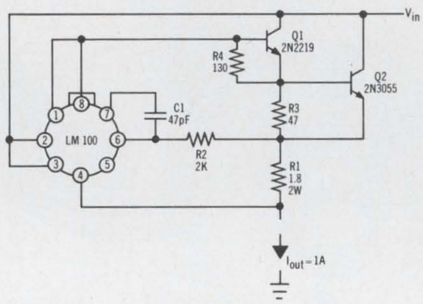


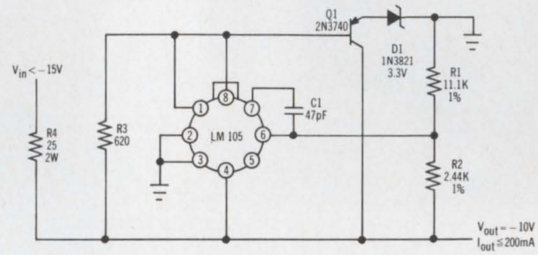
SWITCHING REGULATOR



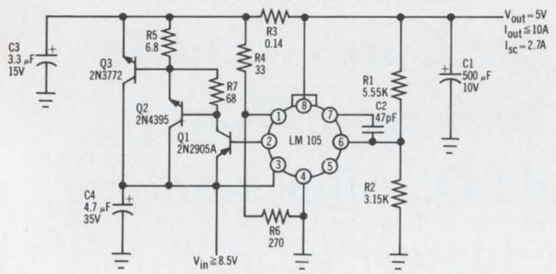
CURRENT REGULATOR



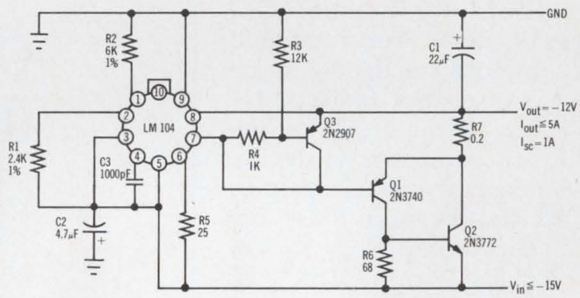
SHUNT REGULATOR



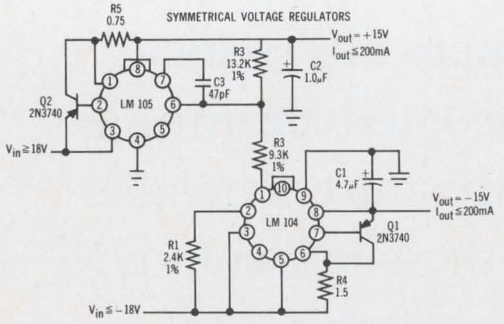
HIGH CURRENT REGULATOR WITH FOLDBACK CURRENT LIMITING



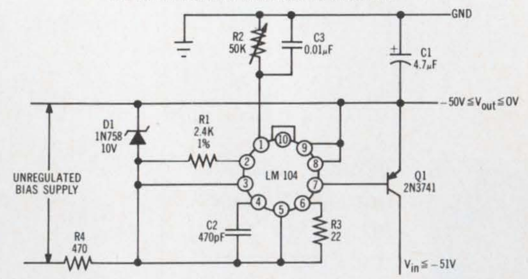
NEGATIVE REGULATOR WITH FOLDBACK CURRENT LIMITING



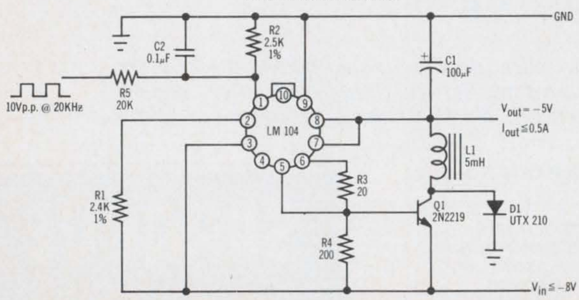
SYMMETRICAL VOLTAGE REGULATORS



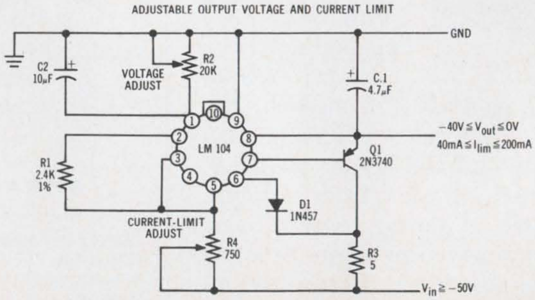
HIGH VOLTAGE REGULATOR USING FLOATING BIAS SUPPLY



DRIVEN SWITCHING REGULATOR



ADJUSTABLE OUTPUT VOLTAGE AND CURRENT LIMIT



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TAA300

A unique 1 W thermally compensated class-B audio output amplifier. It requires no external impedance matching resistors and no output transformers. Its current drain is only 8 mA from a 9 V battery, and it works with less than 10 % distortion even with battery voltage variations of more than 2 : 1. Only 10 mV drive is needed for full 1 W output into a standard 8 Ω speaker. In 10-lead TO-74 envelope.

TAA320

Another original audio pre-amplifier circuit, which combines a MOS FET input transistor with a bi-polar output on a single chip. Its input impedance is at least 100 GΩ. Should you need a lower input impedance, there is also the TAA310. The TAA320 comes in a 3-lead TO-18 envelope. The TAA310 is supplied in a 10-lead TO-74 envelope.

TAA450

This circuit forms a complete FM IF amplifier, limiter, ratio detector, and audio pre-amplifier with 2 V (peak-to-peak) output for driving tube or semiconductor circuitry. Another circuit, the TAA570, is available with a simple quadrature detector and an audio pre-amplifier section. The TAA450 is supplied in a 10-lead TO-74 envelope. The TAA570 comes in a variant of the 10-lead DIL envelope.

TAA500

A unique audio amplifier circuit with a common output and D.C. supply line. Operation is from a current source of between 20 mA and 100 mA, and constant voltage gain is 300 over the full supply range. With an external load of 100 Ω it allows the use of ceramic piezo-electric transducers in circuits designed for carbon microphones. Can be used with dynamic microphones. Applications include mobile transmitters, aircraft communications, and telephone circuits. In 4-lead TO-12 envelope.

TAA550

Designed specifically for TV tuners using varactor diodes, this device out-performs any stabilizing circuit employing discrete components. It stabilizes a 33 V supply with a temperature coefficient of 50 p.p.m./°C. Contained in a 2-lead TO-18 envelope.

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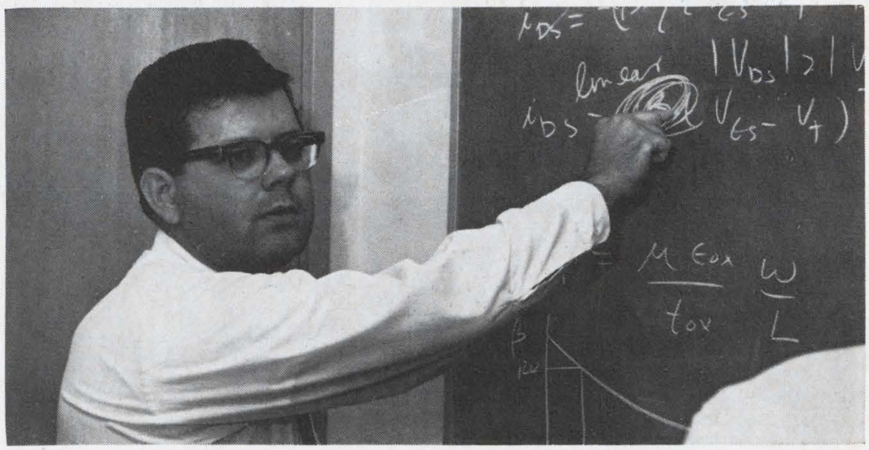
Who's Who in electronics



Thiels

"We're not out to butt heads with the Big Three semiconductor manufacturers, nor will we be a me-too outfit," says Roy Thiels, new manager of metal oxide semiconductor circuit development at the Union Carbide Corp.

Thiels, who was formerly with Texas Instruments, says Union Carbide's Electronics division will break into the MOS market with a circuit that can take up to 150 volts on a gate without protective devices. The closest rival this circuit will have is an MOS device from the General Instrument Corp. that takes up to 40 volts on an unprotected gate. The key to the 150-volt capability, according to Thiels, is a high-integrity oxide process.

First assignment. Thiels' main job initially will be to push existing discrete MOS products, including junction effect, field effect, and p-channel bipolar transistors, through the company's production lines in San Diego. "It will be some time before we can work into depletion-mode, r-f, or MOS large-scale integrated devices," he says.

Union Carbide has recently developed an n-channel, enhancement-mode IC with a controllable threshold and an output breakdown of greater than 150 volts. Thiels says the device will be used as a Nixie-tube driver, and adds that bipolar IC's used for this function have been found wanting. "Their breakdown level is 55 to 60 volts," he explains, "and the user still has to use a pre-biasing network."

Next year will see the development of a 200-bit MOS IC shift register with single-layer metalization and a chip size of under 150 mils, Thiels says. Also in the works is a 2,048-bit read-only memory. Union Carbide, he states, will steer away from multiphase clock schemes and build devices that can interface directly with a customer's bipolar system.

C. Robert Wieser, the new assistant director (defense systems) in the Office of the Director of Defense Research and Engineering, supports, naturally enough, the Sentinel antiballistic missile system. But the reason for his support goes beyond the obvious military arguments.

Wieser, former deputy director of MIT's Lincoln Laboratory, thinks the billions of dollars slated for Sentinel will help to speed advances in a host of electronics fields: radar, infrared, acoustics, telemetry, and many others. The scientist, who has a master's in electrical engineering from MIT, says, "Money determines not what gets done, but the rate at which it gets done."

In his defense of the $5 billion "thin wall" network—and he finds he has to maintain a ready list of arguments to fend off a continuing parade of critics—he maintains that

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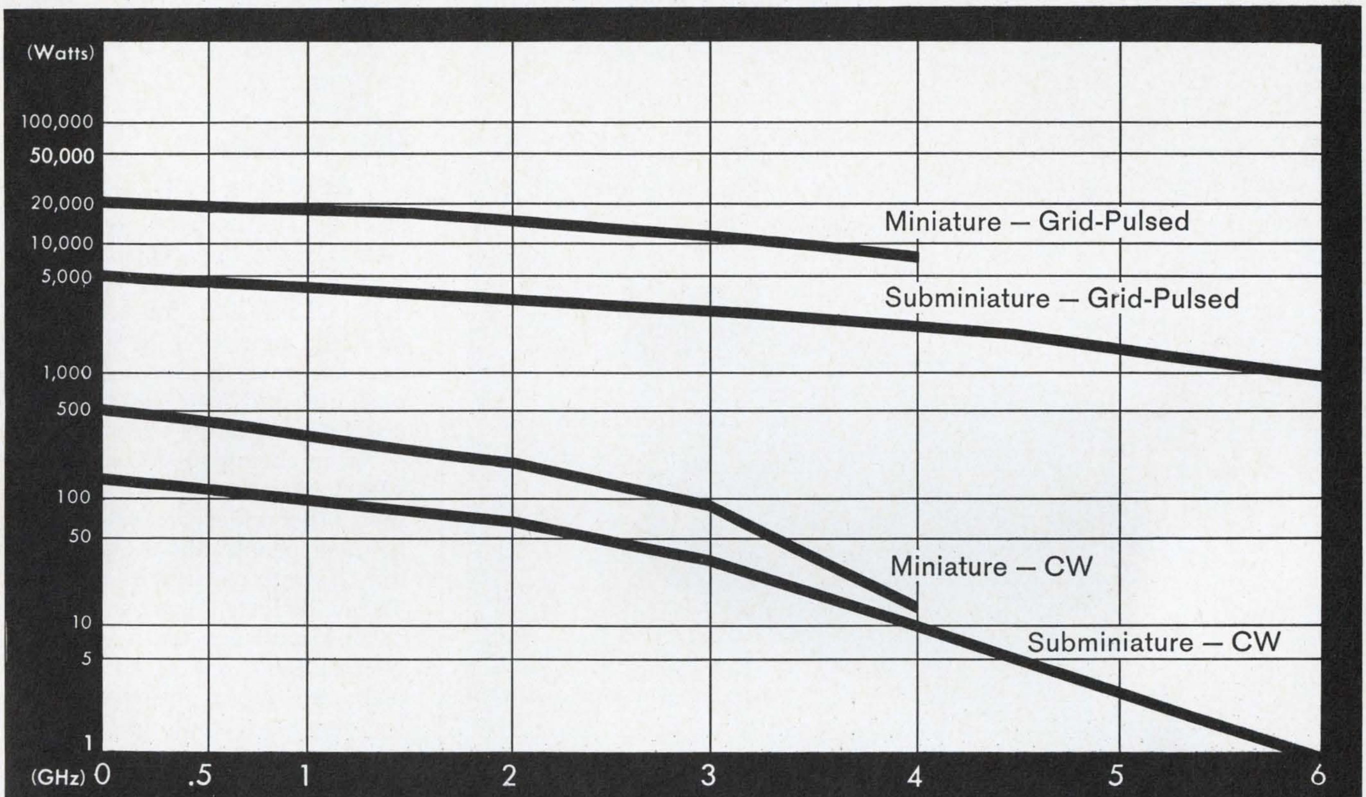

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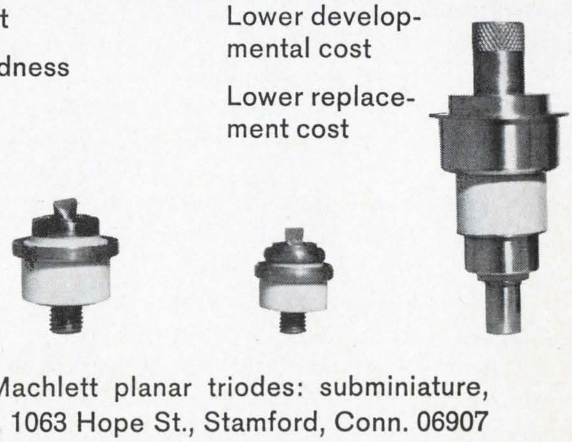

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Who's Who in electronics

Wieser

Sentinel is big enough to stop Russian missiles and isn't the last step toward a nuclear holocaust.

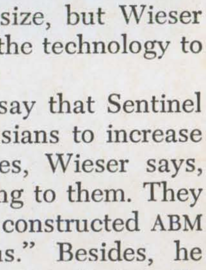
Protection. "People object to such a defensive system because they say it won't work, but they never say what they mean by 'work,'" Wieser says. "They look for an absolute umbrella or shelter to hide under and get upset if the defense isn't absolute, but you can't have an absolute defensive system.

"If an enemy spends all his missiles to get through to New York, then other cities are spared. This irritates people about defense but they have to consider the choices." Today, he feels, "You can't just add 1,000 Minutemen and feel secure." Nor can the U.S. keep conceiving of elaborate paper systems without building any actual missile defense systems.

Since Sentinel is a modular system, he says, it won't become obsolete. "It should be expanded and probably will," he adds.

The biggest problem with Sentinel is its sheer size, but Wieser says the U.S. has the technology to build it.

To critics who say that Sentinel will force the Russians to increase their missile forces, Wieser says, "We are responding to them. They have deployed or constructed ABM sites ahead of us." Besides, he notes that when the semiautomatic ground environment defense system was built (he was design group leader for it at MIT), the Russians did not increase their bomber force.



Lee

When Lee Loevinger finished his term on the FCC last June, the cable-television industry started to worry.

Loevinger was the commis-

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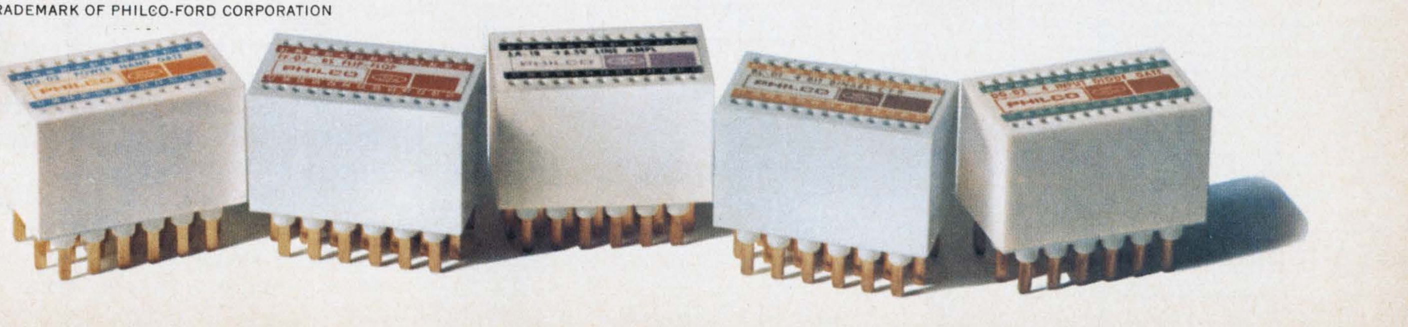

sion's strongest champion of CATV; he firmly maintained that the FCC's regulations were strangling cable technology. His staunchest ally on the seven-member commission has been Robert Bartley. Nicholas Johnson has also been friendly to CATV, believing that it has tremendous potential in serving society, particularly minority groups. Chairman Rosel H. Hyde and commissioner James J. Wadsworth, both Republicans, have generally been middle-of-the-roaders, while Kenneth A. Cox and Robert E. Lee, who favor over-the-air broadcasting, have opposed CATV expansion.

Loevinger's replacement, H. Rex Lee, says he's too new to the communications area to voice an opinion on cable versus over-the-air tv, but his background indicates that he'd probably be sympathetic to CATV—at least so far as educational programing is concerned. And this sympathy could be expected to widen to CATV in general.

Lee, 58, a Democrat, is a career civil servant; he was most recently assistant administrator for the Agency for International Development. From 1961 to '67 he was governor of Samoa, and one of his first and most important projects on the islands was to install an educational tv system.

For the ghettos. Lee evidently knows his way around Congress. Within a few months of getting to Samoa, where he found the school system almost worthless, he had gotten Congress to approve a $2-million, six-channel educational tv system for the 9,000 students on the five islands. The system was also for adult education and some entertainment in the evenings. Operating on 50,000 watts, the over-the-air system could be picked up in the independent island nation of Western Samoa.

"Many things we accomplished in Samoa with our tv system could have application not only in developing countries but in American areas as well, including the ghettos," says Lee.

Obviously, any U.S. educational or public-service programing designed to reach only certain audiences would use cable systems.

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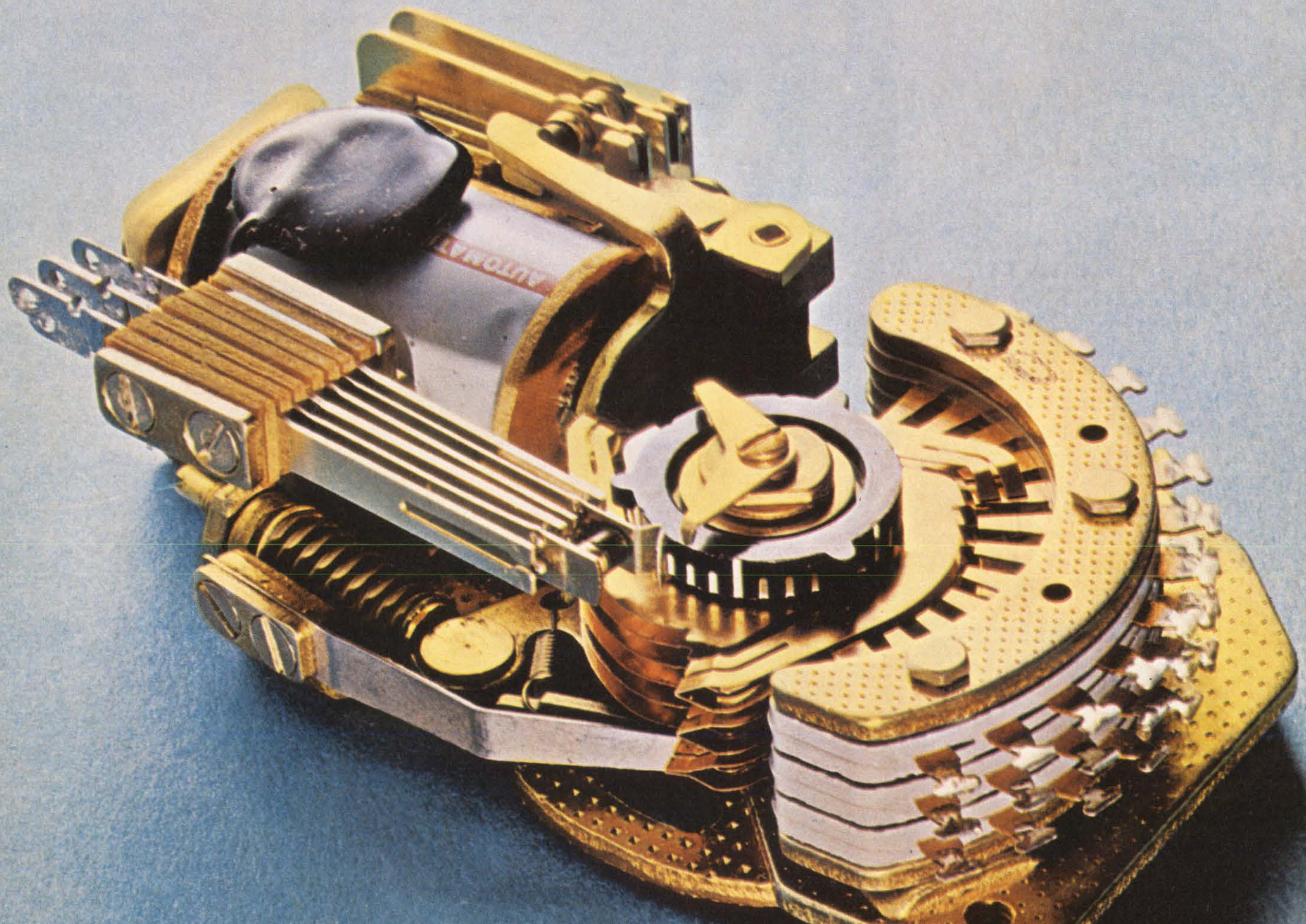

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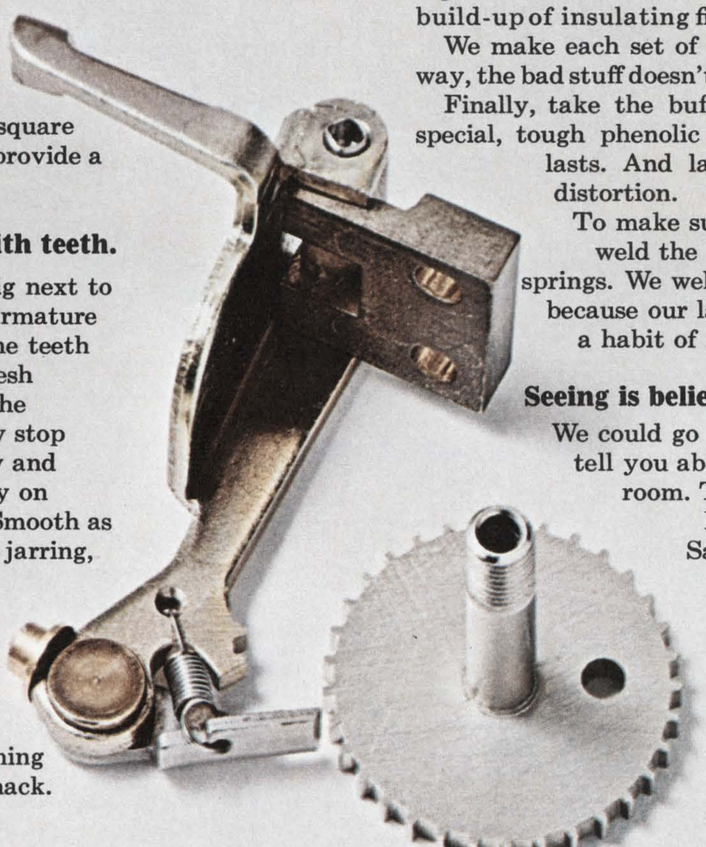
The ratchet wheel is a little different. The way it's made, for one thing. First, we blank it. Next, shave it. And finally, case-harden it. Then it's super strong.

Notice the big, square teeth that always provide a sure bite.



A thingamajig with teeth.

That thingamajig next to the wheel is the armature assembly. When the teeth on the end of it mesh with the teeth on the ratchet wheel, they stop the wiper assembly and position it precisely on the contact bank. Smooth as silk, every time. No jarring, no jamming, no banging.

No adjustments, either. As the teeth wear, they just drop further into the wheel. So nothing ever gets out of whack.

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The other thingamajig.

It's called a contact spring. We've got some strong feelings as to what makes a contact spring strong.

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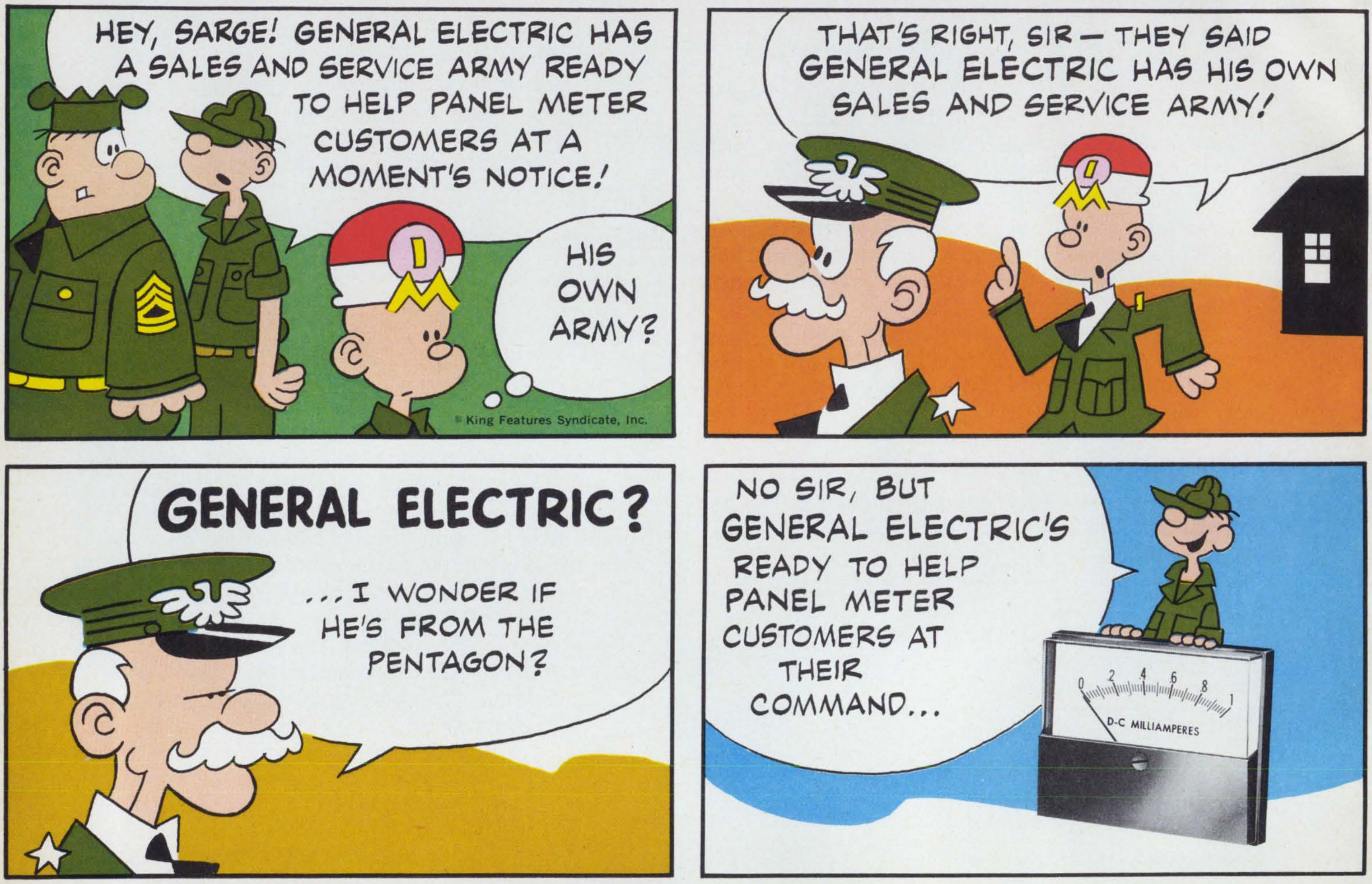

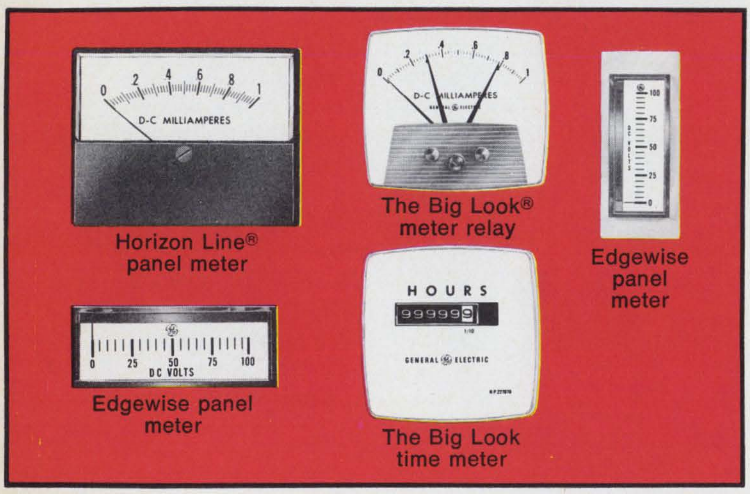

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GENERAL ELECTRIC

Meetings

Nerem dropping its 'second-hand' image

The Northeast Electronics Research and Engineering Meeting is shedding its long-standing reputation of being a stepchild of the IEEE and Wescon shows. A paper presented at Wescon in August is no longer likely to show up at Nerem in November, partly because Nerem's technical program committee is rooting out such papers with more vigor each year, and partly because Nerem is attracting a more national audience —and engineers won't travel across country to hear papers they've heard before.

This year's meeting, Nov. 6 to 8 in Boston at the Sheraton-Boston Hotel and the War Memorial Auditorium next door, features a 25-session technical program as well as four applications sessions on topics ranging from logic circuits to time-sharing computers.

High spots. Nerem's most interesting sessions are those on microwave integrated circuits, metal oxide semiconductors, linear IC's, and hybrid IC's. Another session, on "microsound" circuit elements, gives official recognition to an effort that's been restricted to the lab but now seems about to enter the applications stage.

A paper presented by ITT engineers Charles Greenwald, Raymond Barklow Jr., and Edwin Zaratkiewic, should interest those looking for an inexpensive way to produce microwave IC's. The three will discuss the screen printing of thick-film microwave circuit elements, a technique long used by makers of plastic potentiometers to "print on" resistor elements inexpensively. It's a method the ITT men feel can be adapted to the production of transmission lines, loads, capacitors, and other microstrip circuit elements even though dimensional tolerances are very tight for MIC's.

Frank E. Emery of Texas Instruments will close the MIC session with a paper covering such exotic circuits as Gunn oscillators and Schottky-barrier devices made epitaxially on gallium-arsenide substrates, and a mixer that uses gallium-arsenide active elements on a sapphire substrate.

In the session on metal insulated semiconductor systems and circuits, D.L. Critchlow of IBM will explain why he believes the n-channel, insulated-gate field effect transistor has more potential than the far more widely used p-channel device. Cost and processing problems have held back the n-channel version, he says, but these factors have now been overcome. Use of the n-channel device should give logic and memory designers "more flexibility," he maintains, and may result in even less power dissipation than with p-channel devices.

Passively active. At the same session, three Westinghouse engineers, C.J. Varker, B.V. Keshavan, and H.C. Lin, will describe a metal-nitride-oxide-silicon multifunction device they claim shows promise both as an active or passive element, and which offers a nonvolatile memory characteristic. Such a device could lead to a nonvolatile active memory—which sounds like a contradiction, but exists in a nonvolatile resettable timer developed for the Army by Westinghouse's Molecular Electronics division.

The linear IC session underlines the recent widespread introduction of monolithic IC voltage regulators; three of the four papers at this session will cover such circuits, at least one of which uses pnp and npn and transistors on the same chip.

Two of the three papers at the session on hybrid IC's are tutorial, but the third details the beam-lead substrate technique developed by MIT-Lincoln Laboratory [Electronics, Aug. 19, p. 52]. Robert E. McMahon and Ronald A. Cohen will describe how they apply beam leads and an upside-down flip-chip approach to inexpensive monolithic IC's.

A session on artificial-heart research provides an overview of the field. And a team from New York University, G.H. Myers and G.E. Read, will discuss experiments aimed at transmitting energy to power a heart through intact skin

Meetings

(Continued from p. 23)

using, variously, ultrasonic, magnetic, and electrical means.

Lowdown. Because sound waves travel far more slowly than electromagnetic waves, conversion of electronic signals to acoustic ones would make possible miniature components that could handle the shorter wavelength. Nerem's session on microsound covers transducers, amplifiers, and even acoustical microcircuits. G.R. Pulliam of Autonetics will discuss the epitaxial fabrication techniques that may make such microcircuits possible, and the variety of materials needed —piezoelectric for transducers, ferroelectric, ferromagnetic, or semiconductor for amplification, and low-loss materials for transmission lines.

A team from Stanford University, B.A. Auld, J.H. Collins, and H.J. Shaw, will describe surface-wave transducers, while R.M. White of the University of California at Berkeley will discuss amplifiers. The session ends with a talk by Herbert Matthews of Sperry Rand's research center on the acoustic equivalents of such elements as isolators and circulators—the nonreciprocal elements needed to make microsound circuits operable.

For more information, write IEEE/Nerem, 31 Channing St., Newton, Mass. 02158.

Calendar

Conference on Electrical Insulation and Dielectric Phenomena, National Academy of Sciences—National Research Council; The Inn, Buck Hill Falls, Pa., **Oct. 20-23.**

Meeting and Technical Display, American Institute of Aeronautics and Astronautics; Philadelphia Civic Center, Philadelphia, **Oct. 21-25.**

Shock and Vibration Symposium, Naval Research Laboratory; Asilomar Conference Grounds, Pacific Grove, Calif., **Oct. 22-24.**

International Electron Devices Meeting, IEEE; Sheraton Park Hotel, Washington, **Oct. 23-25.**

(Continued on p. 26)

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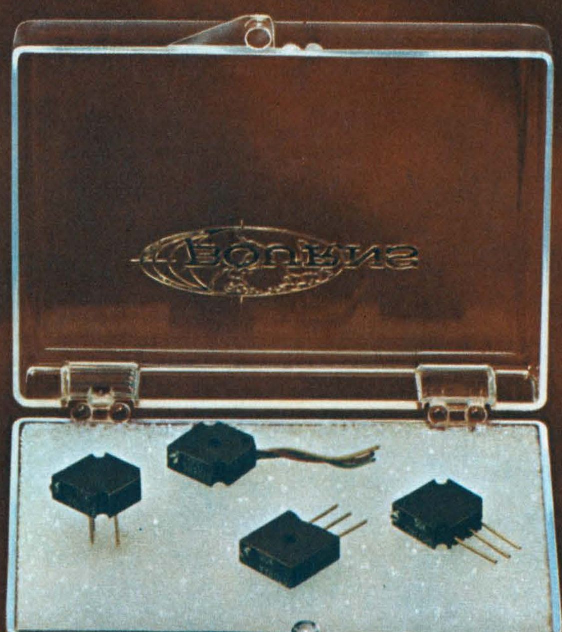

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Meetings

(Continued from p. 24)

Nuclear Science Symposium, IEEE and United States Atomic Energy Commission and Atomic Energy Commission of Canada; Bonaventure Hotel, Montreal, Canada, **Oct. 23-25.**

Seminar in Depth—Image Information Recovery, Society of Photo-Optical Instrumentation Engineers; Benjamin Franklin Hotel, Philadelphia, **Oct. 24-25.**

Instrument Automation Conference and Exhibition, Instrument Society of America; Hilton Hotel, New York Coliseum, N.Y., **Oct. 28-31.**

Machine Tools Industry Technical Conference, IEEE; Wagon Wheel Lodge, Rockford, Ill., **Oct. 28-30.**

Applied Superconductivity Conference and Exhibition, Oak Ridge National Laboratory; IEEE and American Physical Society, Gatlinburg, Tenn., **Oct. 28-30.**

Symposium of the American Vacuum Society; Pittsburgh Hilton Hotel, **Oct. 30-Nov. 1.**

Product Assurance Conference and Technical Exhibit on Reliability, Standard Maintainability and Parts-Materials Packaging, IEEE and Standards Engineers Society; Waldorf-Astoria Hotel, New York, **Nov. 2-3**

American Institute of Ultrasonics in Medicine; Monteleone Hotel, New Orleans, **Nov. 4-7.**

West Coast Conference on Broadcasting, IEEE; Ambassador Hotel, Los Angeles, **Nov. 6-8.**

Northeast Electronics Research and Engineering Meeting (Nerem), IEEE; Sheraton Boston Hotel, Boston, **Nov. 6-8.**

Conference on Speech Communication and Processing, IEEE; Massachusetts Institute of Technology, Cambridge, Mass., **Nov. 6-8.**

Seminar on Electric Contact Phenomena, Illinois Institute of Technology; Sherman House, Chicago, **Nov. 11-15.**

Automatic Support Systems Symposium for Advanced Maintainability, IEEE; Sheraton-Jefferson Hotel, St. Louis, **Nov. 12-14.**

Conference on Thermal Conductivity, Department of Commerce; National Bureau of Standards, Gaithersburg, Md., **Nov. 13-15.**

(Continued on p. 28)

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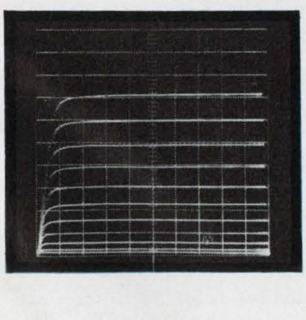

Definition	2N5452
Offset Voltage	5 mV Max.
Offset Voltage Drift —55° to +125°	5 μV/°C Max.
Output Admittance at f = 1 kHz	0.35 μmho Typ. 1.0 μmho Max.
Output Admittance Match at f = 1 kHz	0.05 μmho Typ. 0.25 μmho Max.

All Parameters measured at V_{DS} = 20V, I_D = 200 μA

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Meetings

(Continued from p. 26)

Analytical Symposium Advanced Technical Program, American Chemical Society, Society for Applied Spectroscopy, American Microchemical Society; Statler Hilton Hotel, New York, **Nov. 13-15.**

Meeting of the Anti-Missile Research Advisory Council, Advanced Research Projects Agency and the U.S. Naval Postgraduate School; Monterey, Calif., **Nov. 14-16.**

Symposium on the Applications of Lasers to Photography & Information Handling, Society of Photographic Scientists and Engineers; Airport Marina Hotel, Los Angeles, **Nov. 14-15.**

Conference on Engineering in Medicine & Biology, Biomedical Engineering Society; Shamrock-Hilton Hotel, Houston, **Nov. 17-20.**

Short courses

Oceanic instrumentation & communication, University of California, Los Angeles, **Oct. 21-Nov. 1;** $375 fee.

Reliability engineering and management, University of Arizona, Tucson, **Nov. 4-13;** $275 fee.

Modern small digital computers, University of Wisconsin's Department of Engineering, Madison, **Nov. 14-15;** $70 fee.

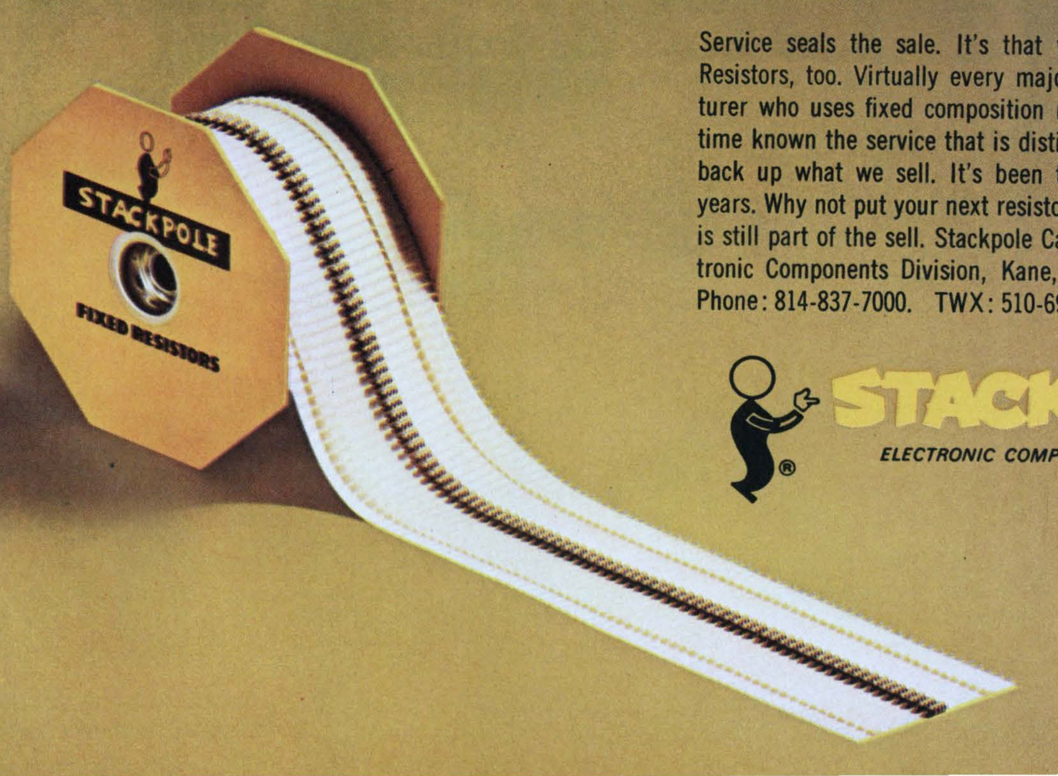
Call for papers

Geoscience Electronics Symposium, IEEE; Marriott Twin Bridges Motor Hotel, Washington, April 16-18, 1969. **Jan. 1** is deadline for submission of abstracts to M.E. Ringenbach, director, Equipment Development Lab., U.S. Weather Bureau, Room 201—Gramax Building, 8060 13th St., Silver Spring, Md. 20910

Electrical and Electronic Measurement and Test Instrument Conference, IEEE; Skyline Hotel, Ottawa, May 5-7, 1969. **Jan. 15** is deadline for submission of abstracts and summaries to Dr. George E. Schafer, Institute for Basic Standards, National Bureau of Standards, Boulder, Colo. 80302

International Communications Conference, IEEE; University of Colorado, Boulder, June 9-11, 1969. **Jan. 1** is deadline for submission of papers and abstracts to Dr. Martin Nesenbergs, Environmental Science Services Administration, Institute for Telecommunication Sciences, R614, Boulder, Colo. 80302

MOST RESISTORS ARE PRETTY MUCH ALIKE IT'S THE NAME BEHIND THEM THAT COUNTS



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Editorial comment

For NASA: days of decision

Despite a history of unprecedented successes, NASA enters its second decade burdened by doubts, uncertain of its role. In the past, the agency's tasks were primarily mission-oriented. In the future this could change, partly as a result of the current deemphasis on space programs and the concentration on aeronautical research (V/STOL and the like). Moreover, the agency has built up an enviable bank of advanced technology and management techniques that some observers think can be applied to solve a variety of critical problems.

It has been proposed that NASA's experience be brought to bear on urban problems such as pollution control and transportation—either by letting the agency itself tackle those jobs or through formation of a second superagency that would exploit NASA's technological know-how and emulate its management of large-scale endeavors.

Ironically, "uncertain and unusual times" are blamed by NASA officials for the drastic curtailment of its funds and programs. James E. Webb, who issued a surprise announcement of his retirement as head of the space agency last month, blames the war in Vietnam, the peace talks in Paris, the problems of the cities, doubts about Soviet intentions, inflation and the balance of payments, and the uncertainties of an election year for putting the U.S. and its space program in "a position from which it is most difficult to chart a clear and certain course for the future."

Budget costs have forced drastic reduction of NASA's work force from about 400,000 three years ago to an estimated 200,000 at the end of this fiscal year. The decision to cut back NASA programs, Webb and other experts assert, puts the U.S. in the position of accepting all the disadvantages of a second-rate nation in space.

Nevertheless, top NASA planners are optimistic about holding together the agency's senior management group so that programs can be reactivated when and if the funds become available. At the same time they're trying to pin down the reasons for NASA's successes and to analyze its shortcomings. Webb, in addressing the John Diebold Lecture at the Harvard Business School on Sept. 30, identified NASA programs as having these distinguishing features:

- Multiple objectives. They include studying the space environment by means of sounding rockets, earth satellites and deep space probes; manned exploration of space; searching for extraterrestrial life; expanding space technology to promote human welfare, and applying it to national defense.
- Work at the frontiers of knowledge. This requires facilities and equipment much of which is without precedent.
- Long lead times. A span of years may be needed between conception and conclusion of a mission. Space projects cannot always be "slipped" in the conventional way. For example, during the 1970's, the planets will line up in such a way as to encourage deep space exploration.
- High reliability. The risks to human life and the public's concern over each mission allow few second chances.
- Persistent and exacting scrutiny. The agency is watched by the mass media, the public, Congress, and the scientific community.
- A complicated dependence of programs on the political mood.
- The crucial role of feedback and quick response to feedback in all phases of planning and operation.

It is clear that not all of these characteristics are unique to the space program. Webb himself noted that they appear whenever the nation undertakes an unusually complex task requiring a concentration of large and diverse human and material resources, and involving the supply of fresh knowledge and advanced technology.

For NASA the race to the moon was a bonus that may be hard to match when the agency turns to urban problems. Yet it would make sense to tackle them as an integrated whole with an awareness of all their interrelationships.

In the end, Congress and the new administration must face up to reformulating the nation's long-term goals, determining NASA's role, and deciding whether a new NASA-like agency is needed to rule over nonspace projects. Without such direction, the agency could undergo serious deterioration in plant (now estimated to be worth $4 billion), personnel and morale.

By the time that NASA's budget is finalized (the agency is now operating on an interim plan) it may be reduced to a figure of about $3.8 billion. Although this is a far cry from its peak of $5.2 billion in fiscal 1965 and 1966 and a billion or two below what Thomas Paine, the agency's acting chief, would like to see, it is still a whopping lot of money to spend.

But without guidance NASA could spread its resources too thin—wasting them on projects that will be curtailed, and inadequately supporting more important ones.

←Circle 30 on reader service card

To solve some sticky ferrite problems, we're pressing tubes and rods up to 20 inches.

The old way of making large ferrite parts is simple: epoxy or glue small ferrites together. But the resulting problems aren't so simple. Magnetic characteristics suffer. Costs are high. And delivery schedules are excessive.

Now, new pressing and firing techniques let Indiana General make single piece large parts. Up to 35 lbs. And in giant sizes, like 10″ sq. x 2″ plates, 3″ dia. x 20″ rods, and 6″ O.D. x 4″ I.D. x 20″ tubes.

Our large ferrite parts have opened up new design opportunities in oceanography. VLF communications applications, in the 10 to 80 kc range, need large ferrite parts for higher power. And our new sizes, in Ferramic® O-5, deliver the massive "brute wave forces" to penetrate denser-than-air media with none of the problems of epoxied ferrite assemblies. O-5's high permeability results in higher sensitivity in antennas where signal strength dissipates rapidly.

So instead of looking high and low for high power, low frequency antenna ferrites, look to Indiana General. Where we keep magnetics problems from making you come unglued. For technical information on our new large ferrite parts capability, write Mr. K. S. Talbot, Manager of Sales, Indiana General Corporation, Electronics Division/ Ferrites, Keasbey, New Jersey.

INDIANA GENERAL
Making Magnetics Work.

Electronics Newsletter

October 14, 1968

Ion implantation gets official nod at Hughes Aircraft

Researchers at Hughes Aircraft will soon be ready to commit ion-implantation techniques to production in both metal oxide semiconductor and avalanche diode (impatt) devices. Samples of a dual 25-bit, two-phase shift register with a speed of 30 megahertz should be ready in six months. That's about 20 Mhz faster than present speeds for MOS shift registers, Hughes officials say. **The Hughes technique reduces parasitic capacitance of the MOS devices by as much as five, allowing a corresponding speed increase.** Projected performance for the shift register is based on tests on a nine-stage MOS integrated-circuit ring oscillator showing an average propagation delay of 4 to 4.5 nanoseconds, versus 20 to 25 nanoseconds for a similar device made on the same wafer with only diffusion techniques.

Ion-doped impatt diodes generating 1.5 watts at X band (9 to 11 gigahertz) have already been made, and a Hughes spokesman says it's "a real fight" to get beyond the 1.1 or 1.2 watts achieved to date in impatt diodes using diffusion.

Beam-lead IC's, still on wafer, get 100% testing

Since early September, Raytheon's semiconductor operation has been performing complete a-c, d-c, and temperature tests on beam-leaded integrated circuits still on the wafer. Customers for Raytheon's flip-tab circuits—among them the Autonetics division of North American Rockwell—can now be more confident of getting only good devices in their hybrid packages.

The circuits are now tested before being etched apart, **but within a month Raytheon expects to have perfected a technique in which the dice are etched apart but held together by an acrylic "glue" during testing.** The circuits must be etched apart, rather than scribed, because the beam leads protrude over the edge of the chip. The test equipment, a modified version of the Fairchild instrumentation testers Raytheon already owned, remembers the location of each failed device—instead of marking it with ink, an impossibility at −55°C. This information is stored on a tape that goes to the customer along with the wafers.

Nevin Kather, head of the semiconductor operation, says that **the process is the first to perform 100% testing before packaging.**

Ferrite cores live on in memories of IBM and another firm

Most computer companies are betting on planar thin films, plated wires, or semiconductors to eventually succeed the ferrite-core memory. **But the biggest of them all appears to have put its chips on cores.** IBM has increased the performance of these standbys through the use of a high-speed buffer technique in its 360/85 computer. **And it will play this hand in the next round of 360 model announcements, expected soon.**

IBM isn't playing a lone hand, either. **A major competitor has confirmed that it, too, is betting on the ferrite core's continued viability; however, this firm is relying on advanced assembly techniques rather than on a buffer.**

Evidence of IBM's position has been building. First, a paper presented by an IBM engineer in 1967 showed how a buffer could increase the performance of the company's obsolescent 7000 series computers. Second, a paper presented this summer discussed how a conventional microsecond-range computer memory could appear to have perhaps a thousand times its true capacity when used as a buffer in front of a magnetic disk file, **indicating that the buffer idea isn't limited to a narrow speed range.**

Third, the stream of IBM papers on thin-film memory technology stopped abruptly two years ago, implying that the company has either discontinued all but the most research-oriented work in this area, or that it has launched a full-scale effort to develop plated wires or some related technology, and has cut off public pronouncements by its employees on the subject.

But the latter possibility was squelched at an IEEE meeting this summer; when asked at that time if the company was working on plated wires, an IBM spokesman—with a directness uncharacteristic of the firm—answered with a flat "no."

Top marketing man at Fairchild spurns raise for Raytheon

This month, Raytheon hired a top marketing man and a production specialist away from its next-door neighbor in Mountain View, Calif.—Fairchild Semiconductor. **They are the first executives to leave Fairchild since general manager Thomas H. Bay resigned the day after C. Lester Hogan's arrival.**

Marshall Cox spurned a Fairchild promotion to director of domestic commercial sales (meaning computer sales, Fairchild's main target) to become director of marketing for Raytheon's Components division. Jack Megarian became manufacturing manager for the division; he had been a minister without portfolio since returning to Mountain View from his post as director of Fairchild's South Portland, Maine, plant just before Hogan and a band from Motorola took over the company.

Cox's move may precipitate another reshuffle in Fairchild's marketing organization.

"Components division" is actually a misnomer for the Raytheon division. Only a month ago, Raytheon reorganized the division to comprise its nonmilitary West Coast operations: semiconductor in Mountain View, computers in Santa Ana, and marine products in South San Francisco.

Both new men will have divisional responsibilities but will concentrate, at first at least, on the semiconductor operation. This operation already has a marketing manager, A. C. Schunk.

U.S. may bar IBM from time sharing

Industry insiders say there is a good chance that the Justice Department will take legal action to force IBM out of the time-sharing business. Justice is now investigating whether IBM's substantial time-sharing operations violate a 1956 consent decree in which the computer maker was prohibited from directly operating a "service bureau business." **Even if the Justice Department decides that time sharing cannot be defined as a "service bureau," there still might be attempts to halt IBM's growth in this field.**

Grumman, charged with excess profit, sues to open files

Grumman Aircraft Engineering's suit against the Renegotiation Board is being watched closely by the aerospace and electronics industries. Using the Freedom of Information Act, Grumman is seeking access to board files to determine how the board can claim that Grumman made excess profits on Government contracts in fiscal 1965. **The Government says Grumman's position could set a dangerous precedent, because the company could also see confidential data about other manufacturers.**

Component and Circuit Design IDEAS

FROM SYLVANIA

IDEAS/*CRT Displays*

New CRT family reduces computer readout cost.

Giving the best of both worlds, Sylvania's new CRT line has performance of special tube designs with the economies of mass-production types.

When it comes to matching the high speed of modern computers the CRT readout is king. Now, Sylvania's new family of computer readout CRTs gives you the best features of CRT readout at a price you can afford.

A typical application for these tubes is shown in the photograph. Here, Ultronic Systems Corp., a subsidiary of Sylvania Electric Products Inc., uses a 12-inch tube to display stock market information and business news reports in a revolutionary desk-top display system.

The Ultronic® Videomaster™ literally makes all other stock quotation machines obsolete. In its basic mode of operation, the machine's CRT displays seventeen separate items of information about the selected stock.

In the Marketminder mode, the Videomaster will keep track of the last selling price of eighteen selected stocks. A third mode, the Limitminder, notifies the user when any of eighteen stocks reaches a preselected high or low limit. In a fourth mode, the CRT display shows the two exchange tickers most frequently used, plus news service reports. With this much data to handle, Ultronic needed a high-performance CRT.

Sylvania's needle-sharp electron gun maintains good edge resolution and provides a highly readable dis-

continued on next page

Videomaster stock market display system uses low-cost computer readout CRT to obtain crystal-clear display in a minimum of space.

This issue in capsule

play. The compact design of the 90°-deflection tube makes the all-solid-state system a real desk-top space saver. Both the 9" and 12" CRTs in the new line feature the new smaller neck diameter, reducing drive circuit requirements.

As can be seen from the table, the tubes in the new line feature either Kimcode or T-band implosion protection. For high-ambient light conditions, special optical panels can be bonded to the faceplate to improve readability. Although the table shows our standard line of computer readout tubes, keep in mind that Sylvania's extensive capabilities permit a wide range of modifications to be made at small additional cost.

In addition, we have a line of high-resolution tubes for more demanding applications.

These high-resolution tubes provide 0.003-in. line widths with center face resolution as high as 3000 lines. As with all Sylvania CRTs, variations from the specifications shown in the table are available at nominal extra cost.

CIRCLE NUMBER 300

Low cost computer readout tubes

Size	Type No.	Defl. Angle (deg.)	Approx. Screen Area (Sq. In.)	Heater (V/mA)	G2 Voltage (V)	Neck Diam. (in.)	Overall Length (in.)	Safety Protection
9"	ST-4716A	85	42	6.3/0.450	100	20mm	8.44	T-Band
12"	ST-4729A	110	74	6.3/0.450	100	0.840	9.19	T-Band
15"	ST-4730A	110	100	6.3/0.450	300	1.13	10.75	T-Band
17"	ST-4549A	114	141	6.3/0.450	300	1.13	11.25	Kimcode
20"	ST-4542A	114	184	6.3/0.450	300	1.13	12.25	Kimcode w/mount. ears
20"	ST-4545A	114	184	6.3/0.450	300	1.13	12.25	Kimcode

High resolution computer readout tubes

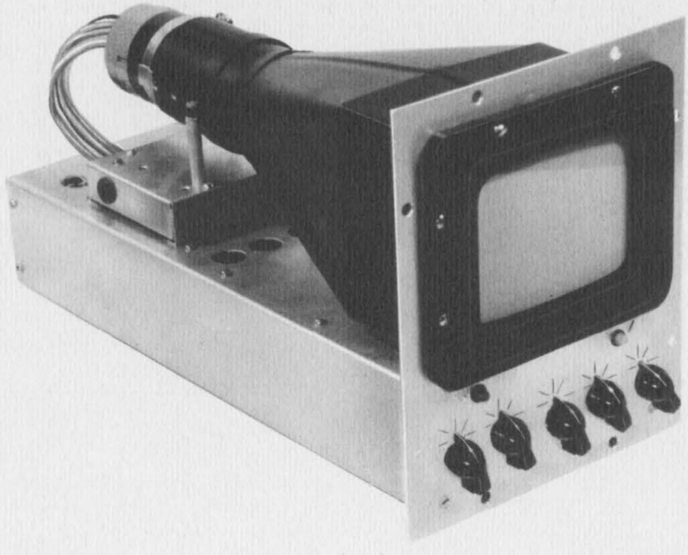
Size	Type No./ Line Width	Defl. Angle (deg.)	Approx. Screen Area (sq. in.)	*Heater (V/mA)	G2 Voltage (V)	*Neck Diam. (in.)	Overall Length (in.)
8"	SC4859/ 0.003 in.	90	35.5	6.3/600	500	1.44	11.063
12"	SC4676/ 0.003 in.	70	67	6.3/600	500	1.44	16.60
14"	SC4860/ 0.003 in.	90	100	6.3/600	500	1.44	13.19
15"	SC5017/ 0.004 in.	70	102	6.3/600	500	1.44	17.5
17"	SC4836/ 0.003 in.	70	149	6.3/600	500	1.44	18.75
21"	SC4604/ 0.005 in.	70	262	6.3/600	700	1.44	22.59

*Variations available for most types per customer specification.
Safety protection, AR treating and RFI coating as required.

IDEAS /*CRTs*

Integrated display modules save you time and money.

Why waste your design time on CRT circuits when you can get a complete integrated CRT package from Sylvania.



Complete CRT display modules can be designed to meet your space and input requirements.

You supply 1-volt inputs for the X, Y, and Z axis drives and we'll supply the rest of the package to give you a completely integrated display system.

Sylvania's modular approach to CRT systems puts the high-voltage supply, deflection circuits, filament supply and video amplifier in one compact package. Custom designs to meet special environmental requirements can also be supplied.

This modular approach can be a real time and money saver in the prototyping or breadboarding of proposed systems. In general, you'll find it less expensive to purchase the integrated modular package than to design and build the individual circuits.

You also get the assurance of quality bought by Sylvania's long experience in the design and manufacture of industrial and military cathode-ray tubes.

Our applications engineers can help you select the best off-the-shelf or special-design CRT to meet your needs.

Pricing on the Sylvania modular CRT packages is based on a one-time engineering charge and a per piece price quotation. Sylvania's Industrial and Military CRT group can supply anything from prototypes to production quantities.

CIRCLE NUMBER 301

Thick film resistors get down to 0.05% tolerance in production.

Fast precision trimming of improved materials allows you to get high-precision networks at low cost.

New materials and improved process controls have enabled Sylvania to turn the manufacture of precision thick-film resistors into a routine affair. With the new techniques, resistor tolerances can be held to 0.05% to 1% with temperature coefficients extending down to as low as 20 parts per million. Tracking of several resistors on the same substrate can be held in the range from 5 to 20 parts per million per degree C.

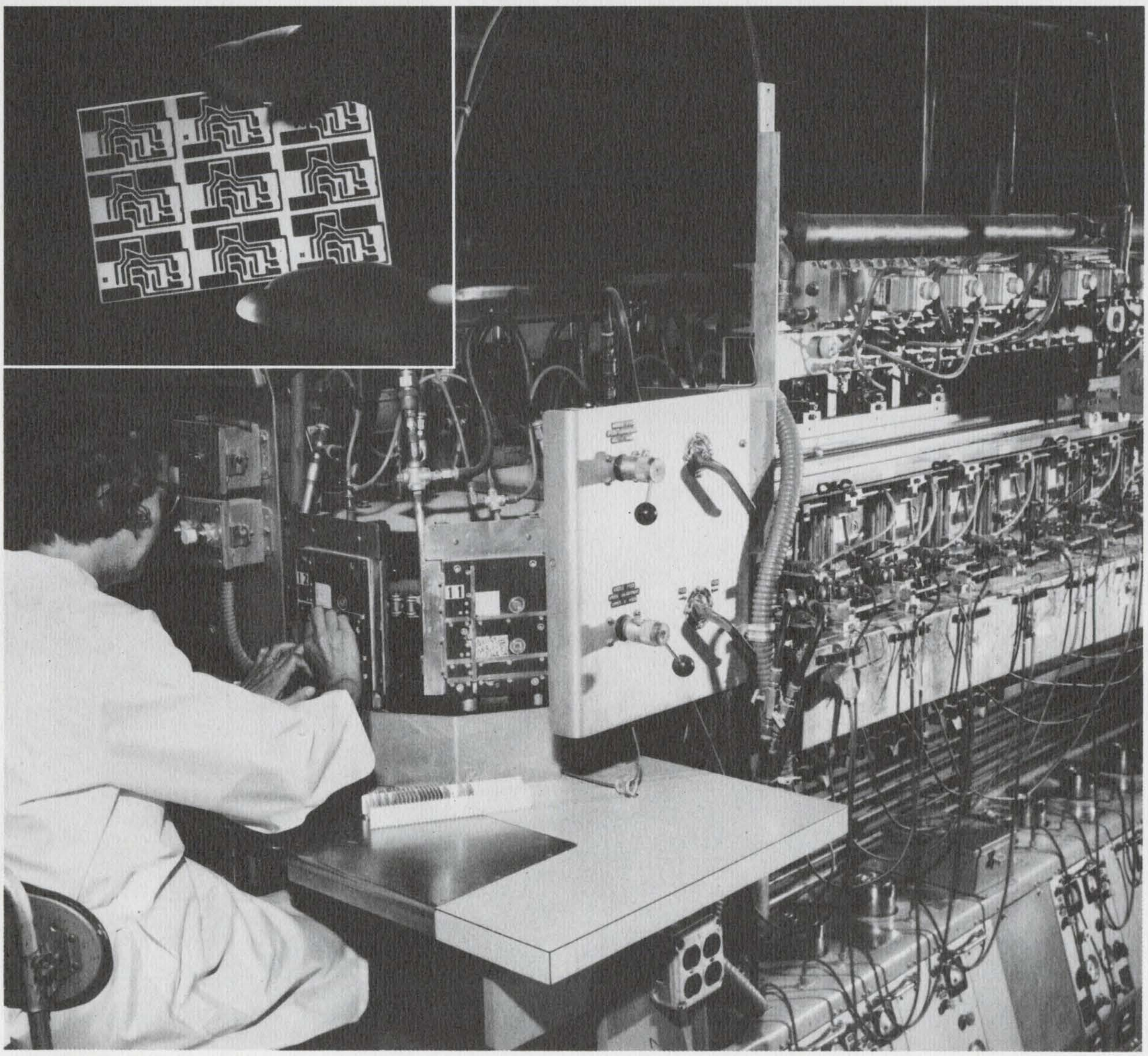
This means that ladder networks of ten to twelve bits can be made with accuracies better than the least significant bit. Similarly, step attenuators with precision of 0.1% can be obtained. R-C networks can be held to 0.25% over a broad temperature range.

And best of all, these devices can be made economically thanks to the Sylvania-developed forty-position trimming machine.

This machine incorporates precision bridges and fast-action abrasive shutoff devices to get high-speed, high-accuracy trimming. The forty-station capacity allows trimming of complex multi-resistor arrays at minimum cost.

Thick-film networks have many advantages over conventional discrete precision networks, including good thermal tracking, smaller size, lower cost, reduced weight and higher reliability. In addition, film networks can be hermetically sealed to eliminate the effects of humidity on the long-term stability of the network. This is difficult to do with discrete components of any reasonable size. Because these film networks are fabricated simultaneously from the same resistor and conductor inks, consistency of characteristics is improved. Reliability is improved by the elimination of many hand-wired connections.

CIRCLE NUMBER 302



Resistor trim machine with forty stations can trim resistors to tolerances as tight as 0.05%. Inset shows typical trimmed circuit.

Now we've boosted the Q of VVCs.

Sylvania's expanding family of voltage variable capacitor (VVC) diodes now includes units with Q's of 500 and better.

When they couldn't get the special VVCs they needed anywhere, a major manufacturer of communications equipment brought their problem to Sylvania.

They required very high-Q VVCs tightly matched into quads by capacitance change ratio for use as the tuning device in high-frequency amplifiers. Fast action was essential to meet the customer's production schedules.

A special team consisting of the customer engineers and Sylvania's engineering and production groups was rapidly formed to concentrate on a fast solution to the situation. By working closely with the user, and applying Sylvania's diode know-how, the required quantities were supplied on time. And the result is a new series of VVC diodes in the Sylvania line.

This high-Q series features typical Qs in excess of 600 and a choice of capacitance values from 4.0 pf to 33.0 pf, nominal. Tuning ratios are closely controlled to the typical values shown in the characteristics table.

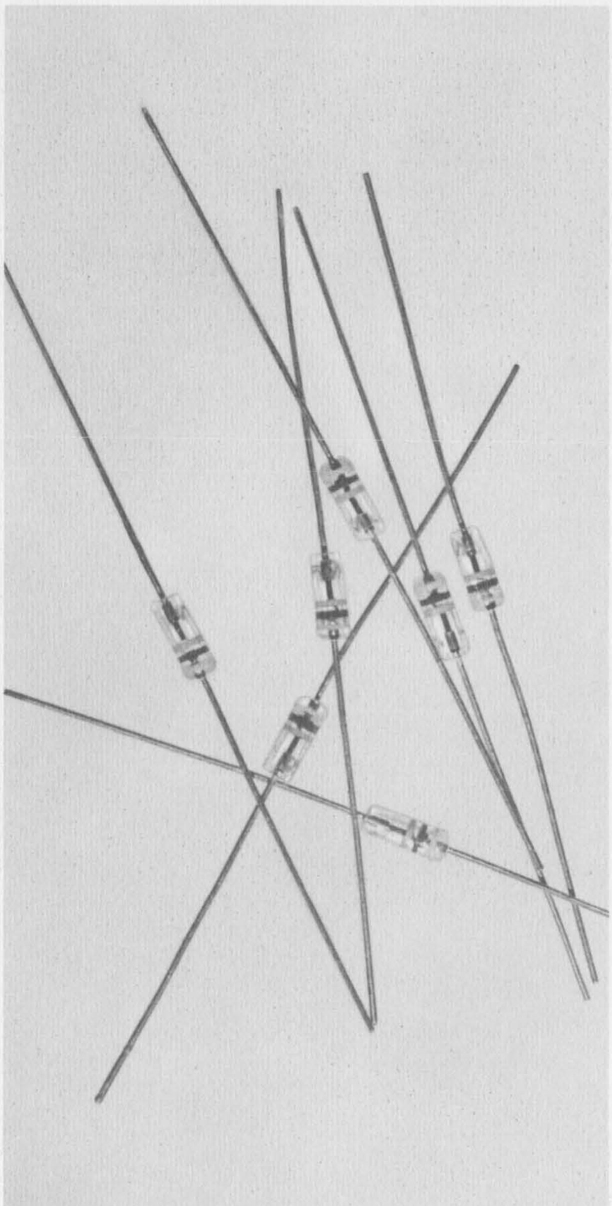
When it comes to packaging, you can write your own ticket because Sylvania has the flexibility to meet your needs.

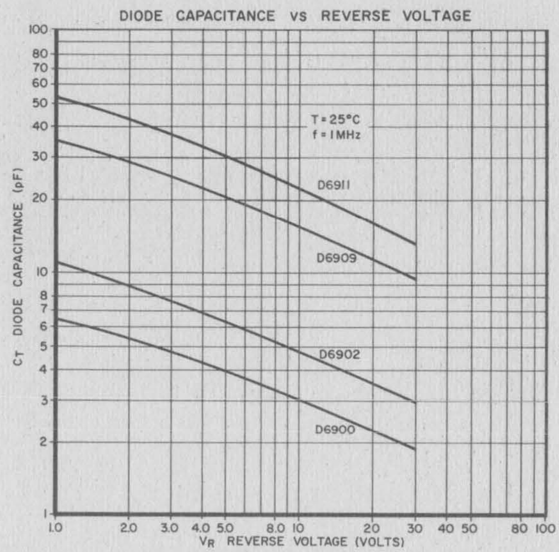
Whether you want your VVCs in chip form, DO-7 package or in any other form factor, Sylvania's VVCs offer a greater design margin.

The new series is also available in matched sets of two or more diodes with tightly controlled capacitance and change ratios between units.

When you need VVC diodes, take advantage of Sylvania's specialized design knowledge and our proven ability to deliver the goods.

CIRCLE NUMBER 303





Typical curve of capacitance versus reverse bias voltage for VVC diode.

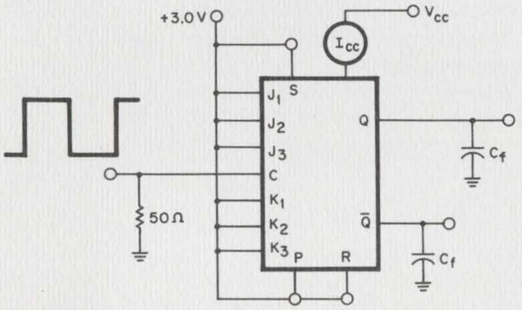
D6900 series high-Q voltage variable capacitors

TYPE	Capacitance (C_T) V_R=4VDC f=1 MHz pF (nom.)	Quality Factor (Q) V_R=4VDC f=50 MHz (min.)	Capacitance Ratio C_{2V}/C_{30V} f=1 MHz typical
D6900	4.0	600	2.8
D6901	5.4	600	2.8
D6902	6.8	600	2.9
D6903	8.2	600	2.9
D6904	10.0	600	2.9
D6905	12.0	600	2.9
D6906	15.0	500	2.9
D6907	18.0	500	3.0
D6908	20.0	500	3.0
D6909	22.0	500	3.0
D6910	27.0	500	3.0
D6911	33.0	500	3.1

Breakdown Voltage (I_R=10μA)=30VDC

Why you need SUHL J-K flip-flops for low power, high speed systems.

Current drain becomes a critical factor at extremely high computer logic switching speeds. The curves (right), applicable to all SUHL single and dual J-Ks, show that current-drain levels, even at high frequencies, are significantly better than those of conventional flip-flops.



Test set-up used to derive data presented in charts.

Recently we conducted a series of evaluation tests to establish typical distributions of current-drain levels for our SF-200 AND-input 50 MHz J-K flip-flops. The data we obtained applies also to other SUHL II single and dual J-Ks since all of them use the same basic circuit configuration.

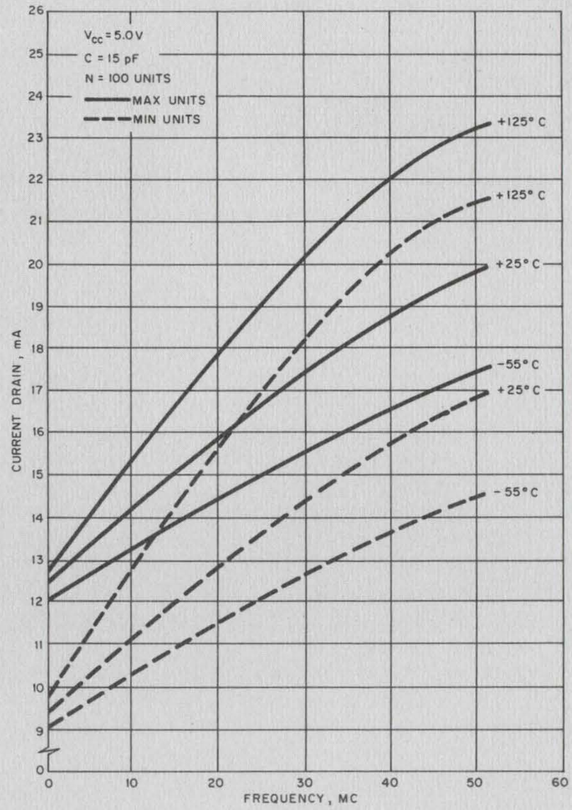
For the SF-210, 50-MHz OR J-K flip-flop, current drain will typically be 2.2 mA higher across the test temperature range. This slightly higher drain is due to the added OR-gate stage.

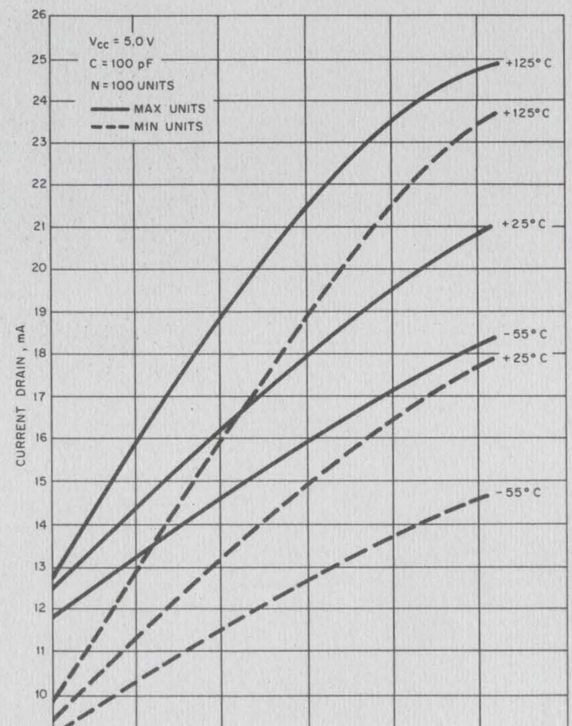
As you can see from the curves, Sylvania's SUHL flip-flops are the way to go wherever low power and high speed are prime considerations.

The evaluation tests began with a lot of 100 units which were representative of product resistor value and Beta distributions. These units were then measured at frequencies of 1 MHz and 30 MHz with V_{cc} 5.0 V at 25°C and C_t 15 pF. Measurements were based on a 50% duty cycle using a Model 122 E.H. pulse generator. Units representing the minimum and maximum current drain observed in the distribution were then selected from the initial lot.

The selected units were measured for current drain at frequencies of 1, 20, 35, 40, and 50 MHz with an operating voltage 5.0V, and capacitive loads of 15, 50, and 100 pf. Measurements were taken at temperatures of −55°C, +25°C and +125°C.

CIRCLE NUMBER 304





Operation at Vcc 5.0V with capacitive loads of C=15 pf and C=100 pf.

How EL devices can simplify photo-recording.

Electroluminescent panels make it easy to place supplementary data on films without complex optical systems.

If you have problems in placing identification marks or other types of data on films you may find your solutions in electroluminescent displays. EL has many advantages in this type of application. First of all, EL devices provide a planar display. The light source is almost in direct contact with the film, assuring a sharp image and minimum light spread. In Sylvania's electroluminescent devices, the use of a thin glass cover plate allows the film to be as close as 0.025 in. to the light source. Since the electroluminescent device is in direct contact with the film, there is no problem of designing or maintaining complex prism lenses and other optical components.

A second advantage of electroluminescent displays is low power consumption, therefore, less heat. This can be a real problem in incandescent lamp systems.

Another advantage is the very uniform light produced by electroluminescence over a given area, as compared to incandescent sources.

Probably the greatest advantage of EL in photographic applications, is the wide variety of display patterns you can obtain. Nearly any shape, symbol or group of symbols can be used. And they can be tailored to any format for a particular application. The ability of EL to display high-density patterns allows substantial amounts of data to be placed on each device (Fig. 1).

There are a number of ways that EL can be used to record information. A straightforward approach is to use a Sylvania ELX-4 numeric display like that shown in Fig. 2 for contact printing. Different combinations of digits can be obtained simply by energizing the appropriate segments.

Similar information can be obtained using an EL matrix (Fig. 3). A negative containing the desired information is placed over the matrix. The data to be recorded is transferred to the film by energizing selected elements of the EL device.

The graphs shown in Fig. 2 give typical exposure times for EL devices used with different types of film. Note that lamp is operated well below rated voltage, thus assuring long life.

It is also possible to use an EL binary dot matrix to place binary-coded information on the film. In this application, the high operating speed of Sylvania EL devices allows the display to keep up with rapidly changing data.

The ease with which EL displays can be modified to meet particular application needs means that Sylvania probably has the answer to your recording problems. Talk to our engineers and you'll find out.

CIRCLE NUMBER 305

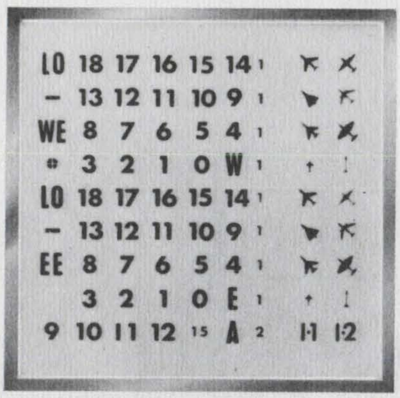


Fig. 1. High-density display using EL light with overlay.

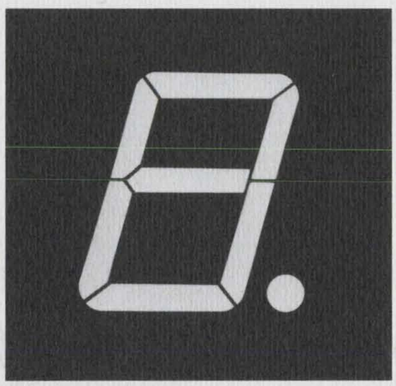


Fig. 2. Numeric EL display can be changed quickly for recording on film.

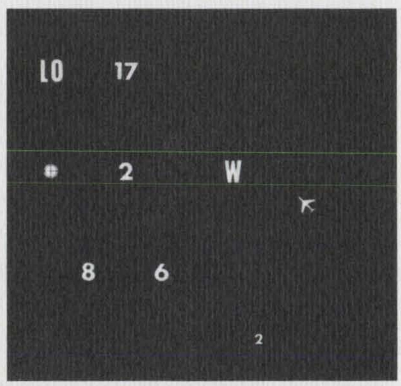


Fig. 3. X-Y matrix EL display can have selected segments illuminated.

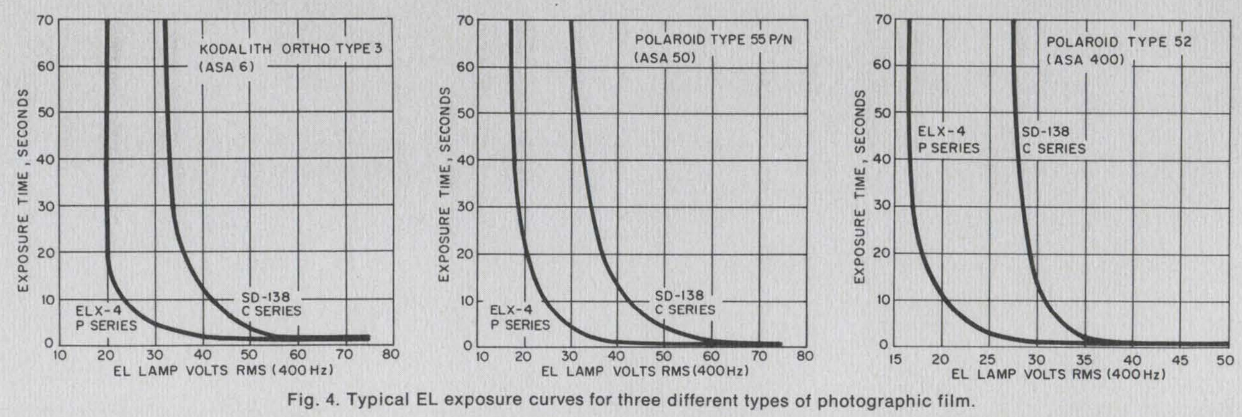


Fig. 4. Typical EL exposure curves for three different types of photographic film.

We've solved the noise problem in avalanche diode oscillators.

New Sylvania design combines the advantages of solid-state construction with noise levels of a klystron.

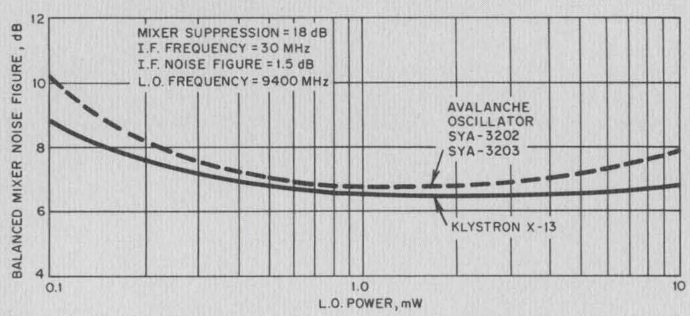
A combination of careful diode processing and improved circuit design has knocked 10 to 15 dB off the noise figure of typical avalanche diode oscillators. The measured noise figure of a balanced mixer using a Sylvania SYA-3202 local oscillator is within a fraction of a dB of that obtained with a klystron. (Fig. 1.) No filters, coupled cavities or other external circuits are used in the new design.

The SYA-3202 (waveguide) and SYA-3203 (coaxial) oscillators are designed for use as local oscillators, parametric amplifier pumps and other applications requiring low AM noise. The reduction in AM noise-to-carrier ratio is obtained over a broad range of frequencies away from the carrier.

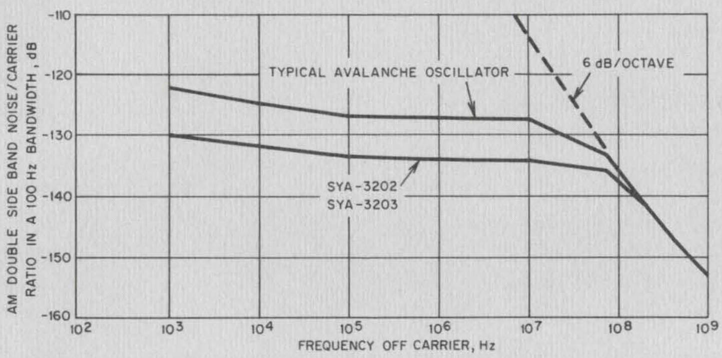
The AM noise-to-carrier curve for a typical avalanche diode oscillator and for a Sylvania low-noise oscillator are shown in Fig. 2.

The X-band oscillators are available in power outputs up to 50 mW, and can be used as a direct replacement for klystron oscillators in many systems.

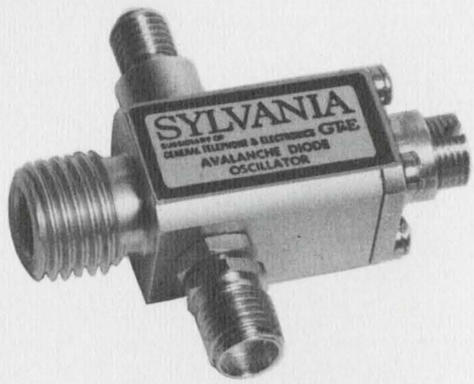
CIRCLE NUMBER 306



Noise figure of low-noise avalanche diode oscillator as compared to klystron in X-band local oscillator application.



AM Noise-to-carrier ratio of a typical avalanche diode oscillator and Sylvania's low-noise avalanche diode oscillator.



Avalanche diode oscillator is available in both coaxial and waveguide configurations.

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Meet tough TV set competition by standardizing.

Standardization is always a valuable tool in cutting production costs. It is especially valuable today where the pricing of black-and-white TV sets is an important marketing edge in meeting foreign competition.

Obviously, a key cost element in any black-and-white TV set is the picture tube. When you pick a standard tube for your design, you get the benefits of high-volume production and, as a result, lower cost. What is the lowest cost tube? In the 17″ to 23″ sizes, we recommend a tube with the following specifications:

> Heater: 6.3 V, 450 mA.
> Accelerator Grid (G2) voltage: 35 V.
> Implosion protection: Kimcode with mounting ears.
> Neck diameter (16″ and above): 1¹/₈″.
> Anode rating: 12 kV min., 23 kV max.
> Button location: short side.
> Deflection angles: 16″ to 22″ —114°
> 23″ —110°

But keep in mind that locking into a standard tube does not have to mean a loss of flexibility in your designs. Because Sylvania is a high-volume producer of many tube types, modifications of standard tube lines can be made at slightly higher cost.

For example, do you need a low-drain filament for a battery portable? We'd suggest that you replace that 6.3 V heater with a 12.6 V, 72 mA, or 12.6 V, 150 mA unit. From Sylvania you can do it with off-the-shelf availability, and it'll cost only pennies more.

What about G2 voltage? For lowest cost and low B+ requirements you can't beat the tried and true 35 V variety. But again, for only pennies more you can select a unit tailored to meet your requirements from our library of electron guns. And again, this is an off-the-shelf delivery with no design or tooling time, or costs. Whether it be 35, 50, 100, or 300 volts, we have the gun ready to go.

For implosion protection we suggest Kimcode, with or without mounting ears. Because we manufacture a wide variety of implosion protection systems every day, we can also offer PPG bonded, T-band, and Shelbond systems at only slightly greater cost.

To sum up, you can meet foreign competition on an equal footing by standardizing your tube lineup. In addition, Sylvania's standard line of 12″, 15″, 17″, 20″, 22″ and 23″ B & W tube offer styling features not yet available in all foreign types. These features include the bold modern "flat-face, square-corner" look that spells the "in" styling of up-to-the-minute design.

J. L. Dangremond
Product Sales Manager

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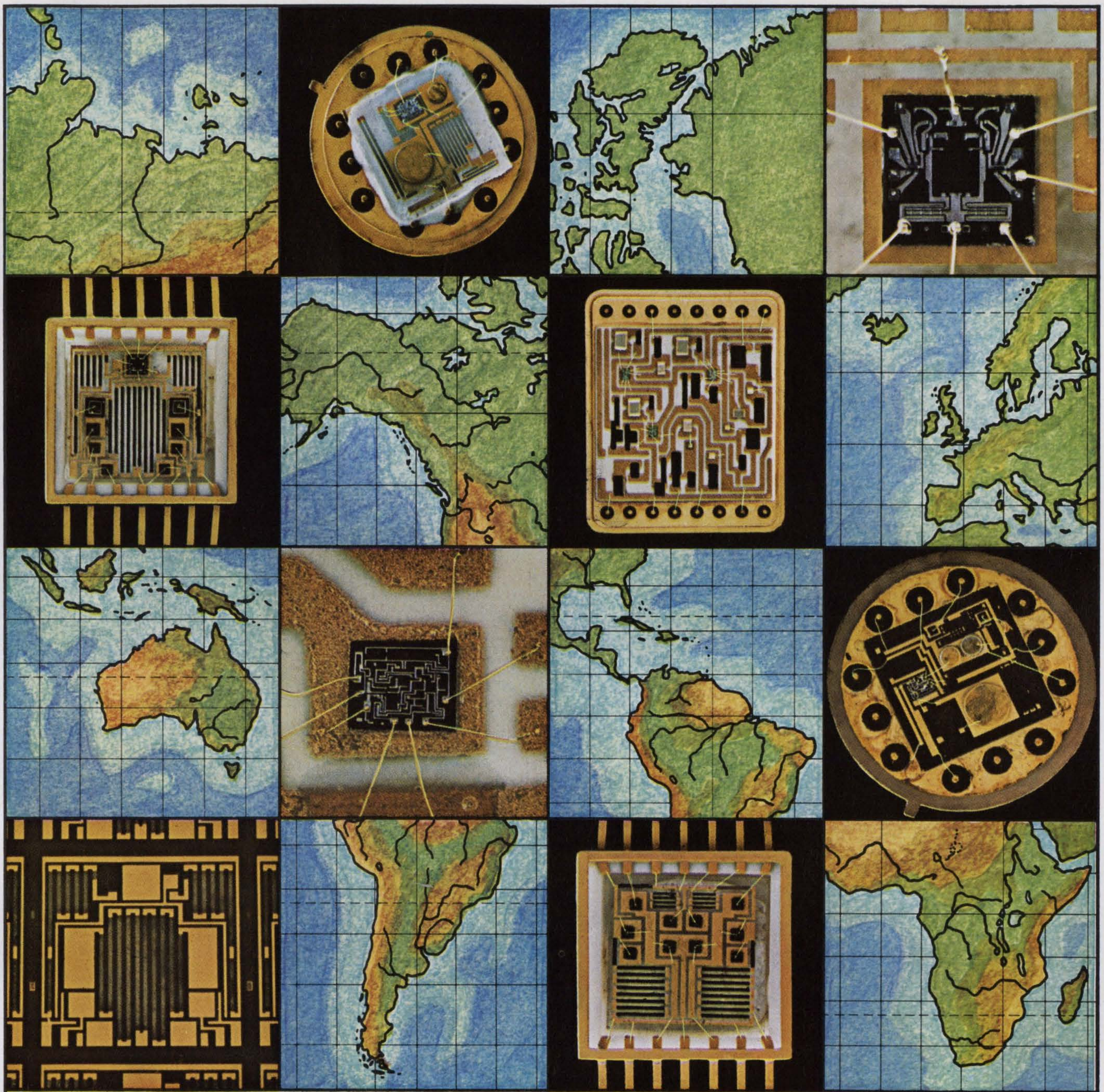

Circle 45 on reader service card →

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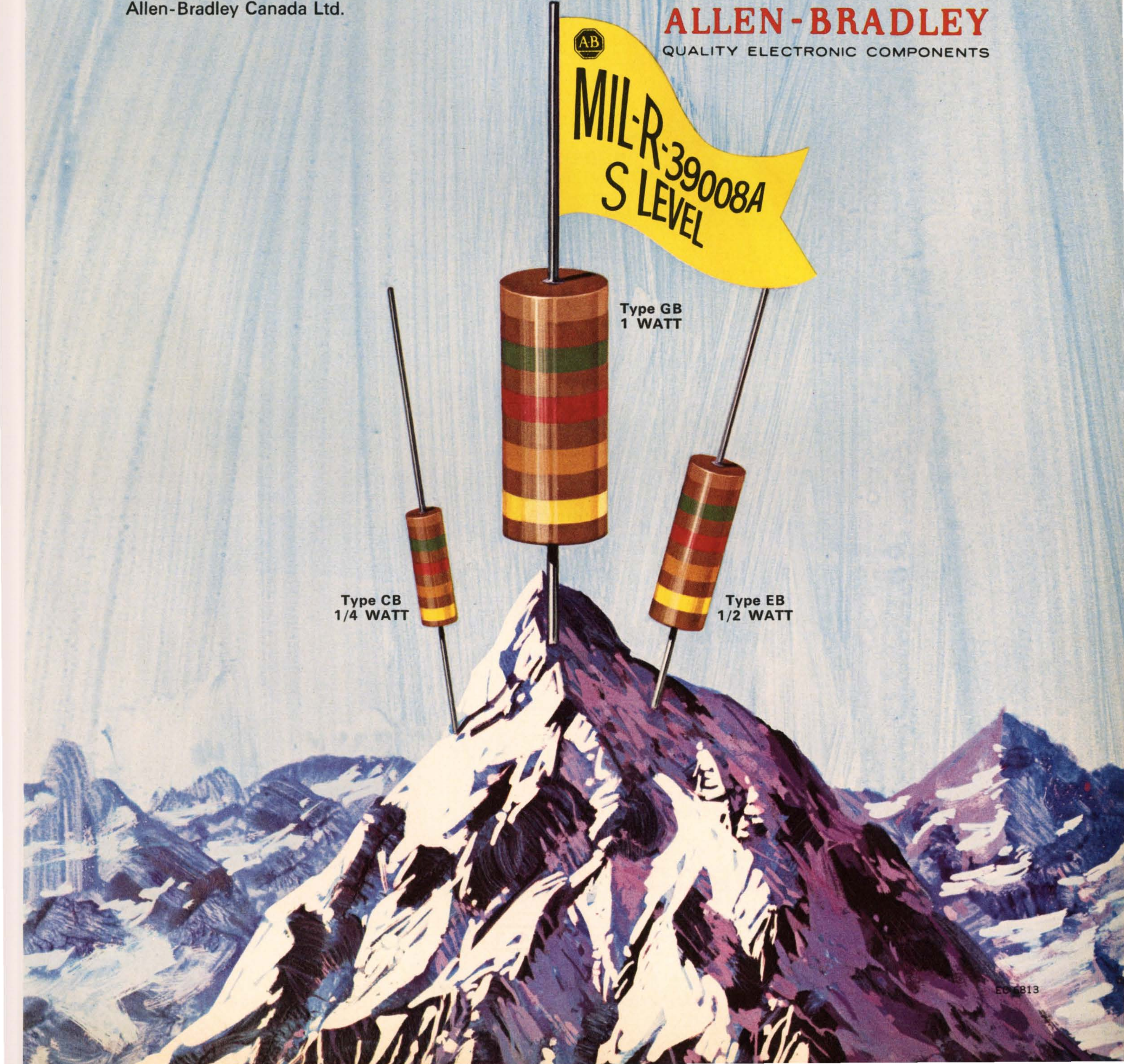

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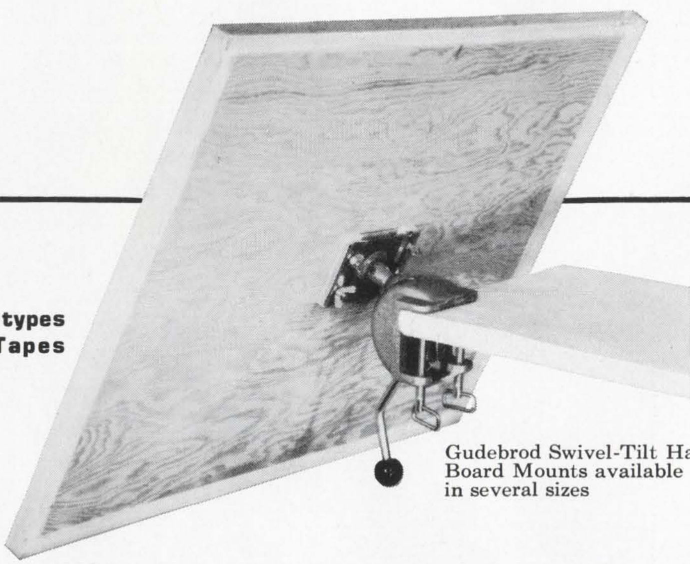

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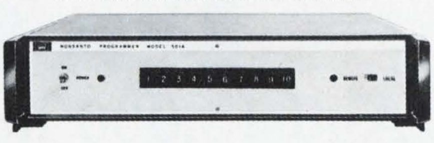

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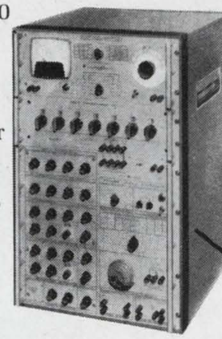

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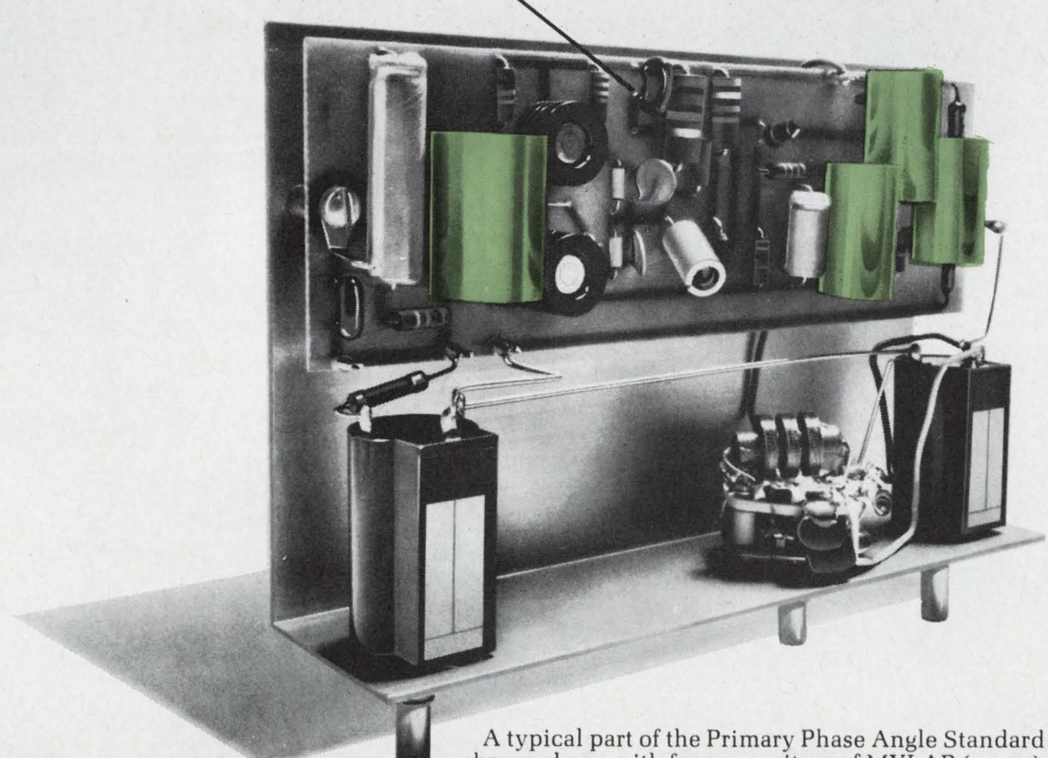


A typical part of the Primary Phase Angle Standard shown above with four capacitors of MYLAR (green).

October 14, 1968

Electronics Review

Volume 41
Number 21

Displays

Bright idea

Replacing a cathode-ray tube with an array of light-emitting diodes doesn't look too hard on paper. But efforts to turn that idea into a workable piece of hardware have left many an engineer muttering in frustration. The initial problem of fabricating such a matrix has, for the most part, been solved. Still unsolved is the problem of interfacing the diodes with buffer electronics that can turn each light emitter on and off separately.

A research team at General Electric's electronics laboratory in Syracuse, N.Y., has avoided this hangup by approaching the problem from a different direction. Instead of adding buffer electronics to the matrix, it puts the electronics into a monolithic integrated circuit that also contains light-emitting gallium-arsenide diodes. Hence, the circuit can contain logic, memory, and light.

Sizing up. GE says it can't make the chips larger than an inch with a density of 400 dots per square inch without bonding. And the present experimental devices still need buffering when used with a computer because of voltage differences. However, GE says the circuitry can be altered to take commands from the computer without buffer electronics. This would reduce the system's complexity since the present switches are two-terminal devices.

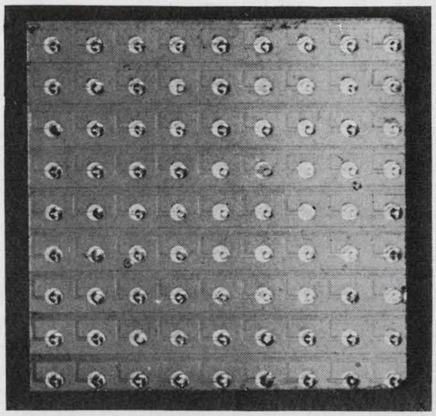
Allen M. Barnett, a member of the research team, foresees the development of proprietary three-terminal devices that will connect to a computer with an output of 10 volts instead of the 90 needed to turn on the two-terminal switches; crt's require thousands of volts.

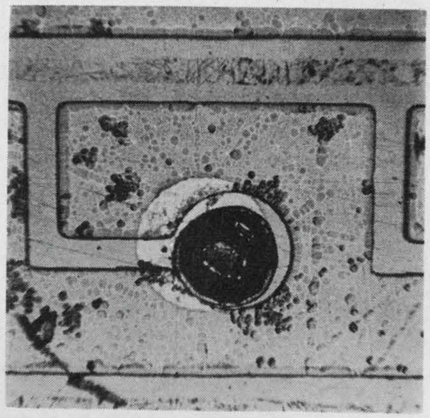
The circuit is made by growing islands of material on gallium arsenide and diffusing the p+ junction into the opposite face. The load resistor is diffused into the same face as the n+ junction and is etched into a mesa structure. The resistor diffusion is also used as a substrate for the metalization.

After the resistors are interconnected in columns by gold metalization stripes, the IC is alloyed to an alumina substrate. The diodes are connected in similar fashion on an isolated p+ junction side, but in rows running at right angles to the n+ side interconnections. Indium metalization connects the p+ rows to the substrate.

Addressing. A matrix array of these devices and associated load resistors uses a minimal number of lead connections. Voltage pulses applied to a single row and single column can switch the device at their intersection; and a similar scheme can be employed to turn off individual elements, which can be steady-state biased in a bistable condition.

GE says it has made the devices of gallium arsenide phosphide and other semiconductor compounds as well. The first devices generate infrared, which can be made visible by an electroluminescent panel.





On display. General Electric's monolithic array of gallium-arsenide light-emitting diodes, left. Individual diode is on the right.

Components

Solid view

The first solid state equivalent of the conventional vidicon will soon be introduced by Fairchild Semiconductor. The product—a two-dimensional array of 10,000 silicon phototransistors and 10,000 metal oxide semiconductor field effect transistors on a half-inch chip—will permit so much miniaturization that a tv camera can be put into a 4-cubic-inch package.

Such an array has already gone into a classified camera built by Fairchild Space and Defense division for the military and has produced television images with a resolution of 100 lines per inch. Images of this quality have been obtained with average incident illumination on the array of 0.013 foot-candle; the lower limit of incidental illumination for a vidicon is about 0.1 foot-candle.

Three years ago Fairchild showed a one-dimensional array of photodiodes and two years ago it developed a two-dimensional array of photoresistors [Electronics, Oct. 13, 1966, p. 33].

Scanning job. Electronic imaging

devices, explains the developer, Gene Weckler of the Fairchild Semiconductor research and development staff, usually perform the conversion of a pattern of incident illumination falling upon a sensing surface into an electrical signal by scanning. In the vidicon, a position-controlled electron beam performs the scanning, but in the solid state image sensor, the scanning function is accomplished by an electronic signal which interrogates only one photosensitive element at any instant, but sequentially in a prescribed manner. The sequential flow of information from the phototransistors forms the video signal, which can readily be accepted by standard television receiving equipment.

In the Fairchild array, the basic device for converting the photons to an electrical signal is the phototransistor operating in the photon-flux, or storage, mode [Electronics, May 1, 1967, p. 75], in which a p-n junction, which is reverse-biased and open circuited, loses charge stored in the depletion layer at a rate proportional to the level of incident illumination. A signal proportional to the incident illumination may be obtained by periodically monitoring the charge required to reestablished the initial voltage condition at the p-n junction.

Stepping pulse. Integrated next to each phototransistor is a MOS FET, which assists in the sampling of the photodetectors in each row of the array. A negative voltage of sufficient value applied to a row will turn on all the MOS FET's in that row. By stepping a negative sampling pulse voltage column sequentially, it is possible to sample the photodetectors in the activated row.

The input to the solid state image sensor is an interrogation pulse from a scan generator, which can take a variety of forms: a ring counter, a shift register, or a counter and decoder matrix. For its prototype camera, Fairchild is using general-purpose integrated circuits to make the scan generator and anticipates that in the future these will be replaced by banks of scanning logic modules 150 mils on the long edge placed next to the array. These logic modules would receive the 200 leads that presently are laid out in fan-shaped patterns from the four sides of the array. The arrays the company will sell will not be equipped with a scan generator, requiring that the customer design his own from currently available circuits.

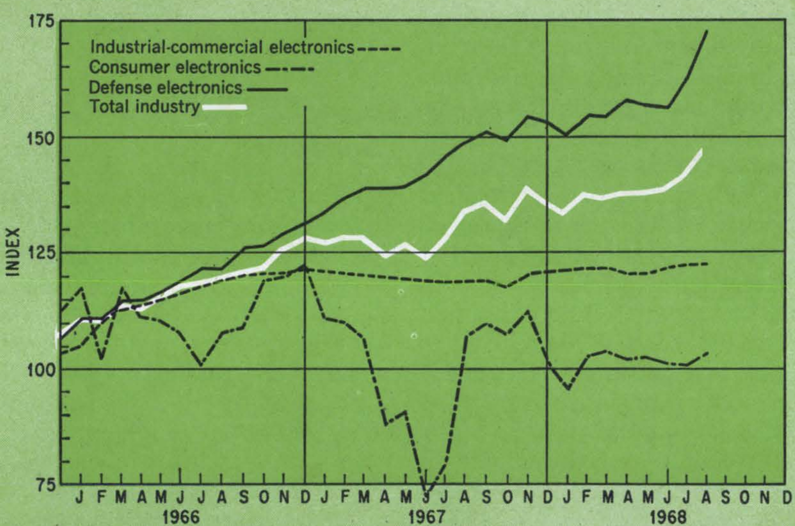
Fabrication of the chip, explains Weckler, requires only standard integrated circuit technology. Uniformity in the array, he says, is achieved by state of the art photolithography, which insures exteme geometric similarity between each unit cell. State of the art planar processing produces the best uniformity of transistor gains, junction capacitances, etc.

In a cube. An entire camera, says Weckler, could be packaged in a 4-inch cube. The package would include batteries to provide the required power (less than 1 watt), the lens, the scan generator, and the single amplifier chip required to boost the output video signal.

The variety of applications for which the array can be used, says John Brown, product marketing manager of photoproducts, ranges from tv viewing of rocket exhaust and aerial surveillance to such terrestrial industrial applications as pattern recognition, print or photoreaders, and image tracking. The area which will find the most ready acceptance, he says, is in industrial applications, where vidicons have not been able to be used because of low light levels, high tempera-

Electronics Index of Activity

October 14, 1968



Segment of industry	Aug. 1968	July 1968*	Aug. 1967
Consumer Electronics	**103.8**	100.1	106.7
Defense Electronics	**172.7**	162.5	148.0
Industrial-Commercial Electronics	**122.9**	122.3	118.9
Total industry	**146.4**	140.1	132.7

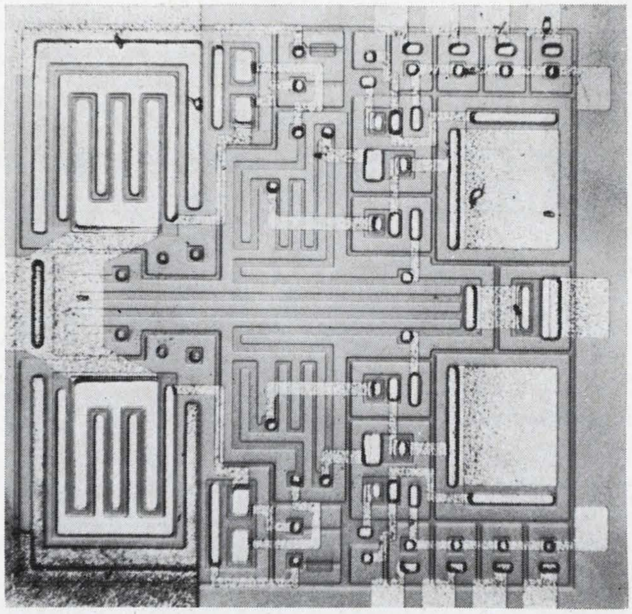
Electronics production advanced 6.3 points in August from July and 13.7 points from August 1967. The rise in the defense electronics index was responsible for most of the gain; that indicator rose 10.2 points from July and 24.7 points from 1967. The industrial-commercial index inched up 0.6 point in the month and 4 points in the year. The consumer index advanced 3.7 points in the month but declined 2.9 points from 1967.

Indexes chart pace of production volume for total industry and each segment. The base period, equal to 100, is the average of 1965 monthly output for each of the three parts of the industry. Index numbers are expressed as a percentage of the base period. Data is seasonally adjusted.
* Revised

tures or because of magnetic interference.

Because of the considerable cost of one of the large 100-by-100 unit cell arrays and the lack of experience most manufacturers have in this area, Fairchild will make smaller arrays available for engineering evaluation and applications research. For subsequent prototype construction, the company will offer the 100-by-100 array mounted on a four-inch square base with the 200 leads in fan-array. During the 1 to 1½ years that Fairchild expects will elapse between prototype delivery and production delivery of the arrays, purchasers will work out individual packaging requirements, which will then be met by Fairchild; at that time, Fairchild may also include the scan generator in the package.

The present cost of the large array (FPA-310) is in the neighborhood of $20,000, says Brown, but he anticipates that within three years the price will drop to less than $1,000. The smaller arrays, which will typically be 16 by 16 cells, will sell for $750. Delivery time for these engineering evaluation models (FPA-311) will be approximately three months; present delivery time for the FPA-310 is six months.



Tough circuit. IC developed by Boeing operates on 28 volts—the output of an airplane's generator—without special protection from noise and transients.

Integrated electronics

Standing up to abuse

An integrated logic gate in an airplane requires more special treatment than a movie star on tour. The plane's d-c power supply, which is specified at 28 volts but may wander from 17 to 29, must be transformed to a nicely regulated 6 volts. And an elaborate circuit is needed to protect the IC from environmental noise and transients that may cause spurious triggering. Only then will the IC consent to make its logical decision—after which the output must be returned to 28 volts to perform the indicated function.

Impatient with this kid-glove treatment, and appalled by the cost in space, weight, and dollars, the Boeing Co. has designed a special NAND gate, using diode-transistor logic, that will operate directly off the power bus and will drive lamps and relays directly. Indications are that this robust newcomer will find a host of applications too rugged for its dainty computer-oriented cousins.

Boeing has licensed Siliconix and the Electronic Components division of United Aircraft to make the circuits. United Aircraft has found considerable interest in the industrial control market. Gerald L. Parker, product manager at Siliconix, says that any system containing lamps and relays will have a 24- to 28-volt supply and that most of the time it's more convenient to make logical decisions at this level. Siliconix says airframe and avionics companies have responded enthusiastically to its queries; it plans to tap the shipboard electronics market next, and it agrees with United Aircraft about the circuit's future in industrial control.

Zeners needed. Boeing will use the circuit in the supersonic transport. (The 747 jumbo jet and the 737 short-range jet may also adopt it.) The circuit's function, says Henry E. Bruner, a research specialist in electrodynamic technology in Boeing's Commercial Airplane division, will be to sequence or monitor controls or situations or to control indicators or systems. It might, for example, drive landing-gear of wing-flap indicators or alarms. As many as 700 dual four-input gates may go on a plane.

One dual gate, Bruner says, will need three external zener diodes to protect it against switching transients that may go as high as ±350 volts. Other approaches would require many more components. For example:

- A relay version would require two relays and 10 diodes.
- An electronic system built with discrete components would take two transistors, 17 diodes, and six resistors.
- A 6-volt IC system would require one dual gate, two output transistors to drive a load, one transistor, and three resistors in the power supply, five resistors and three capacitors to act as filters, and 25 diodes.

Boeing has calculated that for a given airplane, the 28-volt IC system far outclasses—in some cases by an order of magnitude—the other versions in number of components, number of connections, weight, volume, failure rate, and cost. And the relay system, which is a distant second in most of these categories, uses five to 10 times as much power as the electronic systems.

The performance objectives,

however, made the 28-volt IC difficult to design and build. The circuit was the brainchild of David J. Wahl and Ronald R. Mitchell of Boeing's microelectronics facility. Their idea was to produce a circuit that not only worked off the plane's own power supply but was also immune to electrical noise and able to withstand inductive switching transients. In addition, it had to supply an output current of 100 milliamperes, to drive lamps directly. The circuit they devised differs somewhat from the standard DTL gate.

To achieve the high breakdown voltage of 90 volts, Wahl and Mitchell use the base-collector rather than the base-emitter junction of an npn transistor as the input diode; this design results in the creation of a parasitic pnp transistor from each input to the substrate. In addition, the output driver circuit is connected as a Darlington pair to ensure adequate current drive.

Deliberate. Most important, the circuit has been deliberately made slow; it takes more than 2 microseconds to switch and will withstand transients for that period of up to ±65 volts. To reduce the size of the capacitor loading, Wahl and Mitchell used transistors as capacitor multipliers; a small 12-picofarad capacitor provides all the delay required.

To achieve the high collector-base breakdown voltage, Parker says, epitaxial resistivity had to be held within a narrow range: high, but not too high, since saturation voltage on the output transistor had to be kept down to 1 volt at 100 milliamps, clamping the output to one diode drop. "We are actually exceeding the diode drop by only about 300 millivolts," Parker says, "so the true saturation resistance of the output transistor is about 10 ohms."

Siliconix expects to have sample circuits available to outside customers this month. It has already delivered a number of packages (dual in-lines) to Boeing, and expects to complete its initial obligation by December. Boeing will have the circuits company-qualified by the end of the year.

Computers

Illiac cutback

Illiac 3, the University of Illinois' highly touted pattern-recognition computer, has been dealt a blow far more damaging that the $200,000 blaze 18 months ago that destroyed all its wiring and set back the project by more than a year. The Pentagon's Advanced Research Projects Agency (ARPA) earlier this month failed to renew its $250,000 annual stipend, most of which is earmarked for equipment. The result: when Illiac 3 is completed late next year, it will be only a skeleton of what was planned.

Completely eliminated from the system are the video communications network, microimage storage, and microfiche scanners. Also hard hit is the "multi" aspect of the system.

Illiac 3 was planned as a parallel-organized multiprocessor system. It was to include four central, or "taxicrinic," processors, two input-output processors, and eight computational-storage units—two arithmetic, one pattern-articulation, one interrupt, and four storage groups. "Instead," says Bruce H. McCormick, head of the project, "we'll have one of each.

Articulate. In the new design, the input-output processor is attached via seven channel interface units to the input and output devices—including cathode-ray tube flying-spot scanners, which double as film cameras and thus serve as both input and output devices.

The pattern-articulation unit does local preprocessing on the input from the scanners, such as track thinning, gap filling, and line-element recognition. With the input image considered as a line drawing, nodes representing end points, points of inflection, points of intersection, and the like are labeled in parallel.

An abstract graph describing the interconnection of labeled nodes is then extracted as a list structure, which is the output of the unit. The taxicrinic processor then syntactically categorizes the structure via a programed recognition grammar to complete the recognition process.

In addition to overseeing the operations of the pattern-articulation unit, the taxicrinic processor controls the arithmetic unit and initiates the operations of the input-output processors by making requests to the interrupt unit. Although a few simple arithmetic operations, such as integer addition, can be done in the taxicrinic processor, most arithmetic operations are performed in the arithmetic unit, which is designed for double-word, floating-point arithmetic.

Staff cut. In addition to cutting back on the system because of ARPA's pullout, McCormick has had to cut down on his project staff. "We've had to let 12 technicians and researchers go," he says, "and divert some incoming graduate-student assistants to other projects.

McCormick and John R. Pasta, head of the university's digital computer laboratory, were told three months ago that ARPA was ending its support. "We got a phone call from the agency and that was that," says McCormick. "We tried to get some phase-out funding but couldn't get the agency to budge."

Although the video communica-

Junk heap

Illiac 2, the solid state descendant of Illiac 1, is about to be dismantled and junked like its distinguished forebear six years earlier. The huge, high-performance machine will be giving way to make room for a newer generation machine—Illiac 4, the supercomputer expected to be completed within the next 18 months.

Unlike the first of the Illiacs, which was sought after by the Smithsonian Institution and several Latin American universities, there are no bidders for Illiac 2. Retired officially a year ago, it is being used for occasional tasks. But even this is about to end. What little work being handled by Illiac 2 will soon be shifted to the University of Illinois' IBM 360/50, says John R. Pasta, head of the university's digital computer laboratory. "The Illiac is just too costly not to be used," says Pasta.

"Ministic,"

the high voltage silicon rectifier for the engineer who wants

more of a good thing.

A new device technology developed at Semtech Corporation has revoluntionized the multi-junction rectifier. This breakthrough has greatly improved reliability and lowered costs.

Discrete multi-junction devices and sticks made up of such devices are now suited for previously impractical applications. They can compete directly with vacuum tubes and selenium sticks.

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Enlarged unretouched photograph showing multi-chip junction construction.

"Ministic" specifications include:

Peak Inverse Voltages...	10 kV to 40 kV
Average Rectified Current......	5.0 mA
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Size......	25″ D x 1.125″ to 4.275″ L

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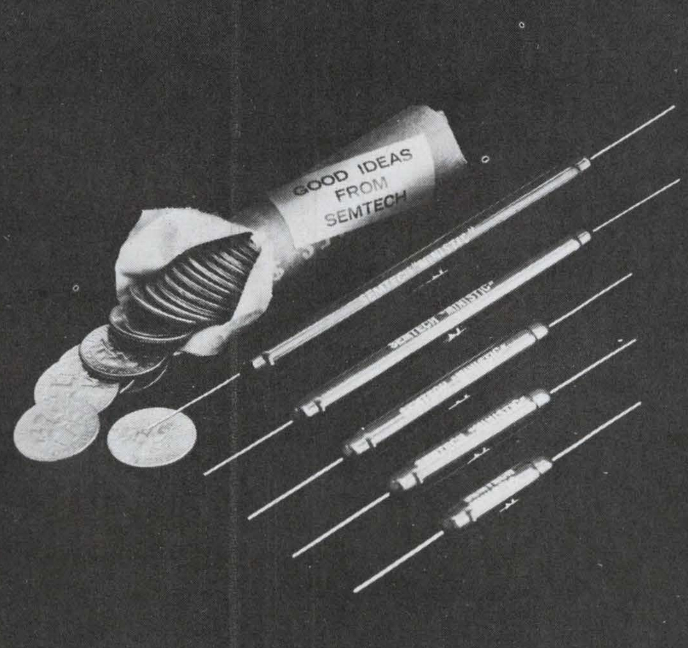
"Ministic" incorporates junctions metallurgically bonded at high temperature producing a high-strength multi-junction unitary stack. This process allows Semtech to use the Suprataxial junction (liquid phase epitaxial) proven to be superior for high-voltage, fast-recovery devices. This is an extension of the technology employed in the Semtech "Ministac" available in voltages from 3 kV to 7 kV. For more about "Ministac," get your copy of "Ministac — Design Freedom with New High Voltage-Low Current Rectifiers."



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Circle 57 on reader service card

tions net—of prime interest to ARPA—was dropped, McCormick plans to continue the work after the slimmed-down version of Illiac 3 is completed. (Illiac 3 is sponsored by the Atomic Energy Commission, and the university has contracted to have the basic machine ready by Oct. 1, 1969.) Some of the equipment called for in the net is already at the university's Urbana campus. Part of the rest is expected to be delivered early next year, to be paid for by funds already set aside.

Still 'good.' The following is what might have been: Remote consoles, the basic stations for the video net, would be equipped for distant input-output of several types of signals, including digital and video data. The digital signals would include teletypewriter data, pulse-coded modulation conversions of audio-frequency analog information, and digital control signals. The video signals would be transmitted between the consoles and Illiac 3 for television monitoring in two forms: fast scan (15 fields per second) and slow scan (1.25 fields per second).

The high-resolution (1,536-line) tv equipment—three dual-scan cameras and 12 monitors—will be delivered by the Ampex Corp. early next year. Already on hand and checked out is a videograph printer from the A.B. Dick Co. and a character generator.

McCormick also has on hand the required components and subassemblies for the microfiche scanners originally destined for the video net's associated storage and retrieval system. When work was halted on this segment, project engineers were working to adapt two microfiche transport mechanisms from the Bell & Howell Co. to operate in the scanners.

Despite the cutbacks on Illiac 3, McCormick is still optimistic about the computer. "It will be a good machine," he says, "but it would have been far more interesting if we had the money."

The Illiac 4, the university's giant parallel processor, is still on schedule. First units will be delivered in about six months and the whole system will go on the air in 1970 [Electronics, May 15, 1967, p. 141].

Avionics

Follow the bouncing ball

Airborne inertial reference systems require complex and expensive precision mechanical gyroscopes. For the most part they do the job, but they're costly because they have to be carefully mounted on air bearings, which also subjects them to wear. But at Martin Marietta's Orlando division, a project that started several years ago [Electronics, June 29, 1964, p. 28] has finally borne fruit: a nonmechanical inertial reference instrument.

A glass ball the size of a dust particle (less than 2 microns in diameter) is suspended in a magnetic field and illuminated by a light beam. Its motion—caused by the movement of the aircraft—is sensed by three pairs of photoelectric sensors, one for each axis. Each time the charged ball moves, the sensors pass the information on to both the navigation equipment and the electrodes that maintain the magnetic field; the feedback to the magnetic field keeps the ball centered.

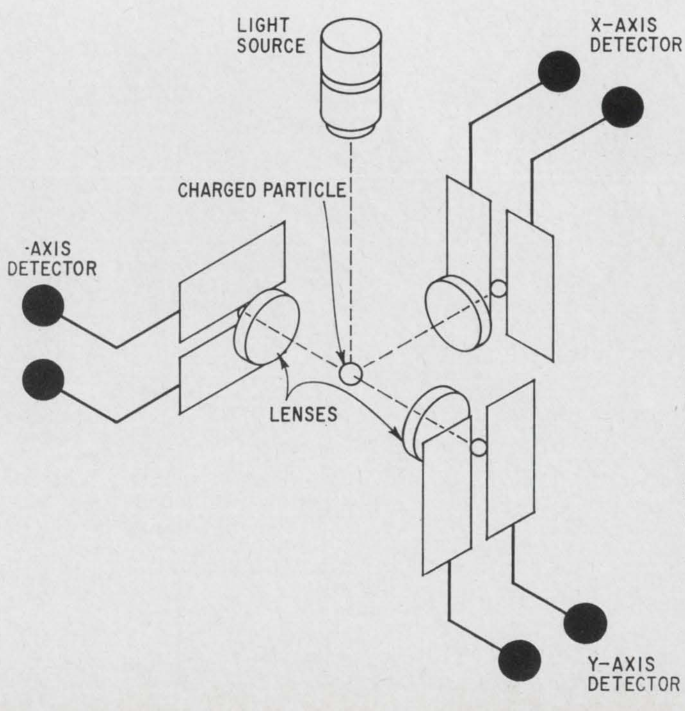
Depending on how it's rigged, the device can be used as an accelerometer, gravimeter, or gyro.

More studies. The difference between each of the three suspension voltages and the at-rest voltage is directly proportional to the acceleration of the chamber along the corresponding axis. This variation can be used as an instantaneous analog acceleration reading.

When the device is used as a gyroscope, which is a two-axis accelerometer, an alternating suspension voltage can be applied to one of the three axes so that the ball will oscillate along that axis but the rotation won't be picked up by the other two sensors. If the chamber turns, the ball's path will lag behind the driving current, and one of the other two sensors will pick up the ball and register the rotation.

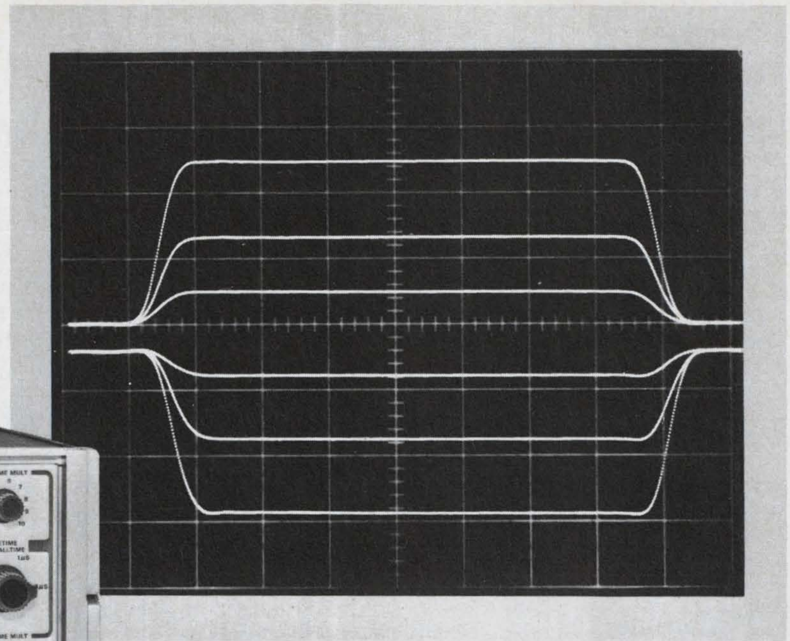
Martin Marietta says the oscillating-ball gyro is particularly suited to small-missile applications. The company is also working on a gyro that uses the electric field produced by four circular metal electrodes to restrain the ball as it is driven around a circular orbit; this increases sensitivity sharply.

The company will turn a model over to the Air Force's Electronics Research Laboratories, Cambridge,



Keeping track. A tiny charged particle suspended in a magnetic field is used to sense motion. Depending on how it's rigged, this device can be used as an accelerometer, gravimeter, or gyroscope.

Pulse Performance



Multiple exposure showing typical waveform aberrations for positive and negative polarities at various amplitude settings. Notice the constant risetime and falltime with amplitude changes. 20 ns/cm sweep time and 4 V/cm deflection factor.

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- **VARIABLE RISE AND FALL TIME, 10 ns to 100 μs.**
- **$\pm$10 V into 50 Ω, with DC OFFSET.**

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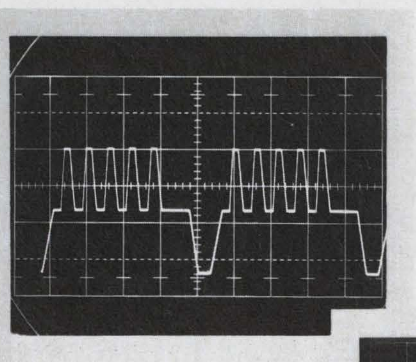
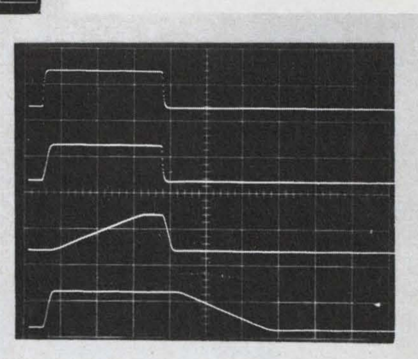


Single exposure showing combined outputs of two Type 115's. The burst of pulses on top of the positive pedestal was triggered by the + delayed trigger from the instrument generating the pedestal. 10 μs/cm sweep time and 2 V/cm deflection factor.



Multiple exposure showing variable risetime and falltime. 500 ns/cm sweep time and 10 V/cm deflection factor.

A detailed description of the Type 115 Pulse Generator is found in the August supplement to your Tektronix Catalog 27.

Tektronix, Inc.

committed to progress in waveform measurement

Mass., in December for test and evaluation of the principle as a gravimeter. Martin Marietta says its own tests show that the device is 10 times more accurate than mechanical ones and can operate over hundreds of times the force of gravity, compared with the few g's of mechanical systems. The Navy has also tested the principle as an accelerometer in a ruggedized microcircuit unit weighing less than two pounds.

Antennas

Way up there

Log-periodic antennas, around since the mid-1950's, are broadband radiating structures. They're in a class of antennas whose performance—radiation pattern, directivity, and impedance—is independent of operating frequency. Such antennas have been limited to operation into the upper X band—about 10 to 12 gigahertz.

But engineers at Bunker-Ramo's Defense Systems division have developed a log-periodic dipole antenna that delivers good directivity patterns, acceptable vswr (voltage standing wave ratio) characteristics, and satisfactory absolute gain over a band from 1 to 21 Ghz.

Higher still? One of the goals of the company-sponsored program was to reach a frequency of 30 Ghz. Jarrell W. Besthorn, a member of the technical staff at the Canoga Park, Calif., division, is convinced that the antenna can reach that frequency or higher, but test instrumentation limited measurements to the 21 Ghz. At that, the performance is at least 5 Ghz better than that of any similar antenna. Besthorn says that Sylvania Electronic Systems, Mountain View, Calif., has reported pushing log-periodic antenna frequency to 16 Ghz, but the E- and H-plane radiation patterns went only to 10 Ghz.

Beyond 12 Ghz, designers have previously abandoned log-periodic antennas in favor of spiral waveguides, but Bunker-Ramo wanted to stick with a rectilinear design to get the small geometry required at the critical feedpoint of the antenna—the last quarter to half-inch that generates the super-high frequency.

Harry B. Sefton, manager of the microwave and antenna department, says the super-high frequency is increasingly dictated for the electronic intelligence systems that might use such an antenna, including Bunker-Ramo's own AN/ALQ-86 passive reconnaissance system now flying in Southeast Asia aboard the Navy's Grumman EA-6B.

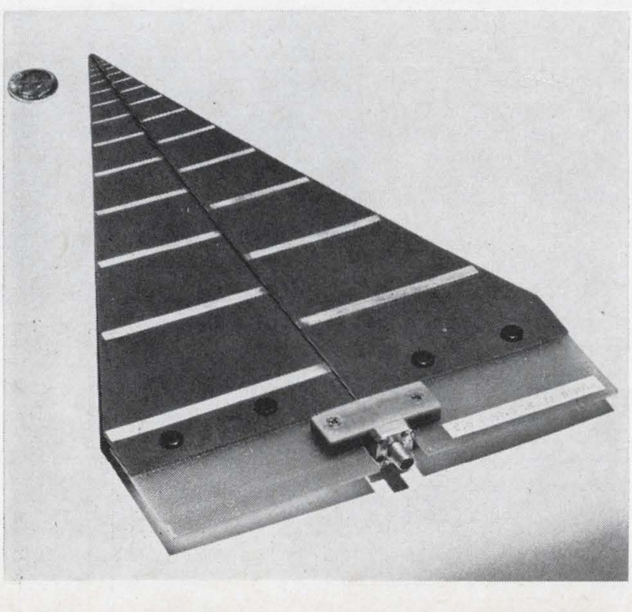
Feed it. "The customers using such a system are asking for all of the antenna-collection capability in a single feed, and you couldn't put enough antennas to do the job at the feedpoint using waveguide techniques," Sefton says. "We've developed a single antenna using coaxial techniques to feed it that operates over a 20-to-1 bandwidth and probably up to 30-to-1, which can replace five or six systems having a 2-to-1 bandwidth.

The rectilinear structure was chosen because it allows use of photolithographic printed-circuit board techniques to define the close tolerances required at the feedpoint. The artwork that was used to make the pattern for the 36 copper dipole elements was generated at 10 times actual size on a coordinatograph that can hold tolerances ±1 mil. When reduced, this yields dimensions accurate to ±0.1 mil. The last four dipole elements at the feedpoint are 3 mils wide, which is the smallest copper deposit that could be maintained in the etching process.

Subminiature, semirigid, 50-ohm coaxial cable is used as the antenna's feed line. It has an outside diameter of 0.02 inch, which presented some problems because the body of the connector to which it's attached has an outside diameter of 0.141 inch. This disparity resulted in a periodic vswr of 7 to 1, which was unacceptable.

Tapered sleeve. Besthorn says the precision coaxial transition developed to overcome the vswr problem and still maintain the 50-ohm impedance between the feed line and connector is a modified flange-mount receptacle. The connector pin's 0.05-inch diameter was tapered by turning it on a jeweler's lathe so that its end matches the 0.0045-inch diameter of the coaxial cable's center conductor. A tapered Teflon sleeve slides over the tapered pin, and the ratio of the two tapers maintains the 50-ohm impedance transmission line.

Three versions of the antenna were made. The second showed the best performance, including operation to the 21 Ghz, essentially constant E- and H-plane radiation patterns across the entire bandwidth,



How high? Log-periodic dipole antenna developed by Bunker-Ramo can generate signals in the 1- to 21-Ghz band, and may even go as high as 30 Ghz.

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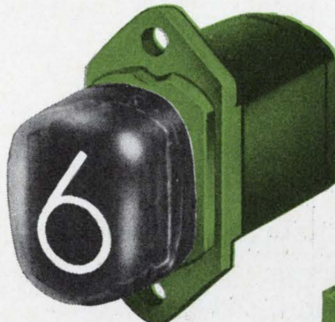

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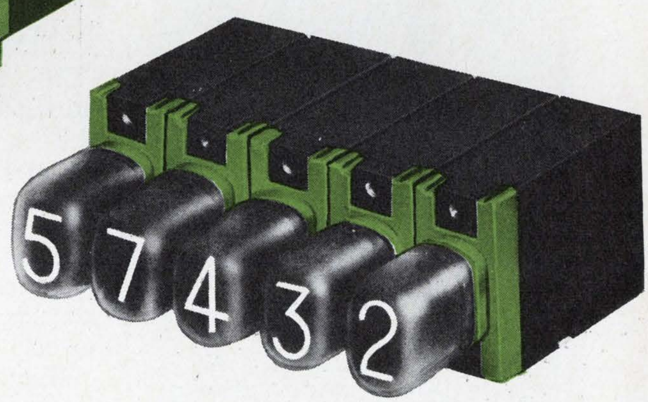

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Part Number	Tube Type	Character Height	Max. Overall Length (with tube)	Max. Height	Max. Width	Has Memory	Input Code	Price 100 quantity (includes NIXIE tube)
BIP-8806	Standard B-5991	0.6″	2.506″	1.583″	0.750″	Yes	4 line 8-4-2-1 BCD	30.00
BIP-8804	Standard B-5991	0.6″	2.506″	1.583″	0.750″	No	4 line 8-4-2-1 BCD	26.00
BIP-9801	Miniature B-4998	0.3″	2.648″*	0.960″	0.480″	No	4 line 8-4-2-1 BCD	42.00

*Note new shorter overall length.

For additional information contact, Burroughs Corporation P.O. Box 1226, Department D2, Plainfield, N.J.

Burroughs Corporation

Circle 61 on reader service card

a vswr of less than 4 to 1, and absolute gains ranging from 6.8 dbi (decibels relative to isotropic radiation) at 2 Ghz to 2.4 dbi at 17 Ghz.

Sefton says that a vswr of 5 to 1 meets military specifications for general-purpose receiving antennas. He adds that the absolute-gain levels are within normal bounds for receiving antennas of this type, and stresses that the significance of the development is that Bunker-Ramo has pushed into the super-high frequency region using miniature geometries. The longest dipole element in the antenna is 2.95 inches; the shortest at the critical feedpoint is just 0.027 inch—only seven mils more than the transmission-line diameter.

Bunker-Ramo engineers are particularly eager to confirm operation above 30 Ghz, because the region around 35 to 40 Ghz is one in which losses caused by water and oxygen absorption in the atmosphere are minimal.

Companies

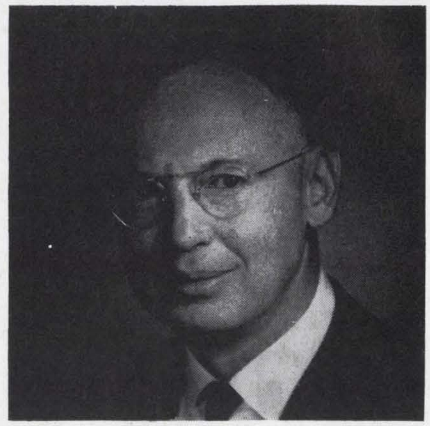
New man at Philco

"Let's face it, they just weren't hitting it off."

That, in a nutshell, is the way one ex-Philco man explains the resignation of Robert O. Fickes as president and chairman of Philco-Ford and the appointment by Ford Motor president Semon Knudsen of his close friend, Robert E. Hunter, to take over the ailing subsidiary.

Hunter, 57, until last April general manager of GM's Euclid division, has heavy experience in earth-moving and mining machinery. Just how that background will fit in with Philco-Ford's product line—electronics, for consumer, industry and the military—Ford spokesmen left unclear, except to say that Hunter has broad management experience.

"It's fairly apparent," says a former Philco executive, "that Fickes' contract was bought out. It was common gossip around the company that Fickes has been a lame duck ever since Knudsen came on board in February."



Boss. Robert Hunter, top man at Philco-Ford.

Lack of interest. One cause of the irritation between the two men, it's reported, was Fickes' apparent lack of interest in Ford's automobile business. Moreover, Knudsen made no secret of his view that the parent company should not be in the electronics business.

Although it's impossible to get someone at Philco to concede it, all divisions except the electronics group under Walter LaBerge are losing money. The appliance business has a cost problem, and television production is outpacing sales.

One rumor has it that there maybe some spinoffs of money-losing units under the new boss. And as one industry man put it: "By the time that's over everyone will pay more attention to Ford."

Meetings

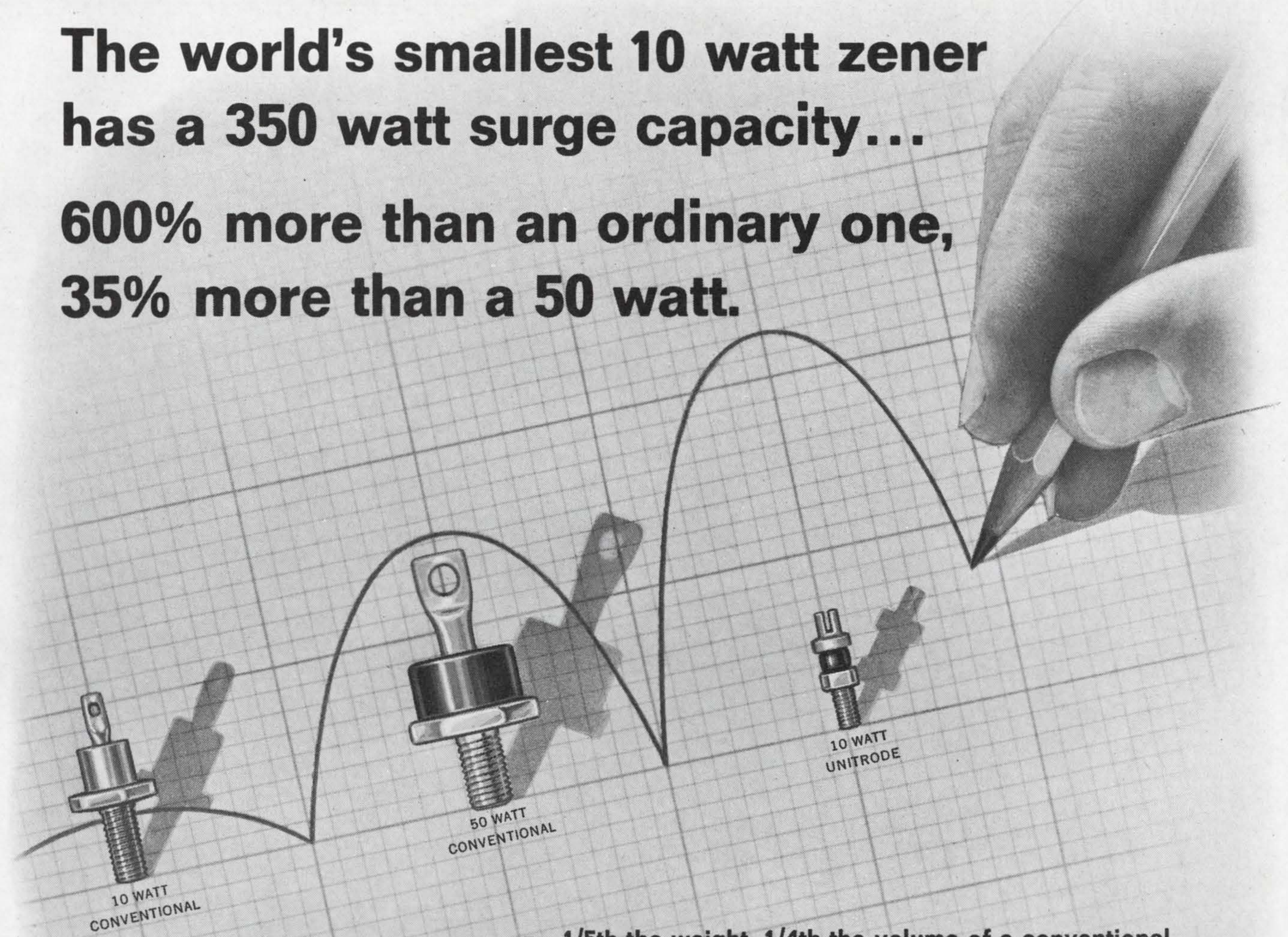
Attracting the user

"Some guys just aren't concerned with magnetic domains and things like that—they just want to know how to select a magnet and put it into a circuit," says Lester Moskowitz, executive director of the recently formed Permanent Magnet Users' Association (Permu).

That, in effect, is Permu's charter. The group, an activity of Phil-

The world's smallest 10 watt zener has a 350 watt surge capacity...

600% more than an ordinary one, 35% more than a 50 watt.



- 1/5th the weight, 1/4th the volume of a conventional 10 watt (smaller than an ordinary 400 milliwatt).
- 1/10th the weight, 1/20th the volume of a conventional 50 watt
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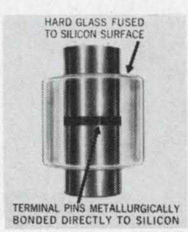

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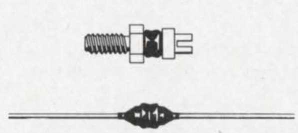

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adelphia's Franklin Institute Research Laboratories, will hold its first meeting Nov. 19 at the institute.

Permu isn't designed for the materials scientist; it's for the designer of circuits, loudspeakers, motors, meters, or traveling-wave tubes. It's already signed up 20 companies, including Raytheon and Bendix, as members.

Its founders have set three tasks for Permu: gather and distribute information, do research, and develop standards and tests.

"Most of the information on magnet use is scattered through book chapters, old and new periodicals, and manufacturers' handbooks," says Moskowitz. "The engineer has no one complete reference to go to. For example, some still-valid tests were described in a book written in the 1930's. That book is out of print now, so how does a guy find out about these tests?"

Deeds with reeds. Permu's own research will look at the problems that no one company or designer is willing to tackle, according to Moskowitz.

For example, Permu scientists are now figuring out which magnet to use with which reed switch to get a certain result.

Instrumentation

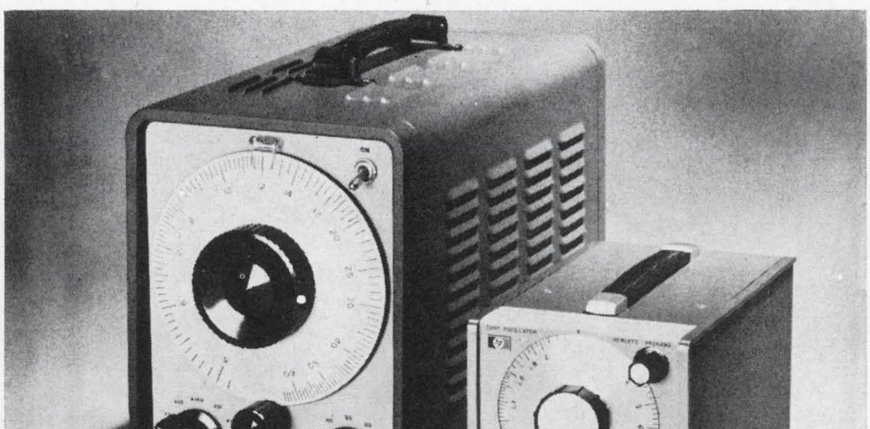
Good old days

In 1938, William Hewlett wrote his master's thesis on the design of a wide-range oscillator; naturally, the instrument made extensive use of tubes. Over the years, Hewlett and his partner David Packard parlayed their tube-designed instruments into a multimillion-dollar corporation. But today, even though Hewlett-Packard Co. offers much-improved solid state counterparts for most of its tube instruments, about 20% of its manufacturing is still devoted to designs that use vacuum tubes.

The buyers of these tube designs —mostly the military—couldn't care less that the solid state design is smaller, more reliable, and often more accurate, points out H-P's national sales manager, Jack Tetrak.

"Many people," he explains, "have vacuum-tube instruments cranked into their systems and are very reluctant to change."

To be sure, the demand for the old tube-designed instruments isn't based on a sentimental feeling for the old days. Tetrak adds: "Many technicians have been trained on the old tube instruments. If the in-



Old and new. Despite the gains of solid state design, about 20% of Hewlett-Packard's production is taken up with vacuum-tube instruments, like this wide-range oscillator, left. On right is H-P's solid state version.

How do you:

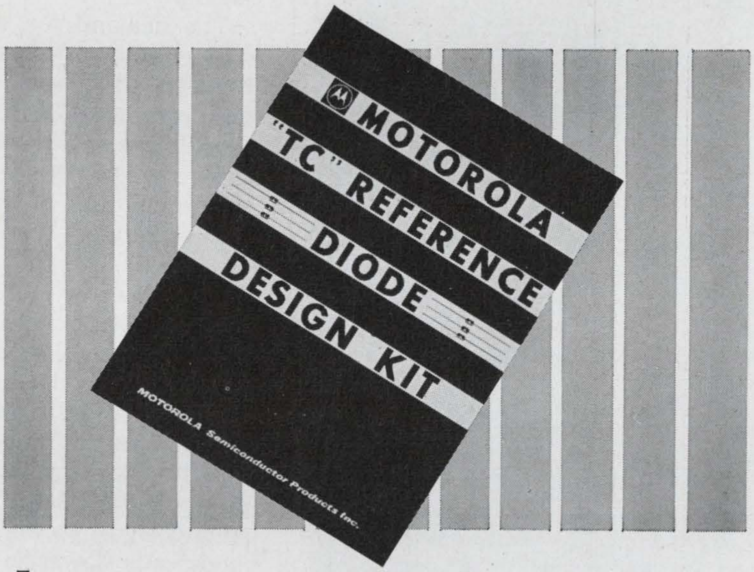
1. Select the lowest-cost temperature-compensated reference diode to meet a particular requirement?

2. Determine the maximum reference diode voltage change over a relatively small temperature change?

3. Evaluate the most voltage-time stable reference device in the most accurate way?

4. Determine device performance when operating at test currents other than those normally specified?

5. Obtain a sample of the highest-quality, temperature-compensated reference diode line available?



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You can select from Motorola 6.2 to 200 V TC voltage reference devices, too, featuring RamRod* construction and oxide-passivation for long-term, low-leakage stability and integrity of characteristics.

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MOTOROLA
Reference Diodes

MOTOROLA SEMICONDUCTOR PRODUCTS INC. P.O. BOX 20912, PHOENIX, ARIZONA 85036 dustry suddenly had to stop and retrain its personnel, the effects would be very expensive."

For the military, such an expense would be astronomical. Not only would the instructors have to be retrained, but thousands of training manuals would have to be junked and new ones prepared.

Unusual strain. To Hewlett-Packard, the continued strong demand for tube-designed instruments is hardly a blessing. "Sometimes," notes Tetrak, "the company loses money on these instruments." But just how much these sales affect its balance sheet, or to what degree other tube designs make up the difference, Hewlett-Packard isn't saying.

The demand for such tube designs places an unusual strain on H-P. First of all, some tubes are getting very hard to find. Manufacturers often won't even consider an order unless it's for outlandishly large quantities of the tubes. And the antiquated tubes are getting expensive, so H-P's profit margins begin to narrow in these areas.

One reason for the expense is on the production line. The wiring and assembly girls used to be able to remember the circuitry and could produce vacuum-tube instruments rapidly. But now the training and production emphasis is on the solid state designs, so work on the older modules is slower and more expensive.

Tetrak notes another reason for maintaining the vacuum-tube business: H-P built its reputation by guaranteeing to restore any of its old tube instruments to working order.

And that's quite a promise: H-P estimates that it has a quarter of a million oscillators and nearly as many voltmeters still in operation.

Memories

Pointing the way

Positioning a read-write head above a spinning disk requires precision; not only must the positioning system select one of 200 possible data tracks (each only 5 mils wide and 5 mils apart), it must also hit the track dead center—every time.

Honeywell's Electronic Data Processing division, expects to do the job with its read-write head-positioning system developed for a new line of magnetic disk memories scheduled to be delivered in late 1969 and in 1970.

Honeywell will deliver its disk drives with an electronic, closed-loop servo system. This should advance the state of the art, which until now has been anything but electronic. Some manufacturers—like IBM—even use gear wheel and pawl combinations to position the head—assuming that after the appropriate number of teeth have passed, the pawl can drop into a space between two teeth and hold the head in position.

If the pawl breaks. But this doesn't always work. Gears wear and are hard to make accurately in the first place; pawls break—in fact some are designed to break if the head is jarred—and heads will record slightly to one side of track position, or read out only part of the width of the track.

Where too much wear or inaccuracy has crept into a disk drive, users find it tough to read out disks recorded on different drives. The problem is compounded for users with many drives and many disk records, recorded at different times on different drives, each of which is wearing out at a different rate. It all adds up to a large maintenance bill to keep the machines accurate.

Instead of gears and pawls, Honeywell uses a linear transducer to close its servoloop. The transducer works on the principle of induced current and has no parts to wear. Not only does it find the proper track, but it helps assure that the head doesn't stray from it.

The transducer consists of two printed circuits, each of which looks like a "series-connected picket fence" in the words of one engineer, or like a ladder with broad, closely spaced rungs. Half the transducer is attached to the disk drive's base plate, the other half is beneath the moving assembly supporting the magnetic head.

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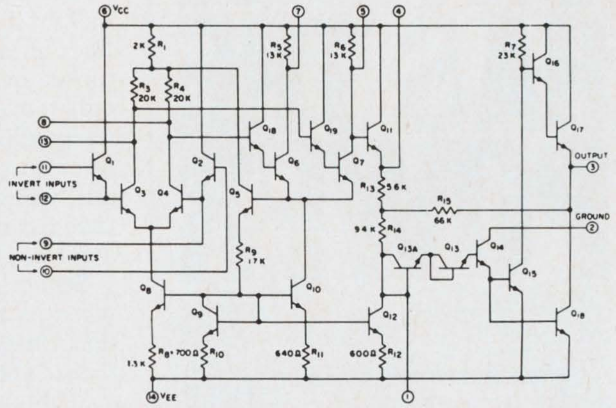
For more information, see your RCA Representative about CA3047 and the other Op Amps in RCA's economy/performance line. Or ask your RCA Distributor for his price and delivery. For data sheets on the RCA-CA3047, write RCA Electronic Components, Commercial Engineering, Section ICN-101, Harrison, N.J. 07029.

Supply Voltage	**± 12 V max.**
Power Output (10% THD) (R_L = 500Ω)	**80 mW min.**
C-M Rejection Ratio	**84 dB min.**
Output Swing Voltage (P-P) (R_L = 500Ω)	**18 V min.**
Input Impedance	**150 KΩ min.**
Open-loop Voltage Gain	**84 dB min.**
Input Offset Voltage	**5 mV max.**
Input Offset Current	**35 nA max.**
Input Bias Current	**350 nA max.**
Slew Rate	**1.2 V/μs typ.**
Operating Temperature	**0° to + 70°C**



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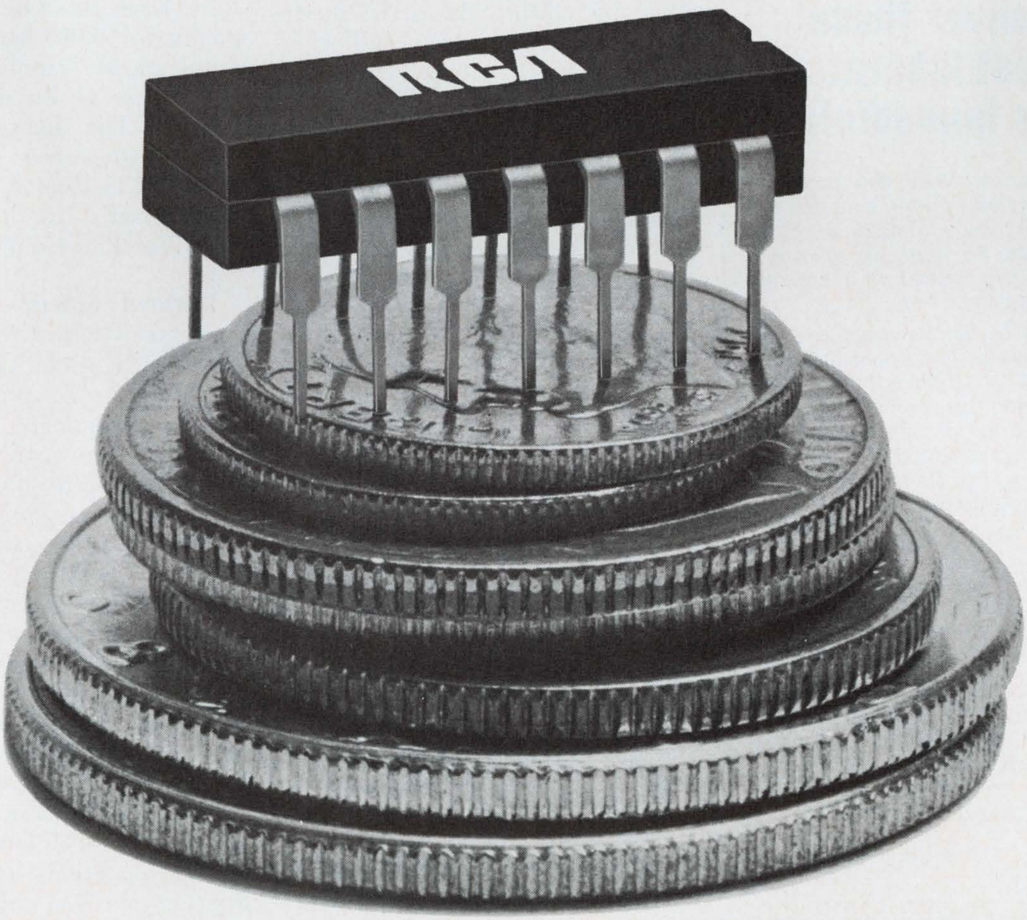

RCA Integrated Circuits

Current passes through the lower half of the transducer to produce lines of magnetic force around each picket or rung. As the upper circuit moves back and forth above, its conductors cut these lines of force and generate a sine wave output whose polarity changes each time a rung or picket is approached and passed.

Speed. Honeywell claims that when its new drives are in production they'll offer average access times about a third faster than available with other systems. According to Harry Scheuer, group director for direct address mass storage at Honeywell's research center in Waltham, Mass., IBM units average about 87.5 milliseconds address time while Control Data units now used with Honeywell computers take about 92.5 milliseconds to reach a given track. The new home-grown units, he says, will only take about 62.5 milliseconds.

Honeywell gets lower access time by cutting down the inertia of all moving parts including its printed-circuit motor. Honeywell has also designed into the servo an acceleration program which moves the head faster when it has more tracks to cross. As much as five gravities of acceleration and deceleration are used; between boost and breaking, the head moves at one of three controlled constant speeds, and finally, when counter circuitry indicates it's near the requested track, its speed drops to as little as two inches per second until stopped by the magnetic brake.

Once poised above a track, the brake holds the head so tightly that a 10-pound push on the head assembly moves the head only one mil, and any movement is automatically detected by the transducer as its output strays from the zero-crossing point. This in turn triggers more braking energy moving the head back to position.

Denser data. Honeywell's positioning system is accurate to within a couple of hundred millionths of an inch, accurate enough for Scheuer to start thinking about putting more tracks per inch on magnetic disks. While initial disk drives will be compatible with all the others around—that is, 200 read and write tracks of data—it's possible that Honeywell might be able to add tracks by reducing the space between them. How many more tracks could be added, Scheuer isn't ready to say; crosstalk between tracks would probably impose a final limit. But even 25% more tracks would mean 25% off a user's disk-pack budget.

For the record

Fourth generation. The Communications Satellite Corp., acting for the International Telecommunications Satellite Consortium, has approved a contract with Hughes Aircraft for the Intelsat 4 satellite. The contract is for approximately $72 million and will cover the cost of four spacecraft and one prototype. Each satellite will have a capacity for 5,000 voice-grade communications circuits. The first satellite is to be delivered in 22 months. The decision to contract with Hughes was made late last month [Electronics, Aug. 5, p. 34] by Intelsat's Interim Communications Satellite Committee.

Sentinel orders. After Defense Secretary Clifford recently ordered that the Sentinel antiballistic-missile program be put on schedule, the Army quickly gave Western Electric two contracts totaling $475.5 million to develop and build the costliest weapon system in U.S. history. As prime contractor, Western Electric will subcontract about 60% of the $273.2 million research and development and $202.3 million production awards. Among the subcontracts let so far are Raytheon, $10 million to develop and $50 million to build a missile site radar; General Electric, $50 million to develop detection radar and $8 million to produce it; McDonnell Douglas, $55 million to develop and produce Spartan missiles; and Martin Marietta, $35 million to develop and produce the backup Sprint missile system.

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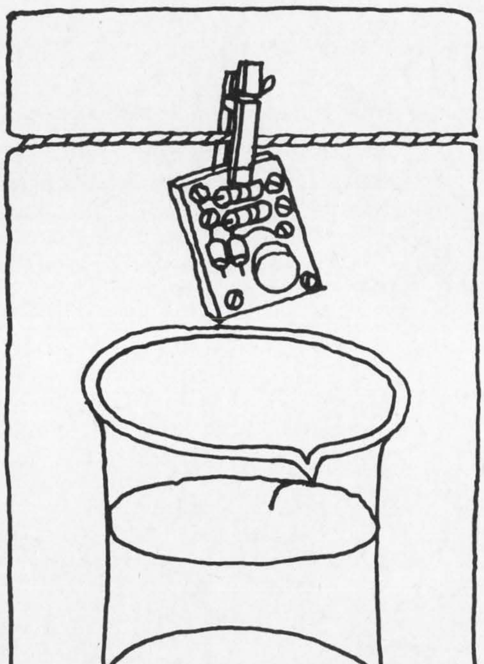

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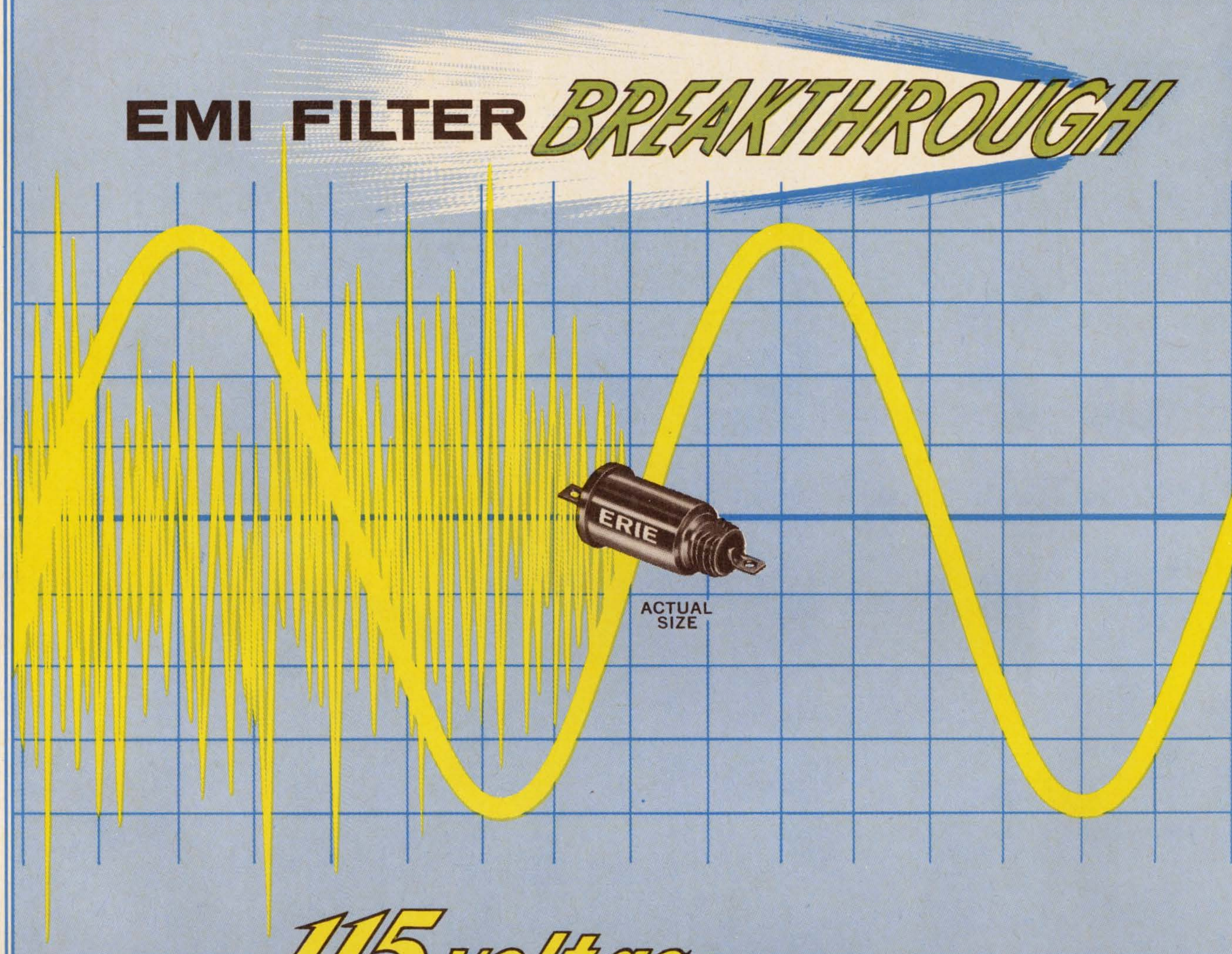

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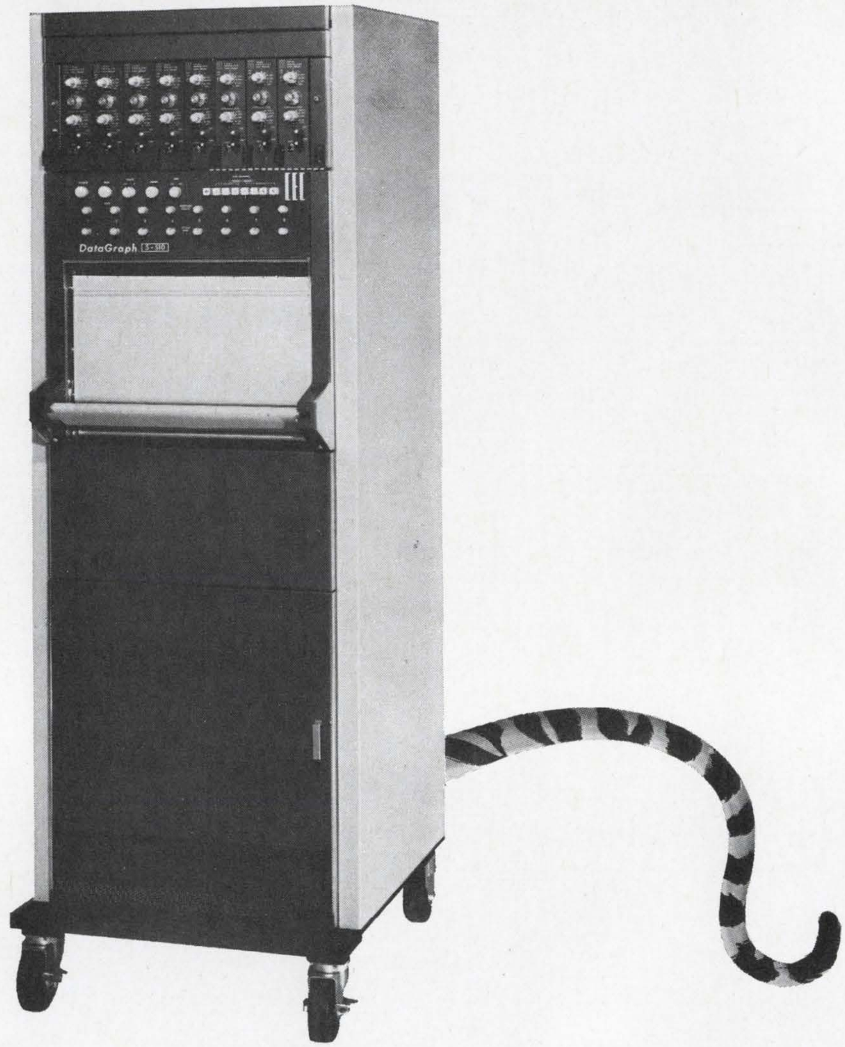

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A "quickie TV" satellite ground station, which Hughes installed on short notice at Bogota, Colombia, made color television coverage of Pope Paul's visit to the Eucharistic Congress in August available to one-third of the world. The TV signals were relayed by the ATS-3 satellite to ground stations at Rosman, North Carolina, and Goonhilly-Downs, England.

Unique ground station was built in 25 days, flown on one airplane to Bogota, and set up in a few hours. It was leased for the occasion by Communications Satellite Corporation, and was built by Hughes Communications International, a Hughes subsidiary, which is currently designing a ground station for Brazil.

Two new air defense network centers have been installed in West Germany. They will be operated by the German Air Force, and are designed to net with Hughes-built centers located in Belgium and The Netherlands. New centers will give the three countries an electronic "umbrella" against aerial attack. A similar Hughes-designed system was delivered to Japan in March and another is being installed in Switzerland.

A cigar-shaped satellite carrying a coronagraph to photograph the sun's corona has been proposed to the National Center for Atmospheric Research by Hughes. It would draw its power from the sun through two solar panels and would snap pictures continuously for nine months from a 300-mile-high Earth orbit. Scientists long have been hampered in studying the outer region of the solar corona because a coronagraph cannot observe it through the earth's atmosphere.

An Air Force contract to develop Maverick, an air-to-ground, non-nuclear missile, has been awarded to Hughes. Maverick is a TV-guided weapon designed to knock out enemy tanks, armored vehicles, and field fortifications.

A communications satellite system for Canada, which would encourage development of the far-north territories by providing 24-hour telephone, telegraph, and TV service, is now under study by two industry teams. Hughes is a member of the team headed by Northern Electric Co. Ltd. Radio -- only form of communication today -- suffers frequent blackouts. Proposed system would also provide national TV distribution and an alternate east-west telephone capability.

A prototype of the ADAR (Advanced Design Array Radar) defense system is now being built by Hughes under a U.S. Air Force contract. ADAR is designed for split-second defense of cities against attack and will pinpoint and identify distant supersonic targets. Full-scale ADAR system, which could be operational in the early 1970s, would be the world's most powerful radar defense.

World's first synchronous communications satellite, the Hughes-built Syncom II, had its fifth anniversary in space in July, though it was designed to operate for only one year. During its five years in orbit it has operated over both the Atlantic and Pacific. Today, though its fuel supply is exhausted and it is permanently trapped by the triaxial force field over the Indian Ocean, it is still transmitting at full power.

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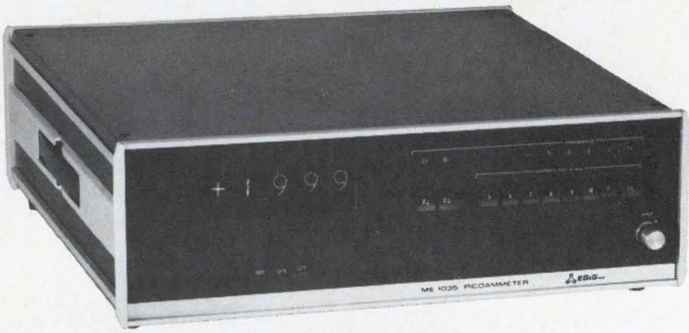

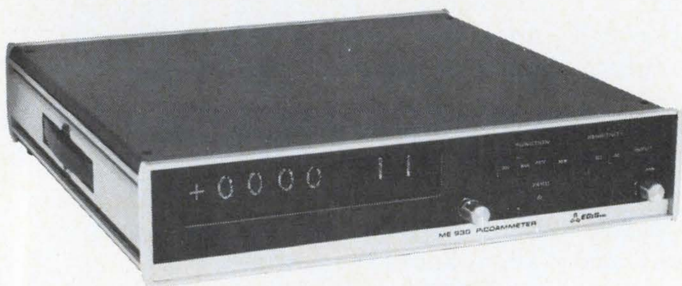

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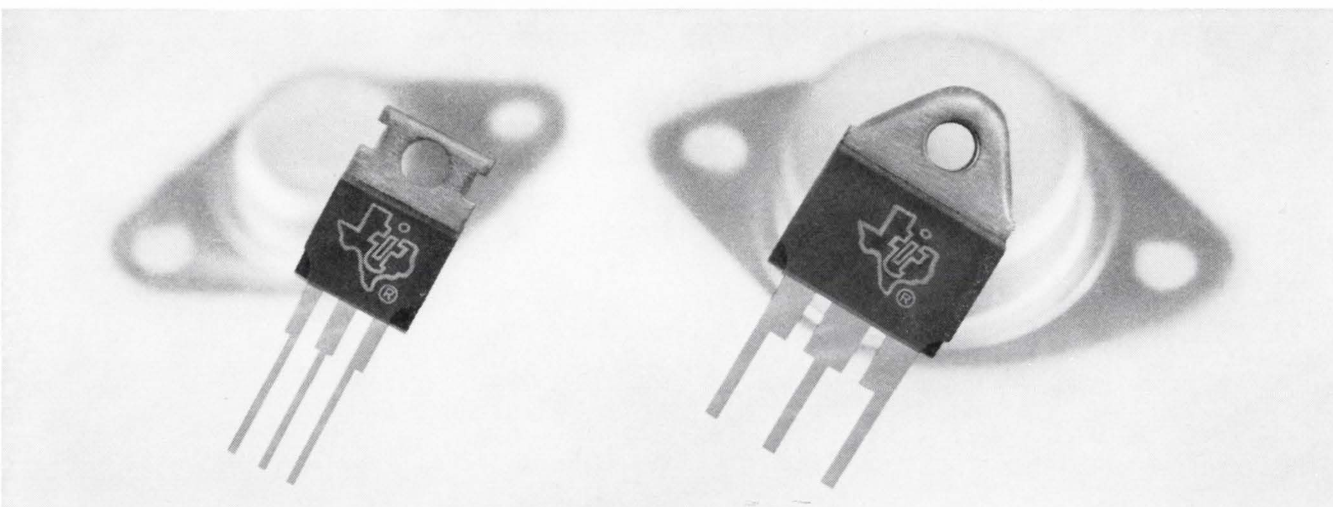

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TIP29A	TIP30A	60	1	TO-66	40-200 @ 200mA	30W
TIP31	TIP32	40	3	TO-66	20-100 @ 1A	40W
TIP31A	TIP32A	60	3	TO-66	20-100 @ 1A	40W
TIP33	TIP34	40	10	TO-3	12-Min @ 3A	80W
TIP33A	TIP34A	60	10	TO-3	12-Min @ 3A	80W
TIP35	TIP36	40	25	TO-3	20-100 @ 5A	90W
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Circle 77 on reader service card

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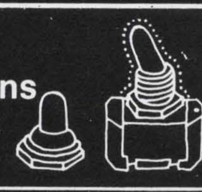

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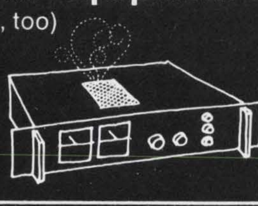

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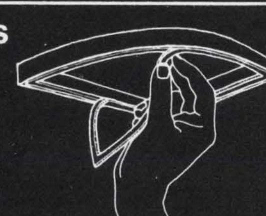

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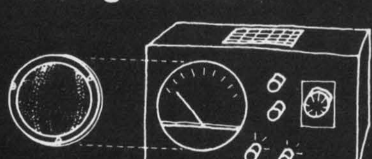

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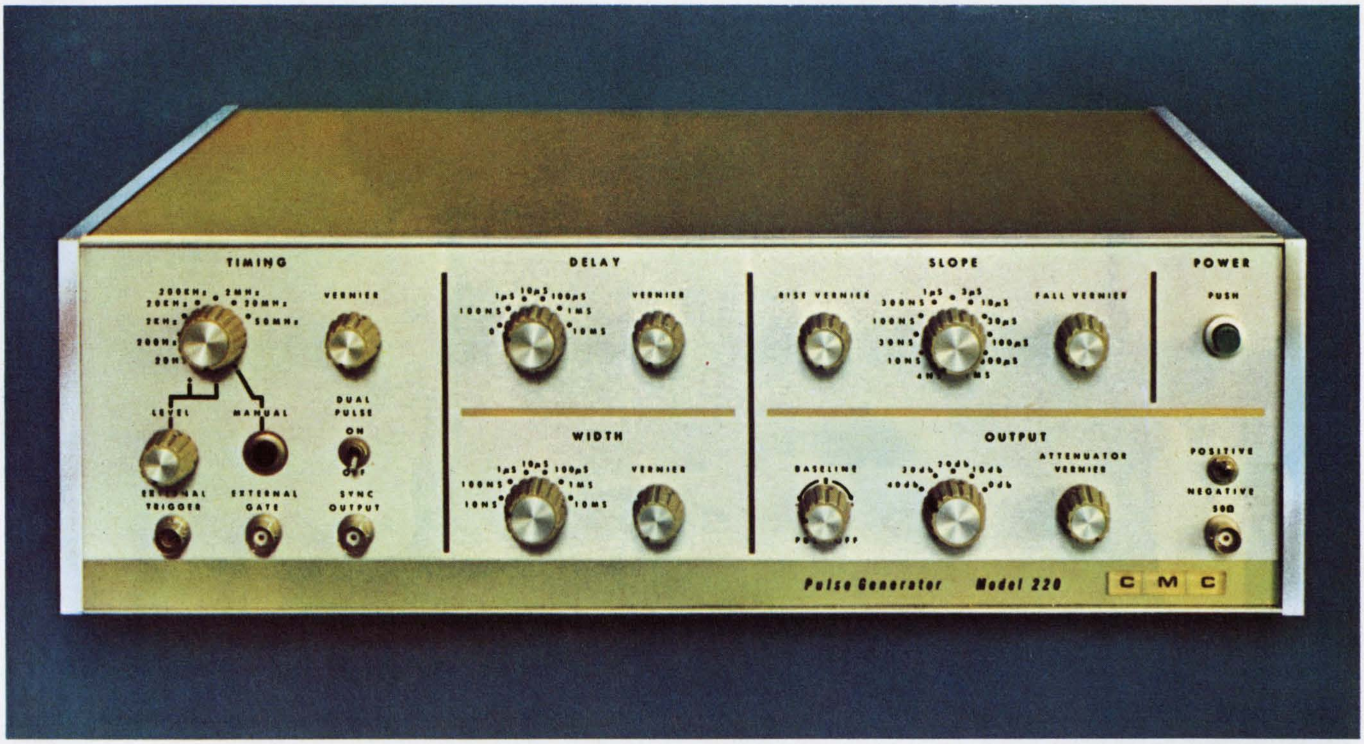
103

Now, here it is—The best pulse generator you can buy for $1225



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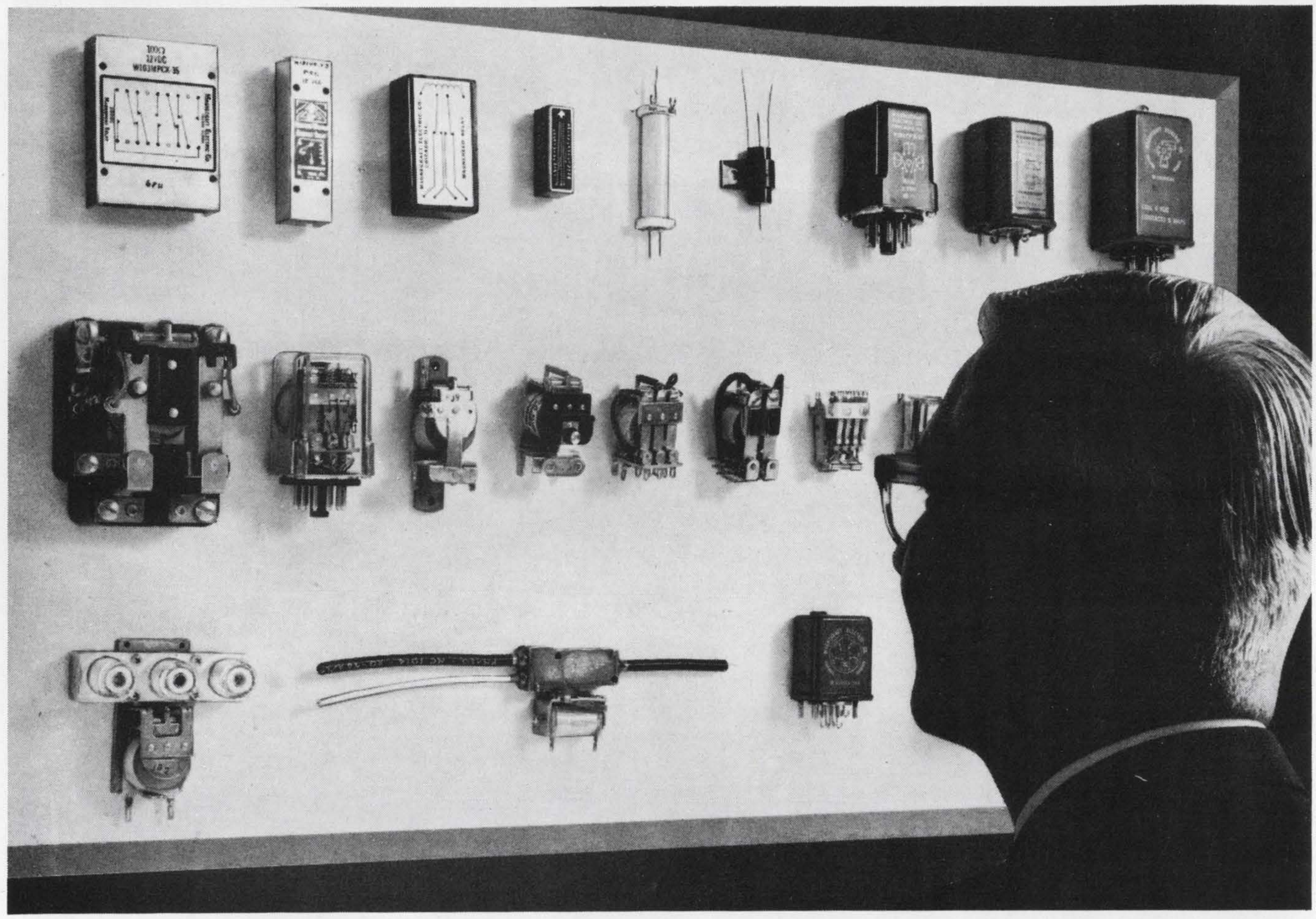

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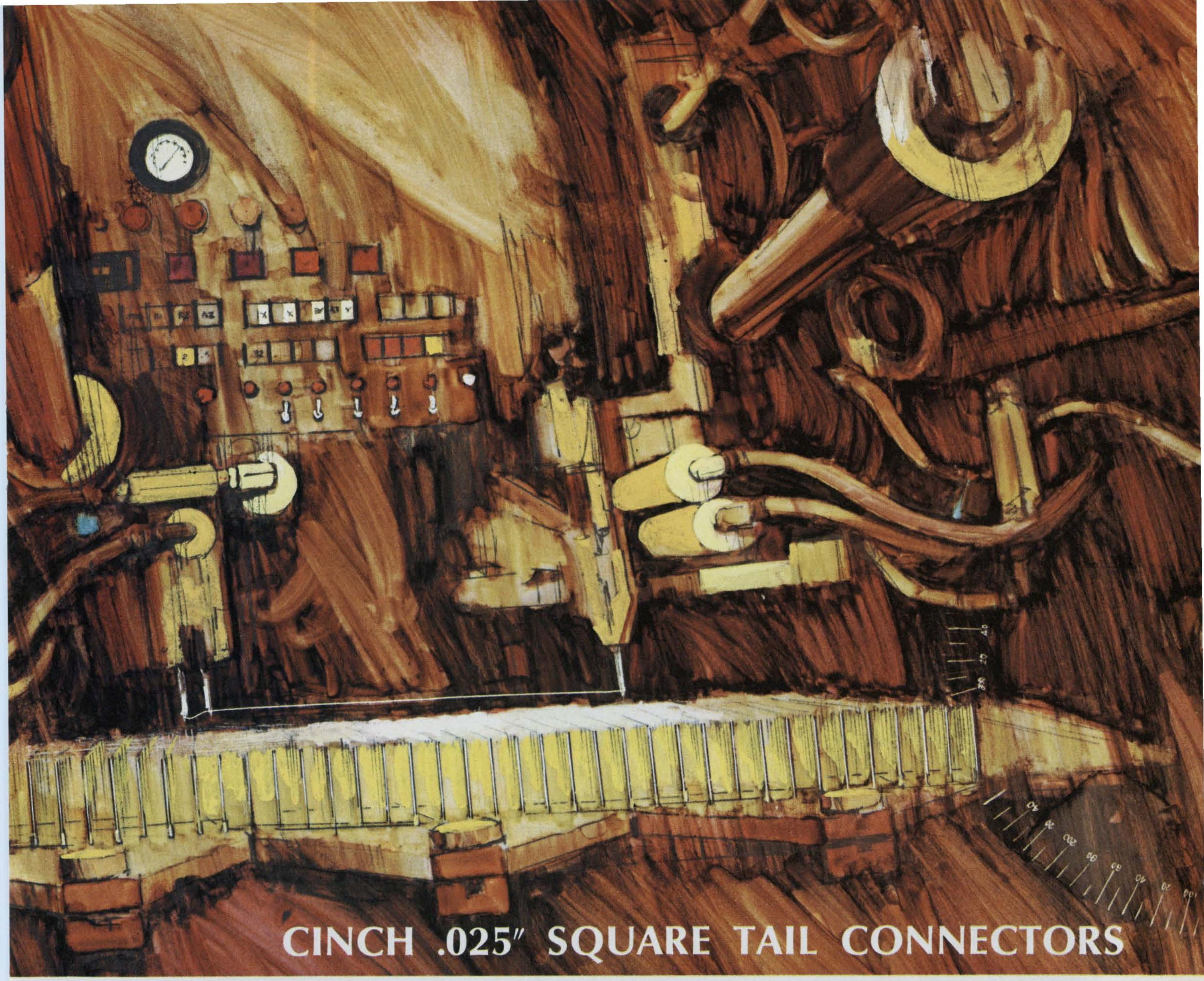
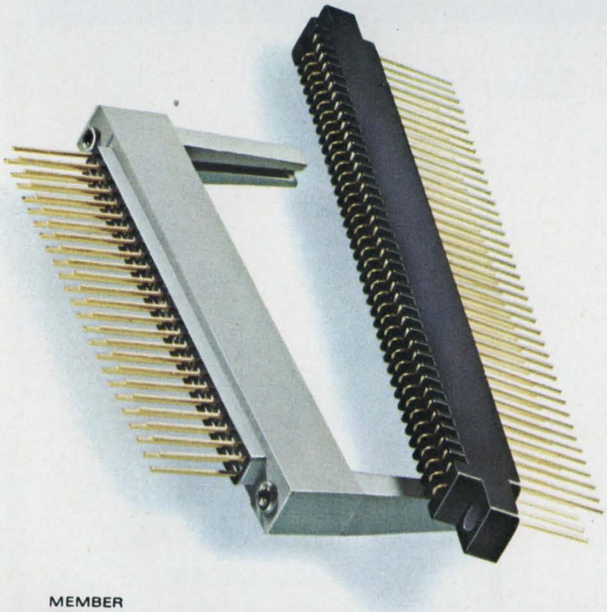


SHARPLY REDUCE HIGH DENSITY WIRING COSTS



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The Cinch .025" square tail contact, available in a wide range of sizes and insulator types, incorporates many cost reducing advantages in automatic and hand wire wrap applications.

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Illustration is artist's impression of Gardner-Denver Automatic WireWrap Machine.

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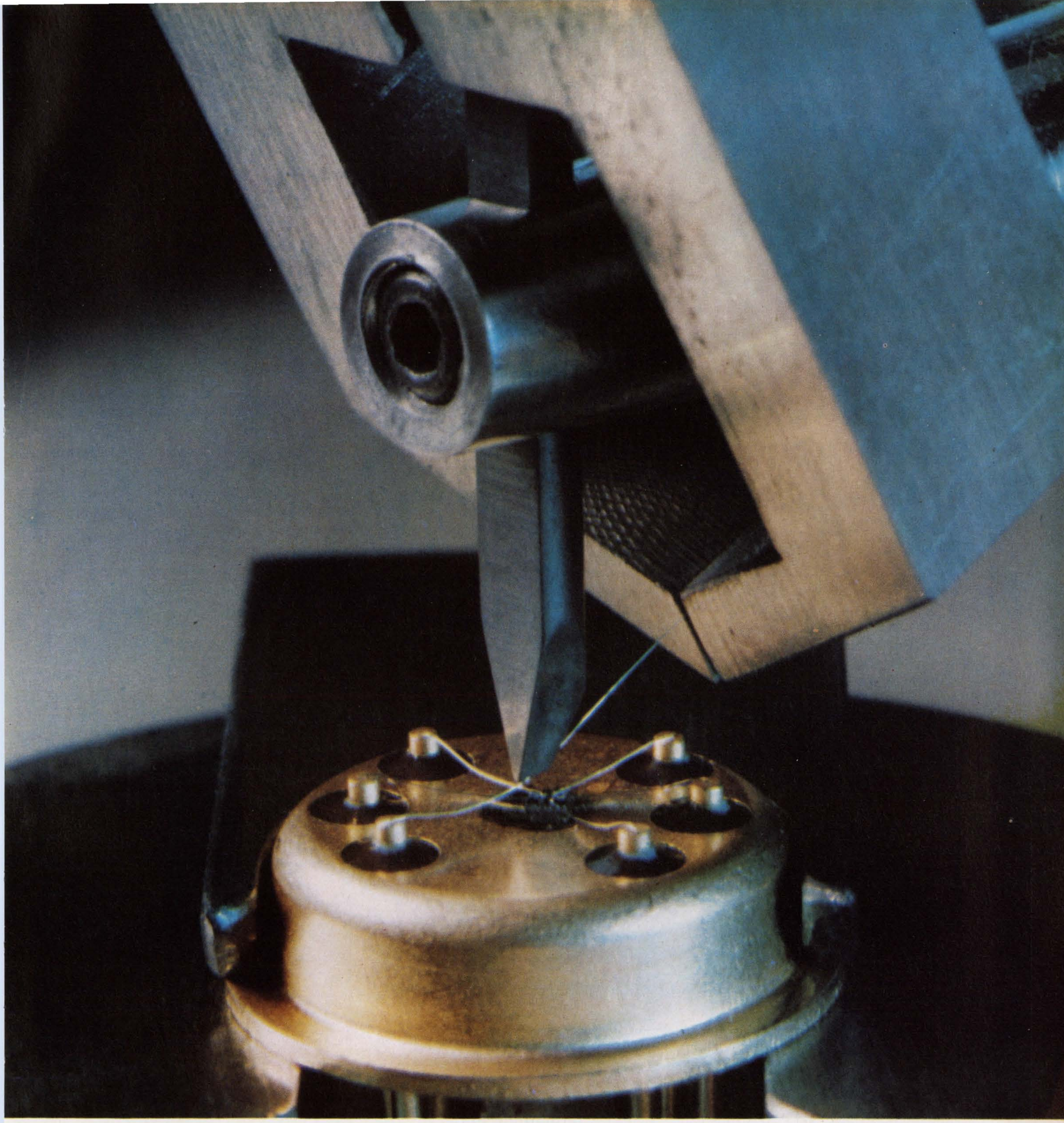


Washington Newsletter

October 14, 1968

Rumors that F-111 will be dropped leave avionics up in the air

The problems the Air Force is having with the F-111A may all be over in the not too distant future. **There's growing speculation that the whole program will be canceled.** Just where this would leave the Mark 2 integrated avionics system being developed by Autonetics for the F-111D version isn't clear.

A well-placed source at one subcontractor says that "more and more, we're writing off the whole F-111 program. And we're thinking about where we'll transfer our people who are working on it."

Behind schedule and overweight, the swing-wing plane has run into increasing flak in and out of Congress because of a series of crashes. Costs have continued to climb. **Another sign pointing to the demise of McNamara's TFX is the increased attention the Air Force is giving to the proposed FX and the Advanced Manned Strategic Aircraft.**

More money seen for P.O. research

It now looks as if the Post Office will seek $55 million for research and engineering in fiscal 1970. Much of it would go for electronics. This would be nearly $20 million more than the current R&E budget of $36 million, and four times the budget of fiscal '67. Next year's proposed budget might be revealed Oct. 16 at the Post Office's second research and engineering briefing for industry to whet the appetite of contractors. **Unless the new Congress has a drastically different outlook on postal research spending, the request for more money most likely will be granted.**

FAA still awaits OK on ATS L-band test

Officials of the Applications Technology Satellite project are rejoicing that the latest round of cuts in NASA's budget didn't affect their follow-on F and G satellites, but **a lack of funds did force them to drop a plan to add a "piggyback" camera satellite to the ATS-E.** Called Camsat, the Hughes Aircraft scheme was well received by the ATS project office, but it would have cost $10 million [Electronics, Sept. 2, p. 54].

Another proposed addition to the ATS-E satellite—an L-band transponder [Electronics, July 22, p. 53]—is still expected to make the flight, but **NASA approval is long overdue and the FAA, which proposed the experiment, is unhappy over the delay.** Says an FAA official: "For three months now, NASA has been telling us that approval was imminent. This delay has been holding up our program to move into L-band communications." The FAA has already earmarked money to develop L-band hardware for the craft and to conduct the tests.

Phone-line backup planned by FAA

The danger of ground communication failure in its air traffic control system has forced the FAA to okay a backup system for existing telephone circuits. **Next month, the agency will ask for industry proposals to supply a number of digitally tuned transceivers.** It will buy as many of the solid state units as it can for the $4 million it has taken from its facilities and equipment budget. Plans aren't yet firm, but the FAA wants to make more big transceiver buys during the next two years.

The decision is one result of a project set up by the agency to cope with the problem of communication breakdown. **The FAA is worried**

about failures in phone lines linking en route and area control centers with remote ground-to-air radio transmitters. For example, a break in a phone cable knocked out 22 of 25 circuits for four and a half hours in the Washington area not too long ago.

Reliability on such links is 99.7%, but the FAA has concluded that even this isn't good enough for air traffic control. The backup system, one official predicts, will cut total average monthly outages to 23 seconds from about two hours currently.

FCC stalls on big cable . . .

The FCC isn't in any hurry to act on AT&T's proposal to build a $170 million cable system between St. Louis and Los Angeles. **Commission staffers are concerned about giving approval to so large an investment in cables before the national policy on domestic satellites is spelled out.** The FCC staff now expects the new Administration to present those guidelines early in its term. Bell System plans call for a cable capable of handling 90,000 phone conversations simultaneously.

. . . as support grows for satellite system

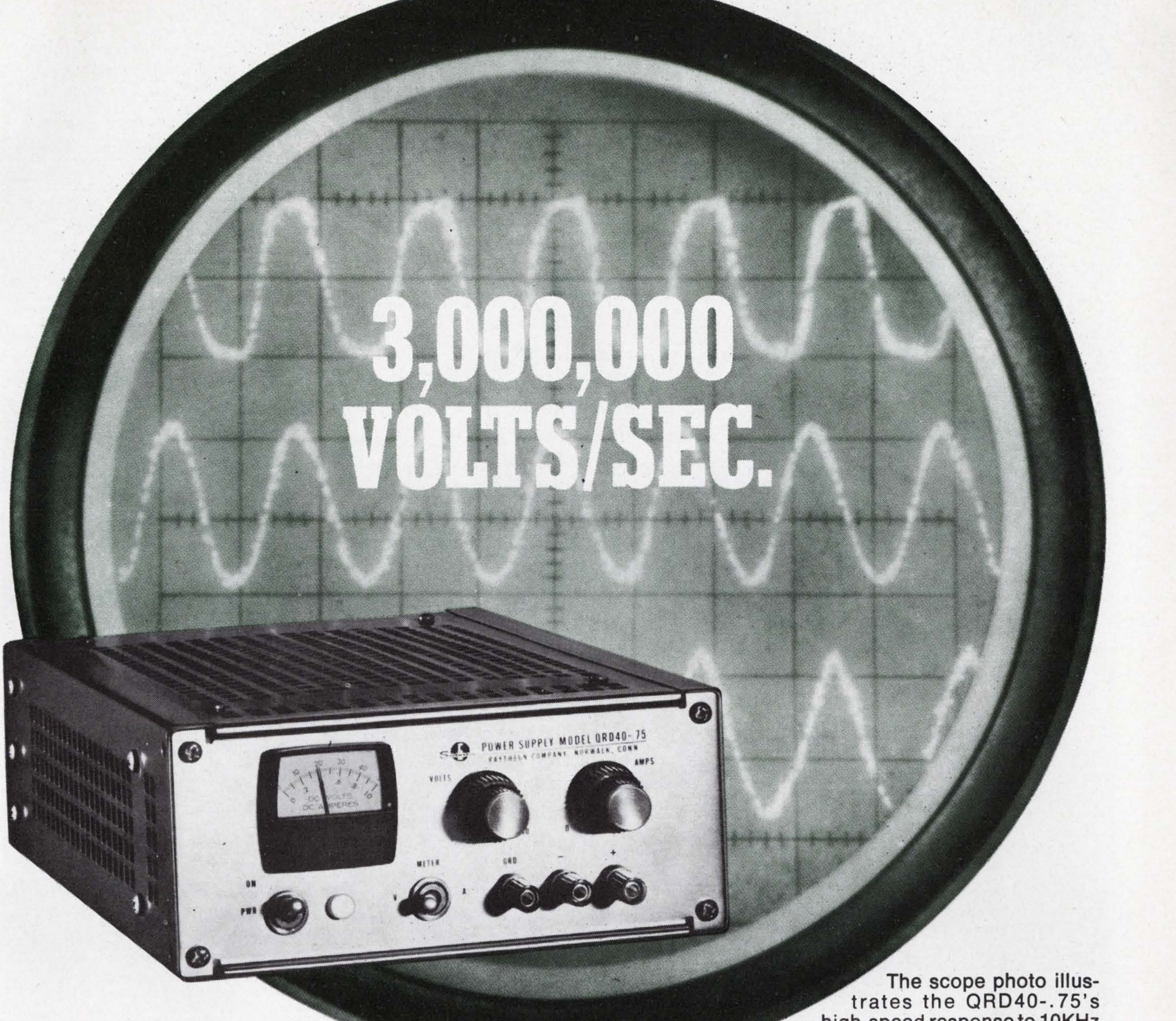
Meanwhile, Comsat officials detect what they call a favorable attitude in Congress toward a domestic communications satellite system. One example of the current Congressional mood: Harley Staggers (D., W.Va.), chairman of the House Commerce Committee, twice said in a recent dedication speech at Comsat's new ground station in West Virginia that he expects to see a domestic system "soon." One Comsat official calls Staggers' comments a prod to those delaying or opposing the domestic system, noting that FCC chairman Rosel Hyde was in the audience at the dedication. Comsat last year proposed a demonstration domestic system to the FCC.

ARTS contract expected soon

The long-awaited FAA contract to install the first 15 Advanced Radar Traffic Systems at air terminals [Electronics, Sept. 2, p. 111] is expected to be awarded by the end of the year. **Raytheon is believed to be the front runner;** Univac is the other company negotiating with the agency. The order, worth about $14 million, originally called for work to be completed in fiscal 1969. But because of the delay in awarding the contract, its doubtful that this timetable can be kept.

Addenda

The current confusion over the patenting of computer software should be cleared up next week. Patent Commissioner Edward J. Brenner will spell out a new policy on software in a speech at George Washington University on Oct. 22. The question troubling both manufacturers and Government officials is whether software is the province of the Patent Office or the Copyright Office [Electronics, Sept. 16, p. 33]. There's no clue yet as to what answer Brenner will give. . . . No FCC action on the St. Louis-to-Chicago microwave link is expected until after the election. Microwave Communications wants to establish the system in competition with Bell and Western Union. The word is that the commission is split three-three and that **chairman Hyde is hoping that H. Rex Lee, the new commissioner [see p. 16] will cast the deciding vote against the link.** The firm wants to offer "discount rates" to large commercial communications users, but AT&T argues that this would throw off the rate-averaging structure.



The scope photo illustrates the QRD40-.75's high-speed response to 10KHz square, sine and triangular waves. Amplitudes are 20V peak-to-peak.

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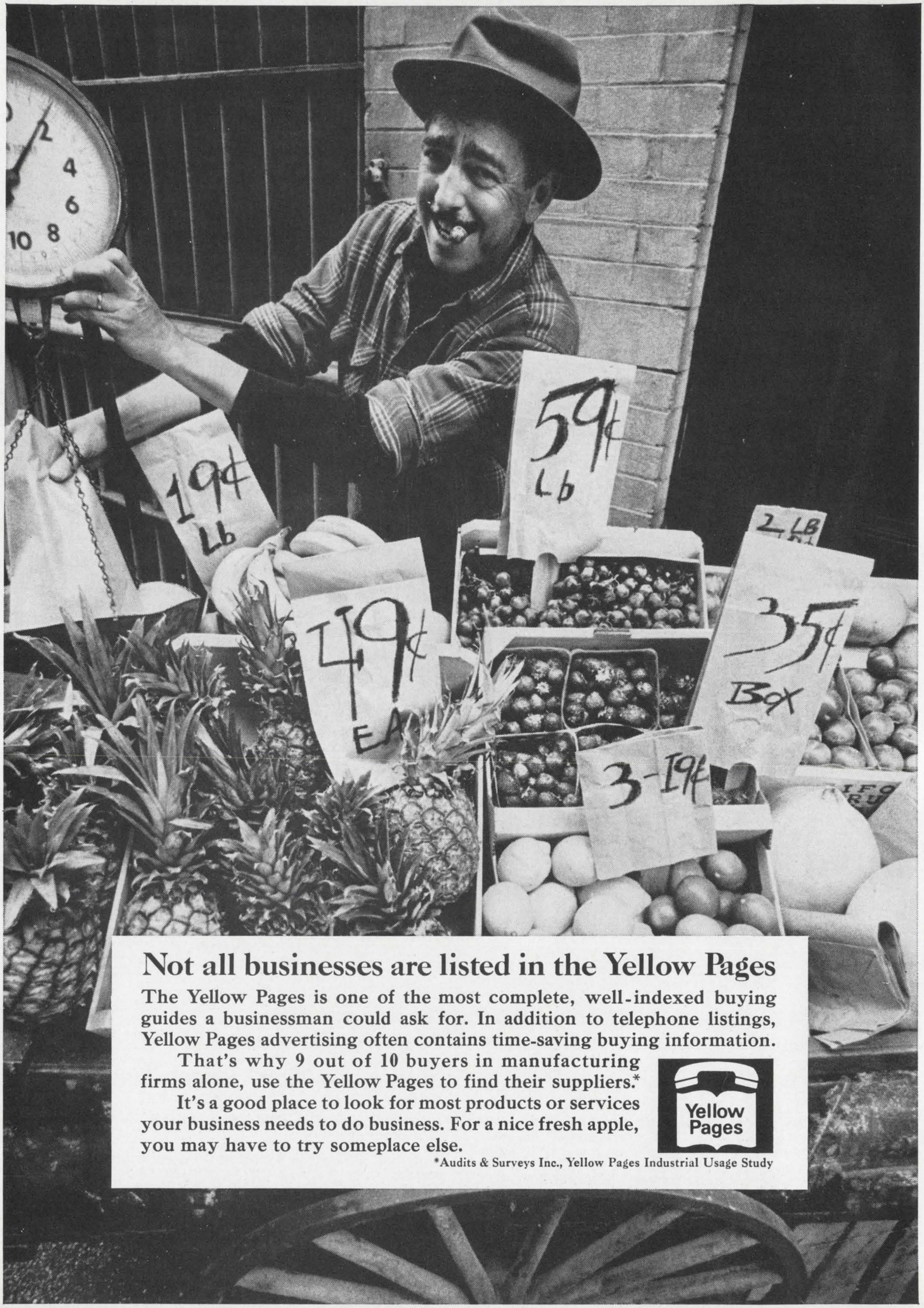

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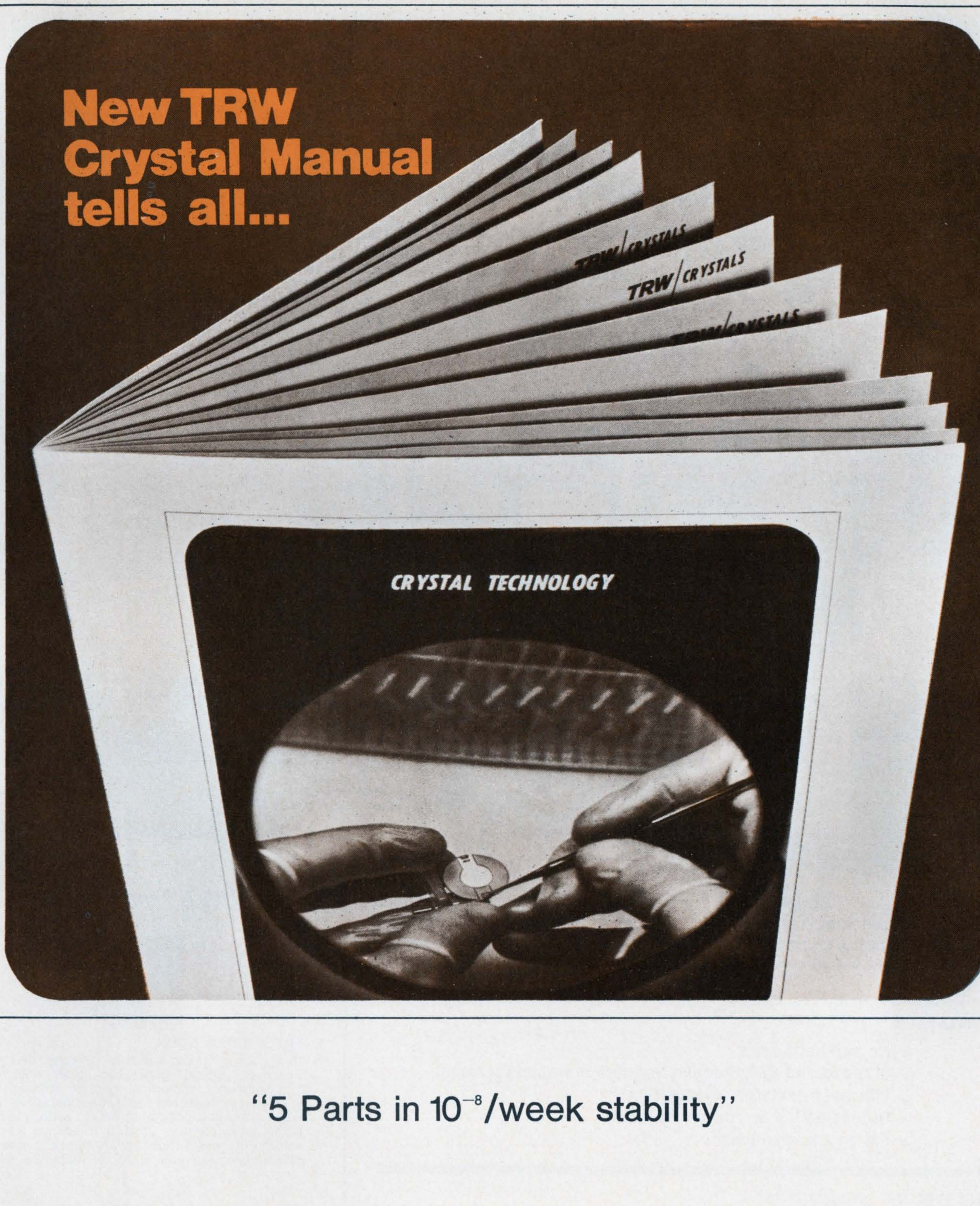
*Audits & Surveys Inc., Yellow Pages Industrial Usage Study



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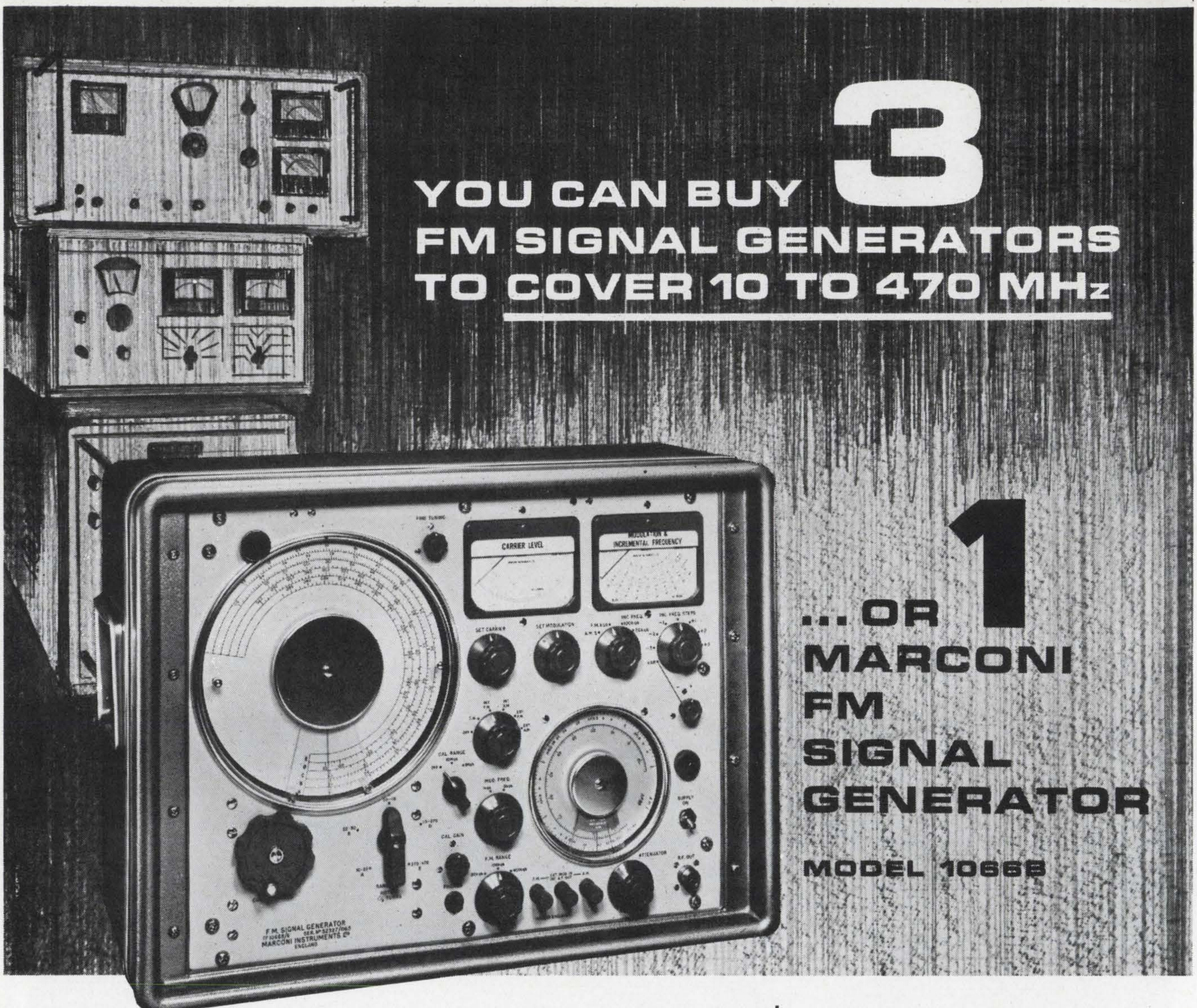

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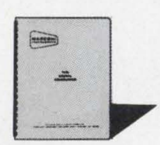

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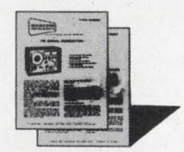

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Technical Data Sheets on the Model 1066B/1 and Model 1066B/6 Marconi FM Signal Generators detail all specifications, operation, applications, features and accessories available.

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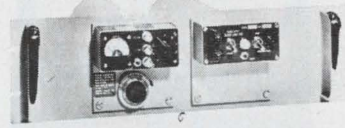

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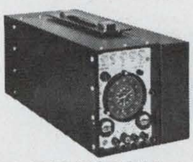

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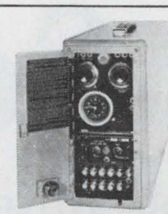

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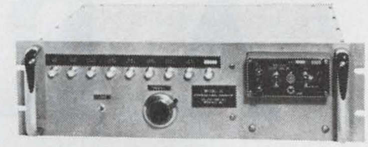

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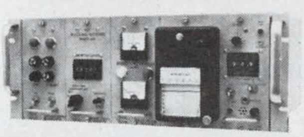

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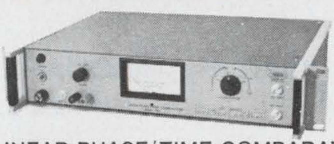

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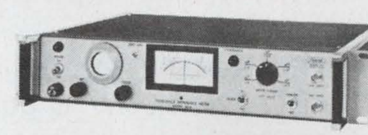

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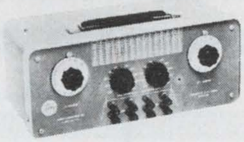

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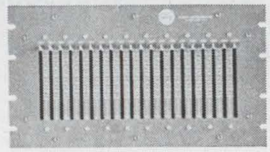

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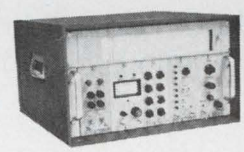

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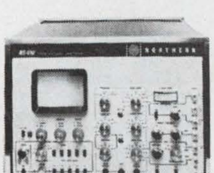

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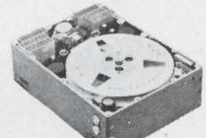

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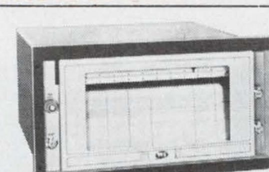

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October 14, 1968 | **Highlights of this issue**

Technical Articles

Big future seen in ferrite crystals page 104

Ferrites have proved their worth in radar and communications systems operating from very high frequencies through the millimeter-wave range. But more important in the future will be the use of these materials as substrates for microwave IC's. Complete systems can be integrated on a single slice of ferrite because of its built-in magnetic properties. The cover photo, taken at Autonetics, shows a model of the materials' crystal structure—the key to their unique characteristics.

Super-ECL: a new family page 124

The fastest mass-produced IC's yet—emitter-coupled logic circuits with scaled-down geometry—have a gate propagation delay of only 1 nanosecond. But their speed creates problems for the equipment designer: he needs elaborate cooling techniques to handle the high power dissipation, and transmission-line interconnections to maintain the speed advantage. And because the speed of the circuits approaches the accuracy of the measuring instruments, a correlation of maker and user tests is difficult.

Hybrid computers help design control systems page 132

It takes a lot of data to design one of today's complex industrial control systems—and a lot of data processing. The designers can gather the information needed about the industrial process itself and about the best possible control schemes by using a hybrid computing facility to develop models, analyze the dynamic characteristics of actual plant disturbances, investigate new control arrangements, and simulate the process and the controller before the completed system is shipped to the customer.

Lasers take a long look underwater page 140

Narrow, high-powered pulses of blue-green laser light have more than doubled the range of visibility underwater. But systems that can peer through the ocean are still rather primitive; it's hard to predict the behavior of light scattered from the beam by water, organisms, and particles. Knowledge of the paths and travel times of scattered light could make scanned laser systems possible and sharpen underwater vision.

Coming

Memories

A series on computer memory technology covering every area in depth will start in the Oct. 28 issue. The first installment will include articles on ferrite-core and thin-film memories.

Ferrites' attraction is magnetic and growing

Their unique properties have won these materials a place in radar and communications systems; next stop: substrates for microwave IC's

By Richard Gundlach
Military electronics editor

Ferrimagnetic materials, with their nonreciprocal properties and high magnetism and resistivity, are cropping up in passive devices for low- and high-power applications at frequencies from 30 megahertz on up into the millimeter-wave range. And several of them are included in just about every microwave system built today, performing functions suitable only to the unique characteristics of ferrites.

In fact, the growing acceptance of these devices is bound up in the over-all progress of microwave technology over the past 10 or so years. Compare present-day electronically tuned wideband ferrite filters with the mechanical monsters of a decade ago. Or consider that ferrite isolators and circulators have greatly reduced mismatches in radar and communications systems, and that they permit an antenna to be used for transmitting and receiving without transmit-receive tubes.

Among other things:

- Yttrium iron garnet (yig) tuned oscillators are starting to replace backward-wave oscillators in frequency-sweep operations.
- Ferrite substrates are being used for microwave integrated circuits, and complete microwave front ends will soon be fabricated on them.
- A mixture of ferrimagnetic materials and glass makes it possible to modulate a laser beam at 10 gigahertz.
- Ferrite delay lines are used as dispersive filters for pulse compression systems.
- Ferrite phase shifters play a leading role in electronically scanned phased-array antennas.

This list could go on. It might be noted, for instance, that certain ferrites make excellent contrast material for X-ray diagnosis. When swallowed by someone having a physical exam, they can be positioned in the gastro-intestinal tract by an external magnet. These materials don't react with stomach acids, and when ingested they can be accurately held over, say, a peptic ulcer by a simple "magnetic bandaid."

These are just a few of the jobs being done by the modern descendants of lodestone; actually there aren't many passive tasks they can't handle.

Gordon Harrison of the Sperry Rand Corp.'s Microwave Electronics division feels that the combination of ferrimagnetic substrates and microstrip techniques will have a great impact on future microwave devices.

Dwight Caswell, an advanced development and planning consultant for Melabs, a manufacturer of circulators and isolators, agrees. He believes stripline techniques are obsolete no matter what substrates are used because of microstrip's lower cost and better reproducibility. "Of course, right now we can't get as low an insertion loss in microstrip as in stripline, but there are ways around this; it's just a matter of time," he says. Caswell expects 30% of the market to be in microstrip two years from now, and predicts that about 90% of all stripline devices will be converted to microstrip within the next five years.

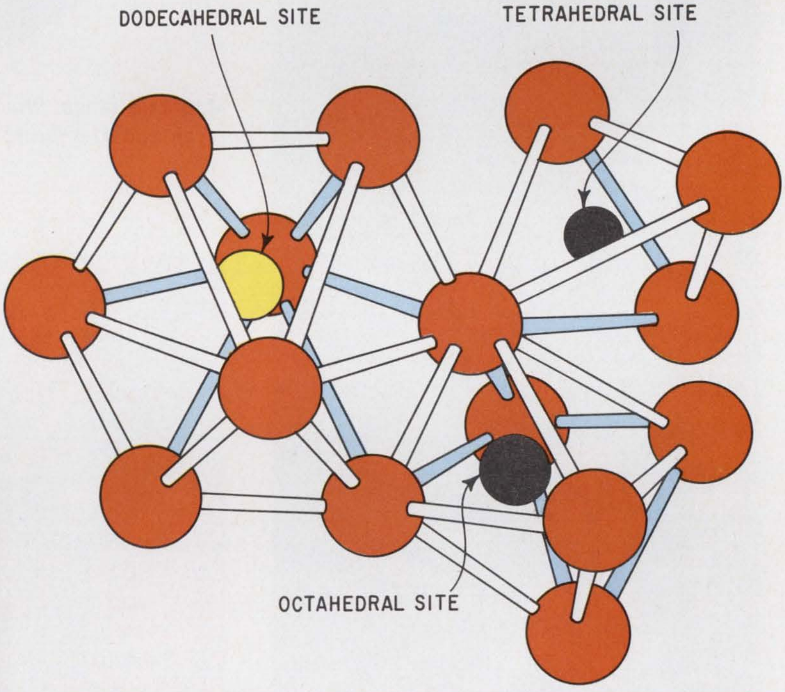
Common ground

Ferrite substrates offer the prospect of building both active and passive, reciprocal and nonreciprocal devices on a single substrate. Recent work at RCA indicates that ferrimagnetic materials can be locally doped to yield semiconductor materials with high mobilities. It should therefore be possible to dope ferrimagnetic substrates to provide such active devices as amplifiers, oscillators, and switch drivers, and use the remaining portions of the substrate for passive nonreciprocal and reciprocal devices such as circulators, isolators, attenuators,

Birth of a ferrite

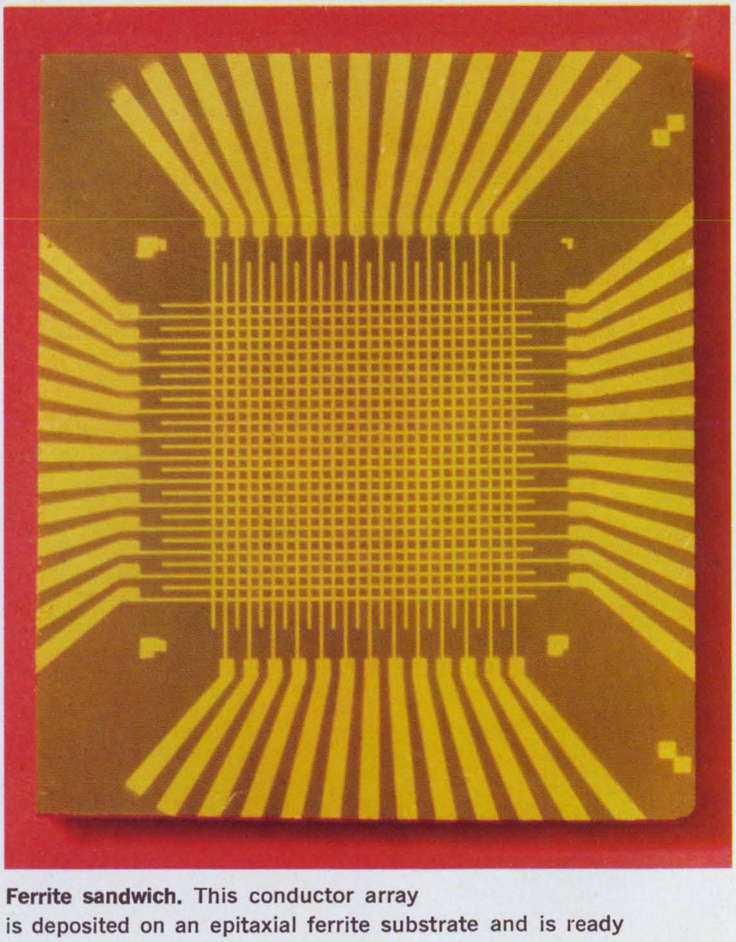
The growth of single-crystal ferrites begins when rare-earth and metallic oxides and other materials that act only as a flux are thoroughly mixed and placed in a platimium crucible. After these materials are premelted and additional powders applied, the crucible is placed in a furnace and held at a constant "soak" temperature of approximately 1,300°C for a day. At the end of the soak period, the furnace is cooled uniformly—2° to 3° C an hour when optimizing composition and growth condition, and 0.2° to 0.5° C an hour when growing larger and better quality crystals.

At 1,065° C, the crucible is rapidly withdrawn and the excess liquid (flux) is poured off, leaving the crystals attached to the crucible. The crystal structure is made up of three types of sites, which are formed by oxygen atoms and occupied by the smaller metal atoms. These crystals are then cut up and reshaped into spheres or whatever particular shape is required.



Many small magnets. All the separate magnetic domains are visible under a high-power microscope.

Mountain range. What appears smooth is really a faceted growth of an epitaxial ferrite film when magnified 250 times.



Ferrite sandwich. This conductor array is deposited on an epitaxial ferrite substrate and is ready for a final encapsulation with ferrite.

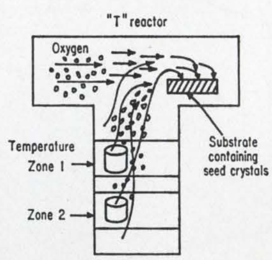
phase shifters, and switches. Here are all the ingredients of a microwave receiving system, including the intermediate-frequency portion, so why not build the system on a ferrite substrate?

Sperry's Harrison asserts that "if you want to optimize the performance of any microwave system, you're going to end up using ferrite anyway." He expects the microwave industry's now indispensable machine shop to be replaced by facilities for the photoetching, vapor plating, and thin-film deposition techniques developed by the semiconductor industry. Sperry is using their in-house materials capability to good advantage, tailoring ferrite characteristics to particular circuit requirements rather than restricting designs to commercially available ferrites.

Ferrite substrates can be sliced directly from a piece of bulk ferrite, or the ferrite can be deposited on another substrate material through chemical vapor deposition and sputtering methods.

Sperry makes their substrates by slicing bulk ferrite into wafers .017 to .040 inch thick and then lapping the pieces to a 5-micron surface finish. A 200-to-400-angstrom layer of chrome is vacuum deposited to provide a surface for a 2,500 Å layer of vacuum deposited gold. A 0.2-mil thickness of gold is electrodeposited and the desired circuit is exposed on a photoresist layer on the gold. The excess gold is than etched away, leaving the completed circuit on the ferrimagnetic substrate.

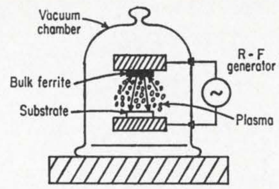
Autonetics is epitaxially growing thin ferrite films of yig. J.E. Mee, a group scientist, is putting the ferrite source materials into crucibles placed in the vertical arm of a chemical T reactor. Each of these source materials is positioned in a separately controllable temperature zone. An inert carrier gas passing up the vertical arm sweeps the materials into the reaction zone—the horizontal arm of the reactor. All the reactant gases then mix over the seed crystals (substrates) and react on their surfaces.



"We're also looking into growing lithium ferrite films for NASA," says Mee. "We plan to continue growing yig and other ferrite films because we believe this work is the harbinger of single-crystal substrates for MIC's.

Bombardment

G.T. Roome, technical director of the microwave materials and devices group at the Syracuse University Research Corp., explains that his group is investigating the use of radio-frequency sputtering techniques to deposit ferrite on thin-film substrates. This process is really an atom-by-atom transference of the original bulk ferrite to a substrate material. The ferrite material is placed on one electrode and the substrate to be coated on the other. When an r-f generator creates a glow discharge in plasma between the two electrodes, ions from the plasma bombard the ferrite material dislodging some of the surface atoms. These atoms, attracted to the opposite electrode, coat the substrate.



Lee Fletcher, vice president of Ryka Scientific Inc., states: "The next step in ferrite technology will be the substrate approach. The advances made today will yield dollars three years from now.

But although most people in the ferrite field agree with him, few have immediate plans for much work in this area. They feel that long-term R&D is great if you have the money to invest without realizing an immediate return, or if you're lucky enough to get Government funding, but they find neither available. Robert Craig, president of Physical Electronics Laboratories, puts it this way: "It's difficult for small companies to do much more than just be aware of this technology."

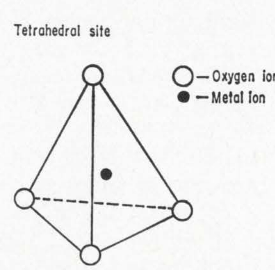
Charles Fulker, new products manager at Western Microwave Laboratories Inc., agrees that ferrite substrates are the coming thing, but he adds a note of caution. "With the possible exception of yig, which is costly, today's ferrite materials have high loss tangents," he says. "Bonding the microstrip to them is difficult."

Molecular architecture

The first natural ferrite, lodestone, was formed by the forces of time and nature. Today's man-made ferrite begin life as several piles of finely ground powders. After they're mixed, sintered, pressed, shaped, and polished, these metallic oxides emerge as a slab of very dense, brittle, black polycrystalline magnetic material with a resistivity many millions of times that of such metal magnetic materials as iron and nickel-aluminum compounds.

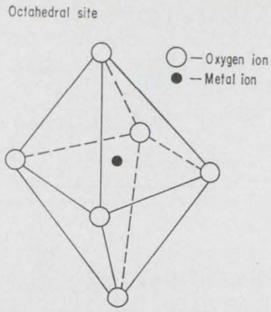
It takes but four days to produce these polycrystalline materials, but around four to six weeks to grow single-crystal ferrites.

The reason for the magnetism and high resistivity of ferrimagnetic materials lies in their crystal lattice structures. Although the crystallographer separates ferrimagnetic materials into spinel, garnet, and hexagonal categories, the engineer lumps them under the term ferrite.



In each of these structures, the oxygen ions are arranged to form two or three distinct sites or pockets that can be occupied by smaller metal ions.

Aspinel crystal structure is cubic; all its sides are of equal area and are at right angles to each other. There are two possibles sites, called the A and B, in which the metal atoms take up residence between the oxygen atoms.

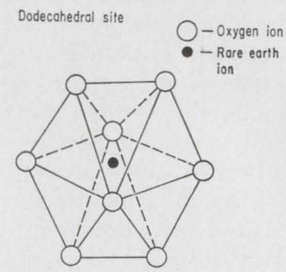


The sites are characterized by four oxygen ions and one metal ion, with three of the oxygen below the metal ion and one above it. The configuration is called tetrahedral; if lines were drawn connecting all the oxygen ions, the resulting shape would be a tetrahedron, a solid figure with four triangular sides.

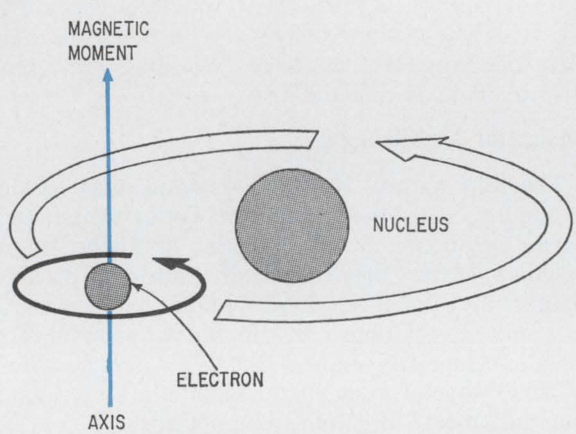
The B sites, contain six oxygen ions and one metal ion. Four oxygen ions surround this metal ion—each at one corner of a rectangle. One of the remaining ions is above the metal ion, the other is below. Connecting the oxygen ions by lines again would produce an octahedron, a solid figure with eight plane surfaces.

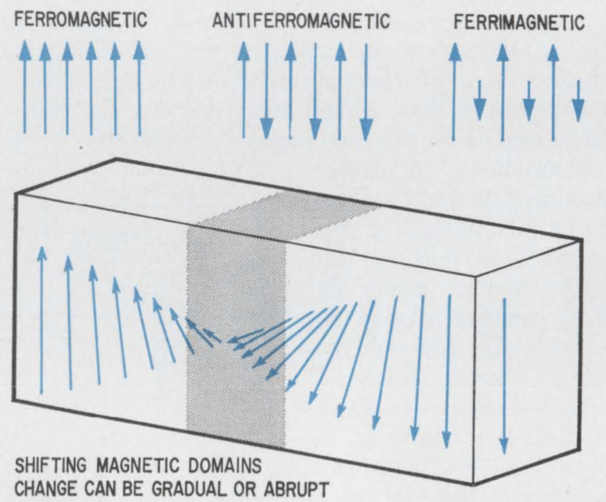
The garnet structure is the same as the spinel except that it has an additional crystallographic site containing eight oxygen ions and an ion of yttrium or a rare-earth element such as gadolinium, holmium, or dysprosium. The site is called dodechadral because the eight-cornered, 12-sided shape that would be formed by lines between the oxygen ions is called a dodechadron.

The physical size and, to a lesser degree, the valence charge of a given metal ion determines the site it occupies in the crystal structure. The bonding mechanism of these molecular structures gives the clue to why ferrites have such high resistivity. Since their crystal structures are ionic—the electrons of all the lattice atoms are tightly



Going around in circles





Spinning electrons account for the inherent magnetism of certain materials, including ferrites. Each of these electrons spins not only about its nucleus but about its own axis, creating a magnetic field whose vector is parallel to this axis. The electron can be thought of as a tiny magnet with, according to quantum mechanics, a strength of 1 Bohr magneton.

Electrons are paired in most atoms, and their magnetism is canceled because each spins in a direction opposite to its mate's. However, in some materials, such as iron, nickel, and manganese, there are one or more unpaired electrons and therefore a net magnetic effect.

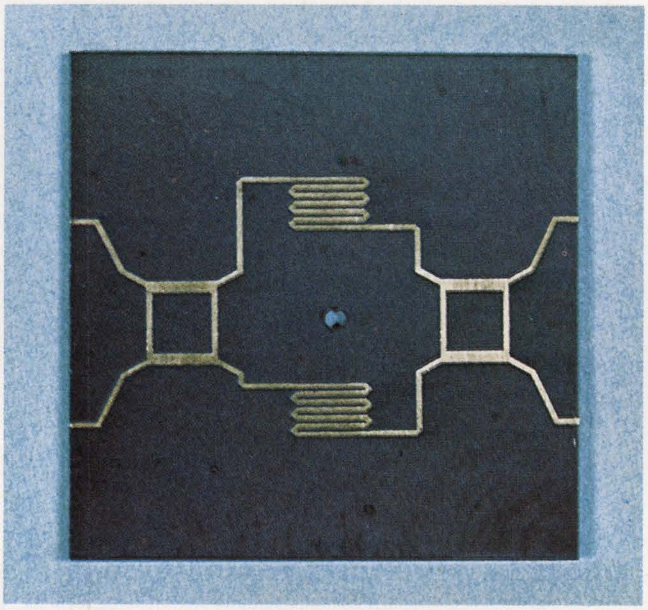
In either case, the electrons—atomic magnetic dipoles—exert a force on each other depending on their distance apart. This force is so low in some materials that even the thermal energy at room temperature is sufficient to overcome it. When this happens, the magnetic moments of the individual atoms become randomly oriented and there is no net magnetism.

What's in a name? In ferromagnetic materials, all the magnetic moments of the atoms line up in the same direction. These lineups aren't exactly parallel; there are many separate regions of magnetism called domains, each one of which contains many millions of atoms whose magnetic moments all point in the same direction. Separated from each other by "walls," or regions where the net magnetic moment shifts direction, the domains usually align themselves in the arrangement that requires the least amount of energy to maintain.

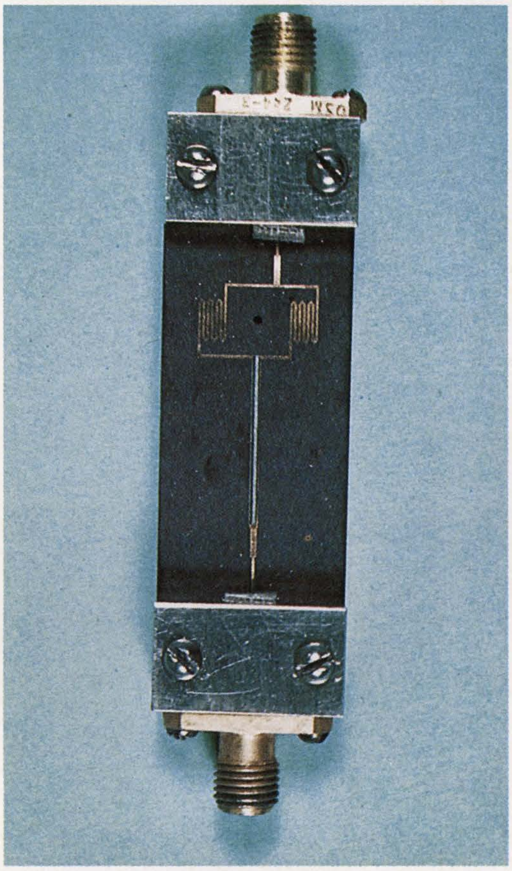
If the magnetic moments of adjacent atoms in a material have the same magnitude but align themselves antiparallel to each other, there is no net magnetization. Such a material is called antiferromagetic. However, all the magnetic movements may not be of the same strength and even though they oppose each other, there is a net magnetic effect. Ferrites are of this type material and are said to be ferrimagnetic.

Variations on a theme

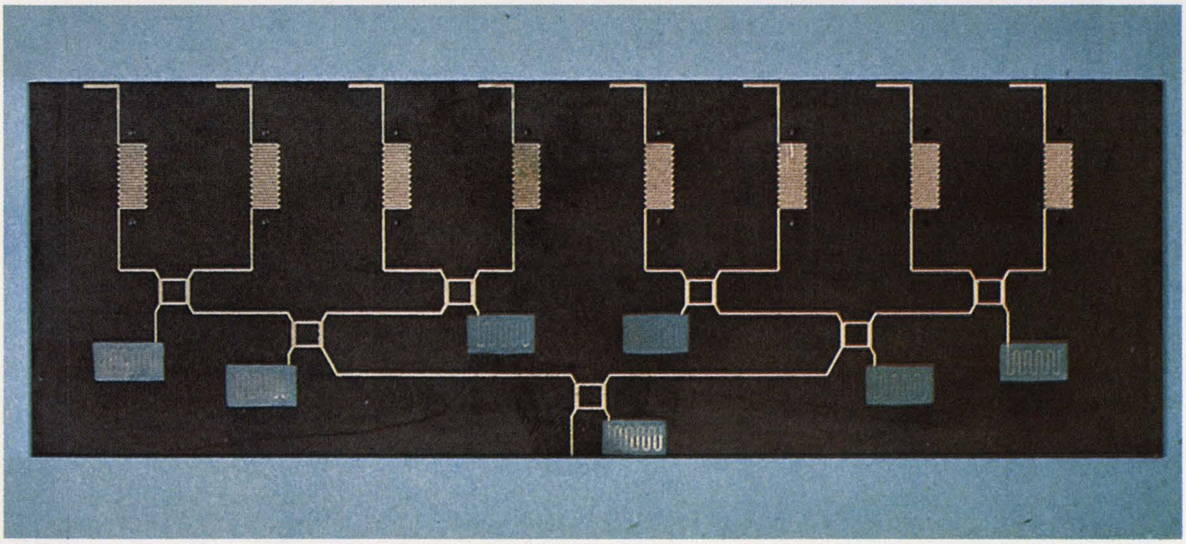
Microstrip phase shifters built on ferrite substrates can serve as the basic elements of other signal-processing components as well as of complete systems. A phased-array antenna has been built by the Syracuse University Research Corp. by combining these components with the phase shifters.



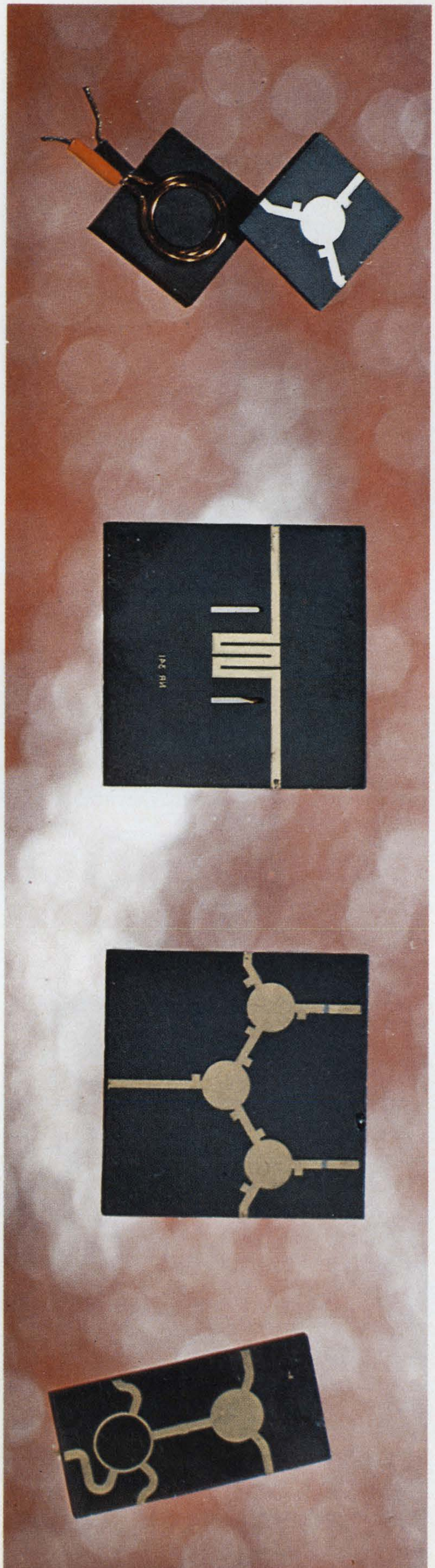
Four-port switchable circulator. This microstrip version of a waveguide phase-shift circulator fabricated on a ferrite substrate can function as a switch, or if two ports are terminated, as a combination isolator and variable attenuator.



Planar field-displacement isolator. This X-band device uses two nonreciprocal phase shifters that feed a resistively loaded coupled line. Microwave energy is attenuated in one direction but suffers little loss in the other.



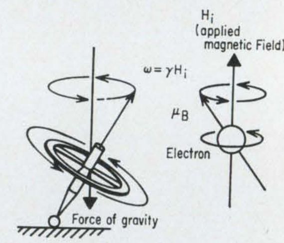
Eight-element phased array. This X-band steerable-array antenna combines phase shifters, branch-line couplers, and dipole antenna elements on a single ferrite substrate. The branch-line couplers divide and distribute microwave power from a single source to the phase shifters. This energy is then phase shifted as it is routed to the radiating elements.



bound—there are no free electrons to move about as in the case of metals, and the ferrite looks like an insulator. Typical resistivities of ferrites range from 10^7 to 10^{10} ohms centimeters compared to 10^{-6} ohms cm for metal magnets and 10^{10} to 10^{12} ohms cm for alumina and beryillia.

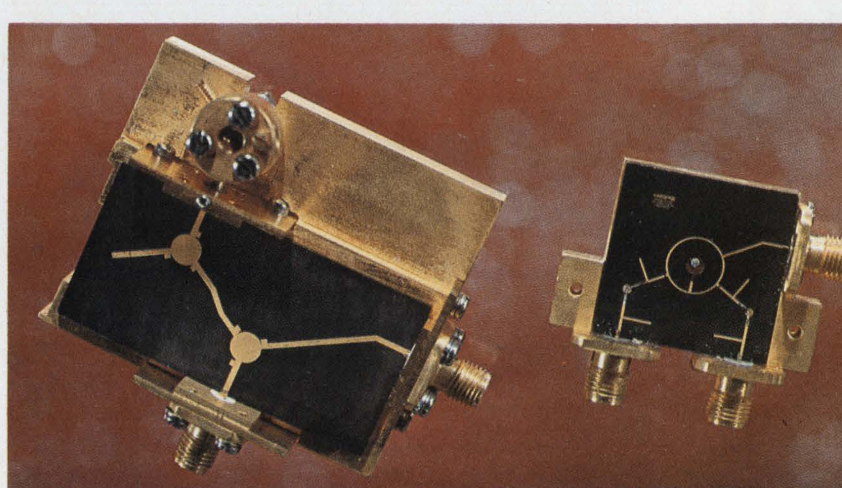
Works like a top

The gyromagnetic effect common to ferrites occurs when the material is placed in a d-c magnetic field. The magnetic moments of the spinning electrons precess about the direction of the applied d-c field until they line up. If an electromagnetic wave whose magnetic field is perpendicular to the d-c field is coupled to the ferrite, the alignment of the electron magnetic moments is disturbed and they again precess about the d-c magnetic field. It is this interaction between the precessing magnetic moments of the spinning electrons and the alternating magnetic field that produces the phase changes and attenuation of electromagnetic waves.



Just as a mechanical top or toy gyroscope precesses or rotates around an axis when it spins in a gravitational field, so does an electron as it orbits about the nucleus. This spinning electron has a magnetic moment, μ_B, and an angular momentum that are in opposite directions. If a d-c magnetic field is applied, the magnetic moments of all the spinning electrons precess at a particular fre-

Similar backgrounds. All these microstrip circuits were built on ferrite substrates at Seprry Rand's Microwave Electronics division. The latching coil and microstrip circuit of a three-port latching circulator are shown at the upper left. Below that are a nonreciprocal phase shifter, a five-port junction circulator, and combination hybrid. To the right of this is an avalanche and transit-time oscillator connected to a circulator through an isolator, and a C-band balanced mixer



quency in spiral motion about the direction of that field because of the gyroscopic effect of the angular momentum. Due to the damping factors of the material, the spirals get smaller and smaller until the magnetic moment vector points in the direction of the appied field.

The phenomenon is called gyromagnetic or ferromagnetic resonance. When the ferrite material is magnetized, the gyromagnetic frequency, ω, depends on the gyromagnetic ratio, γ, and the magnitude of the applied magnetic field. The gyromagnetic ratio is a constant, but the value depends on the material's composition; with yig, for example, the ratio is 2.8 megahertz per oersted.

Although the gyromagnetic resonance frequency is a function of the external field, the shape of the ferrite determines the internal field. The internal magnetic field of a sphere, for instance, is approximately equal to the applied magnetic field, and the resonant frequency can be changed in a linear fashion just by changing the applied field.

Tuning a yig sphere to 2 Ghz requires a magnetic field of approximately 715 oersteds. To double the resonance frequency, the applied d-c field must be doubled.

The ferrite material has no theoretical upper frequency limit, but it's impractical to generate the high magnetic field that would be needed to operate much past 12 Ghz.

The ferrite is placed in a plane of circular polarization, a plane in which the intensity of the r-f magnetic field is constant but the direction changes in a circular fashion. Energy is absorbed from the r-f magnetic field of a circular polarized wave if that field rotates in the same direction and at the same frequency as the precessing magnetic moments of the spinning electrons. The amount of absorbed energy, which depends on the damping properties of the ferrite material, determines the angle at which the magnetic electron moments process about the steady magnetic field.

Breaking the law

The law of reciprocity as applied in passive circuit analysis doesn't hold true for ferrites operated in the microwave region. The general rule is that any passive element is reversible; it should look the same in both directions. But ferrimagnetic materials operated in the microwave region have violated this law. These materials can pass energy relatively unimpeded in one direction and attenuate it in the other.

When a piece of ferrite is placed in the region of electromagnetic waves, nonreciprocal or reciprocal effects take place depending on where the ferrite is positioned, the strength of the d-c magnetic bias, and the polarization of the electromagnetic wave.

Nonreciprocal phase shift takes place when the ferrite is biased below resonance in the region of low or even zero permeability, and above resonance in the high field region, the region where a final steady state permeability is reached. The differences in the propagation velocity that a circularly polarized wave undergoes when travelling through a ferrite material causes the phase shift. The propagation velocity depends on the permeability, which changes as a function of direction.

Nonreciprocal attenuation occurs when the ferrite is biased into the region of gyromagnetic resonance, a region characterized by a rapid change in the attenuation of a circularly polarized electromagnetic wave.

Faraday, or nonreciprocal, rotation of a circularly polarized wave occurs when the wave's positively and negatively polarized components undergo different amounts of phase shift. Actually, the plane of polarization rotates from the original point at which the wave enters the ferrite material. The degree of rotation depends upon the strength of the applied magnetic field and the length of the ferrite through which the wave passes.

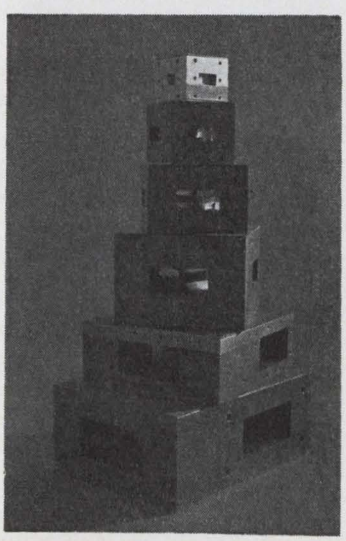
Just as there are nonreciprocal effects when a ferrite is positioned at a point of circular polarization, reciprocal action takes place if the ferrite is placed in a region of linear magnetic-field polarization. Since a linearly polarized wave is just two circularly polarized waves combined, the phase shifts will be the same regardless of the direction in which the wave is propagated.

The most common reciprocal effects are phase shift, which occurs when the ferrite is properly positioned and biased in the low or high field regions, and attenuation, which results when the ferrite is properly biased into the region of gyromagnetic resonance.

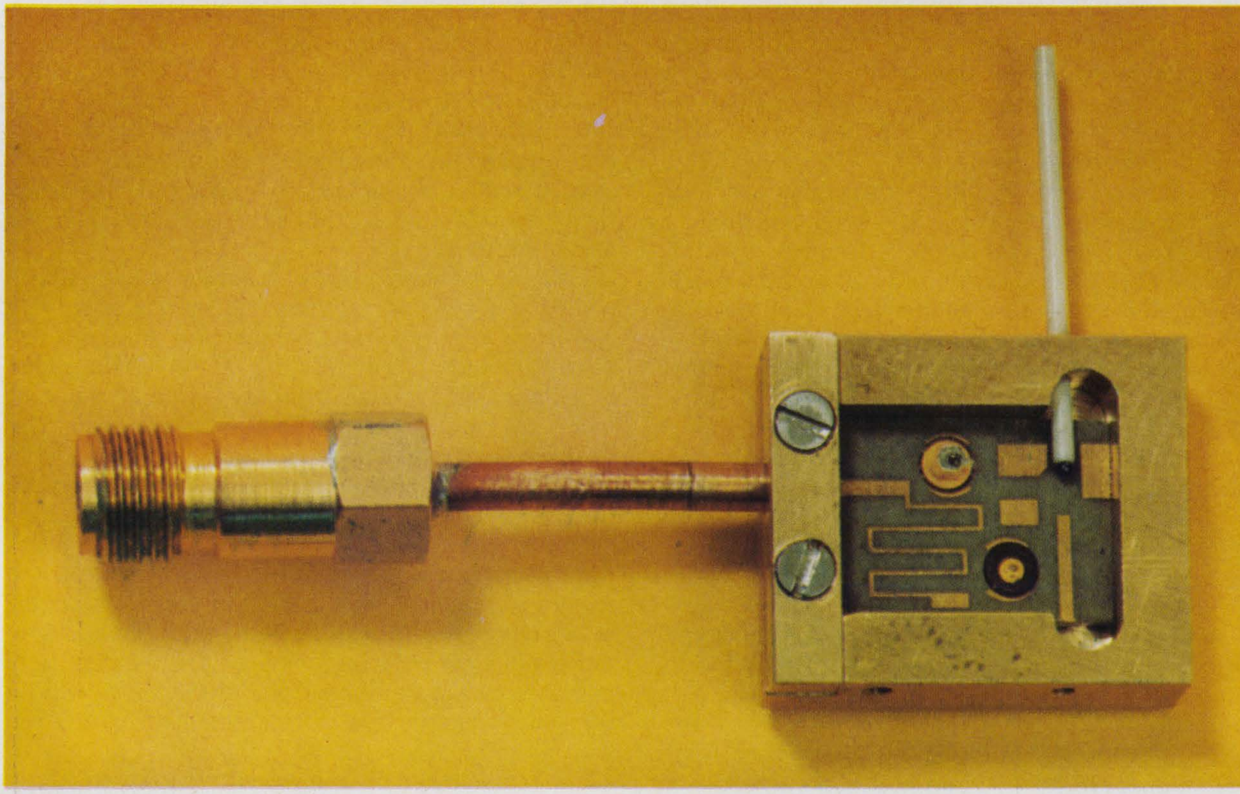
Basic properties

Ferrimagnetic materials of current interest generally fall into four categories,—polycrystalline ferrites, single-crystal garnets, ferrites of a hexagonal crystal structure, and antiferromagnetic materials. Regardless of category, all the materials have such properties as saturation magnetization, $4\pi M_s$; Curie temperature. T_c; linewidth, ΔH; and anisotropy.

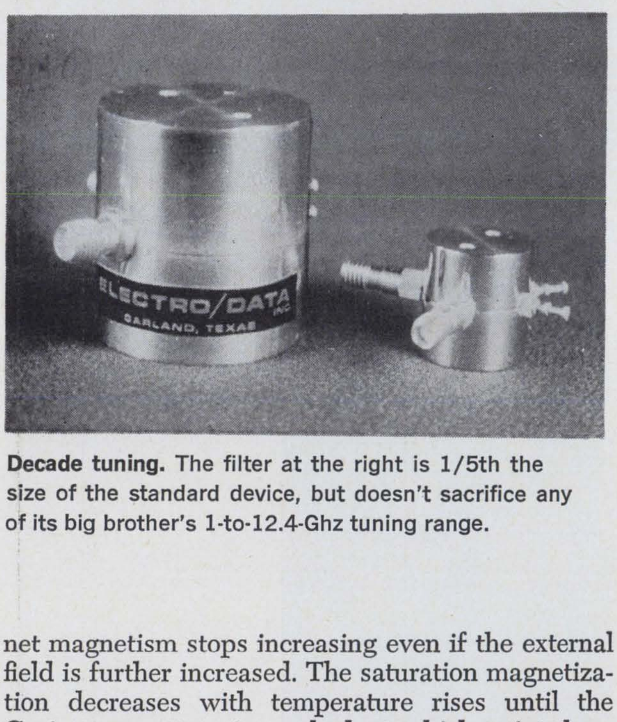
Saturation magnetization is the point at which



Wide circulation. Waveguide circulators handle peak powers of 1 kilowatt and average powers of 10 watts from 3 Ghz to 18 Ghz.



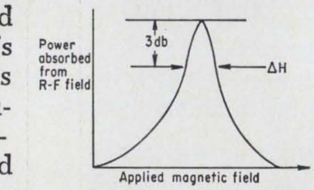
Hybrid approach. The next generation of yig-tuned devices will be designed to connect directly into other microwave integrated circuits.



Decade tuning. The filter at the right is 1/5th the size of the standard device, but doesn't sacrifice any of its big brother's 1-to-12.4-Ghz tuning range.

net magnetism stops increasing even if the external field is further increased. The saturation magnetization decreases with temperature rises until the Curie temperature is reached, at which point there is no net magnetism. It is a factor to be considered when selecting material because it determines the lowest frequency at which filters and limiters can operate. For most ferrites, the lowest operating frequency in megahertz is approximately equal to the saturation magnetization in gauss, which in ferrite materials ranges from almost 0 to 5,000 gauss.

The linewidth determines the relative loss of a ferrimagnetic material. It is most important when building filters because the material's unloaded Q, and hence the device's insertion loss, depends upon it. Linewidth, usually measured at gyromagnetic resonance and commonly referred to as ferromagnetic linewidth, is analogous to the 3-db bandwidth of a typical single-stage filter response. It is the width, in oersteds, of the resonant absorption peak, measured between the points at which the power absorption is half its resonant value.



Linewidth is strongly dependent upon the surface finish of the material; the higher the polish, the narrower the linewidth, because microwave energy is reflected by surface pits and inclusions. It is therefore essential that a yig sphere used for filters be very highly polished.

How do you know a sphere is sufficiently polished? Walter Venator of Litton Industries' Airtron division puts it this way: "When you look at a sphere through a microscope and see your eyeball staring back at you, it's polished." He adds, however, that "we measure each sphere to determine the actual linewidth." Single-crystal yig spheres have linewidths as narrow as 0.3 oersted; linewidths for polycrystalline ferrites can range from 10 to 5,000 oersteds.

Anisotropy is that property of magnetic materials that tends to align the magnetic spins along a certain crystal axis. For example, it's easier to magnetize single-crystal yig in one certain direction, then in another. Logically, these directions are called the easy and hard axes.

The very high anisotropy fields in some hexagonal ferrites provide built-in biasing. They drastically reduce the size of the external magnet that would otherwise be required for millimeter-wave operations—or can even eliminate the magnet.

Substitutes get to play

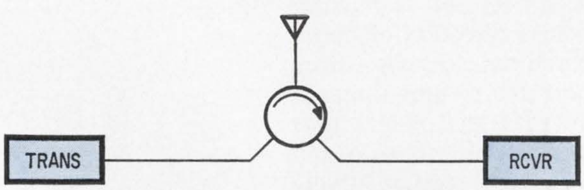
All the characteristics of ferrimagnetic materials can be changed by chemically substituting the atoms of other materials for some of the iron atoms.

There is a wide range of both pure and substituted ferrite material available today. Most producers of ferrites offer a wide choice of properties, and some will fabricate the material to a customer's specifications.

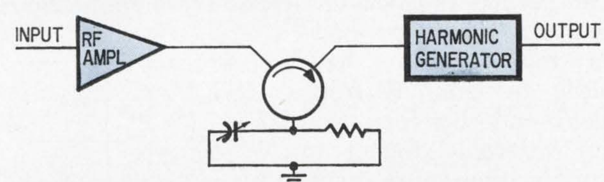
For example, the saturation magnetization of pure yig can be lowered from 1,780 gauss to near 0 by substituting either aluminum or gallium ions for some iron ions; the size of the reduction depends on the amount of substitution. Ferrimagnetic resonance linewidth and dielectric loss are also functions of the material's composition and can be controlled in a similar manner.

Polycrystalline ferrites are available with saturation magnetizations of from less than 100 to 5,000 gauss, and with linewidths of 20 to 5,000 oersteds. This wide linewidth is the main disadvantage of this material. Yig, the most widely used single-crystal material, is characterized by extremely narrow linewidths, which make it particularly useful for high Q filters, low-loss substrates, and delay lines. The main drawbacks of this material are its cost, the difficulty in growing the large crystals required for delay lines and substrates, and the large external magnetic field that's needed to achieve gyromagnetic resonance at higher frequencies.

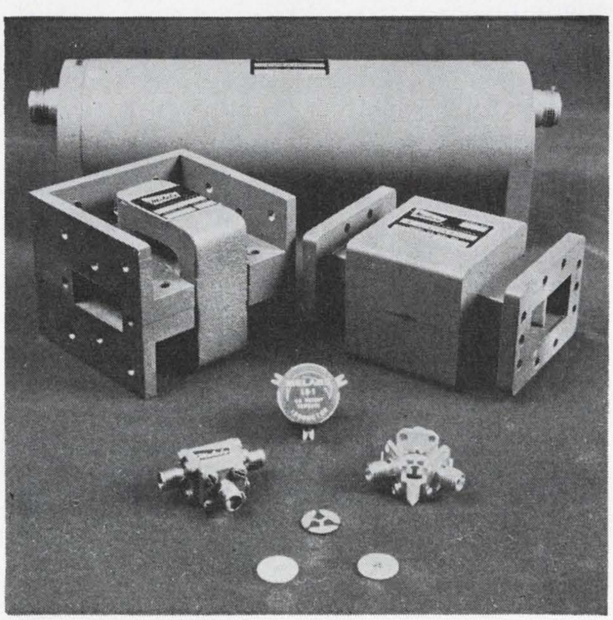
Hexagonal ferrites are complex compositions of barium oxide, iron oxide, and one or more combinations of transition elements such as nickel,



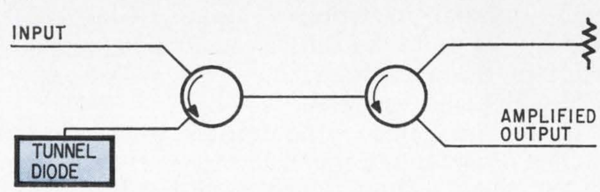
Duplexer. A circulator permits the simultaneous use of a transmitter and receiver with one antenna.



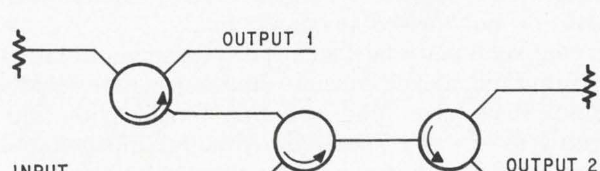
Tuning aid. A tuned circulator minimizes the interaction between any two active stages.



Traffic cops. These ferrite circulators and isolators direct and control the flow of r-f energy over a range from vhf through K band.



Isolation. Two three-port circulators separate input and output, isolating amplifier from mismatches.

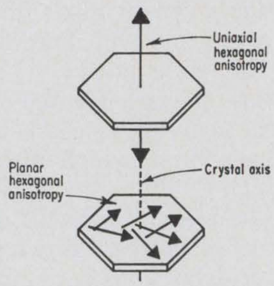


Power divider. Three three-port circulators split the input equally between the two output ports.

manganese, zinc, magnesium, and cobalt. The resulting crystal structures have anisotropy fields as high as 50,000 oersteds.

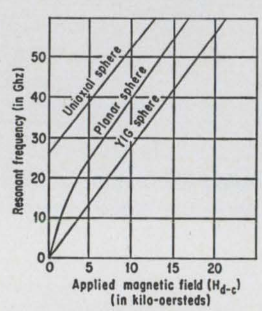
Three forms of anisotropy occur in these hexagonal materials; uniaxial, planar, and conical. Conical anisotropy needn't be considered; it rarely occurs, and then over small temperature ranges.

There is great interest in those materials with uniaxial or planar characteristics, however. With their high anisotropy fields, uniaxial materials promise to find use in resonant isolators, phase shifters, limiters, and other such devices, particularly at millimeter-wave frequencies. And planar materials will be most useful in low-frequency phase shifters and other devices requiring large initial permeability. Also, since their magnetic moments can be switched easily, they can provide microwave switches and harmonic generators.



There is one hangup, though. The hexagonal-crystal ferrites suffer from a serious temperature stability problem that must be solved before they can become practical and tackle these applications.

Single-crystal or polycrystalline ferrites have little or no anisotropy field, and therefore need an external magnet to supply the entire magnetic field required for biasing to gyromagnetic resonance. But external field requirements are reduced by the magnitude of the anisotropy field with uniaxial material, and by not quite the full value of the anisothropy field with planar material.



YIG — $\omega = \gamma H_{d-c}$

Planar — $\omega = \gamma \left[H_{d-c}(H_{d-c} + H_{anis})\right]^{1/2}$

Uniaxial — $\omega = \gamma \left[H_{d-c} + H_{anis}\right]$

$H_{anis} \cong 10{,}000$ oersteds

If the hexagonal-crystal ferrites were selected so that their anisotropy fields ranged from 0 to 50,000 gauss, multiple filters could be constructed that would theoretically tune from d-c past 100 Ghz from one tuning drive circuit.

The anisotropy fields of antiferromagnetic materials are extremely high, but highly nonlinear as well. The fields are so high, in fact, that these materials can operate at infrared frequencies with little or no applied magnetic field.

One such material that's received some attention is rubidium nickel fluoride. Russian experimenters claim they have produced this ferrite with linewidths as low as 1.5 oersteds. Although this material shows promise, it too has a severe temperature stability problem, even at room temperature. In fact, its Curie temperature is below the actual temperature of dry ice.

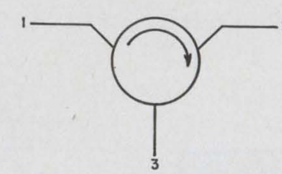
The technology has a long way to go in this area. Calcium vanadium bismuth iron garnet and zinc Y compounds show promise, but unless Government-sponsored research is increased, these materials will remain just that—promising. "Much could be accomplished if only a small percentage of the money spent on developing semiconductors was directed to ferrite research," declares Roome of Syracuse University Research.

Follow the arrows

Among the specific devices using ferrimagnetic materials, the most versatile are circulators.

Just as a traffic circle controls the flow of traffic, so a circulator directs the flow of electromagnetic energy. The basic unit is a passive, symmetrical, three-port device that makes use of the nonreciprocal permeability of ferrites.

With no applied field, the permeability of a ferrite material is the same regardless of the direction taken by electromagnetic energy. But when a magnetic field is applied, the ferrite displays a different permeability for a clockwise polarized electromagnetic wave than for a counter-clockwise wave. This is the principle under which circulators and isolators pass electromagnetic energy unimpeded in one direction and attenuate it in another.



For example, consider a three-port circulator whose direction of circulation is clockwise from port one to port three. If an r-f signal enters port one, it will circulate and leave port two relatively unattenuated, no energy will be coupled out of port three if port two is terminated.

Because of the circulator's symmetry, energy that enters at port two emerges at port three with very little attenuation, but is attenuated at port one, the amount of attenuation depending on how good the termination of the other ports is. Typically, the isolation between ports is 20 db for a voltage standing-wave ratio of 1.25:1.

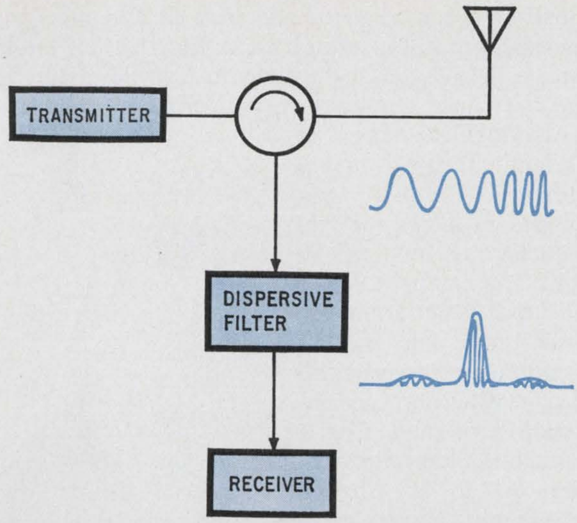
A circulator's performance is thus judged on the basis of forward loss, reverse loss, and vswr.

Forward loss—commonly called insertion loss and expressed in decibels—is the amount of attenuation a signal suffers in going from one port to the next in the direction of circulation. Reverse loss is the attenuation experienced by a signal moving from one port to the next in a direction opposite to the normal circulation flow.

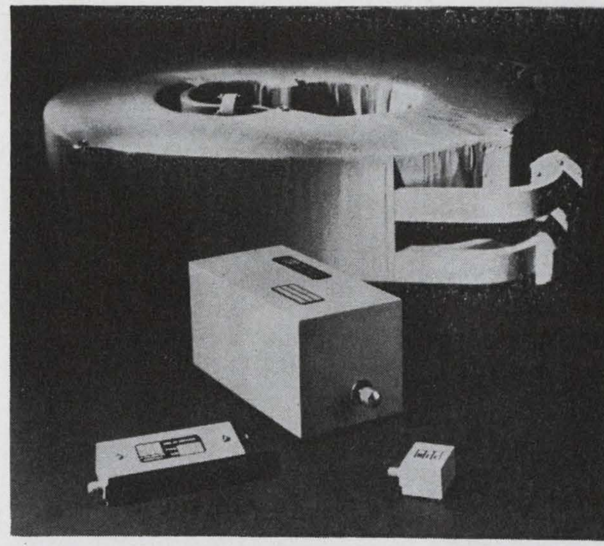
The vswr is the ratio one would see looking into any one port with the other ports terminated resistively in the circulator's characteristic impedance.

A four-port circulator can be made by combining two three-port circulators. Similarly a five-port circulator results when three are combined.

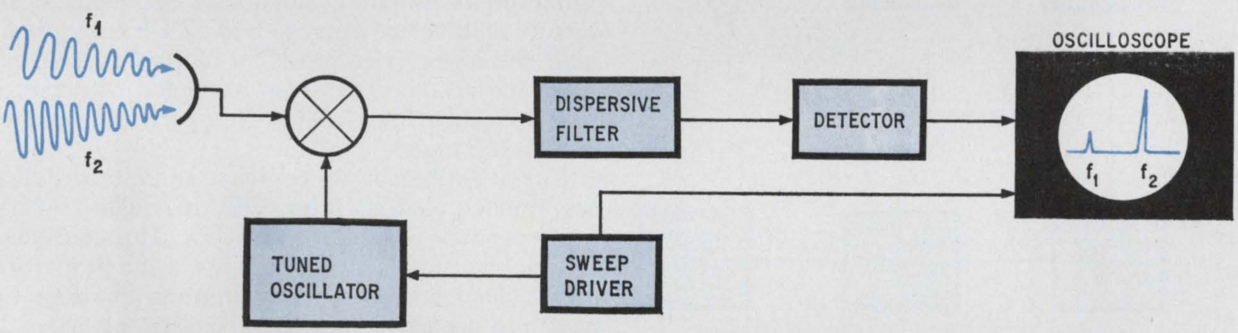
Circulators are built into waveguide and coaxial structures and are made of stripline and microstrip circuits. They can function as switches, duplexers,



Tight squeeze. A yig delay line is used as a dispersive filter in a pulse compression system.



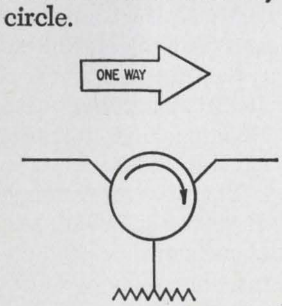
Slimmed down. Fixed, repetitive, and variable microwave acoustic delay devices operate from uhf through X band. The two-port unit at the left replaces the huge waveguide type shown in the background.



Swept panoramic receiver. A yig dispersive filter is at the heart of a system that allows the rapid scanning of a frequency range with high sensitivity and frequency resolution.

and, if the middle port is terminated in the proper impedance, as isolators, which act as a one-way street rather than a traffic circle.

The devices are used, among other things, to isolate receivers from transmitters when a common antenna is used. Combinations of circulators can connect two receivers and two transmitters to a common antenna and switch one in if the other fails. And two three-port circulators between the input and output of a negative-resistance amplifier can minimize mismatches.



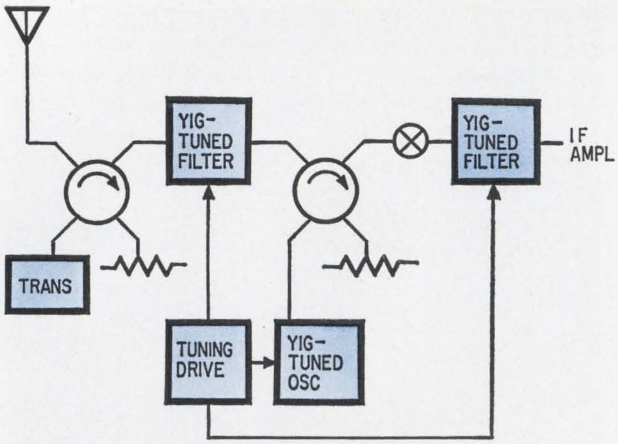
Isolators and circulators also serve to buffer the stages of a multiplier chain, greatly reducing alignment time and permitting the replacement of diodes or transistors without complete realignment.

Circulators and isolators have been built that operate from 100 Mhz to more than 140 Ghz with bandwidths of 5% to 35%. Waveguide circulators have been operated at peak powers of 10 megawatts and at greater than 2 kilowatts of average power. The average power depends on the amount of heat sinking and cooling employed; heat must be removed from the ferrite.

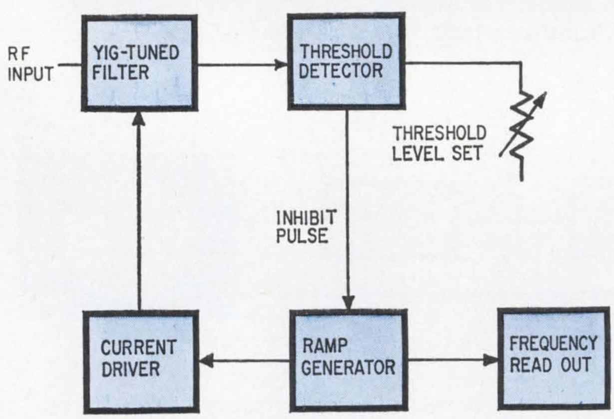
Yig does it best

As for filters, microwave ferrimagnetic devices can search out signals over octave and multioctave bandwidths, and do it electronically in a rapid linear fashion. Of course, tuneable filters have been built using semiconductors and varactors, but not with satisfactory circuit Q's over wide tuning ranges. Also, they require complicated compensating networks to achieve tuning linearity.

The best filter performance has generally been achieved with polished yig or gallium-doped yig spheres. Highly polished single crystals of pure yig material exhibit very narrow linewidths, a fac-



Everything follows. The filters and oscillator are driven from the same tuning circuitry, improving tracking accuracy, even with temperature changes, because all the circuits are affected the same way.



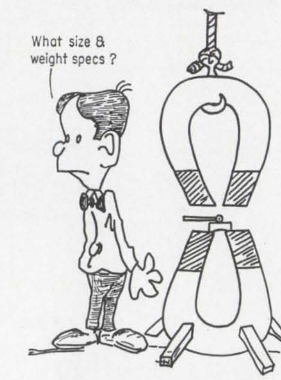
Automatic scanning wavemeter. The yig-tuned filter is electronically swept over a multioctave frequency range by a linearly increasing ramp current. If an r-f signal is detected, the ramp current is stopped and the frequency, which is proportional to the ramp current value, appears on the readout display.

tor that makes the material useful as a high Q resonator; unloaded Q's of 3,000 at frequencies ranging from 5 to 70 Ghz are not uncommon.

At room temperature, pure yig has a saturation magnetization of approximately 1,780 gauss, as noted earlier, and a Curie temperature of 275°C. This allows operation at temperatures in excess of 100°C and at frequencies from approximately 1,780 Mhz through the millimeter range. The ferrite itself has no inherent high-frequency limitations, but the large magnetic field necessary for operation above 10 Ghz would require very large magnets.

Filters of pure yig work very well above 1,780 Mhz, but the production of lower-frequency devices requires the substitution of gallium or some other material for some of the iron atoms. The amount of material substituted determines the reduction in saturation magnetization.

For example, if a certain amount of gallium is substituted for some of the iron in the pure yig material, the initial saturation magnetization might change to 300 gauss, the linewidth to 2.2 ostereds, and the Curie temperature to 150°C.



Electro/Data Inc. of Garland, Texas, is using gallium - doped yig spheres in filters for frequencies as low as 90 Mhz. The company has a filter that tunes from 120 to 275 Mhz and has an instantaneous bandwidth of 25 Mhz and an insertion loss of 1 db. It also offers filters tuneable from 0.1 to 20 Ghz in decade and octave bands.

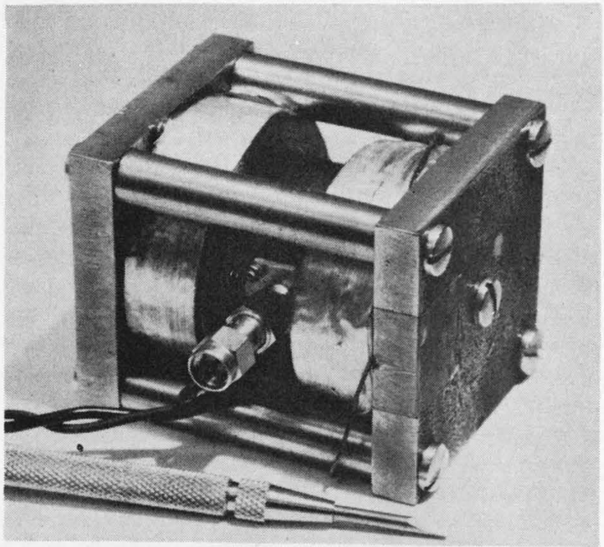
Other manufacturers such as the Watkins-Johnson Co., Scientific Atlanta, Physical Electronics Laboratories, Ryka Scientific, and Honig Laboratories offer one-, two-, and four-stage yig-tuned filters covering a range from 500 Mhz to 26 Ghz, but they can build them to operate at up to 40 Ghz. These filters usually cover octave bandwidths, although multioctave ranges—1 to 12 Ghz—are available. Bill Honig, vice president of Honig Labs, expects the octave type to be obsoleted as soon as the multioctave filters match their performance over the entire range.

N. Peter Albrecht, an engineer at Watkins-Johnson, predicts that yig filters will cover 1 to 26 Ghz, and eventually from 1-to-40-Ghz. He concedes, though, that further improvements in the properties of yig spheres and greater uniformity of magnetic fields are needed before these ranges can be realized.

Watkins-Johnson and Physical Electronics Labs offer dual-channel bandpass filters covering octave ranges from approximately 0.5 through 12.4 Ghz. These units are just two independent two-stage yig filter sections in a common package, but they are much more versatile than single filters. The filter sections can be used in series to achieve the selectivity of a four-stage device, or separately as pre- and post-selector filters for a transistor or traveling-wave-tube amplifier. Also, since both filters operate from a common tuning current and are in the same package, tracking is very close and frequency can be offset.

The price of a two-stage yig filter now runs from $1,000 to $2,000, depending on specifications. Most manufacturers predict lower prices in the near future, but Ryka Scientific recently brought the future a little closer. It's offering a 1-to-12.4-Ghz, two-stage reciprocal bandpass filter at $880 in small quantities, and hopes the device will find general use in laboratories as a signal sorter.

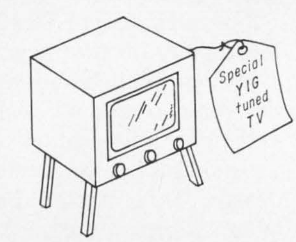
Most people making yig filters feel that growth in this area will parallel the growth in the overall microwave business. Since yig filters are costly, today's market is primarily military; even those devices that wind up in the laboratory are usually



Swept microwave oscillator. Combination of Gunn diode, a yig sphere, and an electromagnet produces at least 50 milliwatts of c-w power from 6 to 12 Ghz.

bought under defense contracts. But the future of the industry lies in attracting a consumer market.

That market will ultimately fall to the first large manufacturer that can automate the fabrication process, according to Lee Fletcher, a vice president of Ryka Scientific. Fletcher forecasts that "this business will go something like the lightbulb business. How many manufacturers of light bulbs are there today? Maybe two or three, and they're tooled up so they can make them for next to nothing. This is the way the ferrite market will end up, but right now there's still a chance for the small company with enough initiative and drive to grab some of the market if it can follow through."



Sperry Rand's Microwave Electronics division and Watkins-Johnson have built yig filters on substrates, and Watkins-Johnson is studying the feasibility of making thin-film yig filters. The basic problem here is that although the sphere is the best shape for filter applications, it doesn't lend itself to substrate fabrication. An external magnet and an air gap around the sphere approximately three times the sphere's diameter are required for satisfactory performance; a smaller air gap creates spurious responses and cuts Q value.

Protectors

Limiters can protect sensitive receivers from burnout and maintain the output power levels of microwave oscillators.

Diodes, with their nonlinear conduction characteristics, can do the job, but their performance falls off in the microwave region. Ferrimagnetic devices have no such fear of heights, and they have some unique limiting properties as well. Devices made of single-crystal yig and of yig materials with substituted atoms, perform as low-level, —25-dbm and high-level, —5-to-+20-dbm limiters. Their exact operation depends on frequency and on how tightly the r-f energy is coupled to the ferrite material.

Low-level, or coincidence, limiters are really filters that have the ability to suppress a large signal without affecting smaller signals only a few megahertz away. If these devices weren't used, a large unwanted signal could saturate a receiver.

This frequency-selective limiting takes place only between frequencies either approximately equal to the saturation magnetization or double that value. Pure yig material will operate as a coincidence limiter from 1,800 to 3,600 Mhz.

The high-level, or premature-decline, limiters aren't frequency selective. However, they don't have a high-frequency limit and can therefore be used over multioctaves. Filters that exhibit premature-decline limiting and that tune from 2 to 18 Mhz are available, and limiters have been built to operate in the uhf region.

Another device made possible by yig-tuned filters is a microwave discriminator that can electronically tune over octave bandwidths. Such a discriminator, using two filters offset a certain amount about a center frequency, linearizes the tuning of microwave oscillators and provides direct frequency readouts with wavemeter accuracy. Both these functions are performed at microwave frequencies; there's no need for complicated conversion of the frequency to a lower one.

Tuned oscillators

On another front, the emergence of transistors and diodes capable of operating at microwave frequencies has made yig filters a natural for linear, tuneable, solid state oscillators. There are yig-tuned oscillators available now that tune over octave ranges from 0.5 to 4 Ghz using transistors, and past X band using Impatt and Gunn diodes; the upper frequency is limited by the active device, not by the yig filter.

Watkins-Johnson, Physical Electronics Labs, and Electro/Data are working on yig-tuned oscillators, and Varian Associates recently built a yig-tuned Gunn-diode oscillator that tunes from 6 to 12 Ghz. It produces 112 milliwatts between 6.9 and 8.5 Ghz and 50 mw at the high end of the range.

These oscillators may be used in wideband systems as exciters for transmitters, sweep generators, and programable frequency sources for digitally tuned receivers and transmitters.

The main advantages of yig-tuned oscillators over varactor-tuned devices is the ease with which they can be tracked; no linearizing network is required. And since the frequency-versus-tuning current of these yig devices is very linear—±0.20% in P band, ±0.1% in L and S band—tracking and frequency readout circuitry can be simple. Also, because yig is a high-Q resonator, the oscillator frequency is quite insensitive to changes in the transistor's supply voltage. For a 1-volt change in the supply voltage, the oscillator shifts less than 0.3 Mhz.

Although the long-term stability of these oscillators is typically 50 parts per million, any ripple on the tuning current supply will produce incidental frequency modulation on the carrier. But if the yig-tuned oscillator is phase locked, a short-term stability of three parts in 10^8 can be achieved.

But for all the advantages afforded by these yig-tuned devices, there are disadvantages.

Residual f-m is mainly due to tuning current ripple and pickup on the tuning coil leads. For example, 1 microampere of ripple on the tuning current supply produces approximately 5 to 10 khz of f-m for typical tuning sensitivities of 5 to 10 Mhz per milliamp. These devices thus need well-filtered current drivers and shielded leads.

Companies working on yig-tuned oscillators generally see a bright future for the devices. But Bill Honig asserts that "while this may be true, I can't see any present market for them. They're just too expensive. You can buy a varactor-tuned transistor oscillator with a frequency linearizer for about $400, whereas yig-tuned devices cost upwards of $1,000." Honig is more optimistic about yig-tuned Impatt oscillators, but he notes that "yig filters limit at relatively low levels. High-power devices require techniques that get around this problem."

Phase shifters

The introduction of phased-array antenna systems has generated a need for small, inexpensive reciprocal phase shifters that have a high figure of merit—phase shift per decibel of loss. The reciprocal type is favored for this application because it can handle the transmit and receive functions without being switched.

Ferrite phase shifters are available in waveguide, coaxial, stripline, and microstrip types, but the latter is best suited to the job. The microstrip devices can be reciprocal or nonreciprocal and can be operated in either analog or latched modes.

The reciprocal microstrip phaser has a figure of merit of 20° to 100°/db for latched operation. The nonreciprocal phaser's figure is typically 200°/db Though these figures or merit fall short of the 500°/db achieved by waveguide types, they do compare with the 200°/db typical of diode phase shifters.

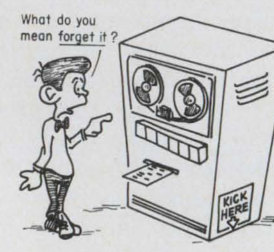
Engineers at Sperry Rand are developing reciprocal and nonreciprocal microstrip phase shifters on ferrite substrates. And Syracuse University Research, supported by the Avionics Laboratory at Wright-Patterson Air Force Base, has developed an X-band, eight-element, linear phased-array antenna feed in which microstrip phase shifters, branch-line couplers, and even the dipole antenna elements are on a single ferrite substrate. According to the company, nonreciprocal phasers now provide a differential phase shift of 360° for about 2.5 db of insertion loss.

Solid state devices using a 1-centimeter yig rod give the same 1-microsecond delay provided by 1,000 feet of coaxial cable or waveguide. The reason: they use acoustic waves, which propagate 10,000 times slower than electromagnetic waves.

Yig delay lines are lightweight, highly reliable devices that find applications in electronic countermeasure systems, target simulators, radar calibrators, memory and fusing systems, and wherever else microwave delay is needed. And because of their magnetoelastic properties, these delay lines can produce continuously variable delay times when the intensity of an applied magnetic field is changed. Such devices, used as pulse compression filters, have been built with bandwidths of several hundred megahertz and 300:1 compression ratios.

Frank Olson, associate director of engineering at Microwave Electronics, puts the market for yig delay lines a long way off—somewhere in the 1970's. He does see a big role for the lines in future systems, however. "Today's pulse compression systems use low-frequency delay lines, meaning that the microwave signal has to be converted to a lower frequency. This severely restricts the bandwidth. The low-frequency delay lines may be adequate for many functions, but they will never do for the ultrahigh bandwidths needed by tomorrow's high-capacity data systems."

One way to get ferrite technology off the technician's workbench and into the mainstream of technological advance is to use computers in device design. Such a step has been taken jointly by Sperry Rand's Microwave Electronics division and the Georgia Institute of Technology.



Using a mathematical model, their computer predicts the loss and phase characteristics of a ferrite device in terms of such material parameters as linewidth, anisotropy field, and remanent and saturation magnetization. One advantage of this analytical approach to design is that any change in device performance stemming from the material's characteristics or shape can be tracked to its source, parameter by parameter.

It's clear that if ferrites are to compete in future markets, the "cut-and-try" methods of today must be scrapped. Computers may indeed be the key to the materials' future.

This overview of ferrite materials, devices, and applications is the first of a series. Future articles will focus on such topics as materials for microwave devices; ferrite substrates for MIC's; yig-tuned oscillators; ferrite circulators, phase shifters and delay lines; and the design of yig filters.

Circuit design

Designer's casebook

Resonance effects yield in-circuit capacitance checks

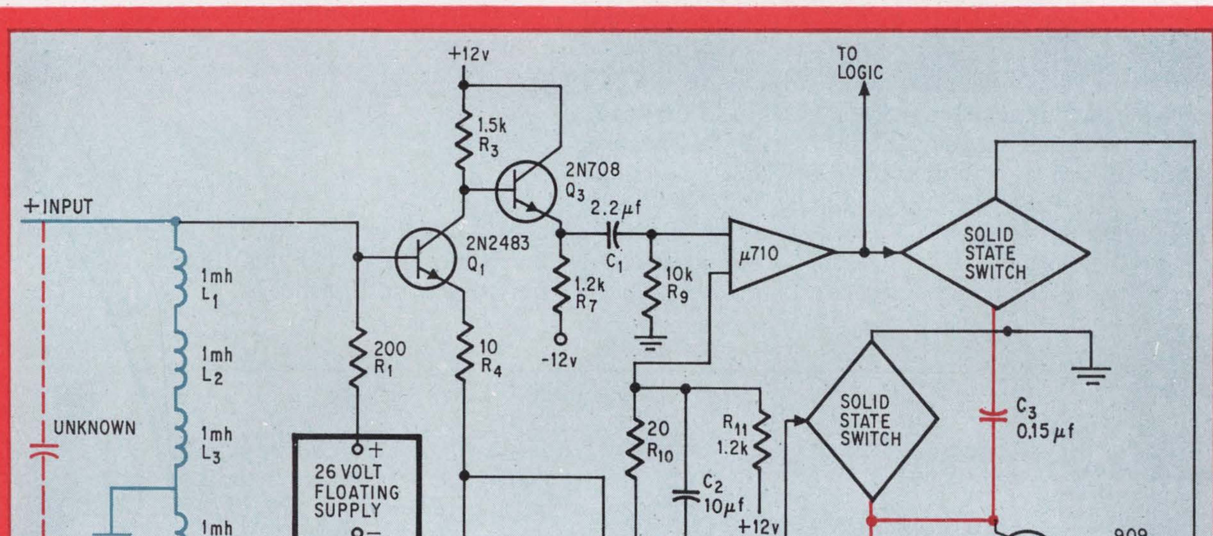
By C.H. Ristad

International Business Machines Corp., Endicott, N.Y.

A test circuit based on sensing a capacitor's resonant action with inductors can be used to measure the capacitance values even when the capacitor is in the circuit. The scheme can also be used to automatically check out printed-circuit modules, because it isn't sensitive to shunting resistance and the voltages used aren't high enough to affect semiconductor junction. The circuit shown can handle capacitances between 1 and 10 microfarads.

In testing capacitors on a p-c board, the board's connector terminals are applied to the input of the amplifier in sequence. To start a test, two solid state switches are turned on, one corresponding to a card pin connected to the capacitor's positive terminal, the other to the card pin connected to the negative terminal.

A floating 26-volt power supply and two series-connected resistors supply a constant current of 65 milliamperes through the six series-connected inductors. When the capacitor is connected across the input terminals, it and the inductors form a tank



Testing. The unknown capacitor and the inductors form a tank circuit that generates a damped sinusoidal pulse. This is amplified by Q_1 and Q_2 and squared by the μ710 comparator. The output turns on a constant-current source (Q_5) that charges C_3. The unknown capacitance is proportional to the voltage across C_3.

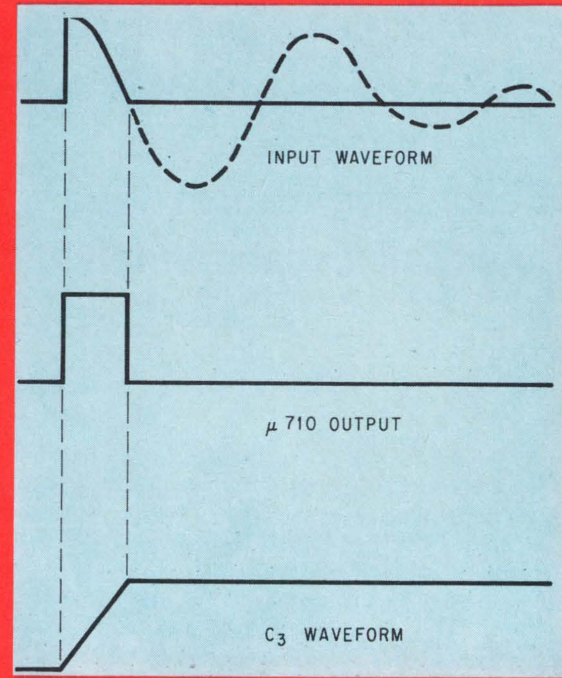
circuit that generates a damped sinusoidal wave with a frequency inversely proportional to the capacitance. This wave is amplified by a differential amplifier (Q_1 and Q_2). Transistor Q_3 provides an emitter-follower output for increased drive capability, and the amplified signal is squared by the μ710 differential comparator.

The comparator's output turns on a solid state switch for the duration of the first pulse, which is one quarter of the sine wave and is the minimum time in which to make a measurement. This gates a constant current source (Q_5) into capacitor C_3, which charges up on a linear voltage ramp. At the end of the sine wave's first-quarter cycle, the voltage across C_3 is read by a digitizer. This voltage is proportional to the pulse width, which, in turn, is proportional to the capacitance.

The comparator's output is also fed to logic circuits that sense the end of the first pulse so the capacitor can then be disconnected from the input.

The 65-ma current develops 117 millivolts across the inductors, which have a d-c resistance of only 0.3 ohm each. This voltage is the maximum impressed on the capacitor, and because it's less than the forward turn-on voltage of a semiconductor junction, the measurement can be made independent of any shunting transistors or diodes. Because the inductors have a high Q, the measurement is changed very little by shunting resistance. For 0.1 μf, a shunting resistance has negligible effect if greater than 500 ohms, and for 10 μf, the shunting resistance can be as low as 100 ohms.

In the differential amplifier, a current source (Q_4) replaces the common-emitter resistor for improved common-mode rejection. The reference input of the comparator is biased slightly positive to provide a noise-rejection threshold.



Square and integrate. The unknown capacitor's resonance waveform is squared on the first quarter cycle sets the charging time of C_3.

Low-distortion limiter uses IC operational amplifier

By Ralph Glasgal

Siemens AG Munich, West Germany

An audio-frequency wideband limiter can be built around an integrated-circuit operational amplifier—in this case RCA's CA 3030, a device typical of the general-purpose, low-cost, high-gain amplifiers now readily available.

A good limiter circuit should limit on millivolt input signals but shouldn't be damaged or distorted by higher input voltages. It should also produce symmetrical square waves with as little even harmonic content as possible, regardless of input voltage. Below its limiting threshold, it should provide clean sine waves and be stable.

The circuit shown begins to limit at an input of 0.4 millivolts, is not affected by input signals up to 6 volts peak to peak, operates linearly below the clipping point without oscillation or other instability, and, because of the external clipper and feedback arrangement, generates less than 0.3% second harmonic distortion over a dynamic range of 54 decibels or 2% over a dynamic range of 78 db.

The CA 3030 is rated for an input voltage swing of from −8 volts to +1 volt. If the input is biased to approximately −4 volts, therefore, the input signal's dynamic range will be appreciably increased. As a further precaution against loading of the signal source by the input of the integrated circuit on large positive excursions, pin 2 of the IC is also returned to −4 volts. This connection reduces the input stage current and prevents saturation with high positive peaks, thus keeping C_3 from developing any distorting bias as a result of input circuit clamping. Filtered bias voltage is supplied by R_2, R_3, and C_2. C_2 enhances the low-frequency stability of the circuit if the —4-volt supply impedance isn't small enough at frequencies close to d-c.

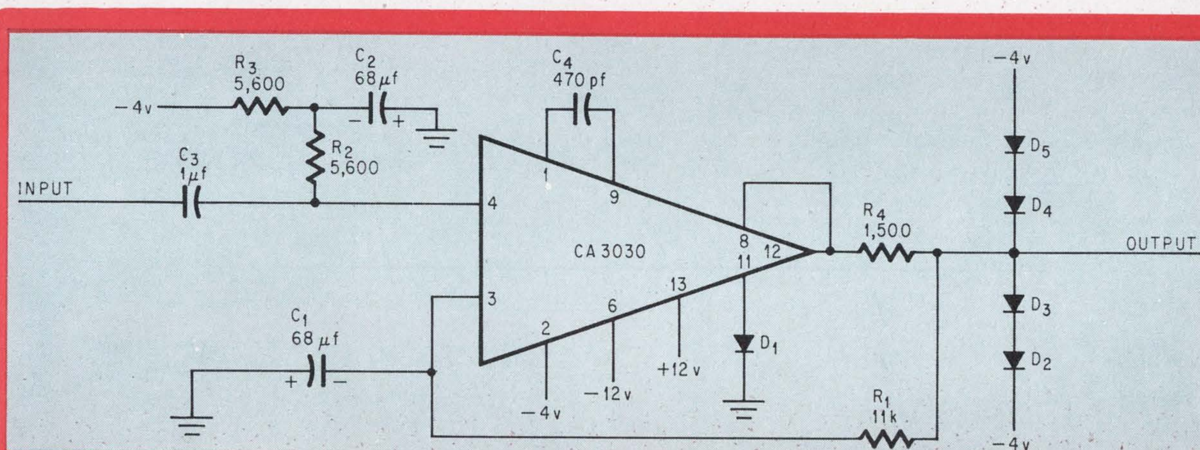
The output impedance of this operational amplifier and its peak saturated output voltages are a complicated function of the input signal's polarity and amplitude. To operate the diode clipper as linearly and symmetrically as possible, it's desirable to reduce the variation in the amplifier's output circuit parameters.

Pin 8 is connected to pin 12 in order to hold the output impedance on negative excursions to something approaching its value on positive excursions. R_4, which drives a simple diode clipper, is then made large enough to swamp the smaller impedance variations. D_1 is used to keep the output voltage symmetrical about the output clipper bias voltage of —4 volts.

Without the diode, the positive output voltage, with the amplifier far overdriven, is a function of the peak positive input voltage.

With the diode, the average output voltage at both large and small input levels stays much closer to the bias voltage at which the diode clipper operates. R_4 and the diodes D_2, D_3, D_4, and D_5 form the clipper. The number of diodes determines the output level, but in all cases, the diodes must clip before the operational amplifier if good symmetry is to be maintained.

Finally, R_1 and C_1 provide d-c feedback of the average output voltage and eliminate the effect of any input offset voltage. C_4 is a high-frequency stabilization capacitor.



To the limit. An integrated operational amplifier driving resistor R_4 and a series string of clipping diodes forms an audio-frequency limiter. The circuit begins to limit at an input level of 0.4 millivolts and can handle up to 6 volts peak to peak. Harmonic distortion is low.

Shunt regulator provides dual output voltages

By Alfred J. Mayle

General Precision Inc., Sunnyvale, Calif.

A shunt regulator can be built to provide any combination of positive and negative output voltages, whose sum is equal to the output of a single regulated power supply.

Input E_{in}, obtained from a regulated power supply whose output is floating with respect to ground, equals the sum of the magnitudes of the required positive and negative output voltages ($+E_{out}$ and $-E_{out}$).

Transistors Q_1 and Q_2 form a differential amplifier, which compares the desired ground reference with ground. The reference is formed by the voltage divider, consisting of R_2, R_3, and R_4. By changing the values of R_2, R_4, and E_{in}, the ground reference can be changed to provide any combination of $+E_{out}$ and $-E_{out}$.

Usually, R_3 is kept smaller than R_2 and R_4 and is adjusted to compensate for their tolerances. If R_3 is assumed to equal 0, then

$$+E_{out} = E_{in}\left(\frac{R_2}{R_2 + R_4}\right)$$

$$-E_{out} = E_{in}\left(\frac{R_4}{R_2 + R_4}\right)$$

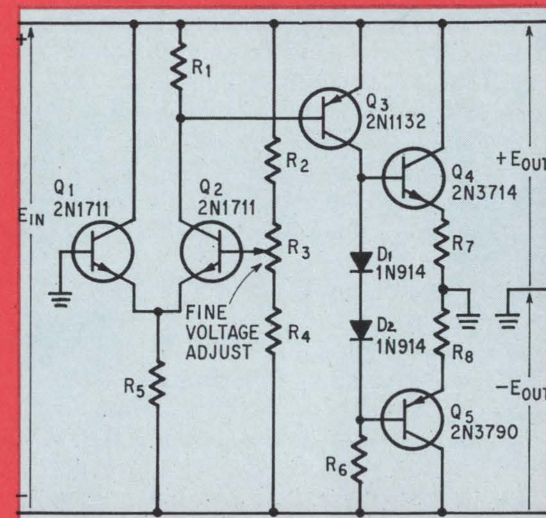
The current through the divider should be many times the base current of Q_2. Transistor Q_3 provides additional gain and shifts the d-c level to drive the complementary shunt regulators, Q_4 and Q_5. Resistors R_7 and R_8 improve the bias stability of Q_4 and Q_5.

The maximum current through the shunt transistors, Q_4 and Q_5, equals the maximum difference in current drawn from the positive and negative outputs of the shunt regulator. The current rating of

E_{in}	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	$+E_{out}$	$+E_{out}$
18	68k	6.2k	1k	3.0k	1.6k	390	5	5	12	6
24	68k	5.6k	1k	5.6k	3.3k	750	5	5	12	12

the regulated power supply must be at least equal to the greater maximum current to be drawn from either the positive or negative output.

The values shown are for an E_{in} of 24 volts and 18 volts with a dual shunt regulator output of ± 12 volts and $+12$, -6 volts, respectively. The maximum current difference is 500 milliamperes. Transistor Q_3 should be mounted in a heat sink.



Variety. Shunt regulator provides any combination of positive and negative output voltages from a single regulated supply.

Third-order active filter uses three transistors

By Paul Bildstein

Ecole Brequet, Paris

Only three identical RC networks and three low-cost unity-gain transistors are needed to provide a sharp-cutoff low-freqency filter.

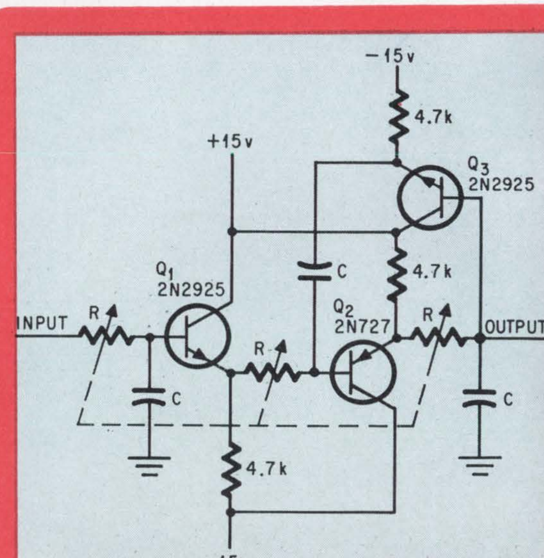
Transistors Q_1 and Q_2 are buffers before the second and third RC networks. Q_3 provides a feedback voltage through the second capacitor.

The gain of this circuit is given by the relation:

$$\frac{V_0}{V_i} = \sqrt{1 + \left(\frac{\omega}{\omega_0}\right)^6} \quad \text{with } \omega_0 = \frac{1}{RC}$$

The plot of output voltage versus frequency is thus a third-order Butterworth curve—a maximally flat response with a uniform 18-decibel-per-octave roll-off after a cutoff frequency of $f_o = 1/2\pi RC$. By simultaneously varying the three R resistances, the response curve can be shifted over a wide frequency range.

The matched pair of complementary transistors, (Q_1 Q_2) minimize temperature drift.



All together. By adjusting the three R resistors at the same time, the response of the active filter can be shifted over a wide range.

By permuting R and C, a high-pass filter of the same type is obtained, and band pass filters can thus be designed in a similar frequency ranges.

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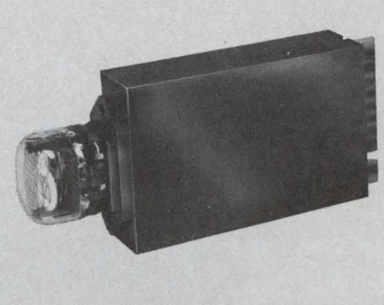

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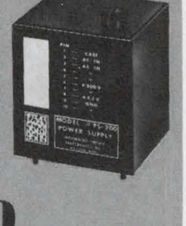

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Super-ECL speeds signals

New logic family is fastest yet, with 1-nanosecond delay, but requires transmission-line connections and special cooling techniques

By Marvin R. Byrd, William H. Julitz, Paul M. Lee, and Curtis D. Phillips
Motorola Semiconductor Products Inc., Phoenix, Ariz.

Real-time systems—pattern recognition, signature analysis and terrain avoidance, for example—have given impetus to the evolution of faster and faster logic circuits. Even in ordinary data processing, there's a constant demand for higher speeds. Motorola, using emitter-coupled logic as the foundation, now offers the fastest integrated circuits commercially available. Called MECL 3, these logic circuits have propagation delays of about 1 nanosecond [Electronics, April 15, 1968].

Emitter-coupled logic is clearly superior to all other known logic circuit configurations when speed is the prime requirement. Both in theory and in practice, it's the only configuration that can give 1-nsec performance at high manufacturing yield.

The cost of this speed is power. The new MECL-3 family requires approximately 80 milliwatts per gate function with complementary output at maximum load. Transistor-transistor logic, on the other hand, requires only about 40 mw per gate at 5-nsec delay time (probably the speed limit for TTL circuits). But even though the power requirement for ECL seems high in absolute terms, the configuration has no peer in terms of speed-power product.

A gate circuit is available in sample quantities, and production is expanding. A flip-flop also has been introduced; later more complex IC's will be manufactured.

Internal delays

The key to high speed IC's is the design and fabrication of the transistors in the basic gate circuit; the transistors must have small geometries and the fabrication processes must be compatible with them.

Scaling down conventional ECL geometry for the 1-nsec version was a tough job. At the start of development, mask definition and photoresist resolution were not adequate to provide an emitter width of only 3 microns, and the diffusion time for an emitter depth of only 0.5 micron was too short for adequate control. New processing techniques had to be developed to make such dimensions possible with acceptable yield.

With such a shallow emitter, the base diffusion must be correspondingly thin. This is really a blessing in disguise because it permits a thinner epitaxial collector region, and all the diffusions—collector contact and isolation, as well as emitter and base—spread out laterally far less than they would for a deep diffusion. The transistors are smaller, the junction and input capacitances are less, the propagation delay in the collector is reduced, and more transistors can be built in a given area of the chip.

To further improve the speed of the circuits, the base contact is highly doped to cut down the extrinsic base resistance. This lower series resistance reduces the propagation delay in the base of the gate transistor, increases the gain-bandwidth product f_T of the emitter-follower transistor, and ultimately reduces the propagation delay in the emitter follower.

To preserve the very low propagation delay, it was necessary to use two supply lines: V_{CCO} for the output devices and V_{CC} for the bias driver and gate circuit. They prevent current transients, caused by unbalanced loads on the output devices, from being coupled to the gate and bias driver.

Termination

No matter how fast the IC may be, the speed can be lost in the external system if there's no provision for transmission-line connections on the circuit board, between circuit boards, and between panels. Accordingly, the emitter-follower output devices are designed to drive 50-ohm lines. However, the output devices are not internally terminated in order to provide logic and wiring flexibility to the user. If the IC drives a line that fans out locally on a circuit board, 50-ohm terminations are not necessary; the impedance of the 2 kilohm version driven IC is adequate.

The circuit can drive the conventional parallel-terminated transmission line [p. 126 at top]. With the full logic swing available at both ends of the line, fan-out circuits can be driven at either end of the line, and at any point along it.

Alternatively, the circuits can drive the recently popularized series-terminated line [p. 126 at bottom] in which the signal propagates down the line at half the logic swing, and reestablishes the full logic swing at the end of the line because of reflection. For clean wavefronts, the input impedance of the driven gate must be sufficiently greater than the characteristic impedance of the transmission line, a condition which is satisfied by all circuits in the MECL-3 family. The reflections are terminated by an appropriate pulldown resistor at point A. (The obvious disadvantage of series termination is that the loads cannot be distributed along the line because of the half-logic swing and reflections.)

The package

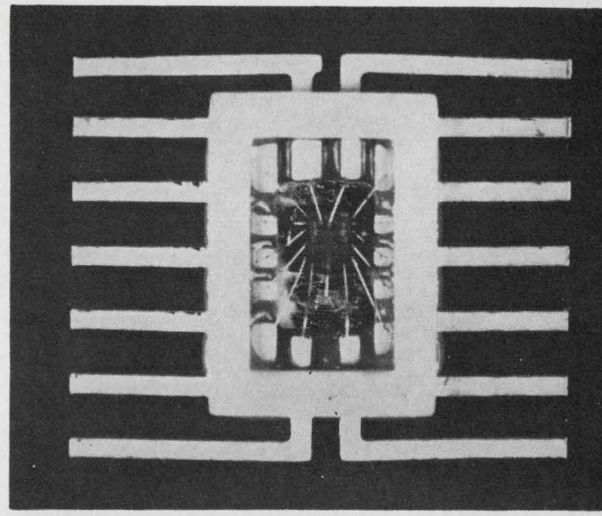
In all practical engineering work, tradeoffs are a way of life. The development of a new ECL family was no exception—greater power dissipation was one of the sacrifices that had to be made to achieve the 1-nsec speed. Because of the high power dissipation in the IC chip, the package has a copper stud which prevents excessive temperature buildup at the junction. The stud also supplies V_{EE} power to the chip. With adequate heat sinking, the stud tends to keep all circuits on a junction board at essentially the same junction temperature (within $\pm 3.5°C$), thus minimizing the decreases in noise margin produced by temperature differences among individual circuit packages.

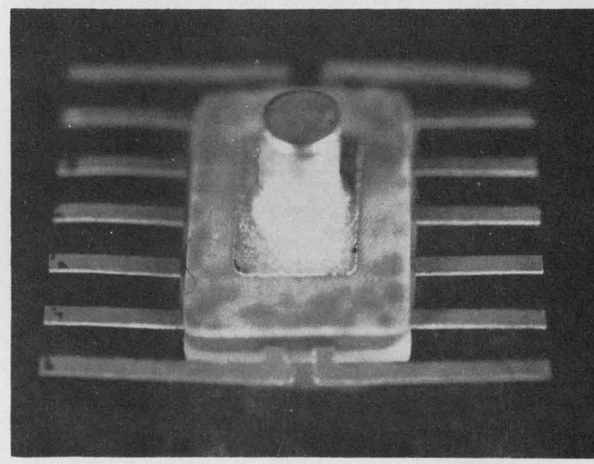
The package is a 14-lead flatpack with standard 50-mil-center spacing between leads. Because the leads are short and the package is only 3/16 inch wide, the lead inductance is low.

It's essential, of course, to remove heat from the stud in order to maintain constant junction temperature. For example:

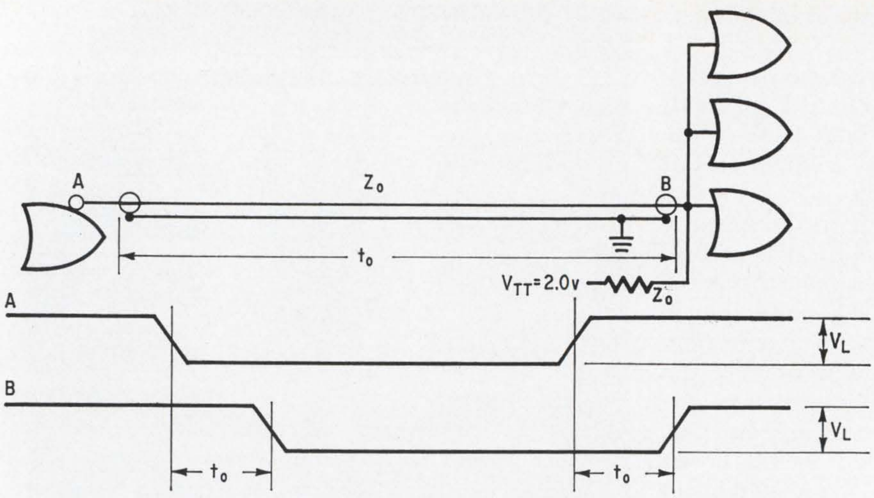
- Mount the package so that the stud goes through a hole in a circuit board that is backed with a thick (20 mils or more) layer of copper. The layer spreads heat over the entire circuit board, greatly increasing the effective thermal emitting area of the stud; if the packages are spaced on ⅝-inch centers on the board, for example, the effective heat-emitting area of a 60-mil-diameter stud is 0.39 square inch. The back of the board can be cooled by a high volume flow of air; however, experiments at Motorola have shown that the air at the inlet must be cooler than the ambient air. Alternatively, ambient-temperature cooling air could enter at several points. (The presence of holes in the circuit boards limits the freedom of the interconnection designer, since no printed-circuit paths can be routed directly beneath the package.)
- Contact the studs (with the flat side of the package mounted on the circuit board) with a heat sink directly cooled by the flow of a refrigerant such as Freon. This is one of the schemes that might solve the problem of highly concentrated heat generation in MSI and LSI circuits. It is even possible to eliminate heat sinking by air-cooling the studs directly, but this simple direct cooling method, unfortunately, requires large volumes of refrigerated air.
- Contact the studs (again with the flat side of the package mounted on the circuit board) with a combination cold plate and voltage plane. If this plate and the circuit board can be designed to detach easily or swing away, it will be no more difficult to change faulty packages than it now is to change studless flatpacks on a regular two-sided circuit board.

Even though a stud package creates problems for the equipment designer, similar techniques for mounting and cooling will be required for any sophisticated high-performance system in the next





Standard. Package for the gate or flip-flop is like the standard 14-lead ceramic flatpack but a copper stud is added to remove heat. The package leads are 15 mils wide, and they are on 50-mil centers. Package is 3/16-inch wide. By maintaining nearly constant temperature among IC's on a circuit board, stud helps to minimize noise margin.



Old way. In conventional method of driving a transmission line, full logic swing propagates along line. With this parallel termination, it's possible to fan out at either end, and at various points along the line as well. For fan out of four gates (2k R_{pd}), emitter follower output is 8.6 milliamperes.

generation of computers. Some computer manufacturers have already implemented elaborate packaging and cooling schemes in systems with logic propagation delays of less than 3 nsec.

The difficulties of making plated-through holes had discouraged many manufacturers from using the multilayer boards which are essential to implement MECL 3. Multilayer boards provide better ground planes and shorter connections between IC's than the conventional single-layer board so, regardless of what IC logic family is used, any manufacturer who plans to compete in tomorrow's market must be able to produce them.

Gate and flip-flop

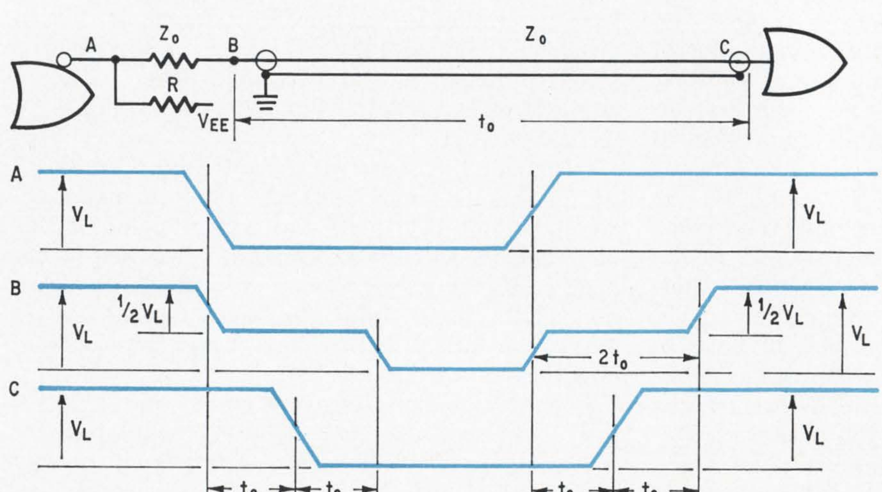
The basic circuit in the 1-nsec logic family is a dual four-input NAND/NOR gate, as shown on page 128. As in ECL circuits, both the function and its complement are brought out, and an internal bias regulator is used.

Each input has a pulldown resistor that circumvents the floating base problem of ECL by providing a sink for I_{CBO} leakage currents. The input resistor also acts as a sink for signals that normally would be coupled to the floating base through the intrinsic base capacitance C_{ob}.

The value of R_{pd} is 50 kilohms or more. However, Motorola will introduce an optional low-impedance version of the gate in which R_{pd} will have a nominal value of 2 kilohms. In this version, R_{pd} will not only act as a pulldown device for the floating base, it will also function as a load for the driving gate. This combined load and pulldown resistor will keep the propagation delay fairly constant with changes in fanout. A well laid-out circuit board with tight spacing (0.625-inch centers) would be a candidate for such loading techniques.

Characteristics of the gate are listed on page 128 and effects of temperature and voltage on delay are shown atop page 129.

No logic family is complete without a storage element capable of counting and shifting. Motorola selected the one-phase D-type flip-flop for this role in the MECL-3 group. This circuit is a master-slave flip-flop in which the state of the master stage is transferred to the slave on a positive excursion of the clock. Set and reset terminals permit presetting or parallel entry prior to shifting operations. To



New way. In series-terminated line, only half logic swing propagates. Full swing is restored by reflection at end of line. However, loads cannot be distributed along the line. For clean wavefronts, input impedance of driven gate must be somewhat larger than characteristic impedance of transmission line.

minimize propagation delay when these terminals are used, the circuit has a look-ahead feature that causes both the master and the slave to go to the same selected state simultaneously when a logical 1 is applied to the input pin.

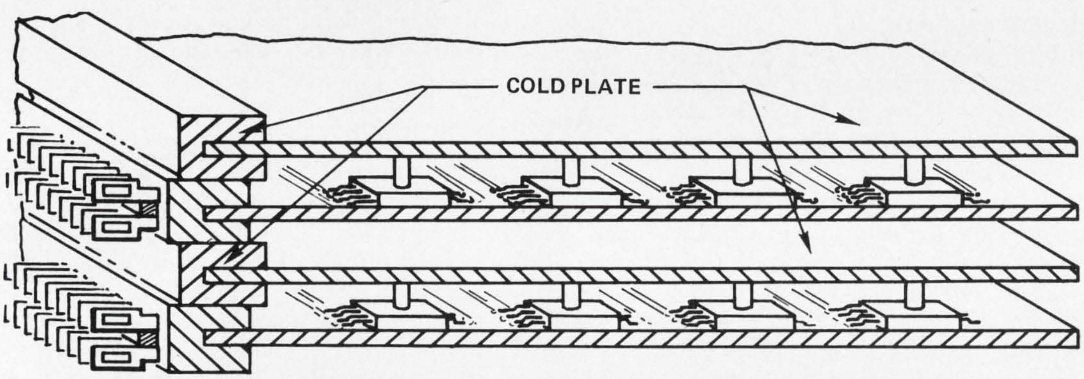
Toggling

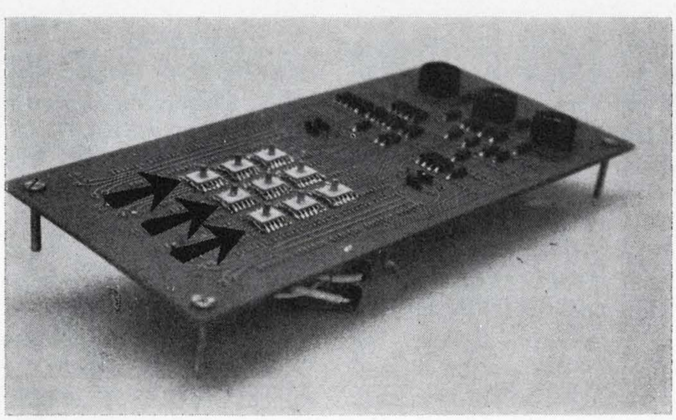
Toggle frequencies in excess of 300 Mhz can be expected. Although normal operation is not guaranteed, it's even possible to toggle at 500 Mhz by shifting the bias voltage of the input waveform slightly, overdriving the clock input with a 1.0 volt pulse amplitude, and increasing the power supply to —5.7 volts (that is, making it 10% more negative). Ordinarily, it's advisable to operate in the 300 to 400 Mhz range.

The system designer will have no problems with minimum clock pulse width. The flip-flop still operates when it is clocked with the smallest pulse width possible in the MECL-3 gate [p. 130, bottom], provided that the clock pulse makes the full logic swing.

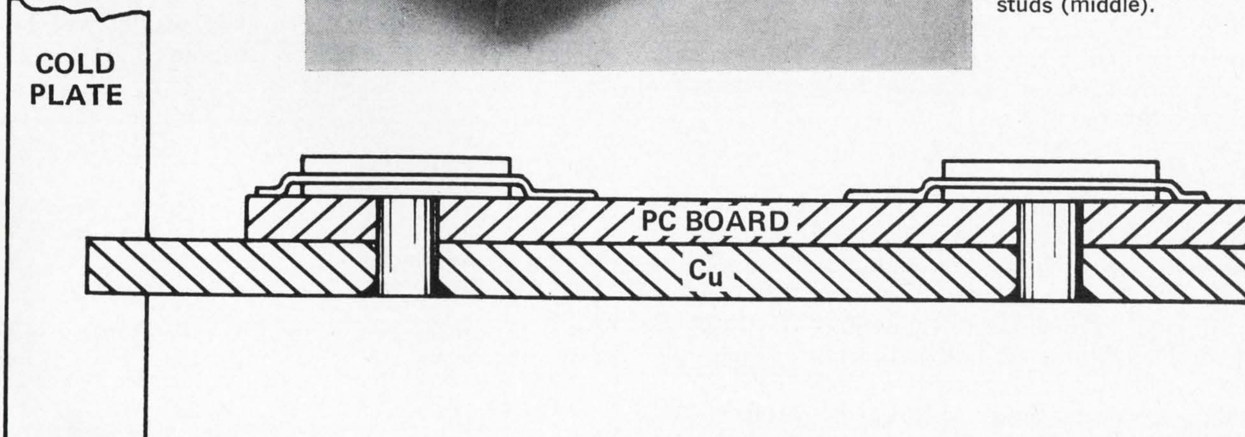
This toggle frequency and minimum clock pulse width illustrate the remarkable speed performance of emitter-coupled logic; no other logic family can come close to matching these parameters.

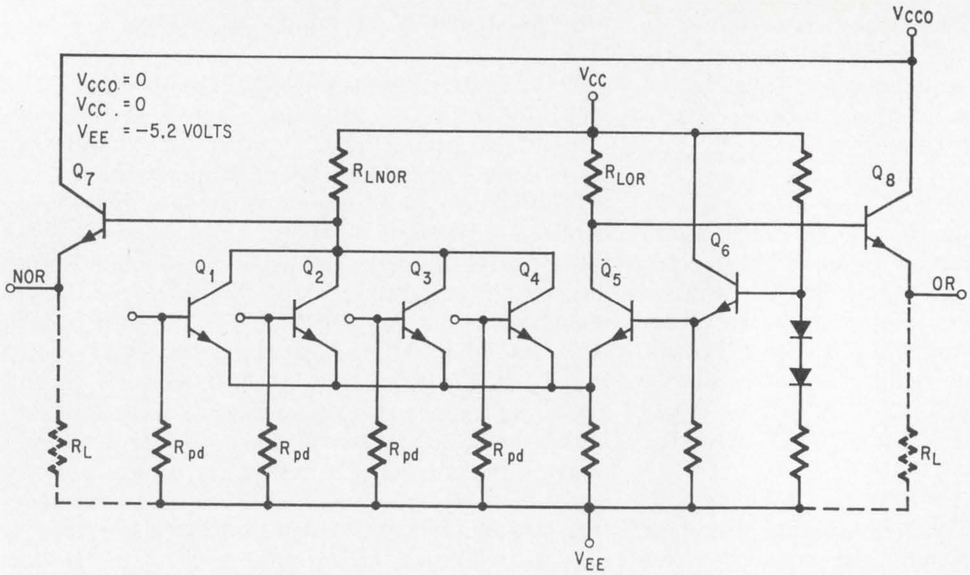
Multilayer metalization—two or more metal interconnection patterns on the IC chip, separated by a thin insulating layer—is usually associated with large-scale integration. Motorola likes multilayer metalization for conventional IC's too and uses it in the one-phase D flip-flop. There are good reasons: it reduces the chip area by 40%, permits shorter signal lines on the chip and thus contributes to high speed, and makes placement of critical components—to prevent SCR action, for example—much easier because of fewer restrictions on intraconnection routing. Multilayer metalization also makes it easy to customize the flip-flop; it can be fabricated in advance with the first intraconnection layer, and





Coolers. To get heat away from studs, cold plate can be pressed against them (top), or they can be soldered to copper baccking (bottom). Simplest way is to blow cool air over studs (middle).





No floating base. Dual four-input NAND/NOR gate gate has input pulldown resistors R_{pd} as sink for leakage currents. Gate comes in 2 k and 50 k input-resistor versions.

the second layer can be designed later to meet the user's particular requirements.

Motorola will add an eight-bit full adder monolithic IC to the MECL-3 family soon. Even by the most stringent standard, this circuit is MSI; by other difinitions, it can be considered LSI. If separate two-input ECL gates were used to implement the eight-bit full adder, 11 to 15 gates per bit would be needed. On this basis the eight-bit adder chip contains the equivalent of 88 to 120 gates. Or, more conservatively, based on an average of 10 components per ECL gate, the eight-bit adder chip with 448 components contains the equivalent of 45 gates.

The characteristics of the eight-bit adder are compatible with those of the other members of the MECL-3 family, and its adding speed is extremely fast, as on opposite page. Average delay from C_1 to an S (sum out) terminal is 1.09 nsec for the sample used for the illustration. The total cycle time is 18.28 nsec, for an average stage delay (C_1 to C_0) of 1.14 nsec.

The circuit will be packaged in a 32-lead, 0.40 by 0.40 inch ceramic flatpack. As with the gate and flip-flop, the package has a stud for heat dissipation. If C_o and $\bar{C}_o$ of the eight bit are externally terminated by a 50-ohm line connected to −2 volts, the package power, exclusive of the external load power, is slightly less than 1.25 watts. Three metalization layers, not two, are used for intraconnections in this circuit.

Forty bits

To show how the circuit can be used, Motorola built a 40-bit adder with look-ahead. It incorporates five eight bit adder circuits and 15 gates; the gates are connected to the $\bar{E}$ terminals of the adders to provide the look-ahead capability. The 15 gates are derived from a 32-gate ECL array, so that only six 32-lead stud packages are needed for the 40-bit adder. A two-by-three array of the packages on 750-mil centers, with the necessary connections, can be put on a circuit board that measures only 2.25 by 1.50 inches. Total power consumption for the 40-bit adder with the look-ahead feature is about 8 watts.

Additions to the family

Two new flip-flops—a dual clocked R-S flip-flop and a dual D flip-flop—will be added to the family next. These circuits provide two storage functions per package; their propagation delays will be similar to that of the one-phase D flip-flop.

Later, Motorola will introduce in sample quantities a decade counter that can count at rates of 300 Mhz or higher, a four-bit up-down counter, and a four-bit register connected for shift-left, shift-right operation.

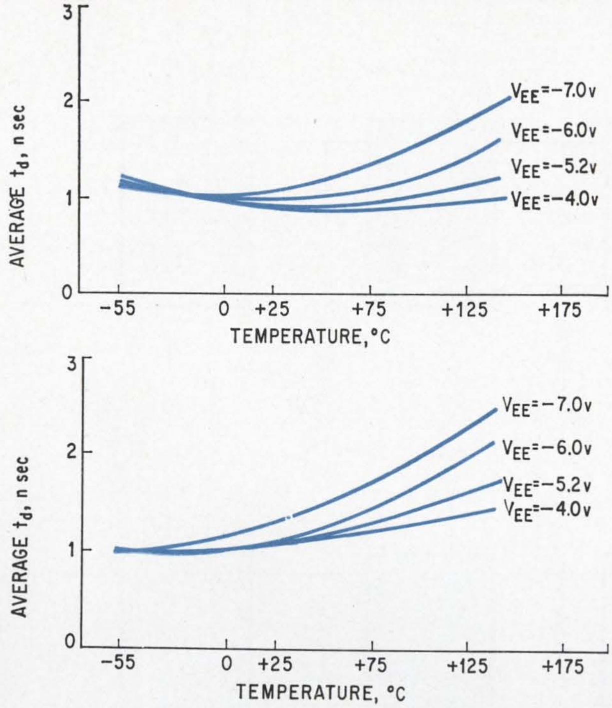
Two memory circuits, fabricated in a two-by-two array, will be introduced as well. One of these will be a random-access memory with a read-enable to read-out delay of 1.5 nsec and a write-enable to write-out delay of 3.5 nsec. The other will be a content-addressable memory with a write-search delay of 3.5 nsec and a search-read time of 1.5 nsec.

Testing

Correlating dynamic test data from the manufacturer with the user's own test results will be difficult at best. It should be possible to get agree-

Gate characteristics

Logical 1	−0.900 volt
Logical 0	−1.700 volts
Logical 1 noise margin	0.240 volt
Logical 0 noise margin	0.240 volt
D-c fanout	90
Power dissipation	80 mw per gate
Propagation delay	
50-ohm load	1.1 nsec
510-ohm load	0.90 nsec



Variations. Average delay is nearly constant with temperature at low supply voltages. Curves are for 50-ohm load (top) and 510 load (bottom).

ment on static parameters, as long as the package stud is carefully affixed to a thermal plane of precisely controlled temperature. With this provision, most of the static correlation problems will be attributable to drift and error in the forcing functions and measuring circuitry.

But correlation of dynamic parameters such as propagation delay, and rise and fall times, is a different story. To accurately measure t_d of 1 nsec or less, and t_r and t_f averaging 0.7 to 1.3 nsec demands a digital-readout sampling instrument with rise time capability of 50 picoseconds or less and time-base accuracy and resolution within 50 psec. The only instrument that comes close to this performance is a plug-in (type 3S5) that Tektronix recently introduced for its sampling systems. The plug-in has 25 or 50 psec rise time, depending on the sampling head, but the accuracy of the time base is still a point of difficulty.

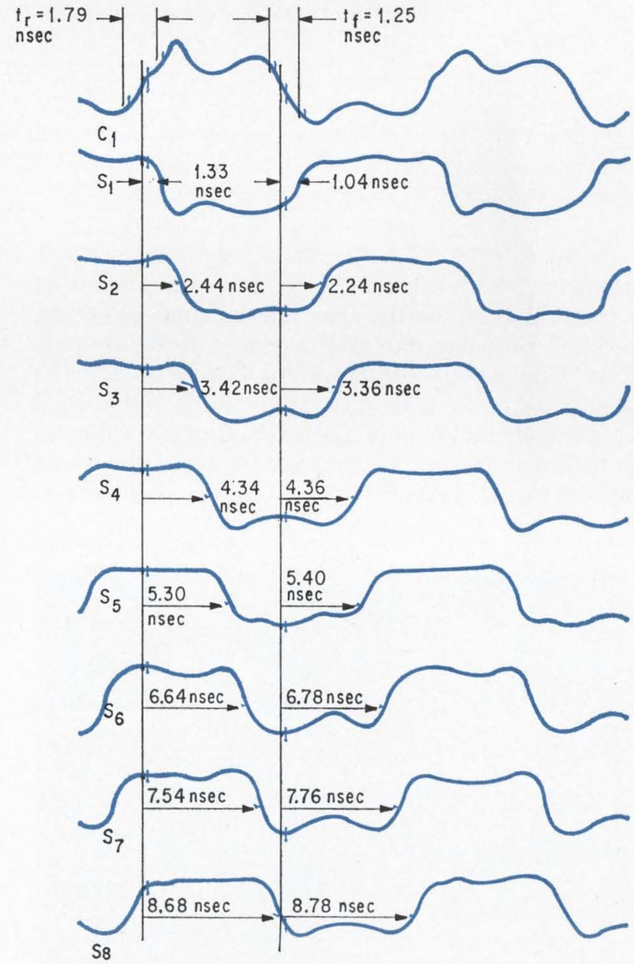
At present, the best way to overcome the timing problem is to measure periodically the delay of a fixed length of transmission line, and allow the computer controlling the test system to adjust the delay measurement results by the percent difference between the initial calibrated delay of the fixed-length line and the value measured at the time the IC is tested.

Another important characteristic of the test instrumentation is repeatability—the ability to measure the same IC many times in the same test fixture and obtain the same results. Repeatability should be considered when the initial specification window is set or—if the specification window is already set—when the guard bands are established.

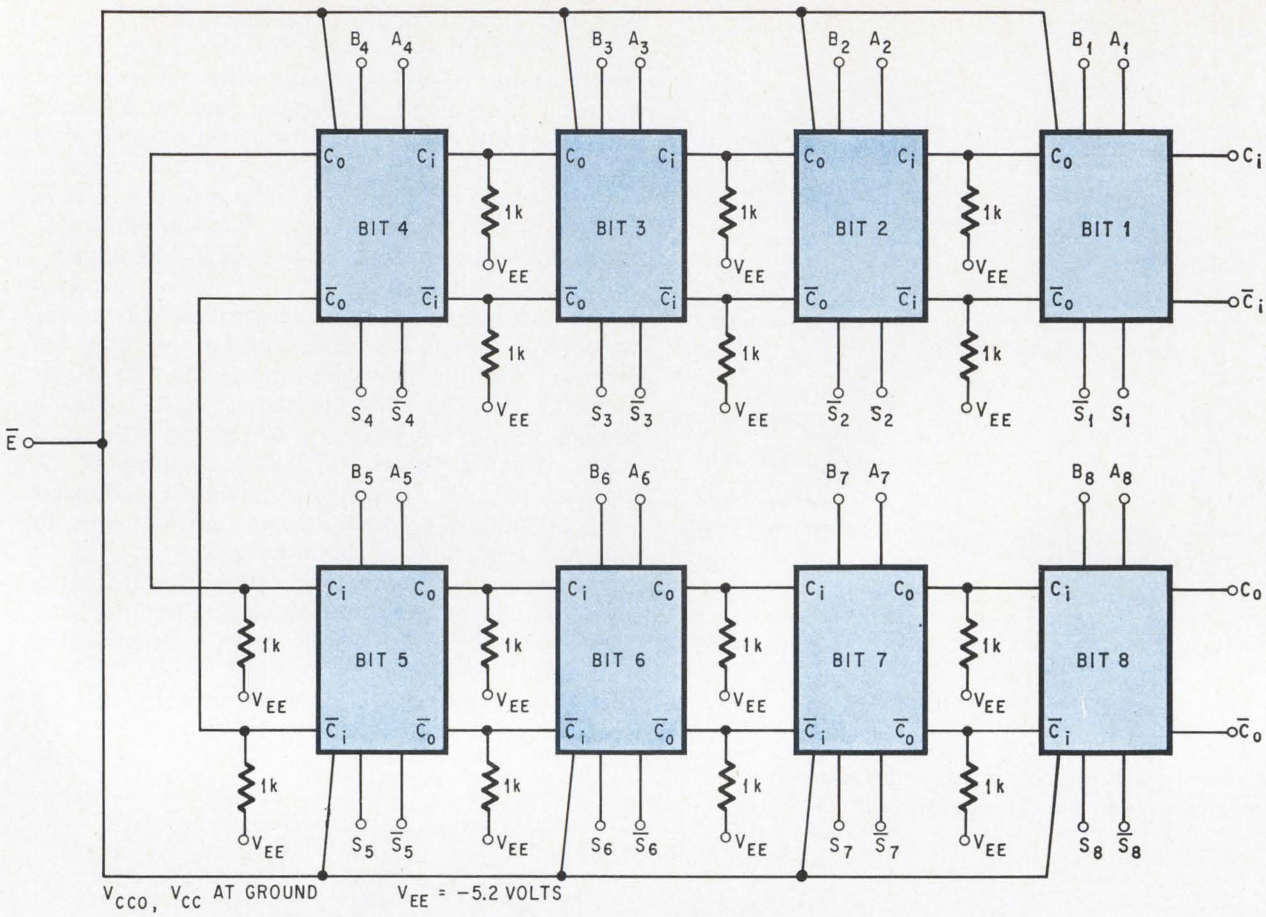
The sampling instrument for the 1-nsec logic family should be able to make measurements that are repeatable within ±20 psec. And for MSI and LSI versions of the family, which will have on-chip propagation delays of only 0.5 nsec, the repeatability will have to be ±5 psec, and timing will have to be accurate within 10 psec. Nonsampling systems, too, will have to meet the same repeatability and accuracy standards.

Just as a transmission-line environment is necessary in the system, it's needed in the test setup too prevent reflections that would upset the time measurements. Work at Motorola has shown that when a 50-ohm transmission line is off by as little as 3 ohms, reflected pulses shift delay readings by as much as 100 psec. Test fixtures should be adjusted with the aid of a time-domain reflectometer to minimize reflections at the interfaces.

The pulse generator that drives the IC being tested can introduce error through jitter, shifting rise time, and drifting levels. A very effective way to prevent such errors is to allow the IC to drive itself through a fixed length of transmission line.

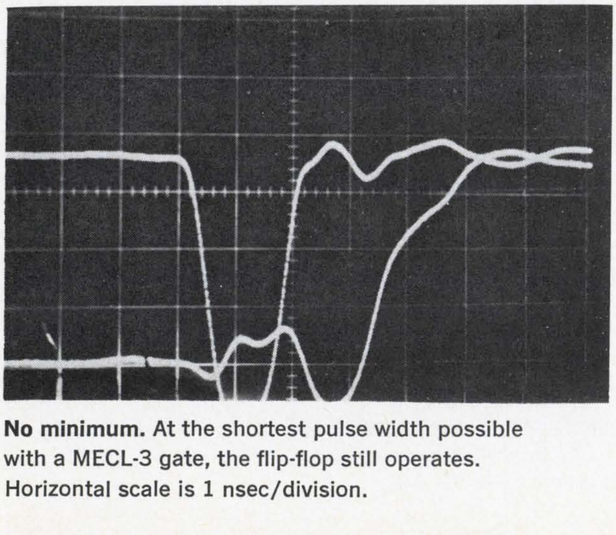


Fast addition. Eight-bit adder goes through full cycle in remarkably short time of 18.28 nsec.



Eight bits. Full adder contains several hundred components on one chip, and uses three layers of metalization. The inverting exclusive-OR terminal, designated Ē, provides look-ahead logic.

Because of the difficulty of making accurate measurements, the problem of relating the incoming inspection tests of the user to the final electrical tests of the manufacturer assume major proportions. The usual correlation procedure is for the manufacturer to take, say, 50 circuits and record all their dynamic and static parameters. The 50 units are then sent to the customer for the same measurements. From both sets of data, a difference factor, DF, is determined. The circuits are now divided between vendor and buyer, and used to check the calibration of their test sets.



No minimum. At the shortest pulse width possible with a MECL-3 gate, the flip-flop still operates. Horizontal scale is 1 nsec/division.

Ordinarily, the buyer widens his specification window by DF/2, while the vendor narrows his window by the same amount. This procedure should guarantee that no failures will be measured by the buyer.

Unfortunately, if the DF is significant (200 psec for a 1-nsec circuit, for example), the vendor's yield decreases almost exponentially. So, until more accurate measuring techniques are available, it's better practice for the vendor to base his specification window on the repeatability of his measuring instrument. Obviously, the vendor will then attempt to get the highest degree of repeatability possible. If a similar effort is made by the buyer, the difference factor will decrease, and the method of widening and narrowing the specification window can be used to correlate the measurements without serious effect on the vendor's yield.

Acknowledgment

Development of the eight-bit full adder was supported by the Air Force's Systems Engineering Group, Research and Technology Division, at Wright-Patterson Air Force Base

Circle 131 on reader service card→

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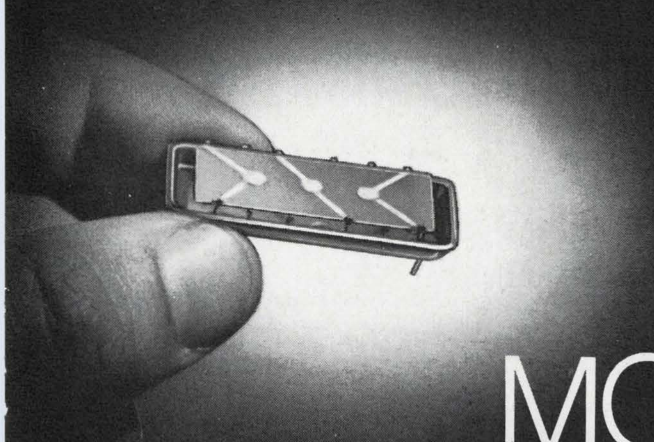

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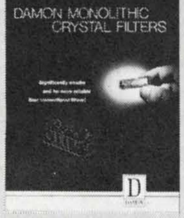


DAMON

Devising industrial control systems

With hybrid computers, engineers can simulate processes, analyze disturbances, and evaluate advanced digital control configurations

By Charles W. Ross
Leeds & Northrup Co., North Wales, Pa.

When the customer buys a digital computer control system he wants an installation that does its job the first time the plant operator presses the start button. He rarely got what he wanted in the early days of computer control, but today his chances are much better. For example, fast startup is the order of the day in two specific applications: control systems for several cement plants and for economic power dispatching from interconnected generating stations.

Rapid successful startup of a computer control system is not accidental. It takes knowledge of both process technology and control technology. And much of this knowledge can be gleaned from a hybrid computing facility. With it, the user can:

- Develop a model of the process and its disturbances
- Develop control criteria, objectives, operability, and system constraints
- Develop a specific control scheme
- Evaluate the control scheme by simulation and field tests

The study and simulation of critical and sophisticated control problems may take man-hours to man-years to complete. Simulation is expensive, and the engineer must be sure he isn't solving a problem whose solution is already known. Further, the simulation will provide useful answers only to problems that are correctly specified, so the engineer must be certain he has included all important aspects of the problem. Too often, he becomes so intrigued with the simulation of details or the pursuit of tangential theoretical information that he overlooks points of first-order importance.

These pitfalls can be overcome, to a large extent, by first developing a control philosophy checklist: complete safety of plant personnel and equipment, high quality of the final product, maximum throughput, minimum production costs, and full reliability of operation even during major upsets in the process. The engineer thus makes sure that all salient operational needs are included in the simulation study. A control configuration—together with its tuning—that doesn't meet these objectives must be re-evaluated, modified, or abandoned for the particular application.

The digital control computer—which can be readily simulated on the hybrid's digital part—has opened up new opportunities for the control engineer. Almost anything his experience and analysis teaches him can be translated into computed execution. With direct-digital control ideas first simulated on the hybrid's digital computer, the engineer can now offer practical solutions to many control problems.

Novel digital approaches

Analytically and practically, the most rewarding digital control studies involve the development and application of new or different techniques that have not been economical to implement with analog control equipment. Novel digital approaches can be efficiently applied to any aspect of control—measuring, filtering, predicting, constraining, adapting, and optimizing.

In contrast to an analog control application, however, every detail in an advanced digital control scheme must be prespecified, and the designer must understand the functional operation of every element in the controller. Also, the design of digital controllers requires digital techniques to handle accuracy, scaling, sampling, and the interaction between controller elements.

Simulation is absolutely necessary for debugging and evaluating new and sophisticated digital control schemes. Again, the hybrid computing facility proves useful. Each bit of the many hundreds of program instructions and each of the hundreds of paths through the controller for digital control execution must be correct if the control is to operate reliably. Errors will be infrequent, but when one does occur its effect will usually be subtle and will not appreciably affect process operation. But some errors could cause dramatic consequences.

Many subtle problems involving the executive program operation, priority interrupts, timing and initializing of input and output operations are best overcome by hybrid simulation. Any errors left to be found after installation of the digital controller are very expensive to correct. More important, they jeopardize the confidence of the operators in the controller's ability to perform properly.

After a new and sophisticated control configuration has been studied, designed, debugged, and evaluated on the hybrid computer, the same simulation can be used effectively for demonstrations to plant management, training of operating personnel, and checking of program modifications and interactions.

The actual digital computer control system to be shipped to the field can be proved out ahead of time on the hybrid computer, or on special portable analog computers to model the plant. Controller settings can be evaluated under expected field conditions and program modifications and interactions can be checked. Tests may be run in speeded-up time and without the pressures of production considerations and curious, often impatient, operating personnel.

The hybrid computer is valuable not only for the actual design of the control system but also in the step ahead of design—developing the general rules of control. Before the engineer can even begin to design the needed control system, he must have a background, or a storehouse of information, on the general characteristics of control systems. This storehouse comes from generalized investigations to:

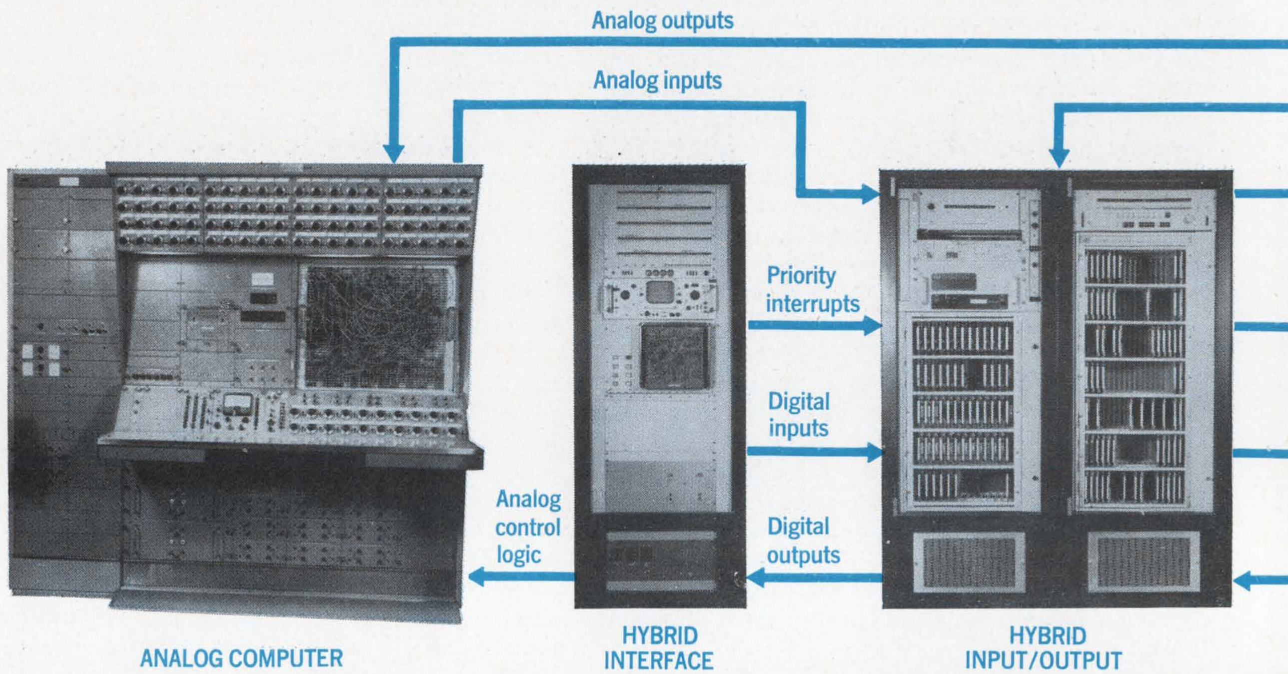
- Study the dynamic characteristics of many different processes and of a variety of the process disturbances.
- Study and develop advanced control, measurement, and simulation techniques.
- Study methods of applying these techniques to the control of industrial processes.

Such investigations, though they are general, should nevertheless relate to real industrial processes. That is, a simulated process being studied must have a dynamic characteristic similar to those found in actual processes.

It's fortunate that many controlled plants, even in different industries, can be represented by the same model (or transfer function or dynamic characteristic)—for example, one containing a dead time and one or more time constants. The difference between these processes would be in the values

Voracious. Because control-system design requires tremendous amounts of data, this converter and paper-tape logger is sent to the field. Here the system is back at the hybrid center reading in tape for analysis.

Custom hybrid computer for control studies



The mission of the hybrid computing facilities at the Leeds & Northrup Co. is simple and straightforward: aid in the design and application of complex control systems that the company sells. With this aim in mind, the systems analysis department, headed by Charles Ross, the author, designed and installed a custom hybrid computer.

In many ways it is functionally like other hybrid computers, but L&N's has special characteristics that tie in with the company goal. For example, the hybrid's digital computer and interface is the same kind L&N sells to its customers.

This up-to-date equipment in the hybrid facility provides a means of testing new hardware designs, debugging new control schemes, and developing software packages on the actual equipment that would be used for field applications.

The hybrid computer consists of a medium-scale analog computer, an EAI 231-R, and a third-generation digital computer, the SDS Σ 2, that Leeds & Northrup uses to produce its LN5000 control system. The hybrid input-output equipment between the analog and digital computers is unique. It uses L&N's process control input-output equipment (called process I/O) to service priority interrupts and analog and digital inputs and outputs.

The hybrid interface is designed around a digital patch panel, and this uses the same logic elements as does the process A/O. This panel provides patchable logic and access to digital inputs, outputs, and priority interrupts for the digital computer, and analog comparators, solid state switches, and mode control for the analog computer. This interface also includes decade pulse generators, presetable recycling counters, a storage oscilloscope, and a logic display panel.

of these dynamic factors.

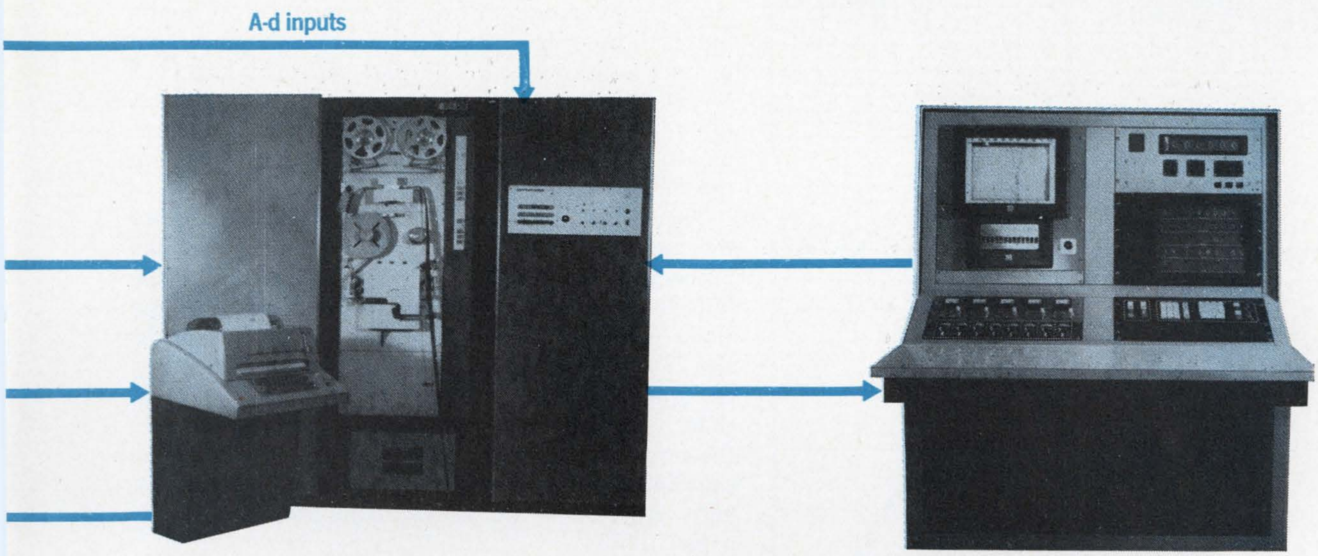
In a typical generalized study, a process with a dead time and, say, three time constants would be simulated. The hybrid computer would be programed to run through many series of tests, each test run showing the response to a given combination of dynamic factors while, say, the dominant time constant is varied. A test study can result in thousands of data points.

Data from the study is then correlated, perhaps as families of curves, to present nearly every detail of dynamic performance. Only some of the information might be used on a current project, but it's all there, ready for the engineer to use without having to go through another simulation procedure for the same class of problem.

In some cases, the model can be determined only from theoretical considerations, particularly if the process doesn't physically exist prior to the study—the model for a fast new boiler for a generating station, a once-through supercritical boiler, had to be developed this way, for example.

Because of their size, theoretical models may have to be simulated first on a large computer like those found at commercial data centers, and the results approximated by curve fitting to produce a manageable model for control investigations on the hybrid computer.

Most of the time, though, the process does exist, so dynamic and steady-state process models then



Configurations. The hybrid's components may be arranged and controlled in several configurations. The analog and digital computers can be operated independently with patchable logic. In combination, the two machines execute true hybrid computation. The process is usually simulated on the analog computer and the control functions executed on the digital computer—or vice versa, depending on the nature of the control problem and the form of the data. Process models prewired on analog patchboards reduce setup time when changing from one control study to another. Similarly, control schemes are stored in the second-level memory of the digital computer for easy call-up when needed.

An engineer may communicate with the digital computer through a typewriter, paper tape, and various control panels—including the Manual Input Console that's part of the LN5000 digital system. With the MIC, studies can be extended to include the man-machine interface problem and facilitate the training of engineers and operators to apply direct-digital control.

L&N's present hybrid computing center results from a number of evolutionary steps starting in 1960. At that time the earliest hybrid work was done on an analog computer modified to include logic and timing operations.

Even though this semihybrid system was relatively simple, it proved invaluable for developing the experience necessary for the application of direct-digital control. These early studies—still used today as guidelines for the design of more sophisticated control schemes—yielded information on sampling rates, control periods, controller settings, aliasing errors, steady-state errors, and input and output resolution requirements.

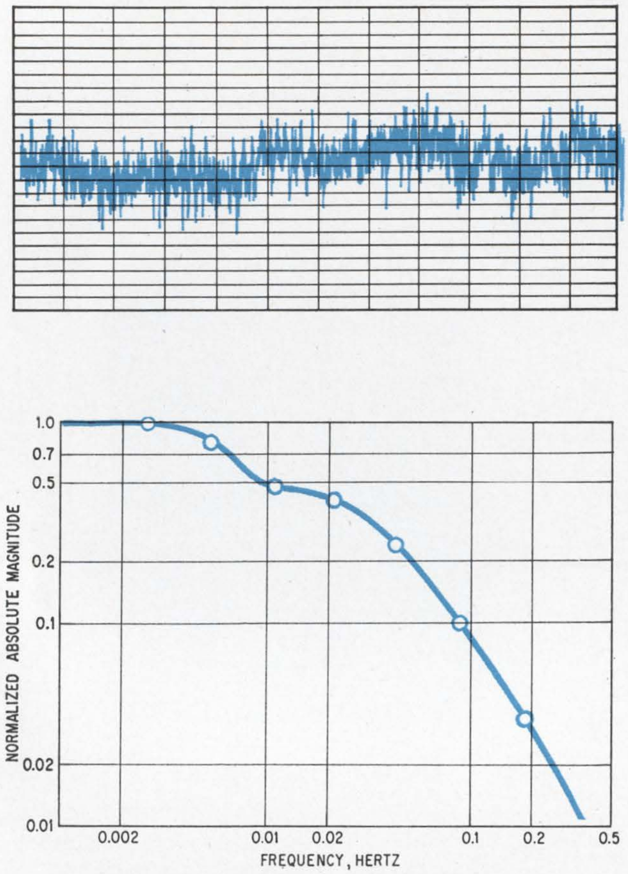
can be obtained by a combination of theoretical considerations, engineering judgment, and experimental measurements made on the process in a field test.

A substantial part of the systems analysis activity, field testing requires an intimate knowledge of a variety of deterministic and statistical measurement and data-analysis techniques.

Some processes, however, prove difficult to test, particularly when their dynamics are quite slow. Tests take a long time to complete, and during the test extraneous disturbances can cause errors or invalidate the results. For such cases, some companies bring a digital computer right into the field to analyze the data.

Certain field-test results are immediately available at the end of each run, so engineers can rapidly determine the validity of the data and make on-the-spot decisions about the parameters of the next test. Of course, the data gathered on punched tape during these quick-look field tests can be preserved and used again for later, more detailed, studies on the hybrid computer.

If test conditions and requirements are not severe —for example, if the signals are relatively free of noise—deterministic tests, the response of the system to known inputs, should prove satisfactory. That is, an analysis may be made in the field of the response-chart records that result from known pulse, step, or frequency-response disturbances.



Noisy. Although not very obvious, an actual random operating signal, top, contains important dynamics information, but to find it the noisy signal must be run through a special analog computer program to get its corresponding power spectral density, bottom.

Measurement methods

Measurement techniques—such as auto-correlation, cross-correlation, and power spectral density methods, which may require large amounts of data—may be used when the process is nonlinear, when high accuracy is required, or when noise masks the signals. Here, the hybrid computer proves most useful: it can provide necessary filtering and time shifting, and repeated solutions can be run in faster than real time.

Generally speaking, the cross-correlation method proves most useful for determining plant dynamics, while auto-correlation and power spectral density approaches are best for determining disturbance dynamics. For cross-correlation, information can be extracted by the computer from punched-paper-tape records of random process noise. Where feasible, the cross-correlation procedure can be aided by adding a deterministic perturbation to the noisy variable being measured.

Cross-correlation takes time-domain information—deterministic or random process signals—and converts it into amplitude and phase-angle data for frequency-response plots. These Bode plots then represent the dynamics of the measured process.

Knowing the dynamic characteristics of process disturbances is also vital to the design of a good control system. Auto-correlation and power spectral density (psd) methods yield the information.

In the auto-correlation method, the noisy random signal is compared with itself over and over again, but each time it is compared a small displacement in time is introduced. The plot can be interpreted to yield the signal's dynamics. Because of the required and exceedingly numerous time displacements, auto-correlation is usually carried out on the digital part of the hybrid system.

The psd method reveals the energy content of the noisy signal at different frequencies. The psd procedure is carried out on the analog part of the hybrid, and its result is somewhat similar to the Bode plot. For determining dynamic characteristics of noisy process signals by statistical methods, the psd procedure generally gives finer resolution than does the auto-correlation method. Sometimes the noise is first processed by auto-correlation on the digital computer; then the auto-correlation results are fed to the analog computer to provide a psd plot.

Informative noise

Consider a real problem. The random frequency variation due to load changes on an interconnected system of electric generators produces a noisy chart record like the real one shown at the left. Time runs horizontally, each division equaling 10 minutes. Deviation from the base frequency of 60 hertz is recorded vertically, 10 minor divisions on the chart paper equaling 0.05 hertz.

To facilitate data analysis, this same analog information is converted in the field to digital form and punched on paper tape. Then the tape is brought to the hybrid computing center for analysis. Here, the digital values are converted back to analog signals that go through an analog computational program to provide the psd—the measured spectral characteristics of frequency variations. The tape may be run many times to produce information at selected frequencies throughout the spectrum.

Engineers designing a control system use the information in the psd plot to determine such things as the degree of controllability, the necessary filtering of signals, and the allowable sampling rate of the digital computer-control system.

The analog computer part of the hybrid system provides the highest resolution for plotting psd curves. The digital computer has its role, too, in evaluating random signals. The digital computer, as noted, processes data to yield auto- and cross-correlations. It also gives standard deviations and averages of measurements, so engineers know how much confidence to give to the calculated data points and plots.

Once the characteristics of actual process disturbances have been determined, the disturbances can be simulated at the hybrid facility to perturb the simulated plant. Both analog and digital function generators are used to produce deterministic disturbances, such as impulses, steps, and ramps, and to generate statistical disturbances (noise), which can be shaped with filters to give the appropriate energy content and frequency distribution.

Rules of thumb

When high accuracy is not needed, engineers in the field often can get a good idea of the characteristic of noisy disturbances, without having to resort to computer analysis, by using rules of thumb developed from generalized simulation studies. For example, with a method based on counting the number of times a random signal, like the one reproduced at the left, crosses the zero-base line in a given time period, an engineer can estimate the dominant time constant representing the disturbance. Also, he can measure the peak-to-peak value to estimate the signal's root-mean-square magnitude. Knowing the approximate time constant will let the engineer decide—for example—on a suitable scanning speed and analog and digital filtering to be sure he acquires the desired high-frequency content of the disturbance.

Model building—whether by theory or field testing, or both—produces dynamic characteristics in a variety of forms: time domain, frequency domain, Laplace transform, Z transform, and statistical functions. To execute a study, models are simulated on the analog or digital part of the hybrid computer, and models may have to be converted from one mathematical form to another.

Analysis in the frequency domain, generally carried out on the analog computer, provides high accuracy for study and for curve matching. Dynamic characteristics expressed in either the time domain or Laplace domain are also most useful for simulation on the analog computer.

With the proper programs, the digital computer part of the hybrid system can convert time-response data or Laplace transform dynamics directly to Z transforms. The Z transform, related to the Laplace transform but suited to the computational time delays intrinsic to the digital computer, permits the digital simulation of continuous processes and the digital execution of their control systems.

The hybrid computer has played an invaluable role in gathering field data and processing it into a meaningful model. The net result is that a real industrial operation with real disturbances and constraints can be simulated on the analog or digital part, or on both parts, of the hybrid computer. Now the engineer can proceed with the development of a suitable control scheme for the process, with reasonable assurance that a control scheme that works for the simulated plant will also work on the actual plant.

From a very practical viewpoint, hybrid simulation gives the engineer two major advantages: he can run tests on the plant in faster than real time, thus shortening development time, and he can experiment with the simulated plant in ways that wouldn't be tolerated by operating management of the real plant.

Developing control criteria

As a general rule, a control scheme that may give ideal performance based on one criterion or test condition may perform poorly under other criteria and process characteristics. Therefore, many tests must be run of the simulated plant and its control scheme to find out under which conditions the control idea proves ideal, acceptable, or unacceptable. During one set of tests, for example, the simulated process is held in a selected state, and for each test the simulated disturbance is adjusted to a new value by the engineer.

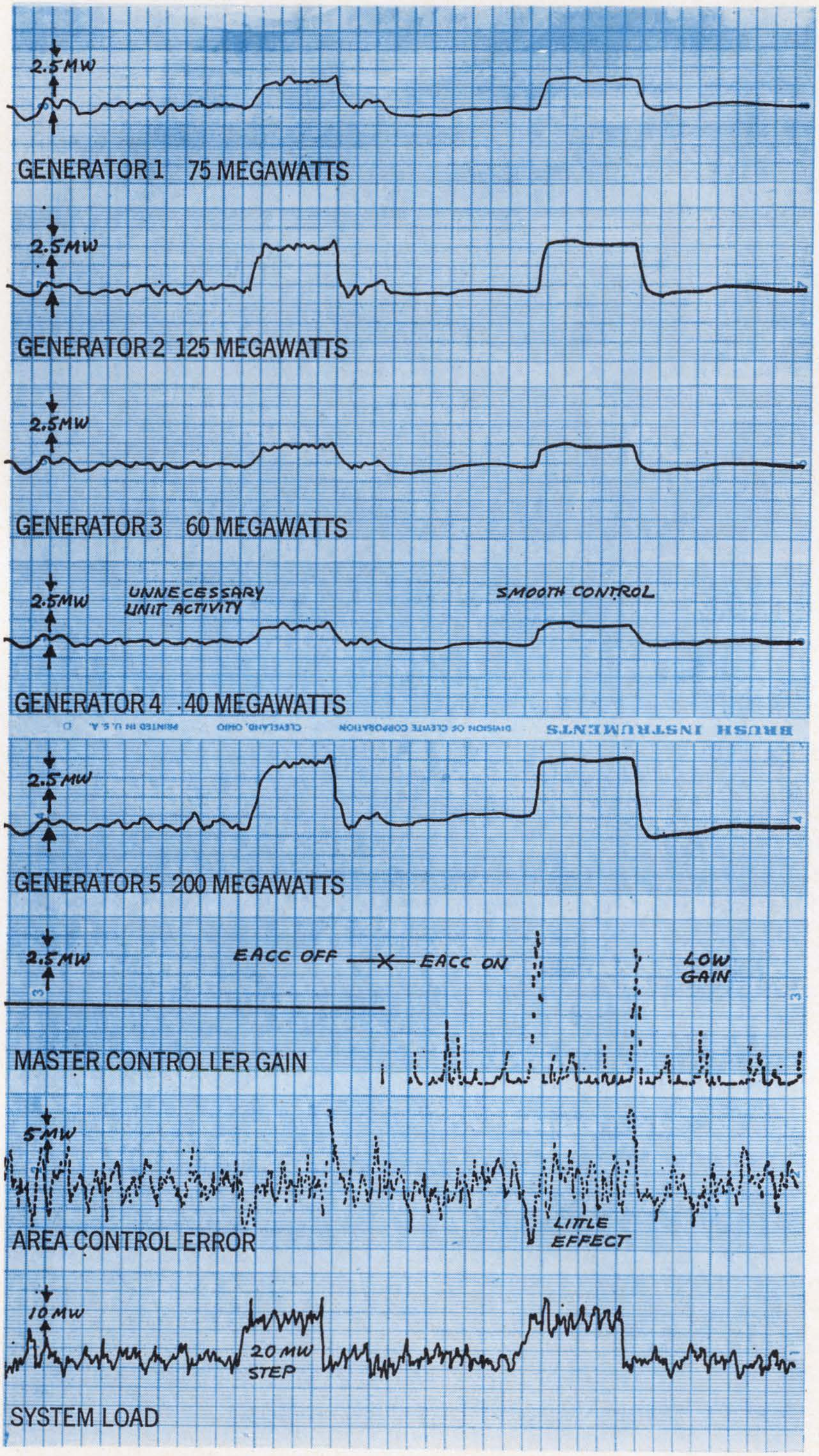
Depending on particular test conditions, various combinations of analog and digital execution of process and controller characteristics can be evaluated. However, most advanced control techniques being studied at present are intended to be executed digitally and are only practical for direct-digital control. Thus, general practice is to simulate the controller on the digital part of the hybrid computer and the continuous process and its disturbances on the analog part.

The versatility of the hybrid computer does allow some variation in where portions of the overall system are simulated. For example, the memory capability of the digital computer simplifies the simulation of a process dead time having a variable delay. Also, process nonlinearities might be programed more effectively on the digital computer.

The use of a digital computer as a controller raises some special problems, and it pays to investigate them on the hybrid system rather than wait until the control system is shipped to the plant. Of particular concern is what happens to controllability at various rates of sampling of the digital controller's input and output signals. For example, if an input signal is sampled too slowly, the high frequencies in the signal can be "aliased" back to the low frequencies. Aliasing errors are difficult, if not impossible, to compensate for.

Keeping in step

The execution time for making calculations must also be taken into account with the digital system. When the control law includes dead time, for example, the computer must complete the dead-time calculation in time to synchronize it with other calculations. Synchronizing problems can also occur in the digital computation of performance criteria. The digital computer programs the starting time of a specified disturbance on the simulated process. The computer also calculates a performance criterion during the disturbance. Both have to be synchronized; otherwise one or more time intervals in calculating the criterion might be skipped, and the net computational error might be as high as 25-30%. For this reason, even though certain time-domain criteria can be calculated



No blackout on the hybrid. To find out what happens when a 20-megawatt load change is made on an interconnected system of five generators totaling 500 megawatts, engineers at Leeds & Northrup simulated the entire problem on their hybrid computer.

These eight charts show responses of the generators and the control system. Five generators, each of a different capacity, were simulated on the analog part. Their responses are shown in the top five charts, including the economic distribution of a 20-megawatt load change (see bottom chart) among them. The second chart from the bottom shows the area control error representing the difference between the area's generation and load. This function was also simulated on the analog.

The third chart from the bottom shows the system's master-controller gain. The master controller was implemented digitally. The gain can be modified by an error-adaptive control computer (EACC), a special form of filtering that weights the present and anticipated area control error and makes logical control decisions. Using the EACC means that the larger and more sustained the error, the more aggressive the control correction. In this study, the EACC was implemented on the digital computer.

The left portion of the top five charts indicates the unnecessary activity of the generators in trying to follow the area control error—with the EACC out of the control scheme. With the EACC connected, unit activity is reduced sharply, yet each generator still responds rapidly to a load change. Note how the EACC keeps the controller gain low—except during load change, when the EACC raises the controller gain sharply to cause fast correction.

digitally, synchronizing problems can be reduced if criteria calculations are made in the analog computer.

The number of tests and the quantity of data required for a process control study, particularly a generalized study, is staggering. The hybrid computer helps in systemizing these tests and greatly reduces tasks that are tedious, time-consuming, and often impractical or impossible for an engineer to carry out by himself. Using the hybrid computer, the engineer need only adjust the simulated process configuration and dynamic constants of the process and control loops.

A typical test series

Consider a representative series of tests. The controllability of a process is typically characterized by the ratio of effective dead time to process lags in the closed loop. These dynamic factors must also include the contributions of the filters and the measuring instruments in the loop. Tests are usually carried out on normalized data that can range in value from zero to infinity. Normalizing aids the comparison of different sets of tests.

The role of the digital computer, besides that of simulating parts of the over-all problem, is to help set up the analog computer simulation, and to acquire and process data generated by the analog computer during the course of the solutions.

Different performance criteria provide selective information applicable to a particular process. Among the more common criteria are: percent overshoot, settling time, maximum error, integral of absolute error, integral of time multiplied by absolute error, and integral of error squared. Since the purpose of a properly tuned controller is to constrain an error, these same performance criteria can be used to evaluate the amount of required control action.

Depending on the application, one or more criteria will be selected to tell how the controller is performing. By normalizing the criteria, several control schemes may be compared with each other under the same test conditions. Or, several criteria can be evaluated simultaneously for each test run, a relatively easy thing to do, since data is normalized and some pieces of data may be used several times in calculating several criteria.

By way of example, the percent-overshoot criterion might be selected for a process variable that must not exceed an allowable deviation as the result of a disturbance. A temperature overshoot of more than 5% might be unsafe, and a control system that didn't constrain temperature error to less than this amount wouldn't be satisfactory.

During the performance tests, the dynamic responses versus time are superimposed on one another on the hybrid's x-y recorder or the storage type cathode-ray tube to permit visual evaluation and comparison of results, say, of combinations of controller tuning values.

Tuning the controller for best response based on some criterion is a tedious, time-consuming, iterative procedure, especially if done manually by the engineer or technician. This chore can be accomplished on the hybrid facility by using digital optimizing techniques, which will automatically search for the best tuning based on specified criterial and constraints. Because more than one optimum may exist, and the one that's more satisfactory may not be clear in advance, automatic tuning by the computer may require human intervention.

Other factors

Many other factors in control studies must be taken into account, and nearly all require simulation studies for a complete evaluation of control performance. These include dead bands, velocity limits, and constraints on motor drive units; soft (high, but safe) and hard (higher, and unsafe) limits on the process; operating constraints; economic considerations; interactions between process variables and between control loops, and the slowly-changing-with-time character of many processes and their operating disturbances.

No control study is really complete without considering the problem of filtering the signal. The analog and digital filters used in digital control loops must satisfy two somewhat conflicting requirements:

- Remove high-frequency components in the disturbances that can't be controlled with a given control scheme. Any attempt to control these disturbances hurts performance.
- Remove those frequency components in the disturbances that would cause excessive control swings, result in unnecessary wear and tear on the control and plant equipment, and cause uneconomic fluctuations in process operation.

The latter type of filtering requirement leads to judicious tradeoffs, since heavy filtering reduces the controllability of otherwise controllable disturbances. A distinctive approach to the filtering problem is the error-adaptive control computer (EACC). The EACC monitors the error and the integral of the error and makes logical decisions on the probability that the error signal requires control action. The EACC can be implemented digitally or by a special-purpose hybrid computer.

The performance of this special type of filter is shown in the charts at the left in connection with the simulation on the analog computer of five interconnected electric generating units, the digital simulation of the EACC, and the responses due to disturbances with and without the EACC connected to the system.

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Blue-green high-powered light extends underwater visibility

Lasers have more than doubled the range of vision possible with ordinary light, but over-all progress is being slowed by the difficulties of predicting the behavior of light scattered by water and suspended particles

By Edward Kornstein and Hans Wetzstein
RCA, Burlington, Mass.

Blue-green nanosecond laser pulses with megawatts of peak power have more than doubled the range of underwater vision possible with high-intensity ordinary light. Objects bathed in such laser light can now be seen at distances up to 165 feet.

These high-power lasers can generate pulses short enough for range gating, a technique that suppresses the main limitation on underwater vision: light scattered back to the viewer not by the object but by the water and particles or organisms contained in it. In a range-gated system, the receiver is turned on when the laser pulse reflected from the object—along with back scattered light in the immediate vicinity—is arriving. However, the receiver is off when back scattered light from other regions in the water is arriving.

Designers of underwater laser systems break down light arriving at the receiver during this gating period into two classifications: object luminance (light directly reflected from whatever the laser is beamed at) and veiling luminance (light present from other sources and laser light scattered by the water).

Lasers were first used in underwater experiments several years ago, about the time optical frequency doublers were demonstrated. These converted the infrared output of neodymium-doped lasers to the blue-green part of the spectrum, which is attenuated least by water.

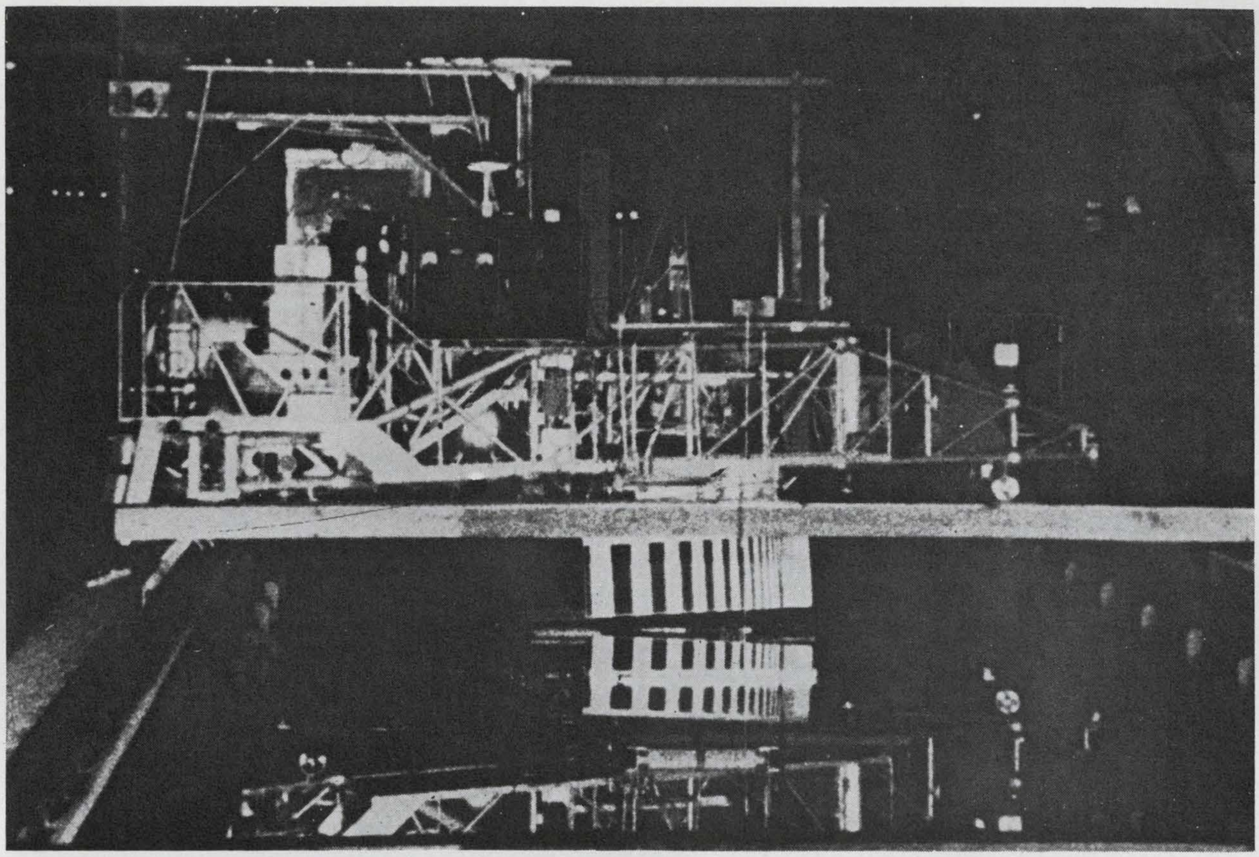
Since them, extensive propagation measurements and some scattering studies have been made. Surprisingly, though, only a few were done in the ocean, where underwater lasers would find the most use. Only recently has range gating been incorporated in a system—built for the Navy by the Kollsman Instrument Corp., a subsidiary of Standard Kollsman Industries Inc. The problem was—and still is—that range gating requires knowledge of how long the backscattered light takes to travel to the receiver. But that depends mainly upon the path lengths that the light has to travel, and these are very complicated and poorly understood.

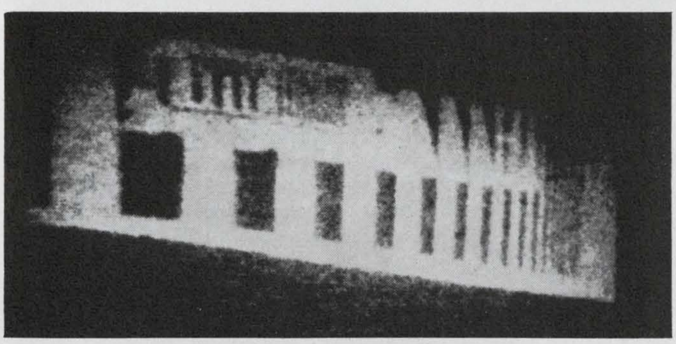
Understanding how light is scattered underwater will be even more crucial in designing laser detection and visibility systems of the future. These will scan objects point by point instead of illuminating the entire object, as the Kollsman system does. Scanned systems are expected to offer maximum visibility, primarily because they take advantage of forward scattering: light that's scattered out of the beam in the direction of propagation—either from the laser to the object or from the reflecting object back to the receiver. Much of this light eventually falls back into the beam.

Because of the complexities of back and forward scattering, engineers are building underwater laser systems now, without waiting for answers from researchers. But, at that same time, many others are trying to devise experiments to increase basic knowledge.

Who needs eyes?

The need for improving underwater vision might not be immediately obvious. Sonar, of course, has been used for many years in underwater detection and ranging, but irregularities on the ocean floor sometimes give false returns. Probably, an underwater laser system would be used after the sonar detected the presence of an object. The laser would scan at highest power to establish a setting for the





Underwater visibility. Suspended on a test carriage, this target is lowered in test tank, then illuminated with Kollsman's laser. The photo shows how the object looks 125 feet away. Resolution was 380 to 400 lines at this distance.

Versatility

An underwater laser system requires:

- Source. The laser would be capable of short, high-power pulses that could be focused into a narrow beam for the longest ranges. Its peak power should be variable so that the pulse rate could be increased for imaging at intermediate ranges. For scanned high resolution at a few attenuation lengths, the laser should be operable in the continuous-wave mode.
- Source optics. For searching and imaging, scanning mechanisms must be included. In addition, the beam must be focused to as narrow a width as possible. And polarization components should be included to discriminate between wanted and unwanted light.
- Receiver detector. In scanned systems this would be a photomultiplier using large-acceptance angle optics, while in imaging systems it would consist of a sensitive imaging tube with intensifiers for short-pulse range gating.
- Receiver optics. Included might be polarization analyzers, spectral filters for suppressing background light, image formers or integrators, and scanning mechanisms.
- Control circuits. Timing for setting range gating would be included, as well as means of synchronizing laser pulses with the image tube scanner. Transmitter power and receiver sensitivity would be adjusted over a wide dynamic range.
- Data processing and display circuits. Images from receivers would be assembled and presented to the cathode-ray tube display, range-gated information stored for data processing, and images processed—for example, photographed—at different ranges.

range gate. Then it would continue to scan the object so that it could be viewed—along with any other structures in the vicinity—to prevent collision if the vehicle approached.

Although present results can hardly be called spectacular, anyone who followed the search for the nuclear bombs off Palomar, Spain, in 1966 will appreciate the need for even modest improvements in underwater visibility. The Navy "tracked" the bombs by skid marks they left on the ocean floor —but then lost the marks. Seeing was so difficult that when the search was resumed each day the divers relied on old beer cans and coffee cups as landmarks.

Lasers, then, hold promise for applications such as searches and surveys of the ocean floor, searches under ice, and semaphore-type communications over short distances.

Of the three types of systems possible, the simplest would use an electro-optic modulator as a range gate between the eye and window. An image intensifier could improve visibility.

A system like that designed by Kollsman would use a television type display that would be synchronized with the range-gated pulses. Such a system could detect very low light levels.

The third and most complex system—using the scanning technique—would have a photomultiplier

Seeing through the fog

The main limit on underwater vision is the blurring caused by light reflected back from the water between the viewer and the object he's looking at. Range gating is a technique that minimizes backscattered light by causing a receiver to detect only the light pulse reflected from the object. The receiver must open just as the pulse arrives at the detector. And the detector must stay open only for the pulse duration. Thus, backscattered light, which arrives at the detector before the reflected pulse, is ignored.

Range gating requires a very fast shutter that can open and close in 10 nanoseconds to accommodate the very short laser pulses. Among the more familiar fast shutters are Kerr cells, Faraday devices, and Pockel cells. However, these are of limited use in underwater range-gated systems, because they pass or block light depending on its polarization and only provide a limited field of coverage. In addition, backscattered light could conceivably be polarized in the same way as the light reflected from an object.

Instead, electronic shutters and a two-step detection process have been used. The light entering the receiver falls on the surface of a photocathode, which emits electrons from each point in proportion to the incident photons. An electric field accelerates the electrons, which are then focused by an electrostatic and/or electromagnetic lens onto the storage or display surface.

When image orthicons are used, the storage surface is a dielectric target; when image converters or image intensifiers are used, the storage surface is a light-emitting phosphor. Pulsing a control grid in the tube, or pulsing the accelerating voltage provides the shuttering action. The shutter must be synchronized with the laser so that it opens at set intervals after the pulse is fired.

Hardware. The outputs of image converters or intensifier tubes are usually coupled to the following image tube by a fiber optics bundle to minimize optical losses.

Because dynamic range is very important in underwater light systems, wide-range, non-blooming, sensitive image tubes, such as the Westinghouse WL-30691 can be used. Alternatively, RCA's intensity vidicon the C-23001D, which has a switchable triode intensifier, can be used.

For long-range scanning systems, a gated scanning photomultiplier or image-dissector tube would be used. These types are less complex than imaging tubes. But to cover a reasonable field of view, scanning must be done mechanically, not electrically.

Brief flash. As the table shows, short pulses are essential in range-gated systems, even in fairly clear water. For maximum contrast between the light reflected from an object and unwanted light, the shutter should stay open for a length of time as close to that of the pulse as possible.

Because the range gate selects only a nanosecond view of the illuminated object, the depth of the field of view is limited. However, unless the detector becomes saturated, returns from a number of range resolution elements can be stored and compared. The same image can then be examined at different ranges.

Pulse length and light contrast

Pulse and gate length	Maximum possible contrast
10 ns	70.5
20 ns	36.1
50 ns	11.1
100 ns	3.19

Pulse length kept at 10 ns gate length	Maximum contrast (Gate opens as reflected pulse reaches receiver)	Maximum contrast (Gate closes as reflected pulse reaches receiver)
20 ns	39.2	31.3
50 ns	20.2	8.35
100 ns	13.0	1.63

$\alpha = 0.1$ meter^{-1}; attenuation length $= 10$ meters

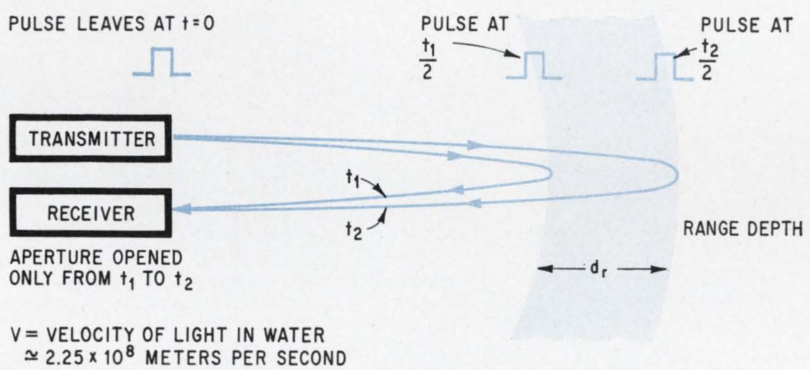
$\sigma = 80° = 0.0002$ meter^{-1} (backscatter coefficient)

$\rho = 0.1$ (diffuse reflection coefficient of object) and store a complete scan in a memory before displaying it on a tube.

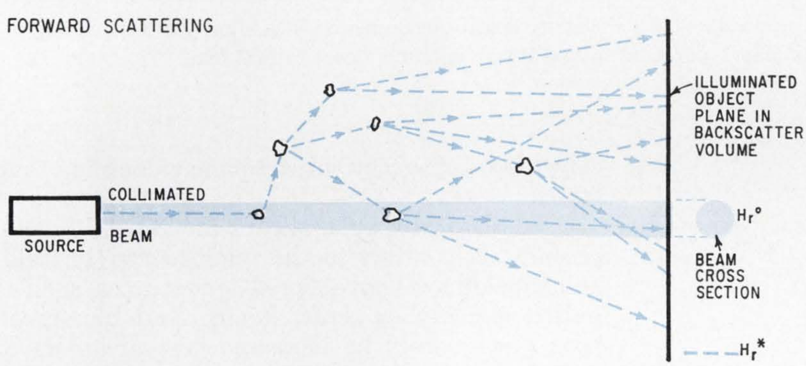
Blue power

Two types of lasers—gas and crystalline— can be used to produce blue-green light. The gas types—pulsed argon, xenon, krypton, and neon lasers—have the highest pulse rates, but their peak power and efficiency is low. The Avco Corp.'s pulsed neon laser, for example, has 12 kilowatts of peak power at a rate of 1,000 pulses a second, a pulse width of a few nanoseconds, and an efficiency of about 0.01%. Argon and krypton lasers have even lower peak powers and wider pulses.

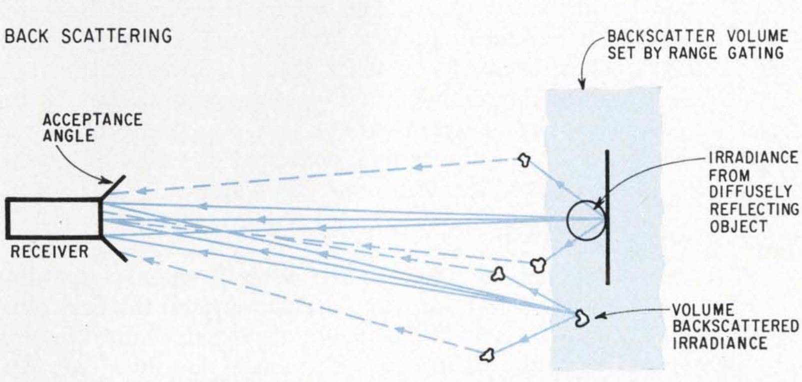
All the significant underwater laser measurements have been made with the crystalline type—pulsed neodymium-doped glass or yttrium aluminum garnet (yag). The 10- to 20-megawatt peak output at 1.06 microns passes through either a lithium niobate or potassium dideuterium phosphase single crystal. This doubles the frequency of the light, producing about 1 megawatt of output power at 0.53 mircon. The high peak power explains why the neodymium-doped, frequency-doubled lasers are preferred even though their pulse rates are low—only about 50 to 60 a second. For higher rates, several lasers would have to be fired sequentially. Efforts are now being made—at Bell Labs, for example—to improve the



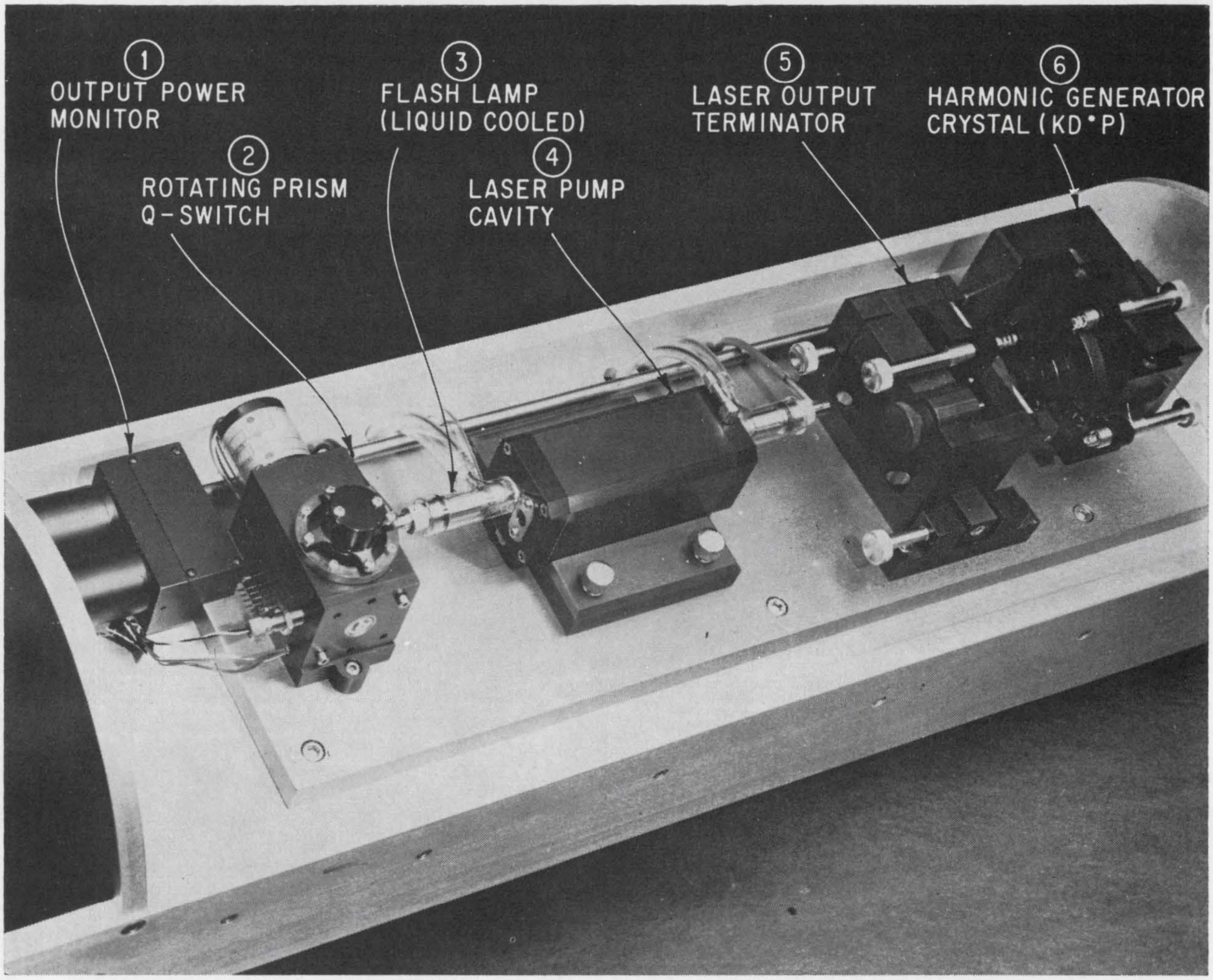
Range gating. Because the object's location is uncertain, the receiver stays open for a time equaling the difference between T_1 and T_2.



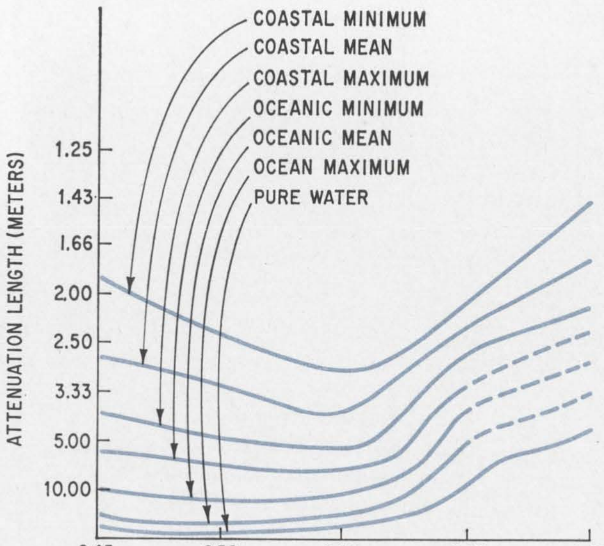
Scattering. During propagation large amount of light is scattered forward out of beam but eventually finds its way back to illuminate object.



Shut out. Most of the light scattered back from the water and particles doesn't enter range gated receiver. Amount that does interferes with light reflected from object, decreasing visibility.



Pressurized. This was the first blue-green underwater laser system. It was developed by RCA shortly after frequency doubling was demonstrated. Its pulse rate was 1 per second and it was operable down to 500 feet.



Wide variation. Attenuation length—the distance light travels in water before its power is reduced 37% —depends on quality of water and light wavelength.

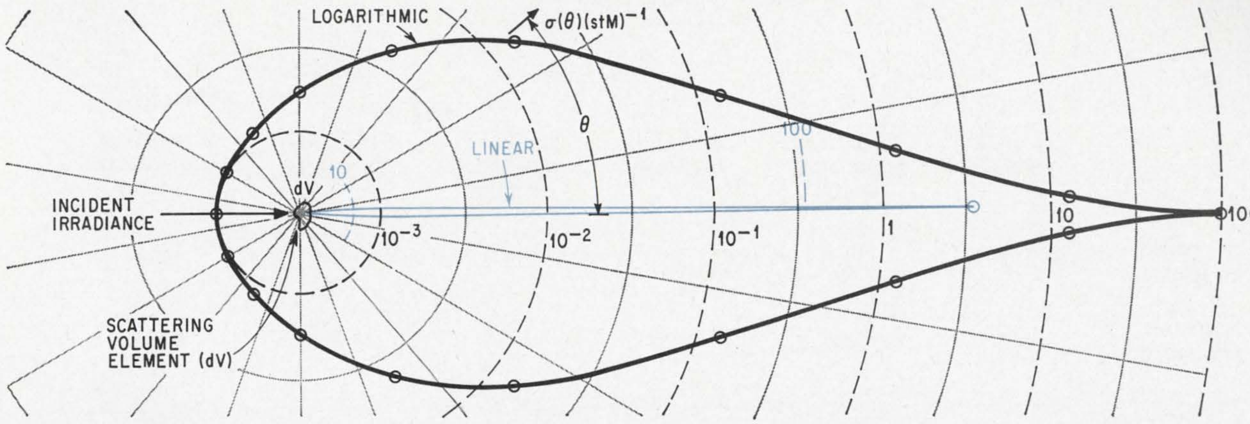
conversion efficiency of frequency-doubling yag lasers.

Crystalline-laser pulse widths are about 10 nanoseconds, in contrast to the microsecond to millisecond widths of conventional light sources, such as pulsed mercury or xenon lamps. And blue-green laser power could be increased several orders of magnitude from the present maximum without boiling or ionizing the water.

But perhaps the most important studies began about six years ago when the Naval Research Laboratories built a laser system for propagation measurements in clear water. However, the laser didn't emit light in the blue-green region of the spectrum, and it was mounted on a platform instead of in a submersible package. A series of prisms deflected the beam into the water.

First dip

Then, in 1962, shortly after frequency doubling had been demonstrated, RCA devised the first blue-green laser. The company used potassium dihydrogen phosphate as a frequency doubler. This first underwater laser, developed for the Navy and pack-



Deflected light. Linear and logarithmic polar plot of volume scattering function shows enormous amount of multipath incident irradiance. The table shows the increase of the volume scattering function as the angle increases. The total scattering coefficient, s, equals

$$2\pi \int_0^\pi \sigma(\theta) \sin\theta \, d\theta.$$

Scattering in the Pacific

Location		Outfall of sewage San Pedro Bay	Halfway between Santa Catalina and San Pedro	Santa Catalina coastal water	San Clemente Island coastal water
Total Attenuation α		0.736	0.129	0.118	0.111
Attenuation Length		1.36	7.75	8.5	9
Volume Scattering Function $\sigma(\Theta)$:Θ= meters⁻¹	0°	—	—	—	—
	30	0.0360	0.00268	0.00358	0.00313
	60	0.00419	0.000356	0.000396	0.000338
	90	0.00134	0.000132	0.000145	0.000142
	120	0.000903	0.000124	0.000146	0.000146
	150	0.001003	0.000156	0.000192	0.000193
	160	0.001028	0.000175	0.000202	0.000208
	170	0.001036	0.000191	0.000206	0.000219
	180	0.001037	0.000197	0.000207	0.000223

aged in a waterproof container, had a pulse rate of about 1 every five seconds. It was used in propagation experiments at the Navy's David Taylor Model Basin, Carderock, Md.

A faster version, with a pulse rate of 1 per second, was also built for the Navy. One of the pioneers in underwater light measurements, S.Q. Duntley of the Scripps Institute of Oceanography, La Jolla, Calif., used this laser to make the first measurements of forward scattering. He worked at the Navy's Diamond Island test station on Lake Winnepesaukee, in New Hampshire.

Designed for operation at depths of 500 feet, this unit has all its electrical and control connections in watertight seals at the rear. Its pressurized container is about 32 inches long and 8 inches in diameter, and weighs about 75 pounds. The main technical problem was keeping the size down and still being able to generate 1 pulse a second with reasonable efficiency. Solving this problem created another: heat. So the designers created a heat exchanger that uses the ocean as a sink. Another design feature of the unit is its rigid construction, which ensures that the components remain aligned even if the laser is buffeted about in the water.

The first range-gated underwater laser system was tested several months ago by the Navy. Developed by Kollsman, it used a 30-pps yag laser and a lithium niobate frequency doubler, both supplied by the Raytheon Co. The 10-nanosecond output pulses varied between 400 and 500 kw of peak power. At the receiver, an electrostatically focused image converter was pulsed by applying a voltage to a control grid to accomplish range gating. The image converter tube's output was coupled to an image-orthicon television camera. Other companies have since built or are now building such systems.

Damping light

The degree of attenuation of light depends both on its wavelength and the quality of the water. For a laser system, the power received is given by $P_r^0 = P_o e^{-\alpha r}$, where P_r^0 is the residual power reaching r meters without having been deviated by scattering and P_o is the total power in the laser beam as it enters the water at $r = 0$.

The factor α is the volume attenuation coefficient of light of a particular wavelength in water of a

Laser peak pulse power $\frac{1}{\alpha}$=7.1 meters; $\frac{1}{k}$=18.9 meters						
	200 Kilowatts		2000 Megawatts		200 Kilowatts x 1.42 x 10^{15} (hypothetical laser)	
	Distance in Meters	Number of attenuation lengths	Distance in Meters	Number of attenuation lengths	Distance in Meters	Number of attenuation lengths
Monopath irradiance	213	29.6	280	39.6	450	63.5
Scattered irradiance	450	63.5	620	87.5	1080	152
effective attenuation length		23.8		32.8		57

particular quality (clear or muddy, for example). It's usually expressed in meters^{-1}. The reciprocal of the attenuation coeffiicent, $1/\alpha$, is the attenuation length, representing the distance in meters over which light intensity is reduced by 1/e—about 37%. Duntley, the Scripps Institute scientist, points out that during the day dark-suited swimmers are just visible underwater when they're four attenuation lengths away.

Attenuation lengths vary sharply, reaching 10 meters in average ocean water at 0.5 micron but decreasing to less than two meters in muddy costal waters. L.F. Drummeter and G.L. Knestrich of the US Naval Research Laboratories showed that there were no narrow windows in the optical frequency spectrum—other than the broad dip in attenuation in the blue-green—that lasers could take advantage of.

Scattering losses

The attenuation of light in water comes from two independent mechanisms—absorption and scattering. The attenuation coefficient, α, is thus the sum of two components, a and s, where a is the volume absorption coefficient and s is the volume scattering coeffiicent. Duntley found that typical values for clear blue ocean water at 0.48 micron are:

$\alpha = 0.05$ meters^{-1}

a $\simeq 0.02$ meters^{-1} (40% of α)

s $= 0.03$ meters^{-1} (60% of α)

Light scattering in the ocean is highly anisotropic because of transparent organisms that have a different index of refraction than the water. On the other hand, scattering is the same in all directions in distilled water. Fortunately, there's less backscattering than forward scattering.

Duntley measured forward scattering out to 30 attenuation lengths. Later, H.J. Okoomian of RCA extended this to about 50. The difficulties of writing equations to predict such heavy and anisotropic scattering and designing equipment to measure it are formidable, and no one has yet devised a satisfactory analytical model.

Light that is scattered out of the laser beam but eventually reaches the illuminated object travels a multitude of complicated paths. It's hard enough to predict the direction and number of these paths. But RCA and others are trying to do something even more difficult. They're divising experimental methods to measure the travel time of scattered laser light. Measurement data will not only help to make range gating more effective but also will dilineate those regions adjacent to the beam where forward scattering is most important. These regions determine how much light eventually falls on the object and also how much a narrow scanned laser beam broadens.

For the moment, then, engineers have to make do with approximations of scattering effects. Four analytic approaches have been taken: multiple integration using the volume-attenuation and scattering coefficients, radiative transfer methods using iterative computation of integro-differential equations, Monte Carlo computational procedures, and diffusion theory.

Multiple integration has been useful in a few cases, but diffusion theory has yielded the best results. It's rigorously applicable only to mildly anisotropic scattering but has been extremely useful in predicting irradiance (the energy falling on the object in watts per unit area). Diffusion theory can also indicate how much of the irradiance is scattered light.

However, the theory can't be used to study the travel times of scattered light or the many different paths it takes.

A surprising result

Duntley applied diffusion theory, working out a complex model for beams spreading more than 20° and later extended it to highly collimated beams. He discovered that beyond a few attenuation lengths, much more scattered light than monopath light will arrive at the object. This finding also showed that the receiver should accept light over a wide cone.

Okoomian used Duntley's technique to show that H_r, the irradiance of the center of the laser beam, equals

$$H_r^0 + H_r^* = (je^{-\alpha r}/r^2) + (cjke^{-kr}/4\pi r)$$

H_r^0 is the irradiance from monopath light, H_r^* the irradiance from scattered light, j the radiant intensity of the collimated beam in watts/steradian, r the range in meters, c a constant determined by Okoomian for his experimental setup as 4.08×10^{-3}, and k an attenuation coefficient for scattered light.

Even though c is quite small, the fact that k is generally 30% to 40% of α means that beyond 5 to 10 attenuation lengths the scattered light is more intense than the nonscattered, eventually becoming the only significant contribution to irradiance. For example, with a receiver having a field of view of 26°, the ratio of H_r^* to H^0_r is about 10^3 at 20 attenuation lengths and about 10^9 at 40 attenuation lengths.

Nevertheless, the energy of the laser beam has spread considerably by the time it illuminates an object in the water. Experiments with a 1.25-inch-diameter beam at 6.66 attenuation lengths show that 20% of the total energy is distributed over a 62-inch diameter circle, 50% over a 134-inch circle, and 80% over a 232-inch circle. Yet experiments also show that the irradiance is highest at the beam center and adjacent to it because of the symmetry of this wide forward scattering. Wide scattering, therefore, tends to form an intense halo around the beam. While this halo does cut down on the contrast between the object and its background—an undesirable effect in scanned laser systems—it doesn't invalidate such systems.

One interesting fact noted can be taken advantage of to discriminate against background or backscattered light, which generally is at a different polarization than the laser beam. At four attenuation lengths where only one out of 10 photons is received without scattering, linearly polarized light is still 90% polarized. And after 20 attenuation lengths, when only 1 out of every 10^6 photons is received unscattered, polarization is down only to 82%.

Scattering vs. power

Actually, forward scattering offers more than a two-fold increase in range. This can be appreciated by comparing the ranges of scattered and monopath light as shown by solving the equation

$H = (je^{-\alpha r}/r^2) + (cjke^{-kr}/4\pi r)$ for both types of light.

$$r_{ns} = (2.303/\alpha)\log_{10}(Hr_{ns}^2/j)$$
$$r_s = (2.303/k)\log_{10}(H4\pi r_s/cjk)$$

H is the irradiance in watts per square meter needed by the receiver for a satisfactory signal-to-noise ratio. Inserting typical values from Okoomian's measurements in these equations gives

$$r_{ns} = -16.3\log_{10}(1.77 \times 10^{-18})r^2_{ns}$$
$$r_s = -43.5\log_{10}(1.03 \times 10^{-13})r_s$$

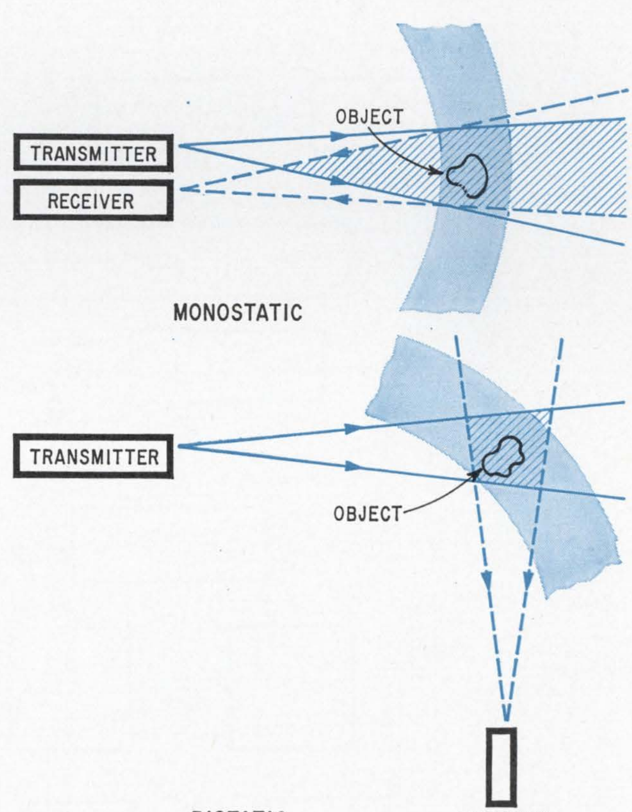
If these transcendental equations are in turn worked out—a somewhat difficult and time-consuming process—they show that forward scattering more than doubles the range. (See the table on page 145). As these equations show, range depends strongly on α, the attenuation coefficient for nonscattered light, and k, the attenuation coefficient for scattered light. And it depends much less on the logarithmic ratio of H to j, that is, the ratio of detector threshold irradiance to the laser beam power.

As the table shows, increases in either receiver or transmitter power by several orders of magnitude only increase the range of visibility slightly. In fact, it would require a 15 orders-of-magnitude power increase to double the range as does forward scattering.

However, the questions of how much detector threshold can be lowered and power increased still must be answered, because there does come a point when there's no other way to further extend range.

To lower detector threshold requires designing a larger aperture that takes in more of the on-axis as well as the off-axis scattered light. Since the equations shown above are only applicable for on-axis light, much more complicated calculations are needed to design such a detector. And for most applications it's not practical to make apertures much larger than a few tens of centimeters in diameter.

Since—as the table on page 146 shows—an order of magnitude increase in sensitivity or power



Visible choice. Bistatic arrangement is preferable but impractical so monostatic is used in conjunction with range gating to suppress backscattered light.

extends visibility about 2.4 attenuation lengths, the question remains: how much energy can be put into the water. A limit is reached when the laser beam either boils or ionizes the water, causing electrical breakdown.

Boiling point

It can be shown that the maximum peak power of a pulse in the water is given approximately by

$$P_e = (\Delta t s \pi d^2)/4atp$$

where a = the absorption coefficient in centimeters^{-1}, tp the pulse length, Δt the permissible temperature rise in water in degrees Centigrade, s the specific heat of water, and $(\pi/4)d^2$ the cross-sectional area of the beam.

This equation ignores heat loss to water molecules adjacent to those in the beam. Such losses are low because the transmitted pulses are so short. On the other hand, the equation doesn't take into account the greater heating that would occur with a high repetition-rate pulse stream due to superposition of heat after many pulses.

Representative values for the parameters in this equation are a = 0.00064 centimeter^{-1}, tp = 10^{-8} seconds, Δt = 50°C, s = 4.186 joules per cubic centimeter degree C, and $(\pi/4)d^2 = 1$ square centimeter. Inserting these values in the equation for a short pulse in water that has an a of 0.16 (that is, 40% of α) gives:

$$P_e = 3.28 \times 10^{13} \text{ watts}$$

Because the cross-sectional area of the beam enters into these calculations, the power density can be thought of as 3.28×10^{13} watts per square centimeter. It's doubtful, though, that such an instantaneous temperature rise could really be tolerated. At the very least, it would probably change the water's index of refraction, causing the beam to become unstable.

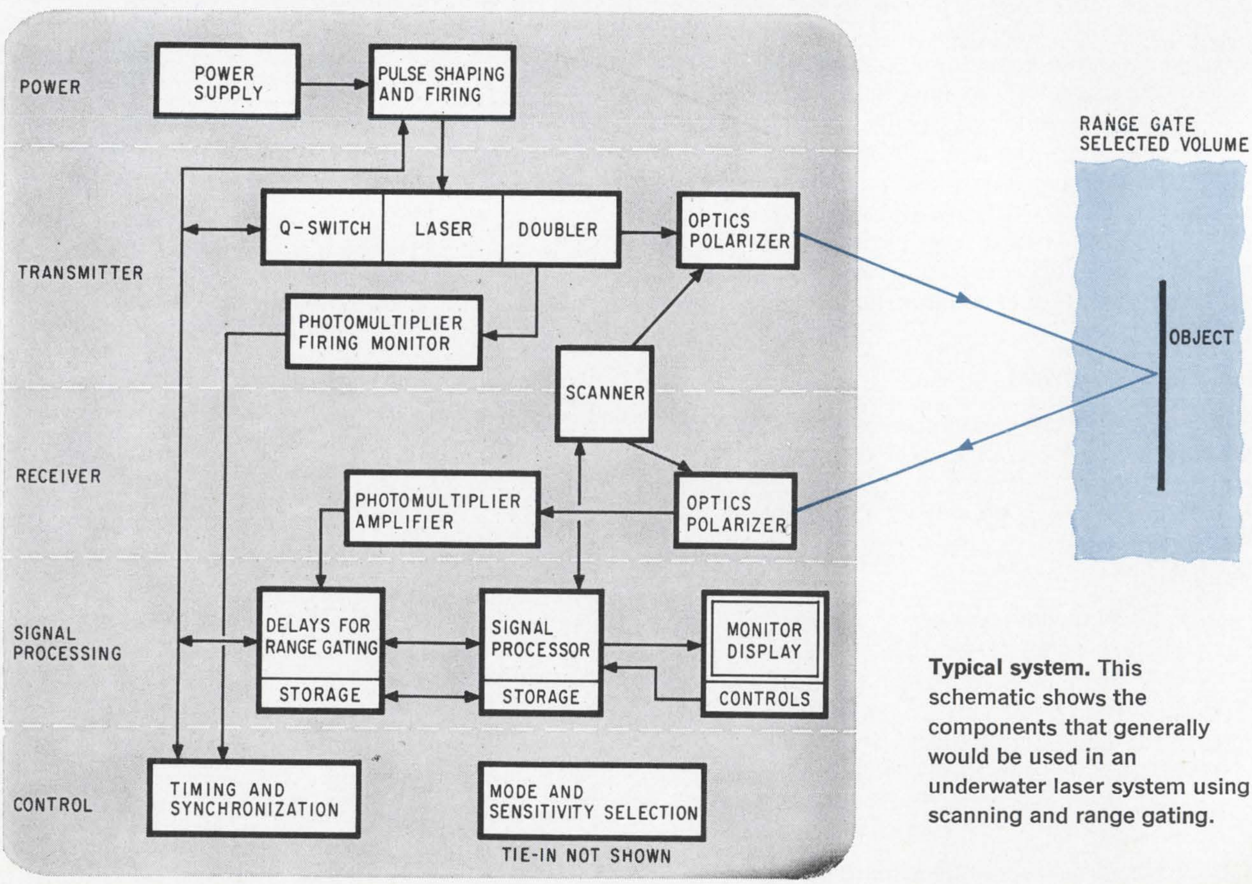
Because of these extremely high power densities, it's important to examine the voltage gradient produced in the water by the beam. Using electrostatic units, it can be shown that

$$(4P'/\pi a^2) = (CE^2/8\pi)$$

where P' = the power in ergs per second, $(\pi/4)d^2$ the cross-sectional area of the beam in square centimeters, which in turn equals 1 square centimeter, E = the voltage gradient in statvolts per centimeter, and C = the velocity of light in water—approximately 2.25×10^{10} centimeters a second. Solving for E gives $= 31.8\, P^{\frac{1}{2}}$ volts per centimeter where P is expressed in watts. If P = 3.28×10^{13} watts, then E = 1.82×10^8 volts per centimeter.

Actual limits

While such a voltage gradient is indeed high, it's calculated on the assumption that all the power is contained in a single electromagnetic transmission mode. That's not likely to be the case. If n modes of equal power were present, E would be divided by $n^{\frac{1}{2}}$ for each. Difficult—though not impossible—calculations would then have to be made of how mode voltages add.



Typical system. This schematic shows the components that generally would be used in an underwater laser system using scanning and range gating.

Because the laser pulses are usually about 10 nanoseconds in duration and electrons and ions have low mobility in water, it's likely that very high voltage gradients can be supported.

So it seems reasonable to push power density up to about 10^{10} watts per square centimeter. Considering that Okoomian used a laser beam in his experiments with a power density of only 10^6 watts per square centimeter, there's some room for increased power in the field.

There are ways, too, of increasing power beyond this suggested limit. For instance, the beam area could be broadened. Or the beam could be made to converge after it enters the water. This would allow more power to be used, because the beam would not disturb the water until it came to a focal point.

Researchers have used laser beams to form bubbles at the point of focus. As the laser-formed bubble collapses, it emits a broad spectrum of sound waves. The possibility thus exists of launching acoustic waves at a distance from the generator.

In practice, the amount of power that can be allowed in the water will also depend strongly on local inhomogeneities and scatterering centers. Similarly, such inhomogeneities limit the onset of cavitation in sonar experiments. And the amount of heat that water can stand is by no means a closed issue, for when bubbles created by intense sound waves collapse, they compress the water vapor, causing it to reach temperatures approaching that of the sun. This has been observed in a phenomenon called sonoluminescence where intense sound waves result in radiated light.

To predict the performance of an underwater laser system, it's necessary to take into account the direction and travel time of the off-axis light. However, experiments have been confined to a small number of attenuation lengths, so that there isn't enough data about this type of scattered light. For that matter, little is known about on-axis scattered light at ranges below 10 attenuation lengths.

Measurements must be performed in water whose attenuation length exceeds the oceanic mean of 10 meters. Also, measurements should be made at distances of 10 to 30 "effective" attenuation lengths. Clearly, optical benches of such lengths, free from interfering boundaries, can only be built on the ocean bottom. So far, the high costs have prevented this.

Engineers have instead turned their attention to the following:

- Range gating
- Designing narrow band filters at the laser-beam wavelength to reduce background light.
- Designing polarization components to take advantage of the differences in polarization between light reflected from the object and background and scattered light.
- Separating source and receiver to reduce unwanted light.

The way backscattered light is handled depends in part on how the underwater laser system's transmitter and receiver are located in relation to the illuminated object. As in radar, when transmitter and receiver are essentially in the same place the system is said to be monostatic. When they're in different places, the system is called bistatic. For measurements from moving vehicles a monostatic arrangement is, obviously, necessary. As the drawing on page 147 shows, range gating can significantly reduce backscatter in such a system.

But the ideal way to design a system is to place transmitter and receiver relatively far apart. When this is done, range gating is not necessary because it produces little if any improvement in visibility. In practice, designers compromise by keeping the transmitter and receiver as far apart as the vehicle's size permits.

When imaging sensors are used in the receiver, only the nonscattered light forms the image because of the need to preserve the rays' geometry. On- and off-axis scattered light is either wasted or shows up as interfering background illumination.

Only a scanned laser system, which would use a nonimaging sensor that accepts light over a large area, can make fullest use of forward scattering. Such a system would build up an image from pulses returned to a nonimaging sensor in the receiver. This type of system offers the highest potential range because it uses forward scattering and concentrates all the laser beam power in a narrow beam that illuminates only one part of the object at a time. Average power would be reduced slightly, however, because a high pulse rate would be necessary in such a system.

Using the table on page 146, an upper limit can be set on the range achievable in a scanned laser system that detects only the outline of an object. One caution: this limit will probably be reduced by the decrease in contrast from the halo effect resulting from off-axis, forward-scattered light. And it's also worthwhile noting that diffusion reflection will reduce power about two orders of magnitude—equivalent to about 5 effective attenuation lengths. A two-way laser system using a scanning and a nonimaging receiver could have a range of about 24 to 37 attenuation lengths over the span of power levels indicated in the table. Some researchers, though, feel that this is unduly optimistic.

R.E. Martin of Autonetics conducted an analytic study, for example, that gave somewhat less encouraging results—probably because he considered only nonscattered light. His hypothetical system used scanning and range gating and had 100 x 100 resolution elements that were scanned 30 times a second with an average power of 10^3 to 10^6 watts. His figures indicated an upper limit on visibility of 10 to 13 attenuation lengths.

The authors believe that future systems using all possible refinements and having low resolution for outline detection will probably recognize objects out to 15 and perhaps 20 attenuation lengths. In clear ocean water with an attenuation length of 10 meters, this would mean that objects as far away as 150 or even 200 meters could be recognized.

Recent work on underwater lasers gives cause for optimism. For instance, Paul Heckman Jr. and R.T. Hodgson of the Underwater Ordnance Department of the Navy's test station in Pasadena did range-gating experiments in water with a 10.5-meter attenuation length and showed that diffusion theory and results coincided remarkably.

G.D. Gilbert of the Naval Ordnance Test Station in China Lake, Calif., and his associates tested linearly and circularly polarized components in an underwater system, showing that backscatter discrimination and appreciably increased range could be provided by distinguishing polarizations.

F.W. Replogle of Perkin-Elmer Corp. used a collimated beam from an arc lamp instead of a laser to define the limits of resolution in water with an attenuation length of 5 meters. He worked out to four attenuation lengths. Replogle's main contribution was the application of an analytic method known as the modulation transfer function, which deals with optical elements and components in a manner analogous to the way the frequency response of electrical systems is calculated. This method describes an optical component's ability to reproduce spatial resolution in a generalized manner for systems analysis. Replogle found that he could get resolution up to 1,000 cycles per radian and detect a contrast between objects with angular sizes as small as 0.0005 radian.

The modulation transfer approach has also been applied by Anthony Immarco and T. Oigarden of Kollsman. Their work showed, as expected, a sharp drop-off in resolution with increasing range for nonscattered light. Later, working with T. Keil and Michael Kerpchar, Immarco got a resolution of 400 television lines out to about four attenuation lengths. Laser power and receiver sensitivity limited the range. The experiment was conducted in filtered water with a 9-meter attenuation length.

Keil, Kerpchar, and Immarco in another test, detected an object over 10 attenuation lengths away that had been backlit. In this test, the resolution was about 600 television lines, indicating that forward scattering caused less distortion at the receiver than was expected.

In another experiment, A.W. Angelbeck of United Aircraft used a scanned but continuous- wave argon ion laser that emitted light with a wavelength of 0.48 micron with 3×10^{-3} watts of power. He did his experiments up to four attenuation lengths in water with an attenuation length of 0.66 meter. To suppress backscatter, he separated the transmitter and the receiver.

His analyses are interesting because they show that even with the best means used to reduce backscatter, light reflected back to the detector saturates it, reducing usable laser power to 10^6 watts for a range of nine attenuation lengths. Allowing for the differences in water attenuation, this result is close to the power limit given in the previous equation.

Lasers have been used to form holograms of objects in murky water to improve visibility. K.A. Stetson, at the time with the Geophysics Corp. of America, first illuminated an object submerged in murky liquid with an incoherent light source and photographed it. Then he illuminated the same object with a laser beam, and taking advantage of the coherence difference between the scattered and nonscattered reflected light, formed a hologram. The photograph made from the reconstructed hologram was judged much better than that made of the object bathed in incoherent light.

Such an application might require very high laser power to allow the imaging photons to form a hologram in the presence of the many scattered photons. Nevertheless, this technique may be applied for short-range work in very muddy water—for example, where the bottom of the ocean has been stirred up. Very high frequency sonar imaging is currently used under such conditions, so more information is needed to prove the practicality of underwater holography.

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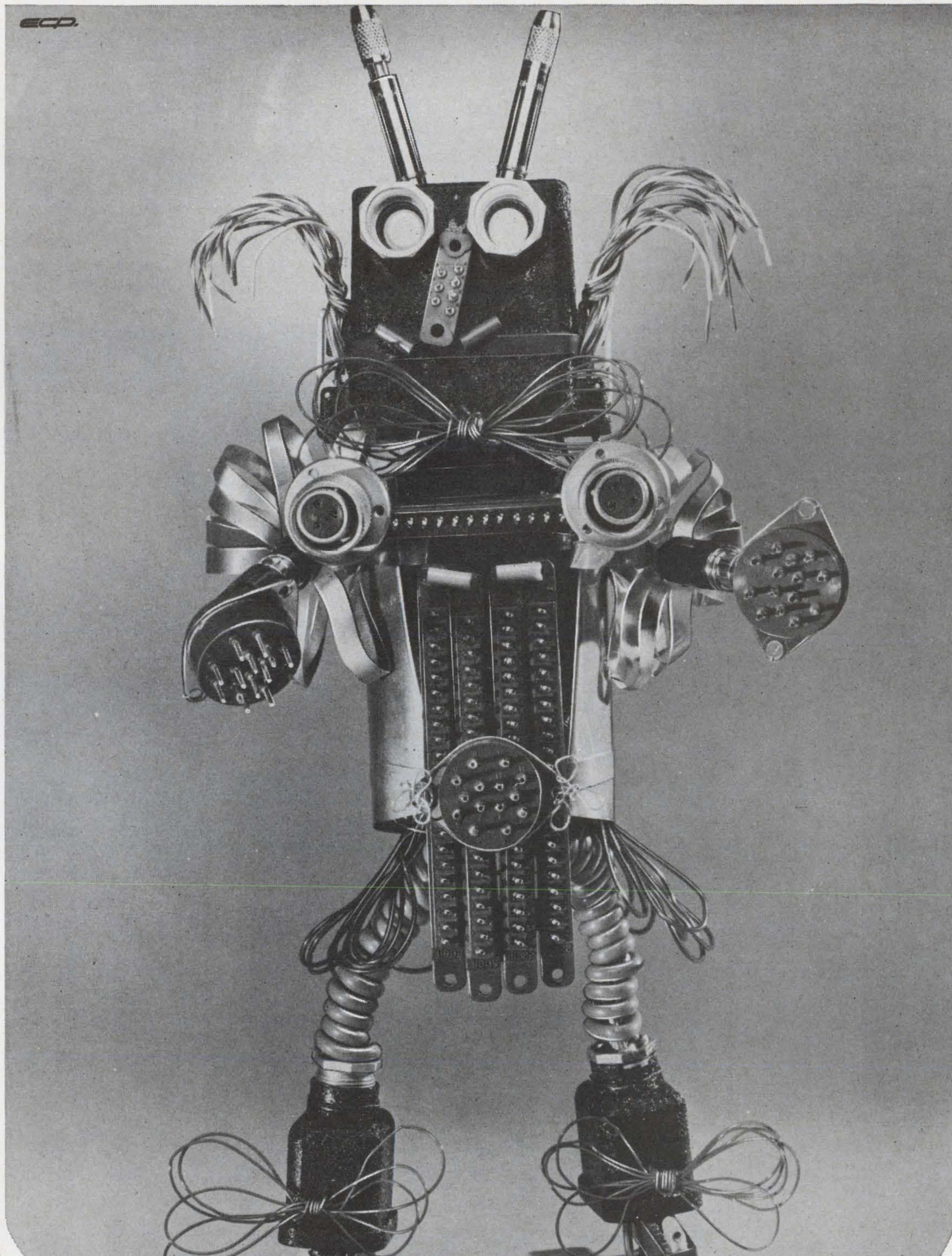

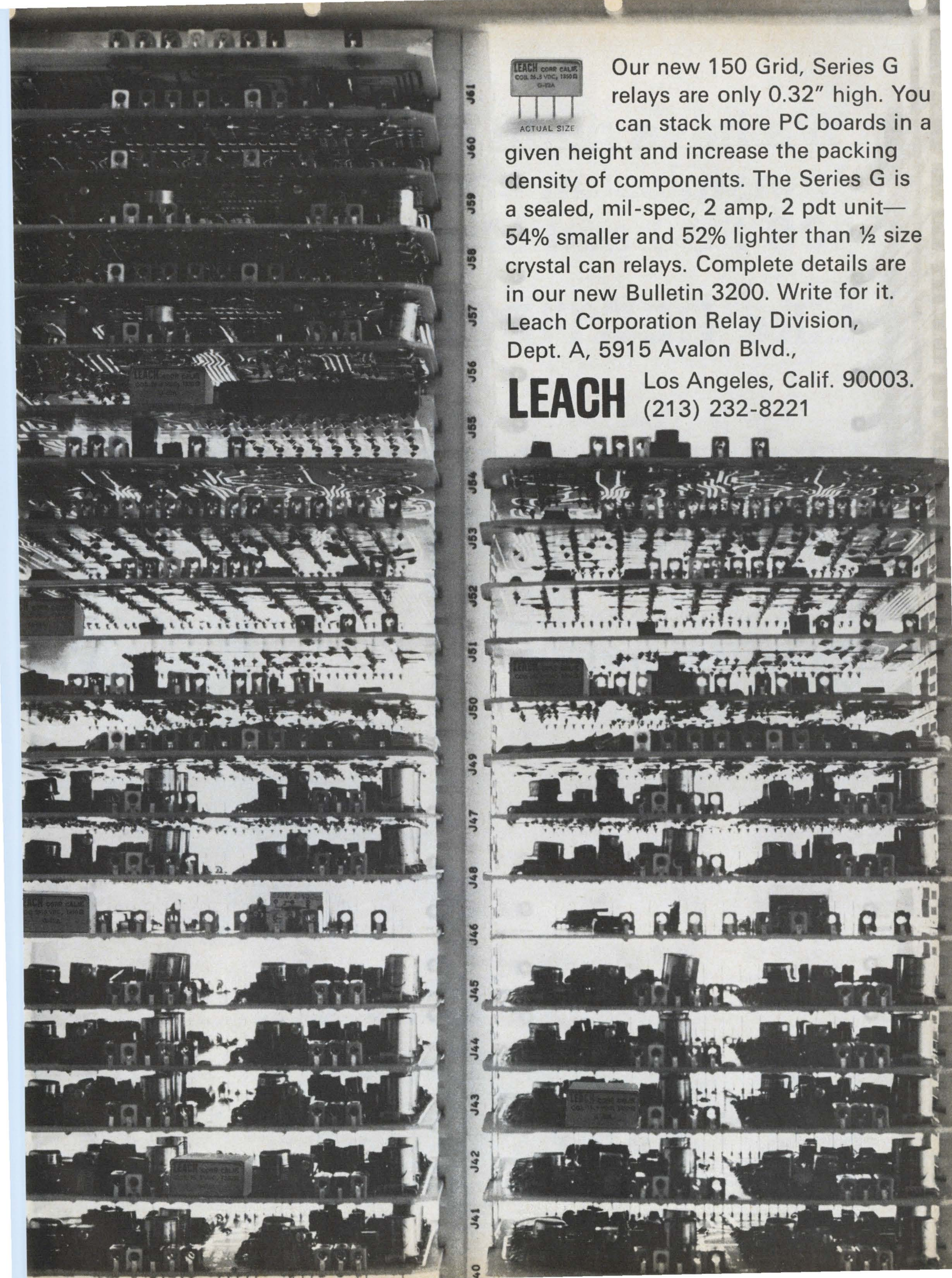
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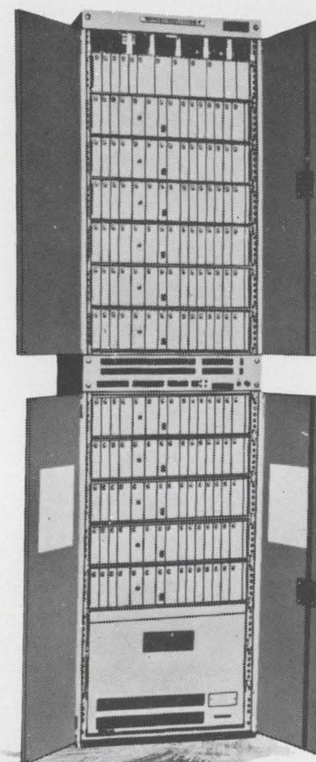

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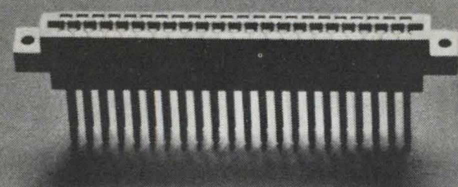

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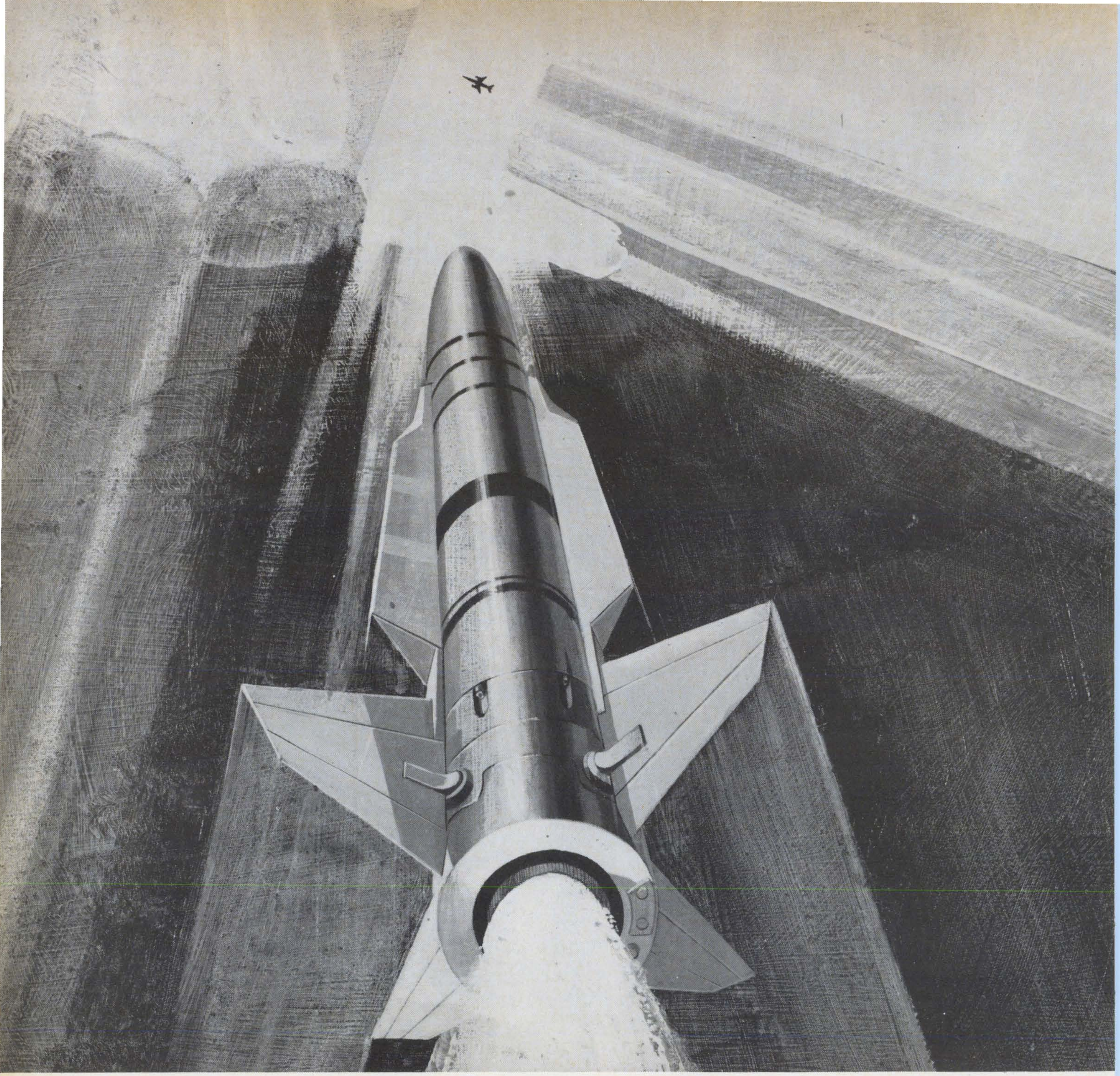

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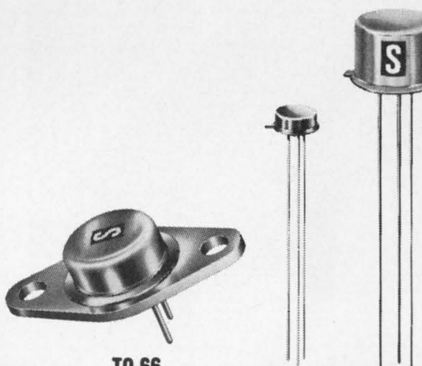

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Type Number TO-46	Type Number TO-5	Type Number TO-66	RATED BREAKDOWN VOLTAGES			PERFORMANCE SPECIFICATIONS						
			BV_{CBO}	BV_{CEO} (SUS)	BV_{EBO}	h_{FE} @$I_C = 0.5A$ $V_{CE} = 5.0V$		V_{CE} (sat) Volts @$I_C = 0.5A$ $I_B = .05A$	V_{BE} (sat) Volts @$I_C = 0.5A$ $I_B = .05A$	I_{CBO} μA		f_T MH_Z
			Min.	Min.	Min.	Min.	Max.	Max.	Max.	Max.	@V_{CB}	Typ.
2N4862	2N4863	2N4864	140	120	8	50*	150*	0.20	1.2	0.1	60	85
SDT5001	SDT5501	SDT5901	60	40	8	50	150	0.35	1.2	0.1	30	85
SDT5002	SDT5502	SDT5902	80	60	8	50	150	0.35	1.2	0.1	30	85
SDT5003	SDT5503	SDT5903	100	80	8	50	150	0.35	1.2	0.1	60	85
SDT5004	SDT5504	SDT5904	140	100	8	50	150	0.35	1.2	0.1	60	85
SDT5005	SDT5505	SDT5905	180	120	8	50	150	0.35	1.2	0.1	60	85
SDT5011	SDT5511	SDT5911	60	40	8	120	—	0.35	1.2	0.1	30	85
SDT5012	SDT5512	SDT5912	80	60	8	120	—	0.35	1.2	0.1	30	85
SDT5013	SDT5513	SDT5913	100	80	8	120	—	0.35	1.2	0.1	60	85
SDT5014	SDT5514	SDT5914	140	100	8	120	—	0.35	1.2	0.1	60	85
SDT5015	SDT5515	SDT5915	180	120	8	120	—	0.35	1.2	0.1	60	85

*$V_{CE} = 2.0V$

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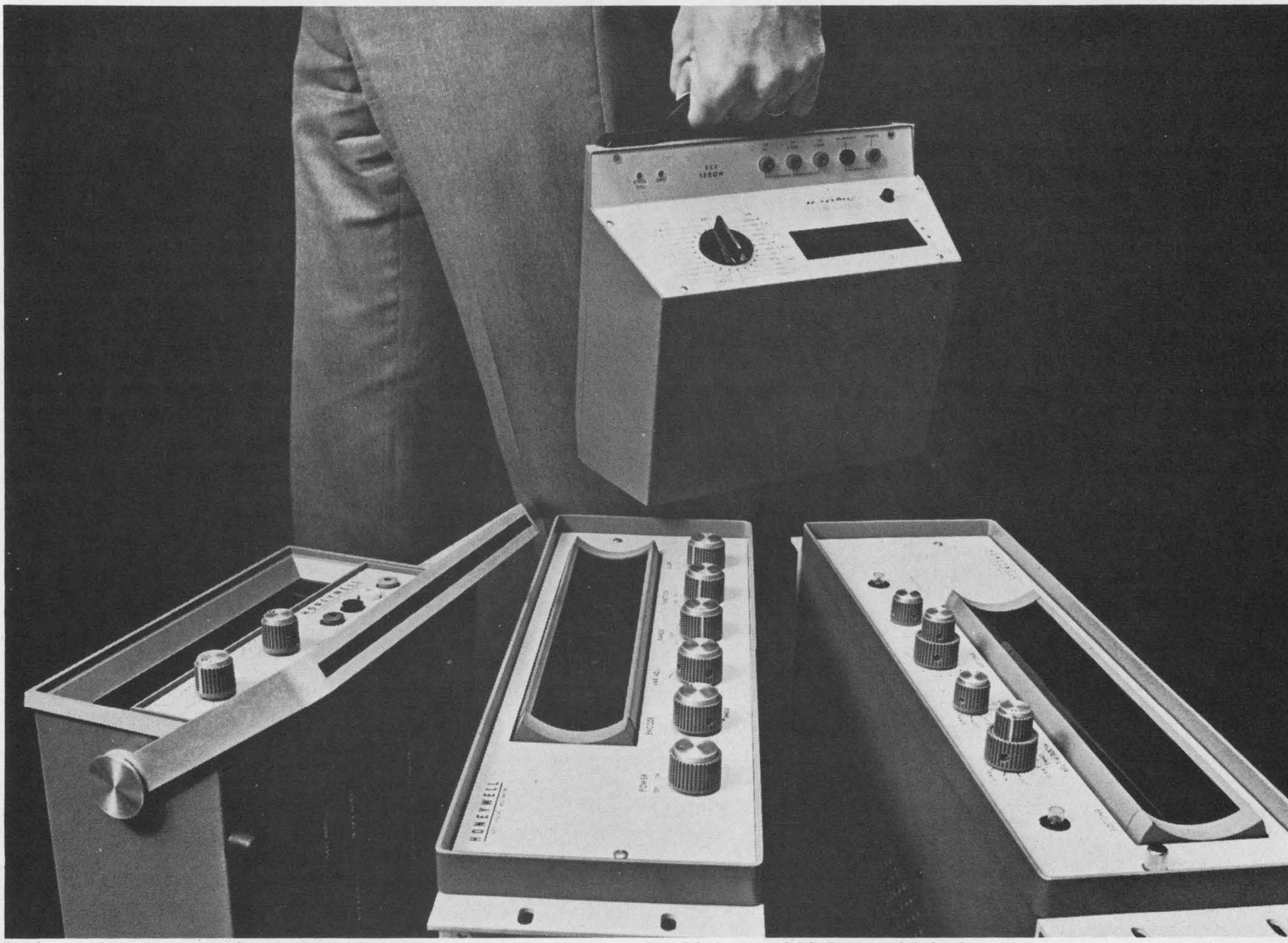

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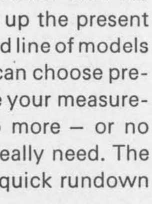

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Features: Portable, integrating units with exclusive "autoject" circuit providing higher noise rejection at any frequency than any other integrating DVM. Full 4 digits plus 5th for 20% overrange; automatic ranging and polarity; isolated differential inputs for over 140 db of common mode rejection of noise.				
630S Series	**$3595**	**.01%**	**DC/AC/Res.**	**10 per sec.**
Features: Highly versatile without additional accessories, this integrating DVM/Counter series gives you 5 full digits plus 6th for 20% overrange; 5 DC ranges, with the most sensitive providing 1μv resolution; differential inputs and integrating logic for up to 140 db noise rejection, and remote programming of all functions and BCD outputs.				
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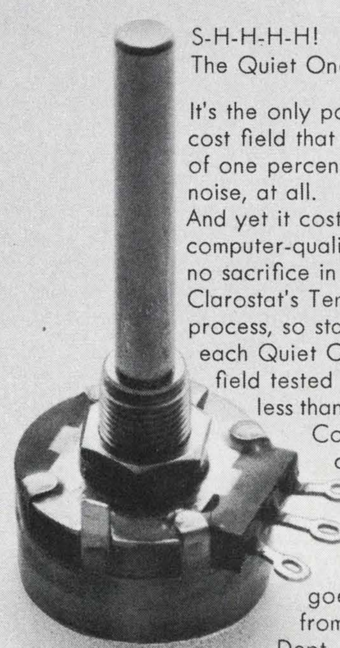

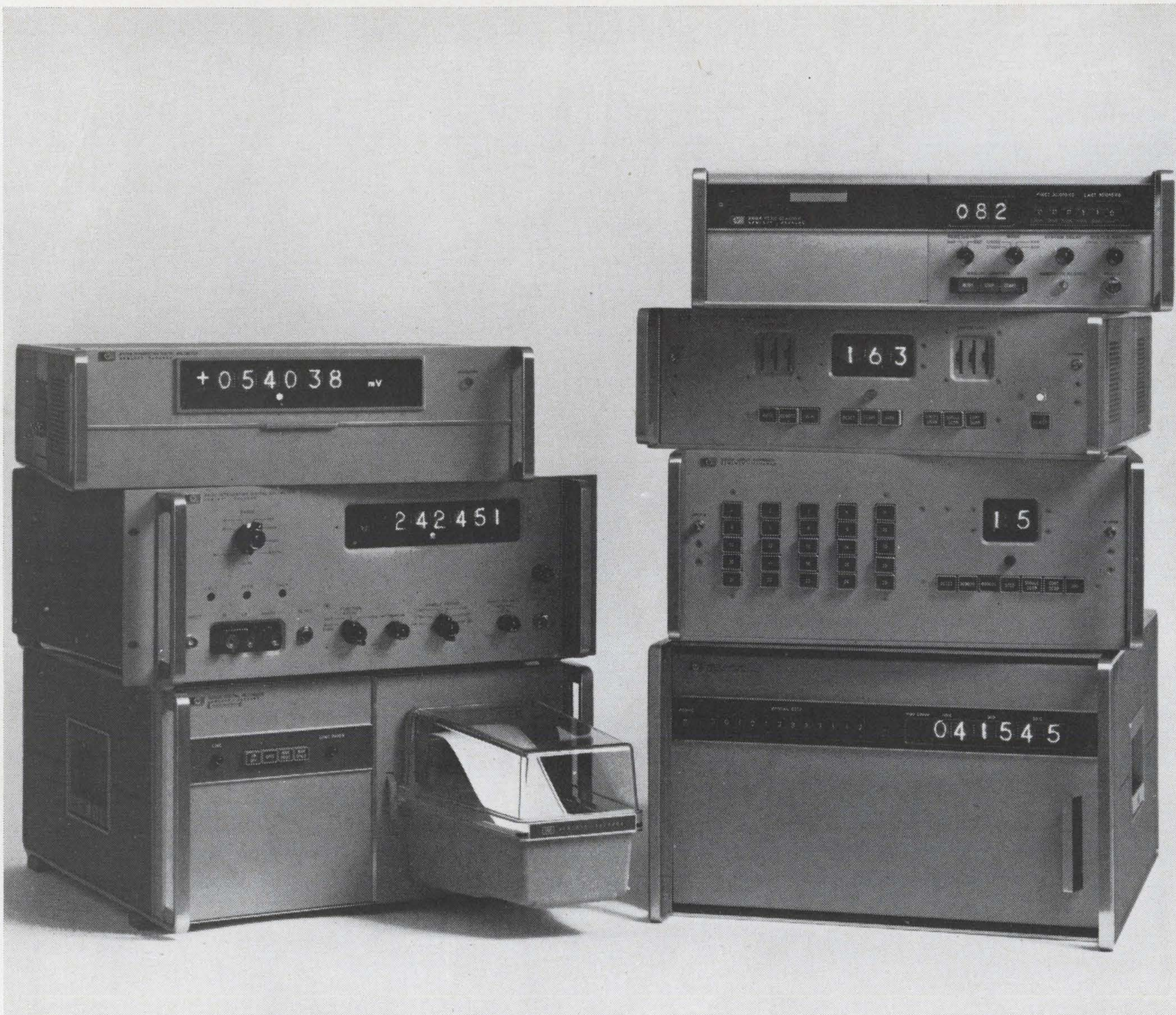

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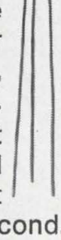

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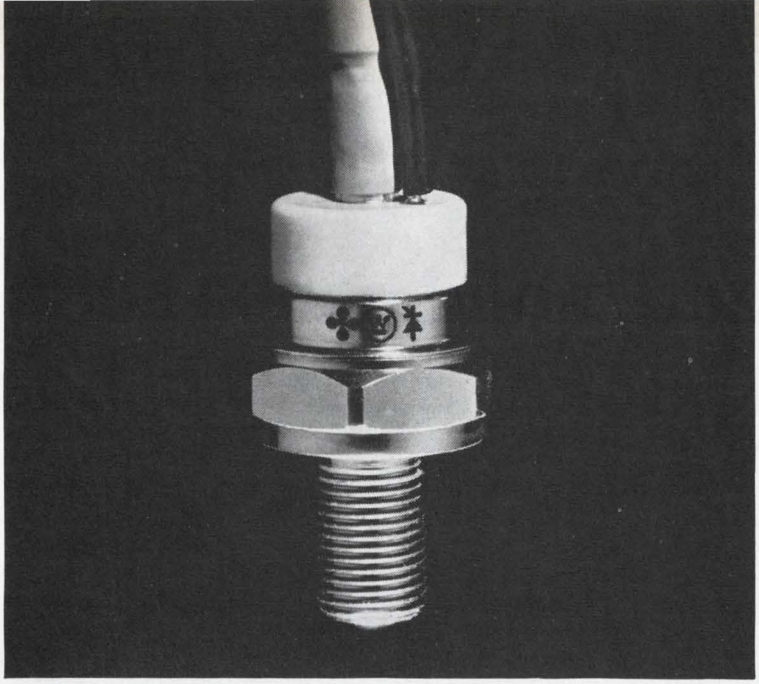

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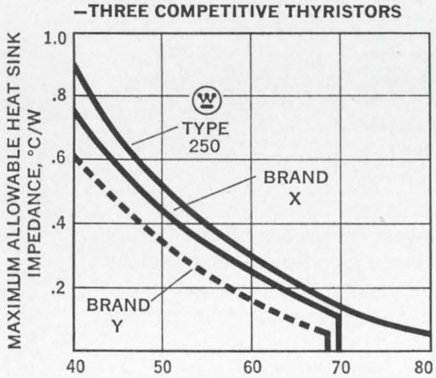

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Applied Current (θ_{SA}=.125°C/W, T_A=40°C)	71.5	64.4	70.0
Voltage (V_{FB}/V_{FT})	1500/ 1800	1300/ 1550	1300/ 1560
dv/dt (Exponential to full V_{FB})	300	200	200
I_{gt} (T_J = 25°C)	100	150	150

COMPARISON OF PERFORMANCE CHARACTERISTICS — 35-40 AMP DEVICES

	Ⓦ251	BRAND X	BRAND Y
Current (I_{RMS}/I_{AVE})	63/40	55/35	55/35
Applied Current (θ_{SA}=.44°C/W, T_A=40°C)	40	35	35
Voltage (V_{FB}/V_{FT})	1500/ 1800	1300/ 1550	1300/ 1560
dv/dt (Exponential to full V_{FB})	300	200	200
I_{gt} (T_J = 25°C)	100	100	150

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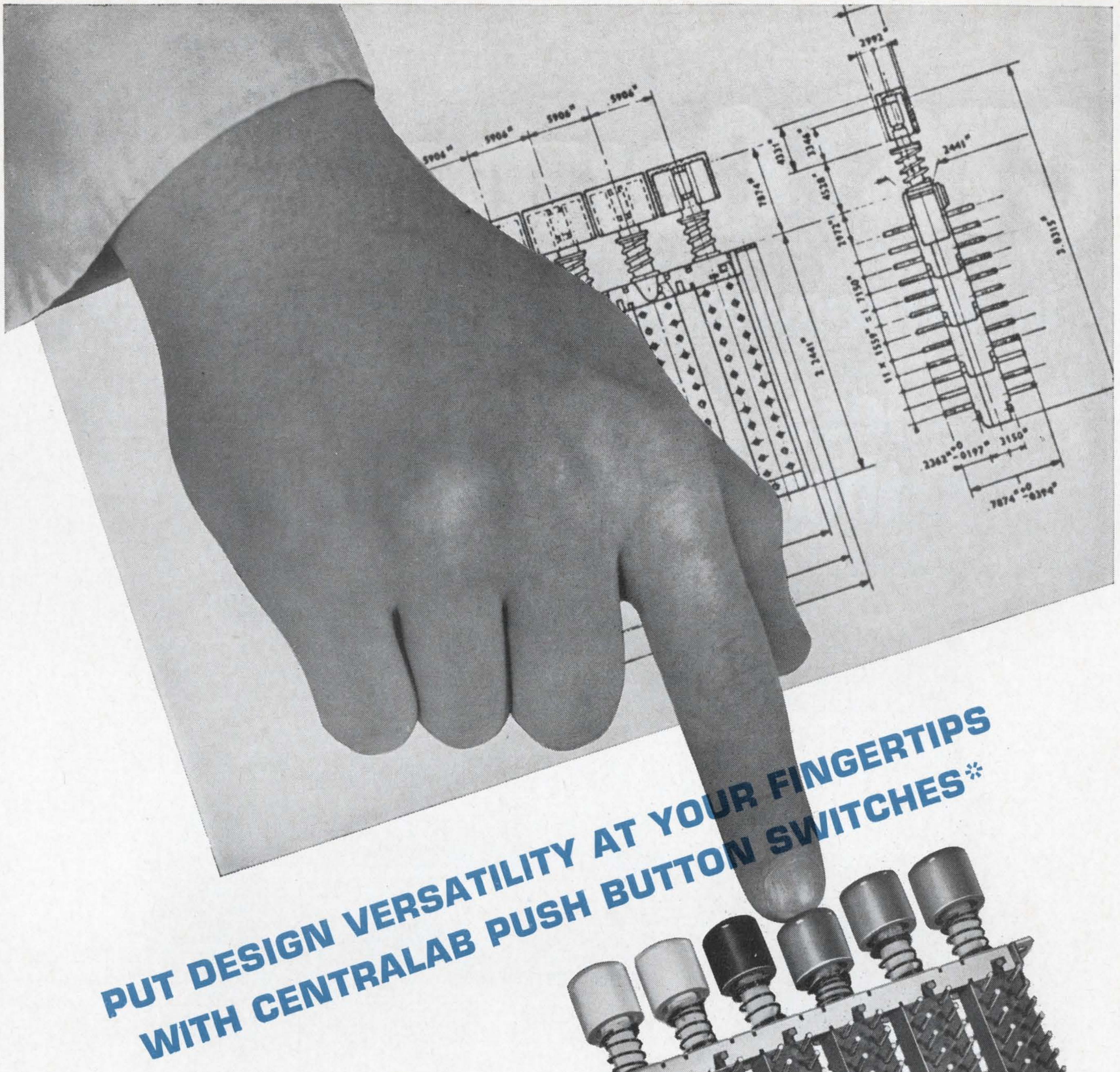

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Government electronics

NASA future earthbound by economics

After landing men on the moon, the agency's activities will largely center on applications of space technology to mundane problems, rather than manned exploration projects

By Paul A. Dickson
Washington regional editor

As it begins its second decade, the National Aeronautics and Space Administration doesn't know where it's headed. Right now, it seems that the agency's work will, literally, be kept close to the planet Earth. Outer space exploration, at least on a grand scale, will have to wait for better times.

Yet, on the face of it, NASA had a lot to rejoice about on its Oct. 1 anniversary date. The Apollo program was finally back on its feet after a tragic 1967 fire; a manned shot was planned for the first two weeks of the month; and a manned lunar flyby was programed for December. Officials, who had been pessimistic a few weeks earlier about the possibilities of putting U.S. astronauts on the moon in 1969, were beginning to say that there was a "good possibility" the deadline could be met. Moreover, the success of the Soviet's unmanned lunar orbiter, Zond 5, was stimulating renewed public interest in the space race to the moon. And finally, the agency could review a number of tangible accomplishments—sizable networks of research centers and tracking stations operating smoothly; hundreds of satellites orbiting the earth; and plenty of extra boosters built and available for follow-on space programs.

Inside story. The sad truth, however, is that the agency has been coming up short in key situations. Congressional—and public—support for its efforts is ebbing. The current budget of $3.85 billion is the lowest in five years. What's more, NASA isn't sure what it will do for an encore once it does put men on the moon. It may well face a Hobson's choice; manned planetary exploration is not going to be supported during the next decade, and the summary fate of the Voyager proposal suggests there isn't a whole lot of interest in costly unmanned programs. At the same time, NASA must take into account the unknowns involved in dealing with a new President. On a less cosmic level, the agency has a new acting administrator, who, according to insiders, is going to take some getting used to. And the fact that his tenure is by no means assured adds further uncertainties.

Goals to go

Long-range planning for the next 10 years is NASA's most important task at the moment. If the agency can develop sound goals that attract broad support, most of the pieces will fall into place. But the organization's direction is a big question mark. This indecision is beginning to create a morale problem. Says a long-time Apollo program manager: "There's a lot up in the air, and quite a few people in the program are, of necessity, thinking about other jobs. Right now, we're being driven by the cry 'push the schedule.' This is all very well, but what it comes down to is the fact that we're pushing ourselves right out of our livelihoods."

The individual now best qualified to comment officially on NASA's goals is Thomas O. Paine, James E. Webb's successor as the agency's (acting) administrator. Paine, however, isn't targeting any single, major objective like landing men on the moon by a certain date. Instead, he anticipates a series of practical projects for the next decade:

- Manned lunar exploration and establishment of an orbital National Space Station
- Unmanned exploration of planets like Mercury and Jupiter and hothouse development of earth orbiters
- Generally greater efforts to apply space technology on down-to-earth problems.

While Paine's operating program is not as ambitious as some proposed by Webb, who pushed valiantly for a major effort in manned planetary exploration and a sizable Apollo Applications Program, it's still pretty far out—given the realities of the situation. Nonetheless, Paine intends to start beating the drums immediately.

Near and far

Specifically, Paine is going to try to get money for the experiment definition work on an orbital space station back into the fiscal 1970 budget; this project was squeezed out as a line item in the fiscal 1969 allocation. Paine will also attempt to "substantially advance" funding for earth applications work. This implies greater use of space for communications, weather observation, navigation aids, and remote surveys of agricultural, mineral, petroleum and water resources. In

. . . the space agency will concentrate on practical, near-earth projects . . .

addition, Paine says: "Due to some fortunate planetary alignments during the 1970's we'll be able to move forward into deep space. We will, however, have to start moving on these programs shortly if we're to take advantage of the situation."

On line. The Jet Propulsion Laboratory would ride herd on this so-called "Grand Tour" series of missions. Jupiter is slated to be the first of the outer planets to be checked; Saturn, Uranus, and Neptune would also be on the itinerary. The lineup will be favorable in 1976 and 1979. Homer Stewart, JPL's advanced studies advisor and a professor of aeronautics at the California Institute of Technology, puts a lower-limit price tag of $150 million on the project, but is convinced it will be approved because of broad support within the space agency. The only technical obstacle he anticipates involves power; a Jupiter flight would require a spacecraft with between 10 and 50 kilowatts of power—a big jump from the defunct Voyager spacecraft for which only 1 kw was specified.

Paine won't put a price tag on the projects he's after, but he is willing to talk generally about funding for the agency. "We're beginning to falter a bit with respect to John Kennedy's goal of making the U.S. number one in space," he says. "The U.S. is in a fine position for the next decade. But we must decide on the role we want to play. If we're willing to yield to the Soviets—but still maintain an adequate program—then annual budgets of around $4 billion are indicated. However, if we want to remain on top and reap space's enormous benefits, we'll need $5 billion to $6 billion a year."

Webb, who, except for a promise to be available as a consultant on transition problems, is now on the sidelines, believes the decision has been made for all practical purposes. "The cutbacks to which NASA is adapting this year are only the most recent in a series that together might be called a national decision," he says. "In other words, for the time being at least, the U.S. has elected not to pursue its goal of preeminence in space; it is accepting both the advantage of expenditure reductions and the disadvantage of a second-rate position."

Crystal ball

Edward C. Welsh, executive secretary of the National Aeronautics and Space Council and an important Presidential advisor, is another official with a clear vision of a likely—as opposed to desirable—course for NASA. Along with Paine, he anticipates a shift in emphasis. "Planners are beginning to realize that projects must have almost immediately realizable public benefits," he says.

Welsh has no quarrel with Paine's list of priorities, but he adds a few refinements. For example, he believes manned planetary exploration should—and could—get going during the next decade. "There are a number of reasons why it can't start now," he says. "But there's a good possibility that we could head in this direction within five years." Welsh also believes aeronautics will get a bigger play. He cites two reasons for this expectation: "The problems are getting more critical, and increasingly there'll be a blurring of astronautics and aeronautics. In other words, the spacecraft of the future will become more like airplanes, and vice versa."

Division of labor. On this point, James C. Elms, director of NASA's Electronics Research Center in Cambridge, Mass., agrees with Welsh. "A congressman asked me how our work was divided, and I told him three-quarters space and three-quarters aeronautics/avionics," he says. "Many of our activities are interrelated or feeder work for upcoming efforts." At the moment ERC is concentrating on avionics for vertical and short takeoff and landing (V/STOL) craft, clear-air-turbulence detectors, pilot-warning and anticollision indicators, and power supplies. "Much of our work involves adapting the lessons learned in space for aircraft," says Elms. "In this light, there's more engineering than research."

Much the same situation prevails at the space agency's Langley Research Center in Hampton, Va. John Duberg, associate director, says the center is heavily involved in such projects as laser-scattering instrumentation for CAT and collision-avoidance systems. He anticipates a continued high level of activity in the broad area of aviation safety.

Welsh, who sports a gold HHH button, says: "I think the future (of space activities) would be more favorable if Democrats are elected." He predicts that Richard M. Nixon, if elected President, would engineer slashes of as much as $1.5 billion from a budget request around the present norm of $4 billion. Hubert H. Humphrey, he feels, would press for an increase. But others contend HHH would emphasize social rather than space programs.

Awkward stage. At lower levels in the space agency, there's real concern about the election. For example, the man who handles finances in one of the larger program offices at headquarters fears the switchover may necessitate the writing of two budgets—one for the outgoing administration and another for the incoming. This, he says, could cause serious delays in getting fiscal 1970 funds into specific programs. And along with a number of colleagues, this source is worried about a Republican victory. "Nixon's on record against heavy spending on space," he says.

NASA is now working on its fiscal 1970 request. But even though the present Administration is considered pro-space, insiders report the agency has been instructed to hold its request around the $4 billion level—well below the amount asked for in fiscal 1969.

Real world

While high-echelon planners can sketch with broad strokes, officials in the program offices must essay detailed pictures of their areas of competence over shorter spans. For example, the Office of Manned Space Flight is now preoccupied with the lunar program. At the same time, however, it's intent on keeping what's left of the Apollo Applications Program alive. Under the terms of the interim operating plan proposed by NASA this summer [Electronics, Aug. 19, p. 59], the AAP request was slashed from $300 million to $140 million; the flight portion of the project will be delayed and limited to a Saturn 1 workshop and single telescope mount.

Charles W. Mathews, deputy associate administrator for this organization admits that the cuts have hurt. However, he says, lunar exploration and the proposed space station should keep his office busy. He expects an average of two trips to the moon each year through most of the 1970's. (But last year, before production of the Saturn 5's was cut back, officials were talking in term of a half dozen a year.) Mathews believes the number of annual lunar visits may rise during the late 1970's when NASA plans to make dual launches from a single booster.

Kurt H. Debus, director of the Kennedy Space Center, is convinced the U.S. will press on with exploration of the lunar surface. "More and more questions will be raised by new findings," he says. "And there's no case in history where an explorer said 'okay, we know it all now.' Once we've made the moon landing, we won't be content to sit back."

By any other name. Mathews has high hopes for the space station, which appeared in the last budget request as the Saturn 5 workshop of the AAP. Next time around, it's expected to appear, rechristened the National Space Station.

"We'll have to go step by step to develop a very large station that could carry a big crew and weigh, say, a million pounds," says Mathews. "The first model will carry a crew of about a dozen and weigh less than 100,000 pounds." He believes number one might be technologically ready to go up by the early to mid-1970's. However, the decision-making process will probably hold the program up for a few years, he says.

Mathews emphasizes the prospective utility of the station as does his boss, Paine. They assert it could pay off quickly as: an observation platform for an advanced earth resources program, a maintenence and light manufacturing center for unmanned satellites, a launch platform for small unmanned spacecraft, or, eventually, a way station for outer space.

Mathews also foresees development of reusable spacecraft—an eventuality that suggests the agency will want less but more reliable electronics. Long discussed, the subject is beginning to surface officially. Welsh, for example, says: "There's a tremendous economic potential in reusable craft. What we're doing now is like taking a plane to Los Angeles and then throwing it away." John D. Hodge, director of the newly formed Advanced Missions Program Office at the Manned Spacecraft Center in Houston, is also an enthusiastic booster of reusable craft. "They could provide a significant economic contribution to space flight," he says.

Poor relation. At the Office of Space Science and Applications the situation is much the same. Ambitious proposals from past seasons like Voyager are no longer under consideration; other candidates—the biosatellite and 1973 Mariner-Mars programs, for example—are in the deferred or doubtful category. And NASA's interim operating plan eliminated Orbiting Atmospheric Explorers C and D; funds for launch vehicles and sounding rockets have been cut as have outlays for support activities in research and technology.

Oran W. Nicks, OSSA's deputy associate administrator, says he's still encouraged by the long-term picture. But he concedes some programs will suffer over the short term. Nicks is still hopeful that the biosatellite and Mariner programs can be saved, but he rates the possibilities of two proposed Pioneer missions to Jupiter in 1972 and 1973 as only fair.

Nicks notes new programs will be sought in the fiscal 1970 budget —for example, an atmospheric probe of Venus, a deep-space Venus-Mercury probe in 1973, and a new push for astronomy satellites. Moreover, he expects space applications work to come on strong through the 1970's. He's particu-

The evangelist and the pragmatist

The prospective differences between the space agency's first and second decades is perhaps best seen in the differences in style of the incoming and outgoing administrators.

James E. Webb, who resigned last month as NASA's chief, acted as an almost evangelical advocate of the civilian space effort for the past eight years. His annual forays to Capitol Hill—with the exception of the last two fiscal years—produced results. Congressional appropriations for the agency peaked at around $5.2 billion in fiscal 1965 and fiscal 1966. Since then, the track has been downward. But even so, Webb's efforts have been relatively successful. In the opinion of most observers, he's forestalled even deeper cuts than those actually made.

"I've watched him in Congress. When they ask him a question, it's like trying to get a glass of water from a fire hydrant," says an agency insider. "NASA's lost a great salesman, and this is going to hurt."

Webb, commenting on the success of his efforts, says that one of the agency's best ploys has been "running between the legs" of bureaucrats.

If Webb was NASA's huckster, Thomas O. Paine, now acting administrator, qualifies as a pragmatist. When discussing prospective programs Paine invariably emphasizes their practical aspects. Moreover, he describes himself as sympathetic to the nation's other priorities.

"A decade ago, Sputnik aroused the country to our deficiencies in space," he says. "Now the clear need for better education in our schools and the too-long-postponed problems of our cities are again waking us up. We shall certainly have to make adequate provisions for these areas."

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. . . NASA was designed from the outset to be an adaptive organization . . .

larly high on unmanned planetary exploration, which now accounts for a scant 2% of NASA's budget. "We're in a period where we have to keep a close watch over every nickel; but if one of our goals is to get the highest scientific yield for our money, then planetary missions will continue to be scheduled," he says.

Richard L. Daniels, chief of resources management at OSSA, is a bit more concerned than his boss about the immediate future. "We're in a position where, frankly, planning is a bit fuzzy. We're trying to work with an operating plan which is still hard to pin down. At the same time, we're going into the next budget cycle," he says. Daniels is concerned about possible cuts during the next two years, pointing out that with Apollo going full tilt, a $3 billion allocation could virtually wipe out his office. "As it stands, we're just hanging on by our fingernails," he adds.

Daniels' sentiments are echoed by Bernard Lubarsky, assistant director of power projects at NASA's Lewis Research Center in Cleveland. "Very few new missions have been approved in recent years," he says. "And this affects the Office of Manned Space Flight and OSSA to a great degree since they work predominantly on approved activities. The effect here is less pronounced right now since we're laying a general base for a class of future missions. However, we're beginning to have trouble knowing what to emphasize since we have no clear idea of the nature of the missions in the 1970's and 1980's." Wesley Hjornovik, associate director at MCS, puts it another way: "We're going through a valley with mountains on the other side. I just don't know how wide the valley is."

Air wing. The Office of Advanced Research and Technology, third largest in NASA's hierarchy, has a broad mandate covering areas from basic R & D to practical problem solving. John R. Biggs, who heads the organization, says: "While aeronautics was not neglected during the last 10 years, it was deemphasized. I believe we'll feel the impact of renewed interest around here." Among the areas he pinpoints are V/STOL technology, air foil design, and structural work on supersonic aircraft. He also anticipates major expenditures for reducing aircraft noise, estimating that up to 30% of the aeronautical allocation would be spent for this purpose during the next few years. Avionics work, Biggs says, will also benefit; guidance systems, highly accurate navigation equipment, L-band communications gear, collision avoidance apparatus, and clear air turbulence detectors are among the areas he cites.

Biggs has a long specific electronics shopping list which, among other things, includes advanced antenna designs, the next generation of inertial guidance equipment, and high-capacity computer memories. In a more general vein, Biggs would like to push ahead in such areas as component reliability, computer software and hardware, and large-scale integration.

Expectation gap

In view of Congressional hostility and public apathy, many observers consider the plans—curtailed though they may be—of top NASA officials unduly optimistic. Certainly, there's no prospect of anything like the "moon fever" that buoyed the agency's efforts to get men and money during the early 1960's. Nonetheless, planners insist that a unifying goal is no longer necessary; the race to the moon has long since served its purpose of building NASA. More practical objectives, they contend, will sell themselves.

Webb views the current situation less as a defeat than as "a challenge of the times." The U.S. will be able to resume its role as a spacefaring nation with a minimum of strain, he believes, since NASA was designed from the outset to be an adaptive organization that could expand and contract in harmony with external exigencies. This contention, however, presupposes the agency's plant and capacities are not permitted to deteriorate below a given reactivation level.

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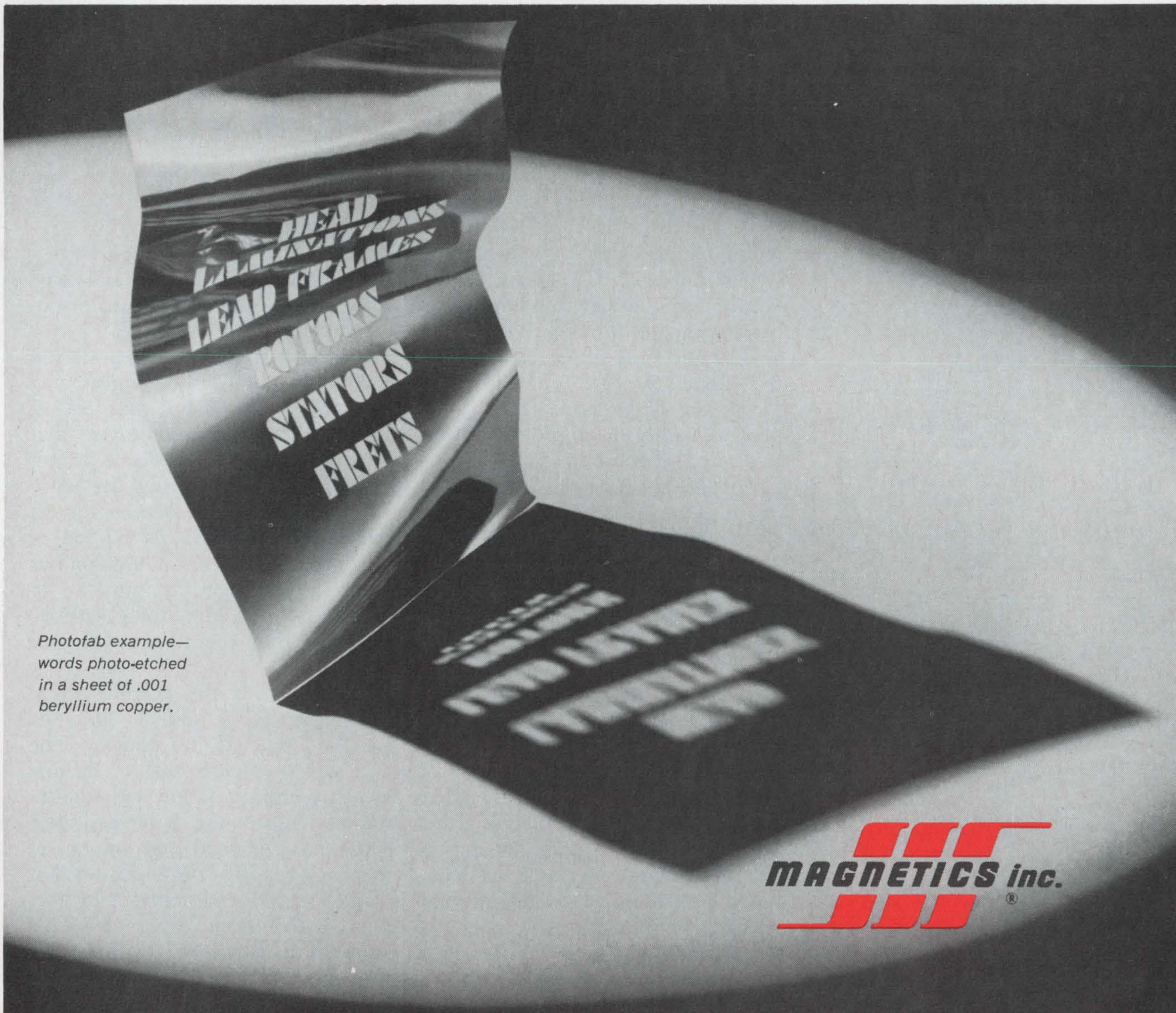

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Aerospace industry keeps its cool

Faced with the prospect of living without big NASA contracts for a while, many firms are reorienting efforts toward earth and near-earth applications

As the space agency moves into its second decade with an almost bare cupboard, aerospace contractors are reconciling themselves to just eking out a living in the civilian sector for the time being at least. Surprisingly, the major companies in the field view the prospect with something approaching equanimity. And so far as possible, most of them plan to keep teams of engineers and technicians together to continue work on space-oriented projects.

"If you start with the premise that the U.S. is not going the way of Britain, you know programs like Voyager and the Jupiter probe will eventually get off the ground," says an official at the General Electric Co.'s Missile and Space division in Philadelphia. "Every time the Congress forces NASA to cut back another program, we patiently tell ourselves that it will eventually be resurrected. However, it does look as though a good many will have to wait until the war is over."

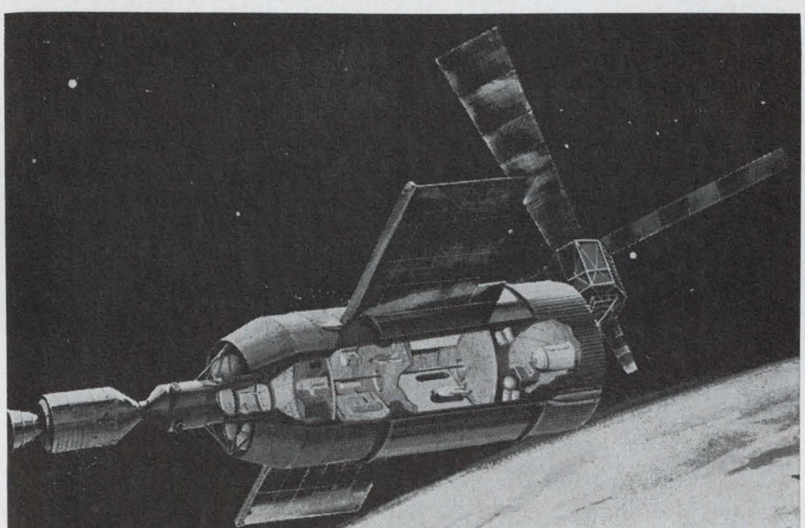
Going it alone

Along with a number of its industry fellows, GE hasn't stopped research and development work on space projects just because funds are in short supply at the National Aeronautics and Space Administration. "We have a stable of scientists whose job it is to decide what the agency's going to be doing 10 and 20 years down the road," says an official. "They spearhead the in-house efforts in these directions. Even five years worth of cutbacks wouldn't panic us. Events like (James E.) Webb's resignation, a Presidential election, and tightening purse strings simply don't have a great effect on our long-range work. We keep pouring in our own money, knowing it will take a little longer to secure a return."

John Healey, vice president for manufacturing at the North American Rockwell Corp.'s Space division, says a highly skilled work force has been marshalled at his company for the Apollo program, and that it won't be let go. The division, which is NASA's prime contractor for the Apollo command and service modules, is currently investigating commercial and military outlets for its talents.

In addition, Healey hopes that there will be a follow-on market for hardware beyond the five manned flights that have so far been authorized. "We're putting some faith in the Apollo Applications Program," he says. "In a money-squeeze situation like we have now, NASA will look to proven technology, and we have the building blocks."

Beating the bushes. Much the same situation prevails at the Raytheon Co. "We have men with space-oriented skills; to keep them on the job, we're bidding almost anywhere we see markets," says Harold L. Evans, vice president and general manager of the firm's Space and Information Systems division. "We're already doing business with the Air Force, and we put in a bid on Intelsat 4. This, coupled with our NASA bookings, allows us



Quick-change artist. This rendering of an orbiting space station was released last January, billed as the Saturn 5 workshop of the Apollo Applications Program. But ever since AAP was wounded by budget slashes, the workshop has been referred to in the trade as part of the National Space Station. Whatever it's christened, the project could eventually emerge as a major post-Apollo commitment for the National Aeronautics and Space Administration. Aerospace contractors and NASA's research centers are already eyeing the program as a source of salvation once the lunar landing is made and emphasis shifts to earth applications. As a matter of fact, the picture itself suggests the prospective intensity of the rivalry; it was released by the Marshall Space Flight Center in less than a week from the time NASA first proposed the project in its fiscal 1969 budget. Clearly, Marshall wants in on the act and figures publicity might be of some help.

A gaggle of scapegoats

When it comes to assigning blame for the increasingly general lack of support for America's civilian space efforts, officials play no favorites. For example, Edward C. Welsh, executive secretary of the National Aeronautics and Space Council fingers the press, the Government, and business. However, he reserves his sharpest criticisms for the latter group. "Corporations do a good job convincing people they need cosmetics, cigarettes, and beer. But aerospace contractors have done little to dramatize the benefits of space exploration," he charges. Moreover, he says, too much of the public relations orientation is intramural. "Industry briefings are all very well, but what about drumming up some popular support?" he asks.

Welsh's convictions stem from his experiences during frequent trips around the country. He's especially upset by the inane questions put to him by representatives of the media in communities that are home base for important space contractors. "And when I speak to business and professional groups, they treat me like a man from Mars," he says. "Afterwards, I have trouble answering all the mail I get requesting further information on applications and technology spinoffs."

Offensive measures. But a top official at one aerospace firm is inclined to pin the blame on NASA. "The agency needs more of a Madison Avenue approach to sell the public on the worth of communications and navigation satellites," he says. "If I were an ordinary guy, I could understand—and even accept—the need for a space platform from which to bomb the Russians. But I couldn't be sold on pure science without tangible benefits."

Another source suggests that the Congress has lost confidence in NASA "because of the lack of coordination in its activities and the petty jealousies of the affiliated research centers working on manned space programs." This man cites a case where the Marshall Space Flight Center bid strenuously for some work involving altitude-chamber tests of an Apollo Applications Program vehicle. "They don't have a chamber, and would have had to go to the Air Force's Tullahoma facility," he says. "And there's a perfectly good installation at the Kennedy Space Center."

Defensive. A highly placed NASA official complains he's tired being made to feel that his efforts are somehow taking bread from the mouths of helpless infants—simply to put men on the moon. "The space program has been the greatest technological forcing factor that the world's ever seen," he asserts. Walter T. Olson, assistant director of public affairs at the space agency's Lewis Research Center, agrees. "A tremendous amount of knowledge with immediate practical value has come out of the program," he says. "Weather satellites are but one example. A 10% improvement in weather prediction can save millions of dollars a day on earth."

Kurt Debus, director of the Kennedy Space Center, blames the public itself for the lack of support. "People want to read about what's nearest their hearts—Vietnam, the student riots, and the like," he says. "Public reaction to Sputnik had a terrific effect. But I don't see much from Zond 5." Debus worries that the majority of those in the Congress don't understand how space exploration "affects the power picture of the U.S."

to cover a spectrum from the outright commercial through scientific and military."

Robert Roney, manager of the Hughes Aircraft Co.'s Space Systems division, believes the current austerity is at least partially due to the fact that projects launched during NASA's first decade fell into the adventuresome category. "Some adventure is good, but it can only be sustained up to a certain expenditure level for a limited time," he explains. "NASA's reached a point where its outlays are a noticeable percentage of the national budget. And this is beginning to bother the conscience of the taxpayer." Even if all our problems were to be solved, Roney believes, the space program would continue to lose its rating as a national priority; he anticipates annual NASA budgets in the $2.5 billion-to-$3.5 billion range from here on out.

Boxed in. The agency's current commitments to manned space flight, Roney reasons, will have at least as great an effect on its short-run direction as the shortage of research and development funds. "NASA can't start any substantial projects until the early 1970's because of its preoccupation with manned flight," he says. "And anything it wants to pursue then must start from scratch." As a result, Roney expects the missions originally scheduled for 1973 and 1975 to slip into the later years of the decade. "R&D work that should have been funded during fiscal 1969 for launches in 1975 just isn't being done," he says.

North American's Healey agrees. "A hiatus in both manned and unmanned missions is inevitable after 1971 no matter what new life is injected into the Apollo Applications Program or a Voyager-like project," he says. "It's just too late to get anything started." He adds, though, that "the study that's been made for AAP and landing instrumented packages on planets will shorten the development time needed for the next project."

A source at another leading aerospace contractor notes that it's getting harder to hold good people aside from the group dedicated to a lunar landing. "They look ahead and see the future vanishing in a year and a half." On the other hand, he notes that pessimism isn't quite so rampant among managers since they realize that programs have been stretched out rather than abandoned. Activity, after men are put on the moon, will be "less than now but more than nothing," he says. "The ebb and flow of effort will parallel threats of war, hardcore unemployment, and the like. If only from an economic standpoint, the aerospace industry can't be completely crushed. We'd have a fantastic unemployment problem. I anticipate an amalgam of programs with a decided military flavor since defense requirements will outlast others."

But Richard DeLauer, vice president and general manager of TRW Inc.'s Systems Group, is a lot less optimistic in his assessment of the civilian space outlook. "I'm not setting up national priorities, but it certainly seems to me that if we can spend $4 billion a year on cigars and cigarettes, we can afford a similar amount for a very important piece of our national welfare," he says. "Cutbacks in NASA funding have drastically lowered the morale of key scientists and engineers inside and outside the agency." DeLauer's concern is that there won't be a consumer for ad-

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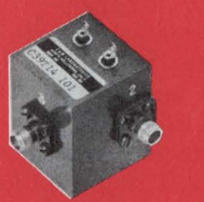

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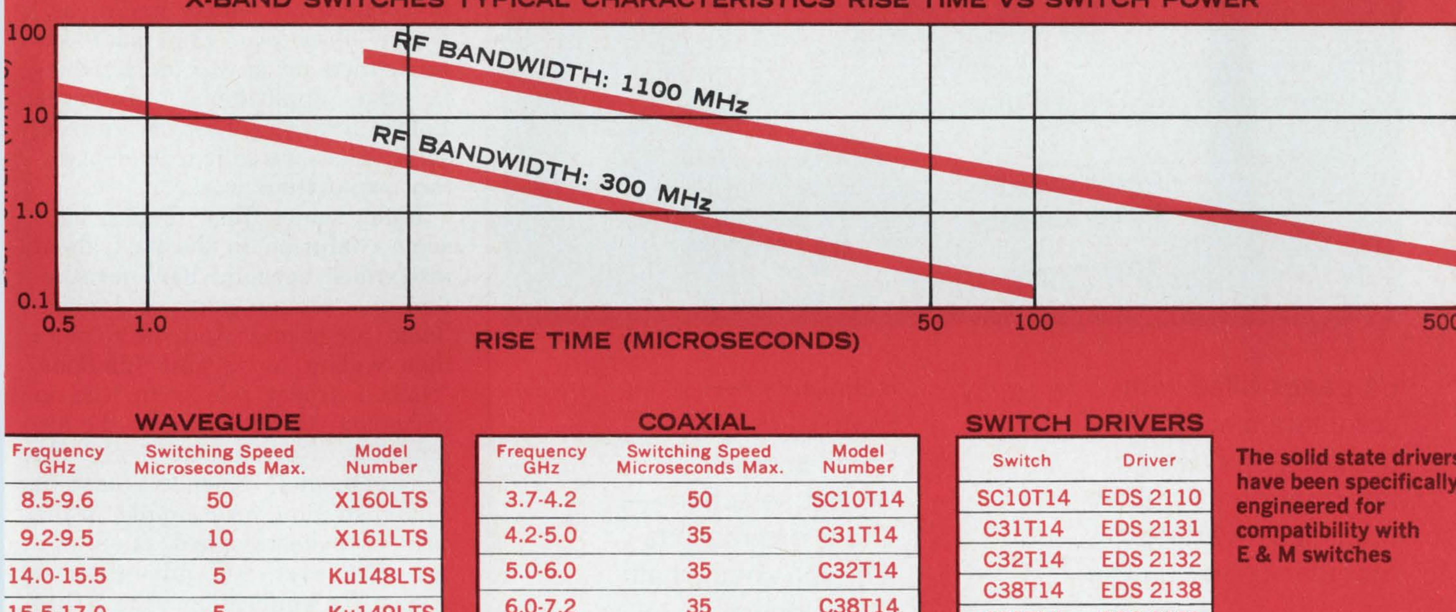

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8.5-9.6	50	X160LTS
9.2-9.5	10	X161LTS
14.0-15.5	5	Ku148LTS
15.5-17.0	5	Ku149LTS
21.0-23.0	5	K115LTS
34.5-35.5	5	R123LTS
Isolation:	20 db minimum	
Ins. Loss:	0.5 db maximum	
VSWR:	1.20 maximum	
Connectors:	Cover flanges w/ tapped holes	

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Frequency GHz	Switching Speed Microseconds Max.	Model Number
3.7-4.2	50	SC10T14
4.2-5.0	35	C31T14
5.0-6.0	35	C32T14
6.0-7.2	35	C38T14
7.2-8.5	35	C39T14
8.0-10.0	35	X21T20
10.0-12.0	35	X22T10
Isolation:	20 db minimum	
Ins. Loss:	0.3 db maximum	
VSWR:	1.25 maximum	
Connectors:	OSM female	

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Switch	Driver
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C39T14	EDS 2139
X21T20	EDS 2121
X22T10	EDS 2122
X160LTS	EDS 1160
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vanced technology. "If you don't have one, you won't turn out the next product," he says.

Closer to home

Many companies are shifting their attention to earth applications projects from the deep space probes and manned missions that are being deferred. "We need something to focus on after the lunar landing; I think the logical candidates are earth applications and an experimental space station," says Arthur E. Cooper, general manager of the International Business Machines Corp.'s Space Systems Center. Cooper sees an orbital space station as a great place to check out programing and processing for computers built with large-scale integration techniques.

Hughes Aircraft is also interested in such near-earth projects as meteorological, communications, and resource-surveying satellites. "Applications efforts aren't hurting in comparison with other areas," Roney observes. "But that's because there never was much money in the applications programs. Lately, however, it's been growing some. The reverse is true of planetary exploration work."

Roney notes that there's been some confusion in the past about just which agencies have jurisdiction over certain parts of applications programs. And he's more than willing to suggest solutions. "NASA's proper role is to lead in technology development so the appropriate Government body—the Environmental Science Services Administration, for example, in the case of meteorological satellites—can take over and administer a system for application once it has been developed."

Short shrift. He complains, however, that things don't always work out just this way. "This is an area where there's a direct return to the taxpayer. But the total effort has been given only a pittance out of the NASA budget," he says. "Moreover, there are administrative—bureaucratic, if you will—issues that impede progress in the applications area." Roney cites the case of the Geostationary (synchronous)

Orbit Environmental Satellite. This meteorological program has been carried on the Government's books for a number of years, he says, but has never gotten off the ground because it lacks precedence in ESSA budgets, and NASA shies away because of its operational nature. "Yet the results of the Applications Technology Satellite program have demonstrated the utility of such a project," he asserts.

General Electric also wants to get into the act; at the moment, it's developing its own version of an earth resources technology satellite. And, notwithstanding the official positions of the Communications Satellite Corp. and the American Telephone & Telegraph Co., the company has invested three years worth of R&D effort in direct broadcast spacecraft. A source at GE says the company anticipates that such systems will be implemented during the 1970's.

TRW also has its eye on a slice of the application pie. "If I had my choice, I'd point U.S. programs toward earth applications," says DeLauer. "And both manned and unmanned shots would be included." He warns, however, that the biggest potential problem in this area has little to do with space technology. "Rather, it's a quasi-management hangup. For example, what do you do with data from space once it's acquired? How do you get it to users in a format that's useful? The real difficulties center on utilization rather than acquisition."

Beaten track

A number of aerospace contractors are aiming their efforts at improving existing gear for near-earth applications. Roney of Hughes, for example, identifies a number of areas of technology that could prove mission-limiting. For one thing, he says, there's a need for larger antennas and for the precision pointing of sensors. For another, the energy-storage apparatus used in periods when a spacecraft is not illuminated by the sun is accounting for an increasingly large portion of the craft's total weight. "We need better technology here to get some pounds off," he says. "And within a decade, we'll also need to be generating up to 50 kilowatts of power. We can probably get this from solar cells, but they'll have to be more efficient than they are now to keep the weight down."

Roney's strictures apply primarily to spacecraft operating "in the neighborhood of the earth." For deep space probes to Mars and beyond, he says, there will be similar power problems, but the craft will use electric propulsion and nuclear generators.

Star trek. The prospect of long–five to 20 years–orbital lifetimes suggests that spacecraft and support systems will have to be more reliable than they are at present, he goes on. In addition, more stable fuels will be required, along with improved thrusters and storage systems. These factors will be especially important in controlled paths such as synchronous orbits.

"We should see a definite shift to more unmanned missions during the 1970's," says Raytheon's Evans. "We need more data and experience before sending men beyond the moon. For the moment, at least, there's no choice but to push ahead in the unmanned field."

Evans discerns three areas of technological concentration. "First the high data rates we'll be transmitting from space suggest a need for broad bandwidths, which pose power problems. Lasers and millimeter-wave systems may offer a solution to these difficulties, but more work is needed before we can rely on such equipment," he says. "Breakthroughs aren't required–just dogged effort and improved components."

According to Evans, the prospect of extended flights also means that more work will have to be done on environmental support and control systems. Finally, spacecraft and data-gathering instrumentation will have to be upgraded. Sensors for planetary applications are going to have to be smaller, more rugged, and use less power than at present, he says, but these goals appear achievable through microminiaturization.

Contributions to this report were made by Lawrence Curran and Burton Bell in Los Angeles; Walter Barney and Peter Vogel in San Francisco; James Brinton in Boston; Sue Butler at Cape Kennedy; Peter Schuyten in New York; Paul Dickson in Washington; Marvin Reid in Dallas; Tom Jacobs in Cleveland; and Barbara LeRouax in Houston. It was compiled by Eric Aiken.

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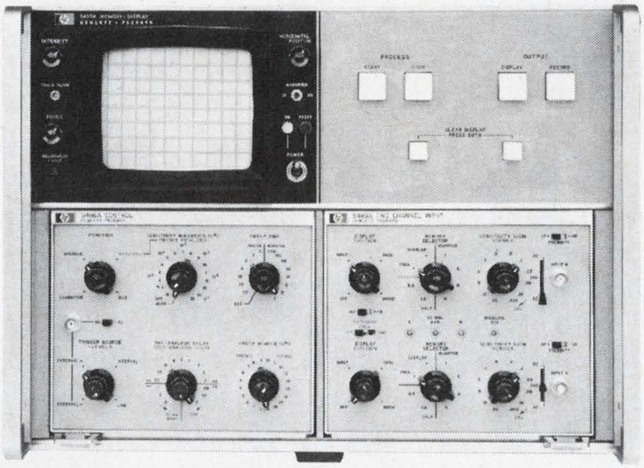

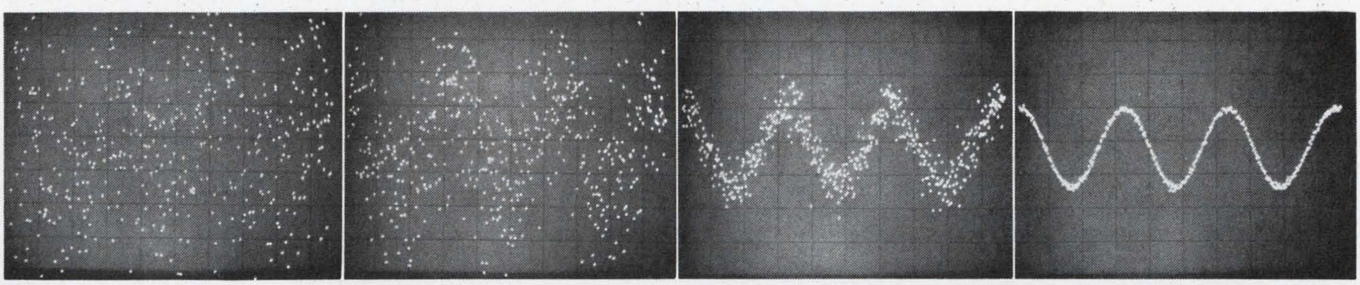

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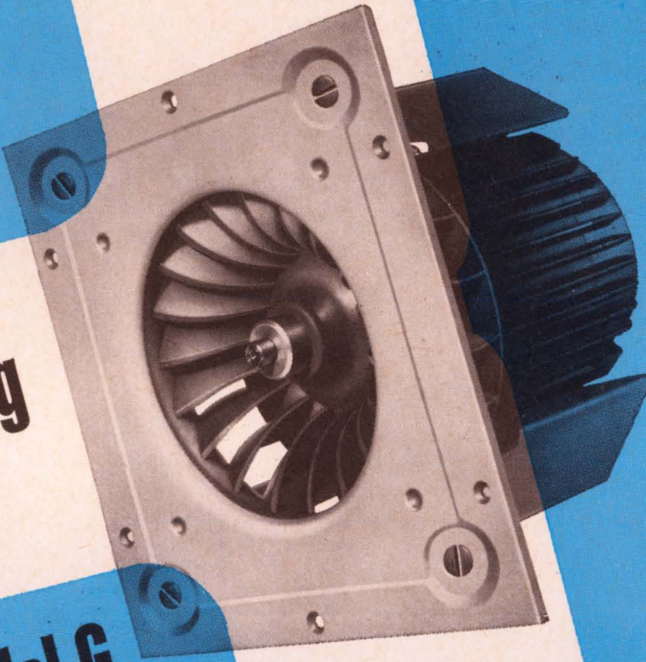

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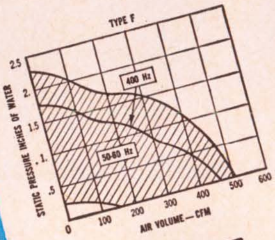

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Programing executives for overseas

Course run by the Business Council for International Understanding in Washington prepares technical managers and businessmen for cultural shock of working abroad

By Robert Skole

Washington bureau manager

This week, a dozen business executives in Washington, D.C., will be learning about religion in Southeast Asia, trends in modern South American art, and labor-management relations and government regulation of business in Western Europe.

Last week, these same men, who come from technology-oriented as well as conventional commercial concerns, listened to a panel of three black militants. They toured Washington ghetto areas, heard a talk on urban problems by the capital's mayor, Walter E. Washington, and lectures on modern American literature, the U.S. stage and screen, and U.S. social structure.

Staging area. These executives are winding up a four-week course designed to help American businessmen operate more successfully overseas. Sponsored by the Business Council for International Understanding—a nonprofit association financed by some 100 major companies—the courses are held at the American University School of International Service in Washington.

The broad areas covered by the lecturers are designed to lessen the cultural shock typically experienced by American businessmen and their wives abroad. But the primary aim, of course, comes down to dollars and cents: to help American companies do a better job overseas.

The program is not new; it opened for business nine years ago and now has some 1,200 graduates, who have worked nearly everywhere in the world in just about every type of business and technical assignment. A growing number of electronics firms, mindful of the intensifying competition in international markets, are sending their overseas managers and engineering specialists to the course. A partial roster includes the General Electric Co., Honeywell Inc., the International Business Machines Corp., RCA, the Sperry Rand Corp., Tektronix Inc., Varian Associates Inc., and the Westinghouse Electric Corp.

Leading light

As far as program director, Richard Butwell, is concerned, more companies should be represented in the program. He feels that although the BCIU has done a good job so far, it has not even come close to exhausting the number of firms that could profit by the program.

Butwell, who was named director of the program last month, has an impressive background. He was formerly director of the Patterson School of Diplomacy and International Commerce at the University of Kentucky; he holds a Ph.D. from Oxford, and was a professor of political science at the University of Illinois. In addition, Butwell was a Fulbright scholar in Southeast Asia, a Fulbright professor of international relations at the University of Burma, and a Seato research fellow in Thailand.

Butwell has seen many of "the ugly Americans" abroad. He believes while many of them muddle through in international business, this does not necessarily mean that a corporation could transplant just any executive or manager, who has been a success at home, and expect equivalent results from him abroad.

Question mark. "You can't be 100% sure when you pull a guy out of the line that he and his wife can adapt successfully to a new environment," says Douglas Taylor of Tektronix, who recently returned to Beaverton, Ore., headquarters after 19 months at the company's plant in the Netherlands. "The BCIU course raises the odds that a couple will adapt. It also gives them the chance to see if they

Guest. Herbert Reid, a law professor at Howard University, lectures BCIU class now going through course to prepare them for overseas assignments.

...Americans overseas should be able to discuss their country's problems...

can. If not, they can back out. After all, the company's loss would be extremely high if they muffed it."

Obviously, companies that send their executives to the BCIU course believe the expense—which is high—is well worth it. The tuition ranges from $900 for a single man to $1,500 for an executive and his wife. This outlay does not include any provisions for hotels and meals. There is an additional fee of about $200 per week per person for intensive language study. And when a company takes a top hand out of circulation for four weeks it's an extra item that must be figured in the cost.

Most of those who attended the course say that the expense was fully justified. "It was so valuable that I would have been willing to have paid my own way if necessary," says O.E. Maniscalco of IBM's Systems Development division, who's back in White Plains, N.Y., after a stint in Peru. Sherman Rutherford, who was until recently manager of Varian Associates' plant in Turin, Italy, is also an enthusiast. "The BCIU course was better than good—it was excellent," says Rutherford, who's now back to the States.

Expansion plans. For all the praise, Butwell readily admits that the current program has certain shortcomings. Right now, five classes a year go through the course; Butwell would like to have 12 so firms could send men anytime during the year. He believes it will be necessary to have courses in the summer, when it is simpler for wives to attend because of school vacations. Butwell also wants to establish an active research program to learn specifically what it takes to help people adjust to living abroad, as well as to help businessmen succeed in foreign lands.

The BCIU has compiled a booklet showing a number of ways Americans can unwittingly offend:

- "If you sit with the sole of your shoe exposed to a Turk, you grossly insult him.
- If you offer a devout Moslem hard liquor, you are quilty of unforgivable ignorance.
- Anyone who places an image of Buddha lower than eye-level arouses the anger of Buddhists.
- If you touch the hand or arm of a Vietnamese lady in public, you are being offensive."

The program at American University is designed to go further than simply alerting its students to possible blunders of this sort; it tries to explain the why of different peoples' behavior. In addition, emphasis is placed on thorough grounding in such American problems as racial strife and poverty.

"An American engineer in Brazil might know all there is to know about transistors," says an instructor. "But if he can't discuss America's race problems intelligently when the subject comes up—and it will come up—then the Brazilians he's in contact with will think him pretty stupid."

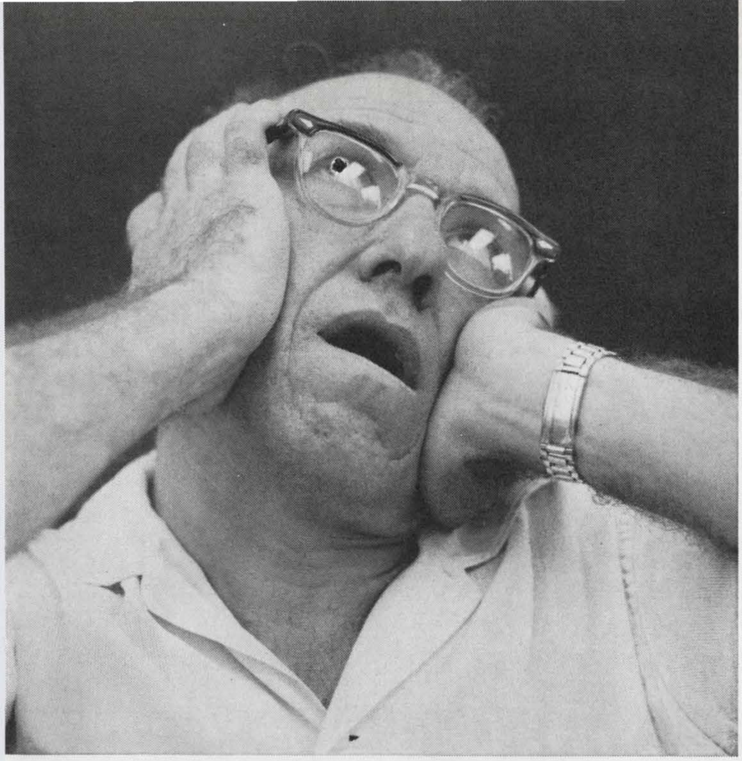
Varian's Rutherford says that in dealing with the thornier aspects of U.S. life—for example, the nation's involvement in Vietnam—"we were told to keep things always on a personal basis by saying something like 'there are lots of things I don't understand or like about U.S. policies, but I think the reason we are there is . . .' and then give the State Department line."

Party line

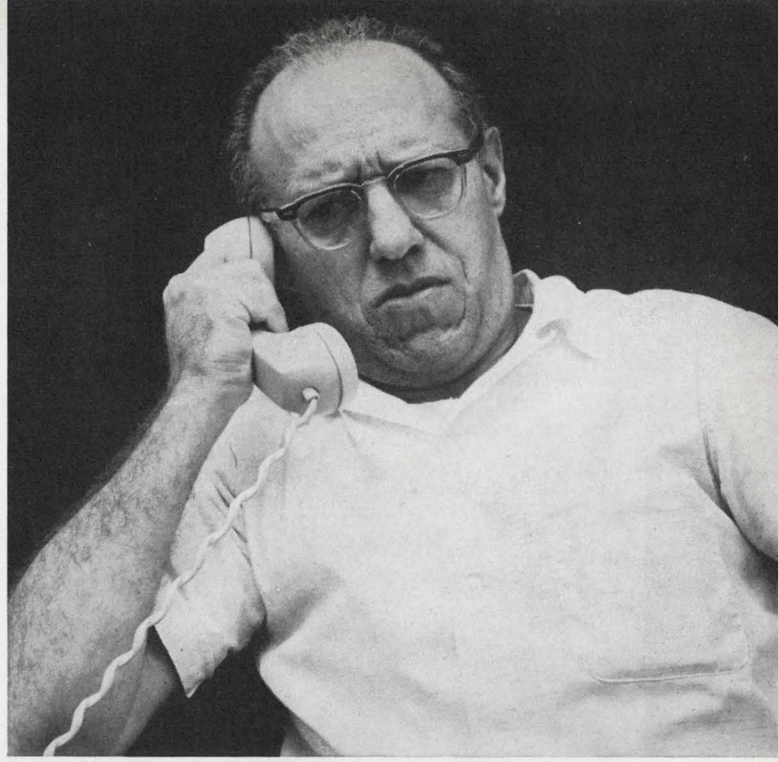
Critics of the course might charge that it is 100% American and 200% free enterprise in conception. One BCIU booklet notes that the course tells students "what the Communists are up to . . . how they are organized . . . their major propaganda appeals . . . how to handle Red-inspired attacks on the U.S., on American business, and on the free-enterprise system."

And the fact that one of the lecturers, who discusses "Communism: theory and strategy," is Henry M. Schreiber of the Central Intelligence Agency, makes some businessmen wonder if it would not be best to avoid the BCIU altogether. "We get enough problems abroad without having lectures by a CIA agent," says one executive.

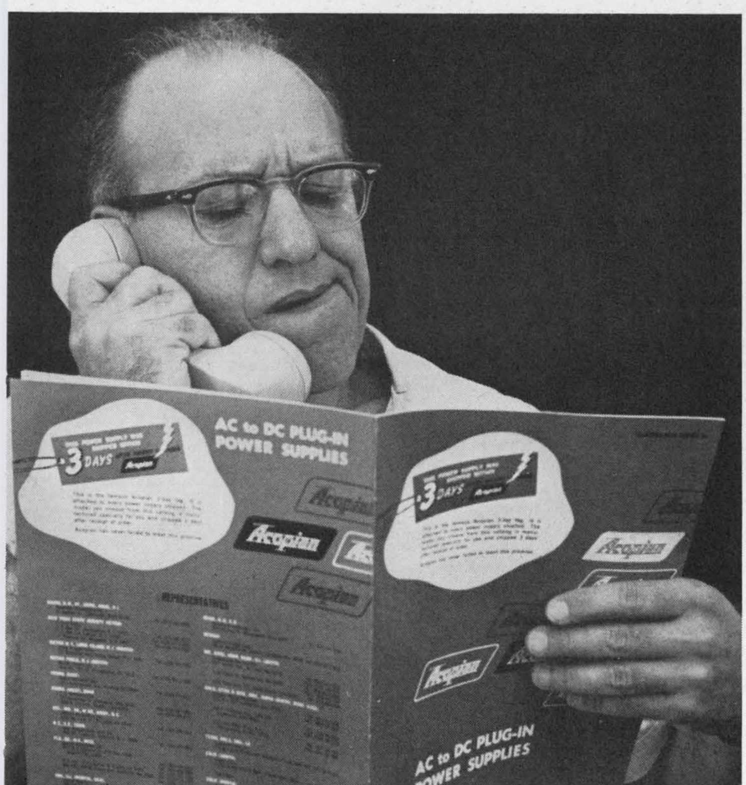
The Council, however, makes



"I was in terrible trouble. The additional circuitry changed my power supply requirements."



"More trouble . . . my usual source of supply said, 'Six weeks to get power supplies with the new ratings'."



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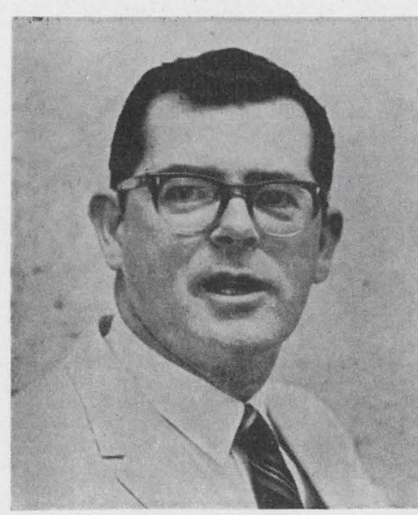
Circle 185 on reader service card

every effort to get lecturers who are tops in their fields. And obviously, the CIA has some experts on Communism. The fact that the course is located in Washington gives officials access to Government experts, as well as highly qualified academic types. In addition, programs—both formal and informal—are arranged to permit students to meet foreigners, particularly people from countries where they will be assigned.

"I remember how delighted one of the participants was when he had dinner with a Spanish couple here," says a BCIU staff member. "He was going to Spain—but he'd never met a Spaniard in his life."

Taylor of Tektronix was instrument production manager at the firm's Netherland's plant; he was responsible for manufacturing oscilloscopes for the European market. As one of five top management people at the plant, he was not only in charge of quality control but also of seeing that the right number of people were at the right place at the right time. This involved considerable contact with Dutch engineers and production workers.

"There was really little cultural shock for me in Holland," he says. "But the men in the BCIU course with me who were going to India really had their eyes opened. I think the course was very valuable. When you're assigned to an operation somewhere, you usually read all you can about it, and BCIU tries to get people who can brief you on



Head man. Richard Butwell, who directs the BCIU program for executives going abroad, wants research on how to help his graduates adjust faster and better.

things the U.S. is doing."

He says that briefings on the Common Market and the interaction of the countries in it were particularly useful in understanding product marketing. One of the greatest values of the course, Taylor believes, was getting background on his assigned country—and he wishes that there had been more of it.

Point maker. Taylor recalls a conversation at a party in Holland where the U.S. was being criticized for backing Sukarno in Indonesia—a move that cost the Dutch their colony. "I was able to point out how much money it was costing the Dutch to keep the colony. They didn't realize the expense and I successfully refuted their argument," he says.

Varian's Rutherford, forewarned about cultural shock, nonetheless experienced a difficult period of adjustment to Italy. "I was told it was a general depression induced by the strangeness of language, weather, and custom that came only after the newness of the foreign country had worn off. We were told that the best way to fight this phenomenon was to kind of grit your teeth, learn to understand the culture, and make the best of it," he says. "I went through it, but was glad to have had the warning."

As others see us

Some of those taking the course are obviously disturbed by the lectures on how Americans are viewed by foreigners. To graphically illustrate the anti-American feelings abroad, political cartoons from a number of overseas publications have been blown up for use in some lectures. The BCIU officials realize this doesn't make for pleasant viewing, but they feel it's their job to get their charges accustomed to such material, so they won't be outraged when they first run into it. And, more important, they'll know how to handle such situations better.

However, IBM's Maniscalco feels there was too much emphasis placed on this phase of the program. Praising the course as "very valuable and useful," he adds: "It had one flaw—too much repetition of the propaganda about the American image. It was a waste of time. We were all adults; they could have said it once and assumed we under-

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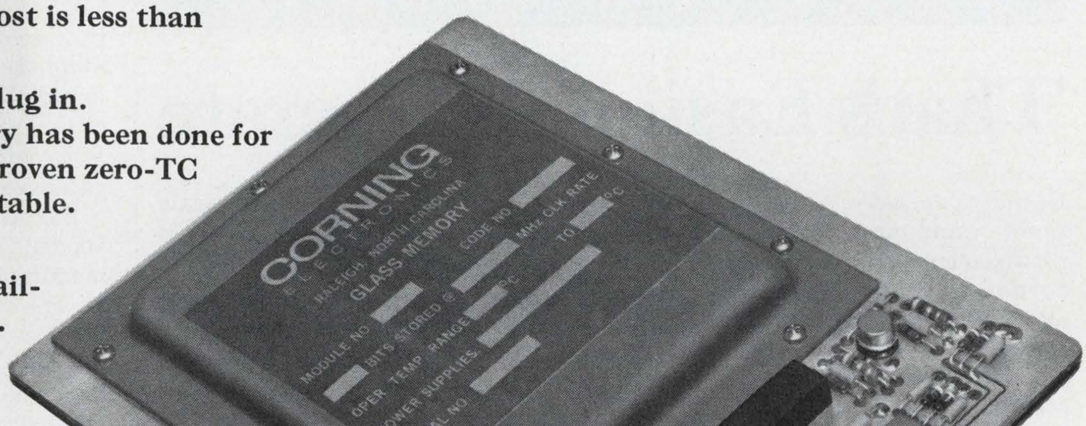

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4 MHz	256 bits	512 bits	1024 bits
8 MHz	512 bits	1024 bits	2048 bits
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Circle 189 on reader service card

stood the subject well enough."

Lawrence Mayhew, who has been resident manager of the Tektronix plant in the Netherlands for the past three years, was the first man from his firm to go through the BCIU course. He is particularly enthusiastic about the preconditioning and believes that wives should also attend.

Give and take. The members of the course are not only given a full briefing on how foreigners do business, but they also learn the difficulties their opposite numbers experience dealing with Americans. During the current session, for example, there was a lecture on the subject by Peter Altvater, a German attorney associated with a French firm with offices in Washington.

Fast shuffle

Most American executives and engineers abroad have not had the preconditioning that is offered by the BCIU course. In many cases, executives are sent abroad with nothing more than a handshake from the president of the company and the advice "just act naturally, George, and you'll do alright." And in spite of George's "natural" bumbling, he probably does do alright largely because what he is selling—or the company he is representing—is so advanced technically that he can hardly fail to succeed.

But foreign competition grows keener. For example, Japanese manufacturers have a dozen technicians stationed in Sweden just to service their numerically-controlled machine tools there. As a result, their sales have been climbing—at the expense of American and European producers.

By the book. And Europeans are becoming sharply aware of the competitive threat of the American giants. The thesis was clearly and dramatically expounded in the continental best-seller, "The American Challenge," by J.J. Servan-Schreiber [Electronics, Dec. 11, 1967, p. 253]. He uses the electronics industry as a good example of Americans' ability to couple technological advances with business know-how in order to gain great leads.

The fact that the book is now used by the BCIU as an important text would probably be cited by Servan-Schreiber as another proof of his thesis.

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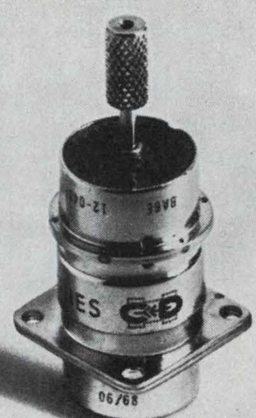

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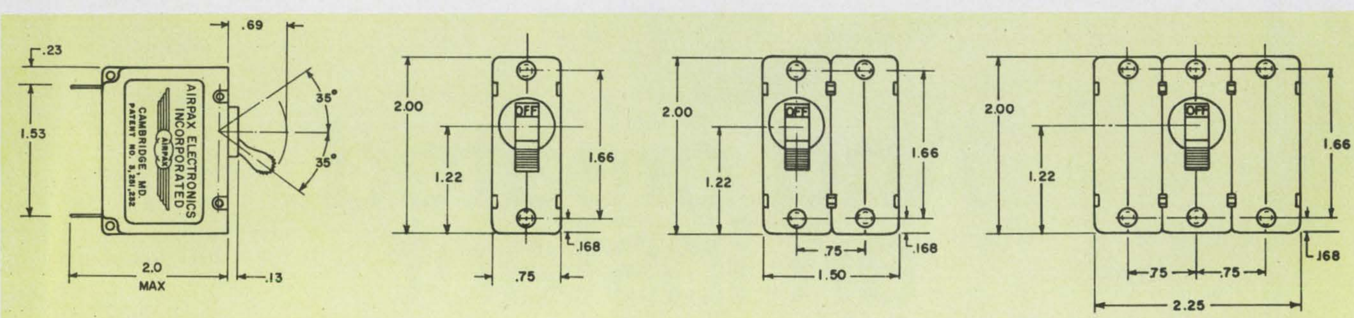

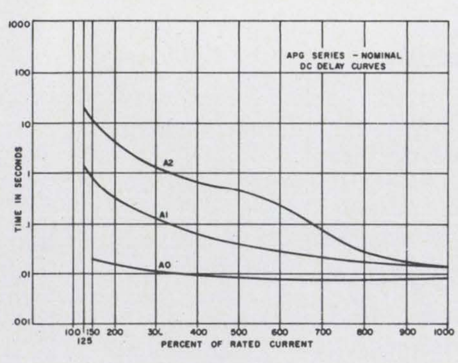

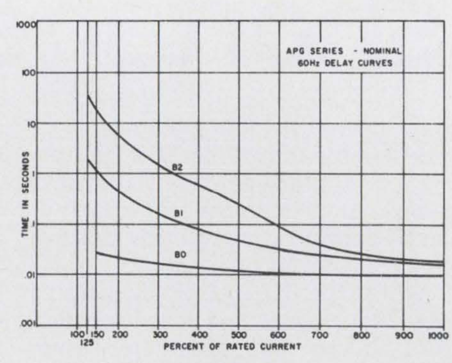

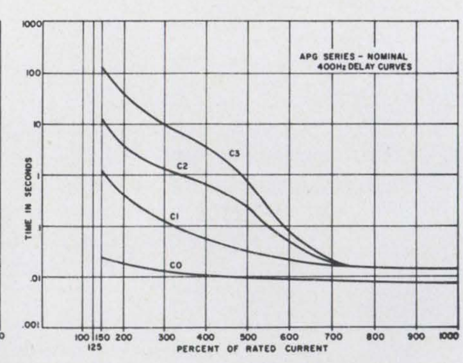

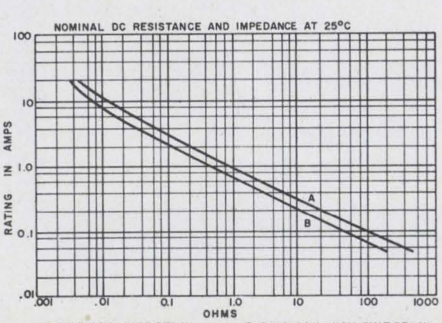

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New Products

Data handling

Computer with peripherals will rent for $40 a month

Mass production of MOS circuits is key to cost of keyboard-display-storage net; new company plans volume merchandising, novel field maintenance policy

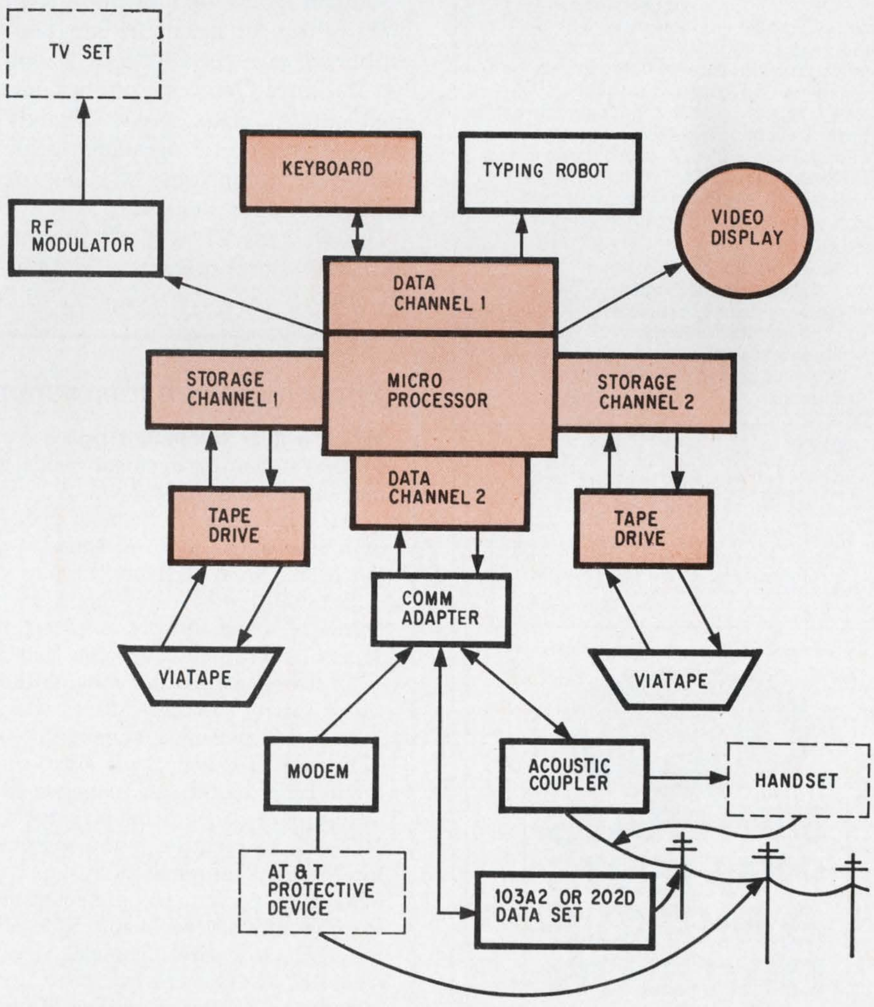
By James Brinton
Boston bureau manager

Soon it will be possible to rent a small data-handling system for under $40 a month—less than some family telephone bills. The system will include a data processor, keyboard, video display, and two miniature magnetic-tape memories. Its makers call it the System 21.

Prototypes of the new system will be shown publicly for the first time this week.

System 21 is the first product of a new firm, the Viatron Computer Systems Corp. of Burlington, Mass., and it differs from the products of other companies in technology as well as price—its circuits are composed almost entirely of very large arrays of metal oxide semiconductor devices [Electronics, Sept. 30, p. 48].

"Low-cost MOS and large markets are essential to our success," says president Edward M. Bennett, whose company is making probably the biggest bet on MOS since the one Victor Comptometer Corp. made and lost [Electronics, March 6, 1967, p. 231]. But the technology has come a long way in the interim, and Bennett doesn't think that MOS is a gamble. He expects to be the nation's largest user of MOS arrays and says that not even the National Security Agency—believed to be biggest user now—will be buying



Rental package. Blocks in color represent the basic System 21. Other units within solid lines are available from Viatron at extra cost.

more than Viatron.

A penny a bit. Bennett sees a need for as many as a half-million arrays a year by the end of 1969, based on 50 arrays per System 21. This volume production should help drive down the cost of read-only memories and shift registers to as little as a penny per bit.

Even initial units in the Viatron line will probably use shift registers with capacities of 1024 bits, and read-only memories of equal size. These will be 90- by 90-mil chips. Capacities of 2,048 bits may be used if cost-per-bit is low enough.

The Viatron president hopes to make data handlers like the System 21 as common as electric typewriters. "We want to sell to large corporations that haven't yet been able to decentralize their data processing as they have other clerical functions—it's been too costly. Viatron hopes to sell eventually to the man who never used a computer, and to give him a console at every desk in his company."

Viatron claims it had more than 2,000 letters of intent in late September; it expects a total of 10,000 by its mid-October public announcement date. "We already have several rental agreements for evaluation quantities of tens of machines," says Bennett.

The System 21 is built around the 2101 Microprocessor, an 8-bit-per-byte, one-byte-per-word machine. Rental for a 2101A with a 512-instruction microprogram, held in a large MOS read-only memory, is $20 monthly. The 2101B has a more complex 1024-microinstruction program, and it'll rent for $36 monthly.

The 2101's microprogram uses a bit-setting, matrix-programing strategy. Its instructions are 12 bits wide. Two bits are used for its operational code and the remaining ones serve as re-address. Its programs are generalized, so that one data retrieval program could also serve inventory control and many other business functions.

Fitting into or around the basic 2101 are a variety of input, output and storage devices, many of them designed with a philosophy unique in the EDP industry. One device is the video display which rents for $5 per month and is placed atop the processor.

The 2130 is an inexpensive transistor television set without a radio-frequency section. Data is formed on its screen in a standard 525-line raster display. The microprocessor is capable of driving the display to show 16 lines of text totaling 320 characters. It uses a standard ASCII 64-character all-upper-case font, delivering the signals to the 2130's video amplifiers. The video display will probably be made by one of Japan's larger electronics firms, but

Spiraling spinoff from nonprofit Mitre Corp.

When a new company's prices are as far below the market average as Viatron's, the management needs good credentials to convince potential customers of its solidity.

Says Edward M. Bennett president of Viatron: "Most of the letters of intent we've received came in with a wry comment like 'Sure, take our order; we'll be happy to help you go bankrupt.' "

But with rental agreements for hundreds of machines, thousands of letters of intent already in house, and prototypes ready to introduce this week, bankruptcy law is the last thing Viatron's managers worry about.

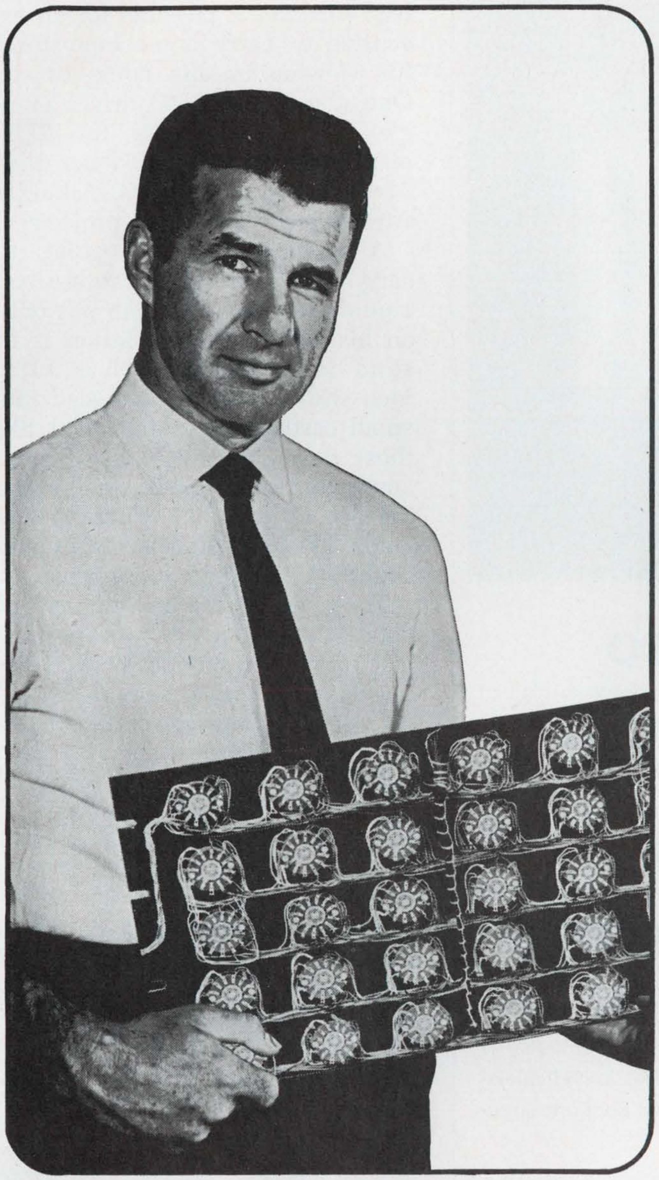
Of the 90 employees now on the payroll, most are engineers who left Mitre Corp., Bedford, Mass., the Air Force-sponsored nonprofit organization that performs engineering systems work for government agencies.

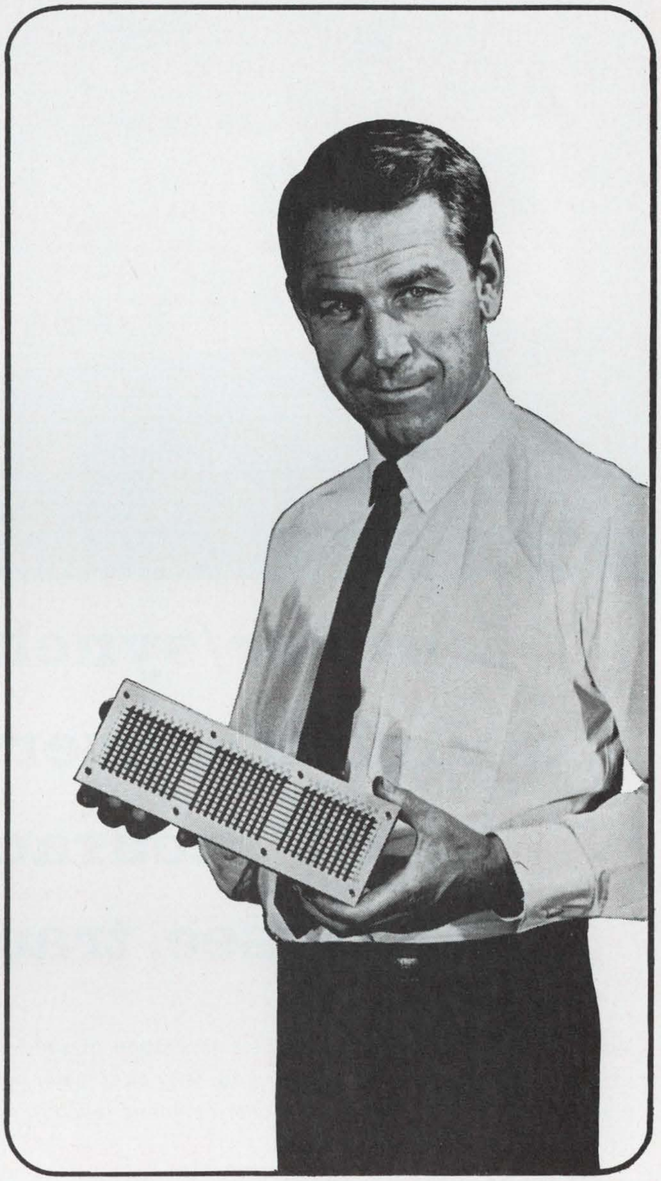
Bennett had been with Mitre since 1959. He managed Project Aesop, a real-time digital data management system for Southeast Asia.

Joseph Spiegel, vice president for operations, also joined Mitre in 1959. He headed the Aesop engineering group, and directed the Institute for Military Information Systems which advised high-level government officials on present and projected electronic data processing developments to solve military problems. Spiegel's doctorate was earned at Columbia.

Lloyd O. Ireland, financial vice president, had been corporate comptroller of the Colgate-Palmolive Co. since 1963. While there, he planned installation of C-P's world-wide EDP system.

TWO ENGINEERS WITH THE SAME PROGRAMMING PROBLEM





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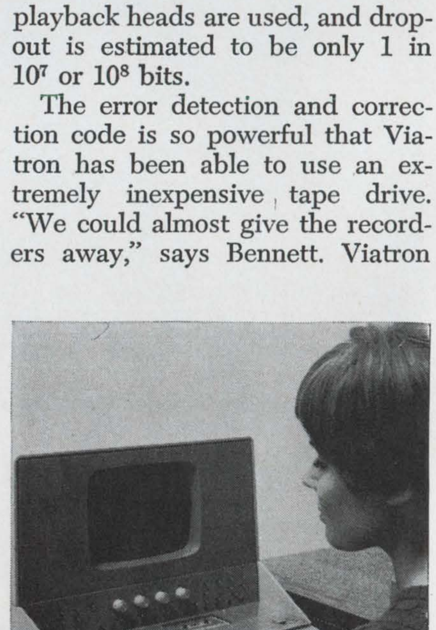
Data homework. Viatron will also rent two adapters, each of which converts the output of the processor to standard broadcast-frequency television signals. The adapter outputs can be either 70-ohm coaxial cable or 300-ohm twin lead—making it possible for an executive to carry home tape-stores for viewing on his home tv set. One adapter, the 2140, drives a single tv set and rents for $7.50 monthly; the 2141, which can drive 2 to 12 sets, rents for $23, making it attractive for education projects.

A businessman isn't going to carry home a refrigeration-sized tape drive, just so he can put data on his tv. Viatron's solution is to store data on tape which is 0.150-inch wide. The tape is reeled into small cartridges looking a lot like those developed by Philips Gloeilampenfabrieken for its small audio tape recorders. The Viatron tape holds 500 bpi, using an oxide only slightly better than audio types.

To get a maximum amount of data on the tape and to prevent lost bits, or dropouts, Viatron has developed a coding scheme for error detection and correction, and a two-track record scheme which adds redundancy during read and write. Conventional audio record-playback heads are used, and dropout is estimated to be only 1 in 10^7 or 10^8 bits.

The error detection and correction code is so powerful that Viatron has been able to use an extremely inexpensive tape drive. "We could almost give the recorders away," says Bennett. Viatron



Three-in-one. Display, processor and keyboard make up a console.

. . . tape cartridges to sell for $4 each . . .

charges $4 per month per tape drive. Two drives fit the 2101's front panel and add $8 monthly to the rental charge.

The cartridges are being manufactured by Data Packaging Corp. of Cambridge, Mass., and are identical in most parts with Philips cassettes. But design has been changed to reduce internal friction, tape binding, skew and other faults. Most of the fixes have been simple, like adding washers and controlling tape slitting more accurately to assure that edges are parallel and width is constant.

The cartridges, called Viatape, will be sold for $4 each. One Viatape will hold 100 records, with 80 characters per record and 8 bits per character. Tape speed will be approximately 5 inches per second.

Operators will be able to enter, alter, and read data on these tapes by using a keyboard built for Viatron by the Microswitch division of Honeywell, Inc. The keyboard, which plugs into the front of the processor, is known as the Model 2120 and will be rented for $5 monthly.

For hard-copy printout, Viatron will rent what it calls the 2180 typing robot, an MOS-logic-driven collection of solenoids which fits over the keyboard of an IBM Selectric typewriter. Since only the MOS logic is inexpensive in this module—the rest is almost all electromechanical—the rental is the same as that of the 2101 mainframe, $20.

Designed to communicate. Many companies already have invested in other EDP gear and would like to connect System 21 with existing services. The logic was designed with this in mind.

"The 2101 is a character-asynchronous, bit-parallel serial processor to which you can couple inputs and outputs through either of two data channels," says Bennett. "Communications adapters—MOS parallel-to-serial converters and vice versa—help the machine to communicate with remote keyboards, real-time devices for industrial control, printers, acoustic couplers for telephone linkups, and other external equipment.

So a 2101 mainframe equipped

. . . will farm out parts production . . .

with two data channels can communicate through one channel with its keyboard and a typing robot ($5 and $20 monthly), though not simultaneously. Through the other, it can feed data into a communications adapter (Model 2190, $25 monthly). This in turn can connect with other machines through an acoustic coupler, through a data set from the Bell System, or through a model tailored to the Bell System's proposed network-protection device [Electronics, Sept. 16, p. 55].

Where massive translation is needed, as from punched card format to Viatape coding, the company will supply bidirectional translators for either magnetic tape or cards. Viatron's card translator (Model 2170, $100 monthly) not only can convert data on punched cards to Viatape coding and record it in cartridge format, but it can act as a card duplicator, with the extra logic a relatively inexpensive item because of MOS.

Extra job. The card translator will drive an IBM model 29 punch. But Viatron will build its own large tape drive for its 2171 tape translator. This is a far more complex device than the company's cartridge tape drives, and because most of it is electromechanical, its rental will be a relatively high $250 per month. The 2127 will do extra duty as a tape duplicator.

Viatron plans to do as little construction of parts or subassemblies as possible, with the aim of keeping overhead down.

The company will not have a field service organization, and field maintenance will not be necessary. Repairs will be made at the company plant. One plan under discussion includes shipping extra machines to a large user at virtually no cost. In the event of trouble, these machines would replace the defective ones, which would be shipped back to the factory for repair.

Delivery of System 21 production units is scheduled to start in the spring of 1969.

Viatron Computer Systems Corp., 105 Terrace Hall Ave., Burlington, Mass. 01803 [338]

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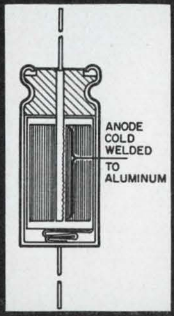

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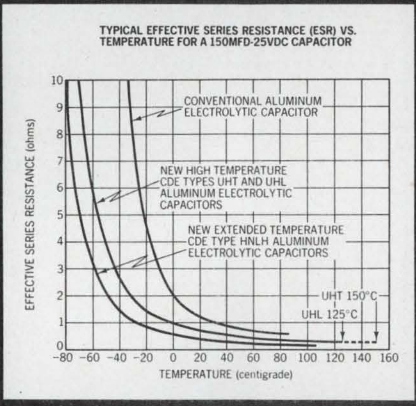

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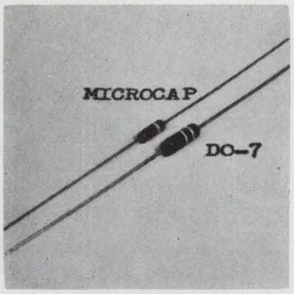
UHR	Large Axial Lead Case Sizes: ⅝ x 1⅛ to 1" x 3⅝". Ratings: 10 mfd to 12,000 mfd, from 5 VDC to 200 VDC, designed to meet and exceed MIL C-39018/3.) (Also available in –55 to +85° C specifications.)	**–55 to + 105° C OPERATION**
HNLH	Miniature Axial Lead Case Sizes: ¼ x ⅝ to ⅜ x 1½". Ratings: 1 mfd to 600 mfd, from 3 VDC to 150 VDC. (Already stock standards on our Distributor's shelves.)	**–80 to + 110° C OPERATION**
UFH	Computor Grade Case Sizes: 1⅜ x 2⅛ to 3" x 8⅝". Ratings: 5500 mfd to 300,000 mfd at 5 VDC 240 mfd to 9000 mfd at 150 VDC.	**–55 to + 105° C OPERATION**

For your design considerations, ask for details from your local CDE Sales Engineering Office. Or write:

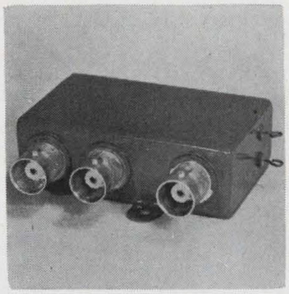
CDE CORNELL-DUBILIER
50 Paris Street, Newark, N. J.

Circle 201 on reader service card

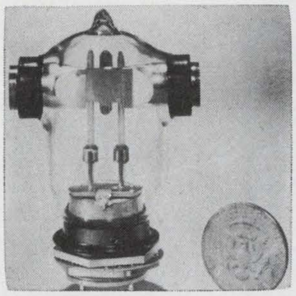
New Components Review



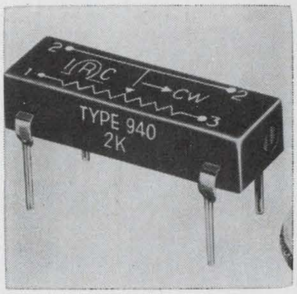
Voltage variable capacitors are available from 1 pf to 22 pf (at 4 v bias) in a smaller-than-standard package (45% of the DO-7 size). They feature high capacitive reactance at high frequencies and high Q. Micro-caps are 100% glass encapsulated with true hermetic seal. They make tuning practical from 200 to 1,500 Mhz. Eastron Corp., 25 Locust St., Haverhill, Mass. **[341]**



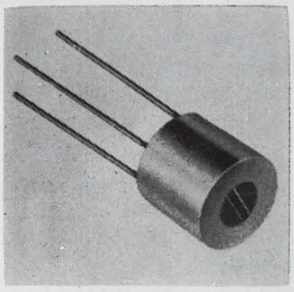
Coaxial relay RC62 handles 500 w c-w power at 30 Mhz. Insertion loss is less than 0.1 db. Frequency range is 0 to 40 Mhz. The unit weighs 3 oz and measures 2¼ x 1½ in. The interrupting element is a low cost vacuum ceramic relay in a stamped metal housing equipped with BNC or TNC connectors. ITT Jennings Div. of ITT Corp., Box 1278, San Jose, Calif. **[342]**



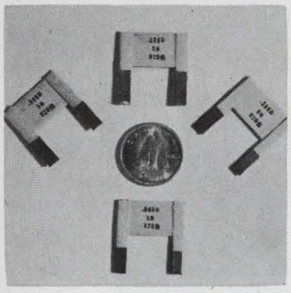
High vacuum relays series TS are for high power switching in communication and power equipment for airborne and ground applications. They are available in normally open (Form A), type TS8 normally closed (Form B), type TS10. Quantity price is approximately $150 each; availability, 3 weeks. Torr Laboratories Inc., 2228 Cotner Ave., Los Angeles 90064. **[343]**



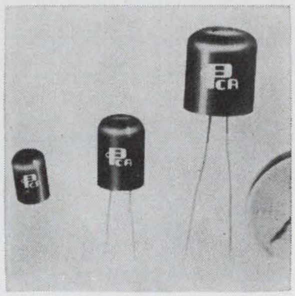
Wirewound trimming pot type 940 comes in the dual-in-line package and can be handled by the same automatic insertion machinery being used for the IC. Resistance values available range from 10 ohms to 20 kilohms, ±10% tolerance. Power rating is 1 w at 40°C. Price (100 to 249) ranges from $2.60 to $2.86 each. IRC, Div. of TRW Inc., 401 N. Broad St., Philadelphia. **[344]**



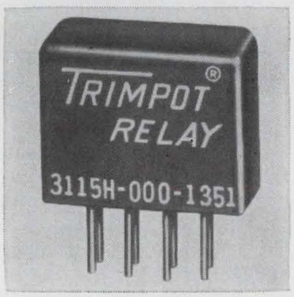
Metallic film trimmer potentiometer is a ¼-in. device used in the design of high frequency printed circuits. The single turn unit comes in 2 models, the MF2 without stops and the MF2S with stops. It features infinite resolution, low temperature coefficient, and a full range of resistance values for 10 ohms through 100 kilohms. Minelco, 600 South St., Holbrook, Mass. **[345]**



Ultra-low-ohm ribbon resistors for high current and high frequency applications feature high reliability and low temperature coefficient of ±35 ppm. They are rated at 2 w and from 1 to 200 milliohms with 1%, 2%, 5% and 10% tolerance. Units are useful in r-f power amplifiers employing semiconductors. Constanta Co. of Canada Ltd., 280 Regina Ave., Montreal, Canada. **[346]**



All-molded chokes designated Spacemate are for p-c board use. Available in both shielded and non-shielded designs, units operate between −55° and +125°C environmental temperatures, meet Mil Specs 15305-C, Grade 1, Class B, and provide inductance ranges from 0.01 to 225 mh. Delivery takes 4 weeks. PCA Electronics Inc., 16799 Schoenborn St., Sepulveda, Calif. **[347]**



Industrial relay model 3115 has a 1.0 amp, dpdt contact rating. Pickup sensitivity is 200 mw and operating temperature range is −24° to +85°C. Coil resistance range is 65 to 1, 350 ohms. The unit measures 0.26 x 0.53 x 0.43 in. and features 0.1 in. pin spacing. Price is $6.91 each in 500-piece quantities. Bourns Inc., 1200 Columbia Ave., Riverside, Calif. 92507 **[348]**

New components

Tiny pot does precision jobs

Plastic device for crowded control panels is ⅝ inch wide; resistance change less than 5% over 50,000 rotations

For the engineer who thinks there can be very little that's new in potentiometers, Clarostat Manufacturing Co. has news. Next month, the company will introduce what it calls the smallest commercial plastic pot yet marketed—⅝ inch in diameter—and its specifications meet or exceed military standards. It will be designated the model 381.

John M. Muir, marketing manager, says that the company developed a ⅝-inch pot because control panels are fast becoming more crowded. "While active circuit elements have shrunk, control elements haven't," he says.

Also, a small pot allows Clarostat to take better advantage of the trend toward modular instrumentation. Function-changing modules naturally are even smaller than their mainframes, thus the size squeeze is even greater.

Design and manufacturing techniques for the 381 were developed over about two years. The new methods make possible:

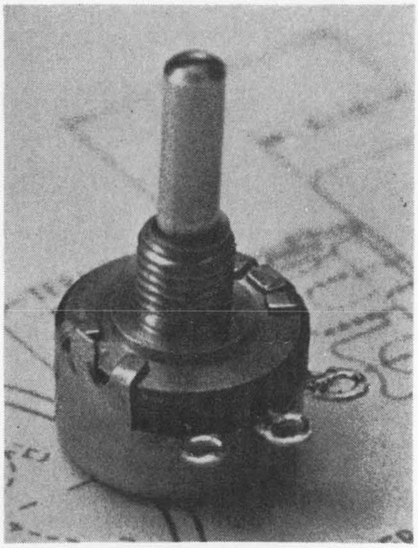
- Dynamic noise that is less than 1% of maximum resistance. Dynamic noise is the change in contact resistance which occurs as a pot's shaft is turned. Static noise is also low.

. . . four fingers instead of one brush sweep over the resistance element . . .

▪ Independent linearity, ±5% compared to 10% to 20% for commercial carbon-composition pots. And the company says some prototypes have linearity as good as 2%.

▪ Longer life, 50,000 rotations with a resistance change of less than 5%. By contrast, MIL-R-94 requires less than 10% change over 25,000 cyclings.

▪ Effective rotation of 270°. This is the rotation through which a pot will change its resistance. Miniaturized terminals which take up little of the pot's circumference make it possible to pack in a greater range of resistances, or to spread out a given range (in degrees) to make control less critical. Muir says, "270° is very long for a pot this size."



A good turn. The shaft of the model 381 rotates through 270°.

▪ Mil-spec degradation characteristics, resistance to humidity, spec changes with temperature variation, shelf life, and other characteristics all meet demands of MIL-R-94.

Right mix. Clarostat attributes the 381 specs to a good mix of materials and manufacturing steps. An intricate series of stampings, moldings, and insertion moldings provides a unified base, bushing, and terminal assembly which acts as substrate and heat sink for the special resistance element. After 16 hours of curing at 220°F, the base is ground to a 10-microinch flatness. The grind is intended to make the pot turn smoothly and to avoid lumps or high spots where the resistance element can wear through.

Then Clarostat runs the assemblies through automated screening equipment which lays on a resistance element of diallyl-phthaate ink. The ink's temperature coefficient of resistance is very low, thus helping the device to operate over its mil spec temperature range.

After drying and another brief heat curing, the assemblies are sorted for final resistance. Then they are held at 400°F for 20 hours more. This cures the ink and also relieves stresses within the base itself.

The three heat treatments constitute a burn-in, or pre-aging, that eliminates unreliable pots.

The contact assembly is built of Monel 400 because the alloy has good spring properties, wears well and is free of iron, and thus is not apt to oxidize.

Rather than use a single brush to sweep the resistance element and contact rail, Clarostat has designed its contact with four fingers. This adds redundancy and allows the designers to reduce contact pressure to about 30 grams per finger. By contrast, one of the company's other standard pots, the type 53, has 10 times the contact pressure—and about 1/10 the life.

A stainless steel shaft finished to 32 microinches coupled with a high-temperature lubricant also boosts life.

Linear models of the 381 have ranges from 100 ohms up to 5 megohms; tapered versions are available from 500 ohms to 2 megohms.

Linear or tapered, the 381 is rated at 1 watt when its temperature is 70°C.

The price when the pot is bought in 1,000-unit lots runs from $1 to $1.25. Delivery time is four to six weeks.

Clarostat Manufacturing Co., Washington St., Dover, N.H. [349]

Philbrick/Nexus has got it... a $15 FET op amp

That's the price of QFT-5's in quantities of 100. Philbrick/Nexus has a lot more to offer in FET operational amplifiers — the broadest and best line in the industry. No matter what your requirements, Philbrick/Nexus has the FET for you. If you need a FET with the lowest offset voltage in the industry, Philbrick/Nexus has got it. Looking for the lowest noise and lowest input current anybody can offer? Philbrick/Nexus has got it. No matter what you need Philbrick/Nexus offers you more in FET operational amplifiers — including the lowest priced FET. Check below for some of the outstanding specifications you'll get from Philbrick/Nexus. Call your Philbrick/Nexus sales representative for complete specifications, prices and applications assistance. Or write, Philbrick/Nexus Research, 22 Allied Drive at Route 128, Dedham, Massachusetts 02026.

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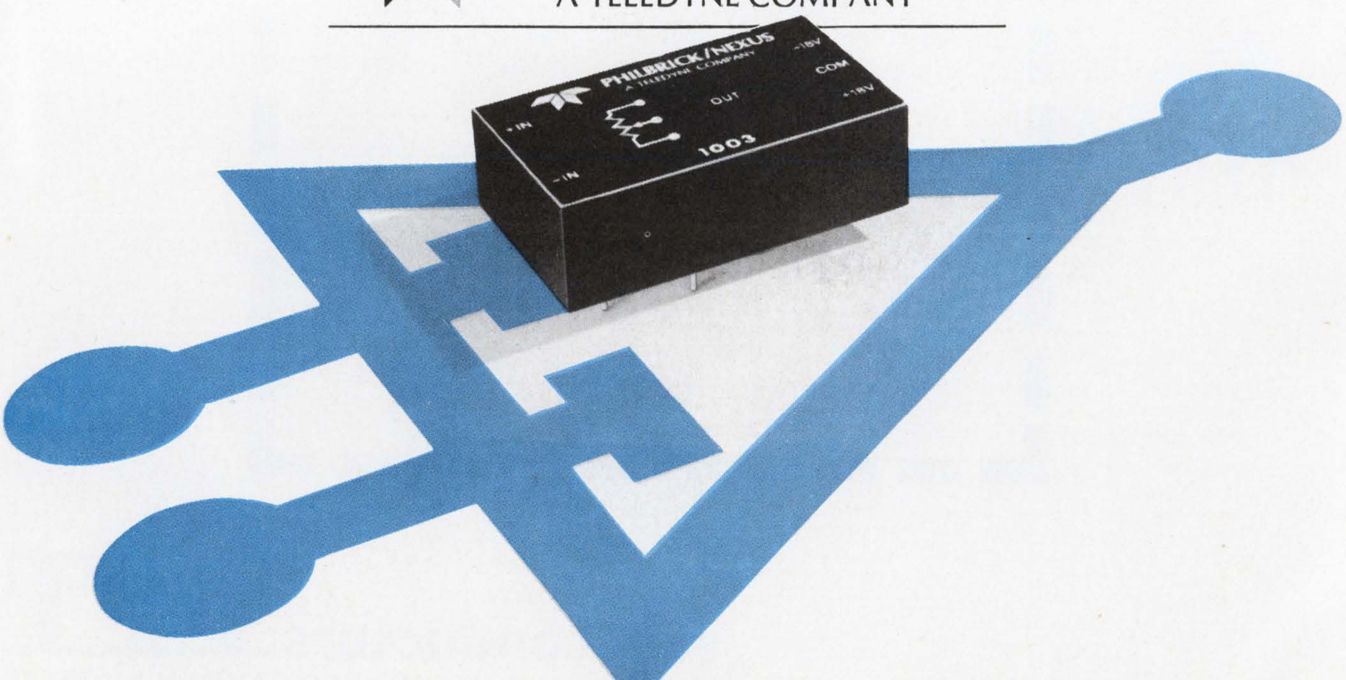
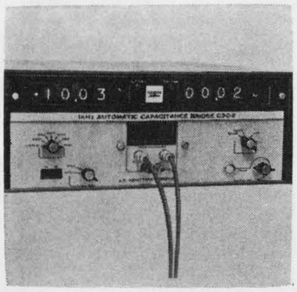
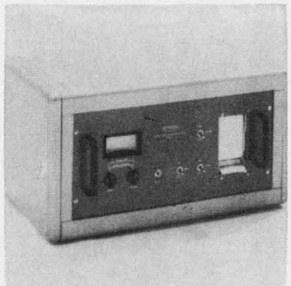
PHILBRICK/NEXUS RESEARCH

A TELEDYNE COMPANY



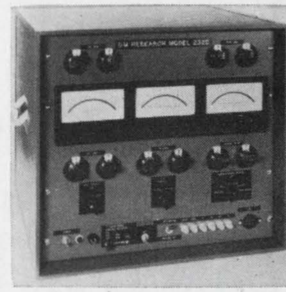


High-speed automatic capacitance bridge C302 can measure capacitance as a percent deviation to an accuracy of ±0.01%. The transformer ratio-arm bridge uses highly stable internal standards, selected by front-panel digit switches. Two tolerance ranges are provided: −15.9% to +15.99% and −100% to +159.9%. Teradyne Inc., 183 Essex St., Boston, Mass. 02111. [361]

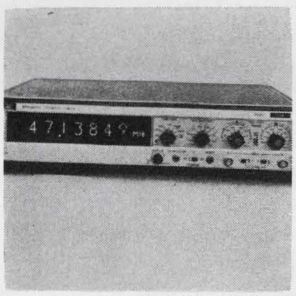


Frequency Printers series FP and FPS offer continuous analysis and simultaneous recording on a paper strip chart of 30 adjacent frequency components covering 5 octaves of spectrum (32:1 frequency ratio) in the range 0.1 to 100,000 hz. The FPS series provides an additional amplitude/frequency bar-graph profile on command. Listening Inc., 6 Garden St., Arlington, Mass. [362]

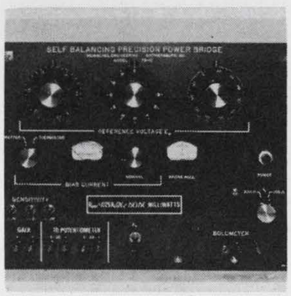
Digital multimeter 8300 offers all-push-button selection of 7 functions and 5 ranges. Measurement functions include a-c and d-c volts, a-c and d-c current, resistance, frequency and ratio. Five Nixie numerical display tubes plus a Nixie polarity indicator provide true readout storage. Price is $1,495. California Instruments Corp., 3511 Midway Drive, San Diego, Calif. [363]



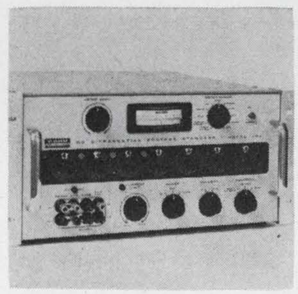
Analog and go/no-go instrument 232C measures capacitance, dissipation factor, and d-c leakage. Capacitance from 0.001 to 1,000 μf is expressed in % of deviation from nominal value. DF is 0 to 100% with programed limit detection at an accuracy of ±0.2% DF. D-c leakage range is 0 to 100 μa with 0.1 μa resolution. D.M. Research Corp., Madison Ave., Lakewood, Ohio. [364]



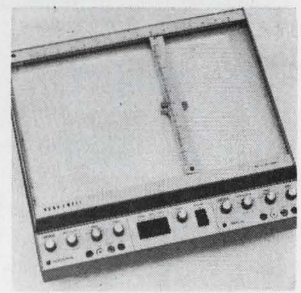
Counter/timer model 110A is a d-c to 50 Mhz unit featuring simplified remote programing. The instrument has IC design and offers a full range of functions and BCD output. Applications include measurement of frequency, period, period average, time interval and totalization. Price is $1,185. Monsanto Electronic Instruments, 620 Passaic Ave., West Caldwell, N.J. 07006. [365]



Power bridge PB-1C features a self-balancing bridge circuit that eliminates the need for bias power adjustment, and an ultrastable temperature compensated zener referance that eliminates the need for periodic reference voltage adjustment against a standard reference. It measures over a power range of 0.1 to 45 mw. Price is $1,595. Weinschel Engineering, Gaithersburg, Md. [366]



Differential d-c voltage standard model 365 provides a null indicating, potentiometric d-c voltage measuring instrument, a direct-reading d-c voltmeter, or a precision d-c standard with 0.001% accuracy. Difference voltage is indicated on a no-parallax meter with 9 decade ranges from 10 μv to 1,000 v. Price is $3,500. Cohu Electronics Inc., Box 623, San Diego, Calif. 92112. [367]



X-Y recorder model 530 is designed to display low-level data signals for industrial, medical and general laboratory use. It features true differential input (measurements from grounded or floating sources); common mode rejection, up to 130 db; high speed, typical 30 ips on X axis, 20 ips on Y axis. Honeywell Test Instruments Div., Box 5227, Denver. [368]

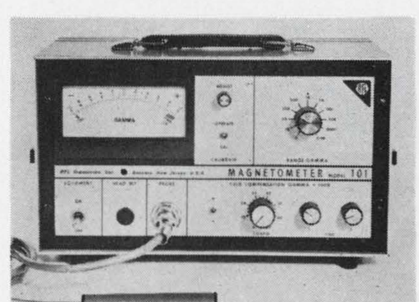
New instruments

Portable unit sees millionth-of-a-gauss

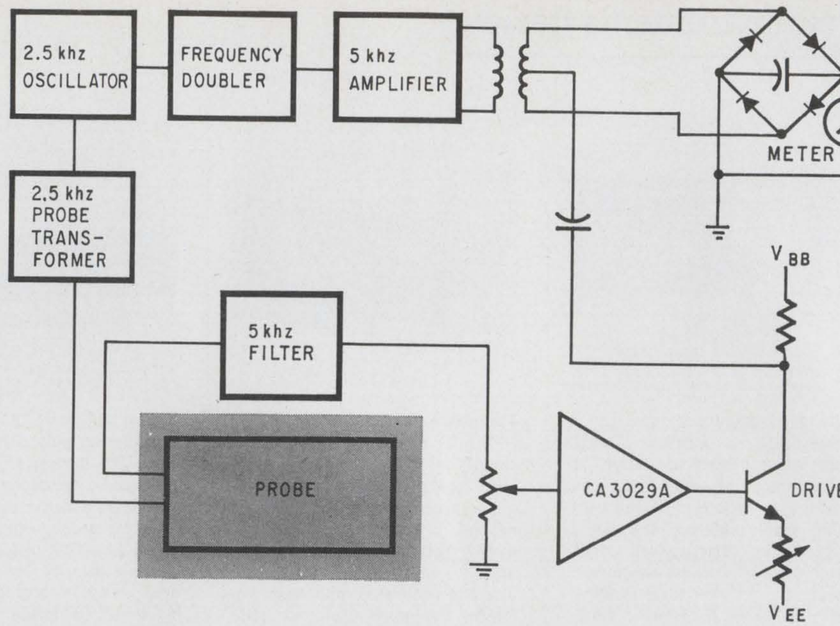
Low-priced magnetometer operates in one-gauss field, can find flaws in metal and spot a car at 200 feet

Blood on its way to the heart and a gun on its way to a crime have one thing in common. Each generates small magnetic fields. It's possible that each could be detected by the same type instrument, like the portable model 101 magnetometer made by RFL Industries Inc.

"Measurement of low-level magnetic fields is just coming into its own," says Jack Janicke, vice president of the company's instrumentation division. "We can't know all the uses people are going to think of for this instrument. Nothing else in its price range can measure such



Magnetic eye. The two permalloy elements in the probe sense both the intensity and polarity of a field.



Balancing act. When a magnetic field exists around the probe, the field generates a 5-khz signal. This signal is amplified and applied to a ring modulator, which is continuously driven by a 5-khz square wave.

low fields and buck such high fields."

The 101's price is $600. It measures changes as small as 0.25 gamma (10^5 gammas equals 1 gauss) in fields whose intensity is as high as 1 gauss.

On the job. Janicke expects the first application of the 101 to be in the nondestructive testing of metal castings, pipes, welds and frames. "The permeability of an object changes if there's some defect", he says. The 101 could also be used to find underground pipes or metallic rods imbedded in concrete walls.

Putting the finger on shoplifters is another application. If goods are tagged with permanent magnetic tape that is removed when an item is purchased, the 101 will sound off anytime unpurchased merchandise is leaving the store.

RFL predicts a big market for the 101 as a counter and as a surveillance instrument. It can spot a car at 200 feet and a rifle at 30 feet.

Searching people for firearms is another suggested use. This would be fine for police who can frisk a suspect after a quick check with the 101. But it could not be used alone to spot gunmen or bomb carriers boarding a plane. Any metallic object, like a lighter or a flask, could set off the 101, and frisking passengers just because they're magnetic has no future in the friendly skies. So RFL engineers are thinking of using the 101 in conjunction with other instruments, like microwave detectors. In this way, they hope to be able to identify objects, not just detect magnetic fields.

A magnetometer can be used as a flowmeter. A fluid moving through a non-metallic pipe, like an artery, induces an opposing magnetic field when it passes through a permanent field. The strength of this induced field is proportional to the flow velocity.

The RFL magnetometer is 13 by 7½ by 7½ inches and weighs 15 pounds. Attached to its front is a probe, 5 inches long and 0.75 inch in diameter.

Bucking the field. To set up the 101, the operator first switches to a scale, −5 to +5 gammas up to −100,000 to +100,000 gammas, and then zeroes the meter.

Besides compensating for drift, the zeroing cancels the effects of static ambient fields.

To check the power supply, the operator turns the range selection knob to Pwr. Chk. The needle should swing to the green-shaded region on the right side of the meter face. This check can be done whether the instrument is running from an a-c line or from two 6.75-volt batteries.

Double up. Inside the probe are two permalloy elements, chosen be-

. . . magnetometer drifts one gamma per hour . . .

cause of their high permeability and low saturation level. Each has a coil wound around it, and a third coil is wound around both elements. From an oscillator in the instrument comes a 2.5-kilohertz signal that's fed to the two single-element windings.

When the elements are exposed to a magnetic field, harmonics of the 2.5-khz signal are generated in the third coil. All but the second harmonic are filtered; the passed 5-khz signal is amplified, and sent through a transistor driving circuit back to the instrument. There, it's superimposed on a 5-khz square wave.

Besides driving the two coils, the oscillator feeds its 2.5-khz output to a frequency doubler which in turn feeds a transformer. The 5-khz signal saturates the transformer, so a 5-khz square wave appears at the secondary.

It's at the center tap of the secondary that the probe signal is superimposed on the square wave; the resultant wave feeds a ring modulator that drives the meter.

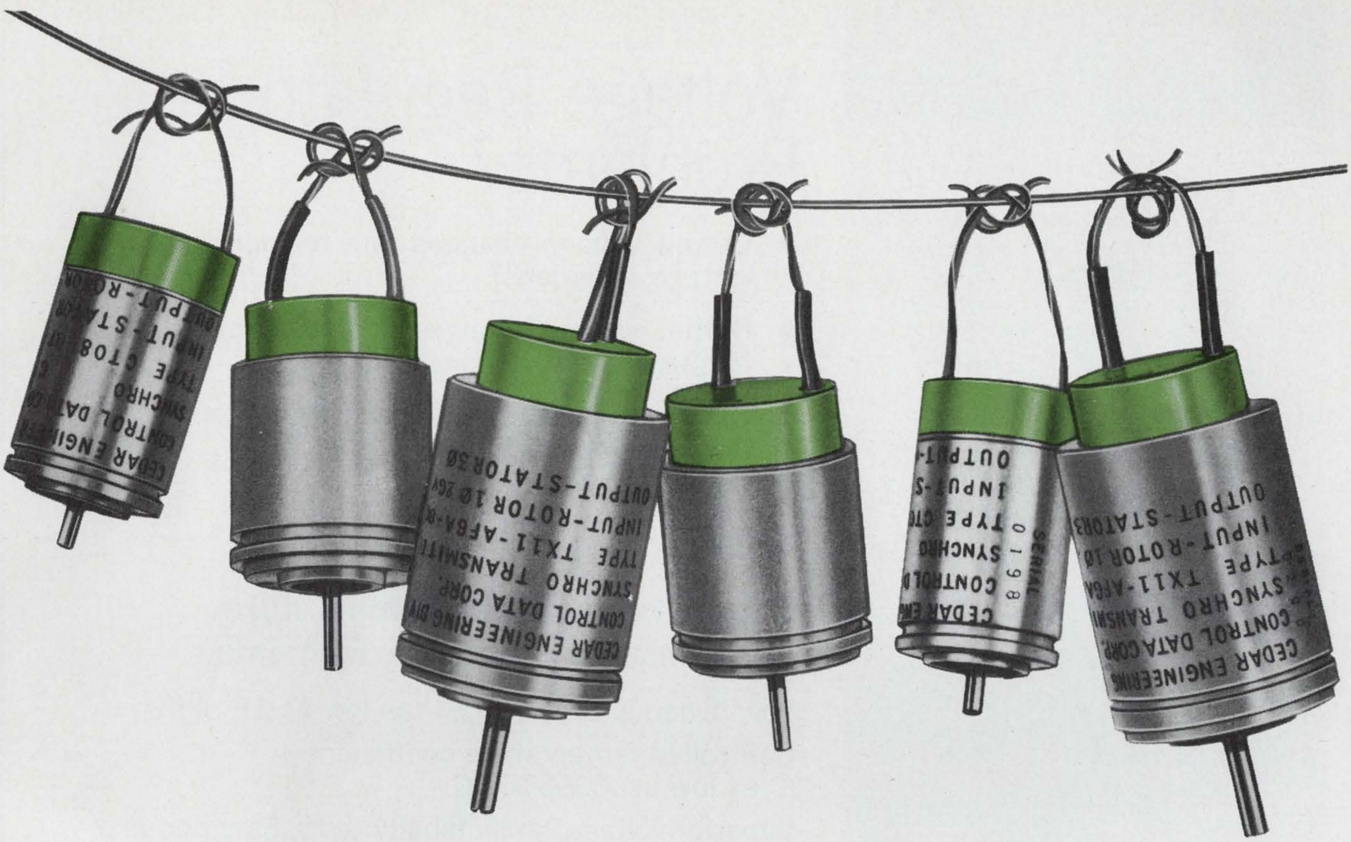
For compensation, RFL engineers wind a second coil around the two elements. This winding is connected, through some potentiometers, to a mercury battery in the instrument. When the operator zeroes the instrument, he's actually adjusting the pots and changing the strength of the compensating field in the probe.

To the rescue. The probe has trouble handling the curve of the earth's magnetic field or other ambient field. So the user has to be careful how he orients the probe. In some applications, he may even have to continually zero the instrument.

RFL engineers are working on this problem and expect to have an answer soon. Their solution is a differential probe—one with a pair of two-element detectors that ignores the changing direction of ambient fields.

Over a range of 0°C to 50°C, the 101's drift is one gamma per °C. It's stability is one gamma per hour. Delivery time is six months.

RFL Industries, Inc., Powerville Road, Boonton, N.J. 07005 **[369]**



CEDAR'S line of synchros is growing fast

There are now six kinds of Cedar synchros. In addition to the Size 11 synchro transmitter announced earlier, Cedar now offers Size 11 synchro transformers, Size 8 and 10 synchro transmitters and Size 8 and 10 synchro transformers. The line will keep growing. Other types are in testing now.

All of these Cedar synchros have the high accuracy and reliability that result in performance plus. In addition, they have the durability and long life to match their precision. This high quality is the result of a combination of advanced design concepts and modern manufacturing methods and materials, along with proven-in-use techniques developed through Cedar's many years of experience with precision servomotors.

To get full information on Cedar's fast growing line of synchros, write or call Cedar today. When it's made by Cedar, you know it's a quality product.

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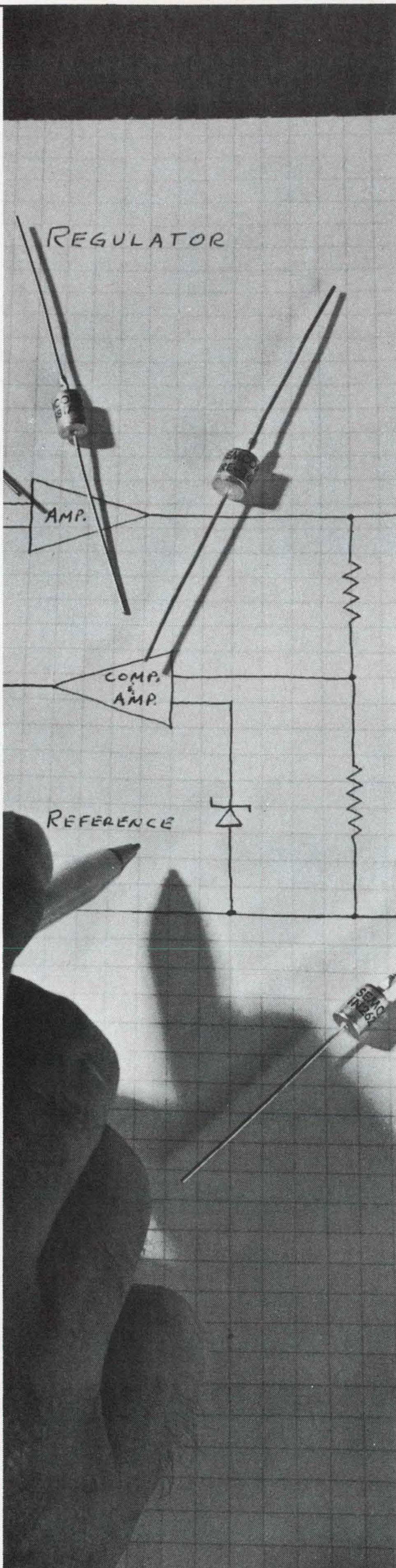
Circle 211 on reader service card



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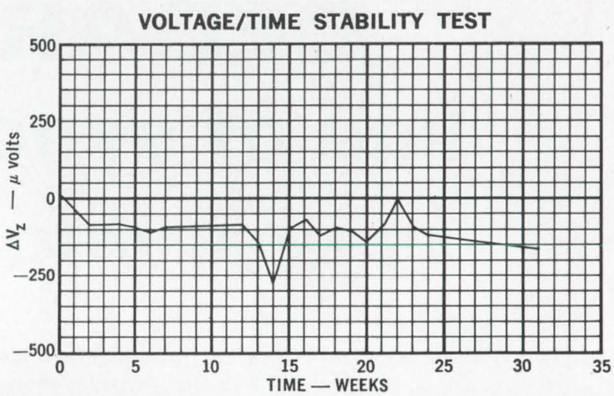

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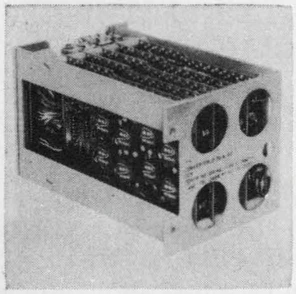
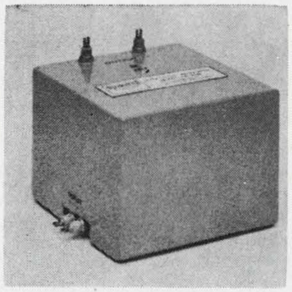
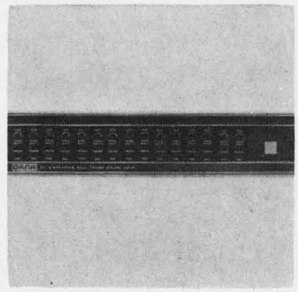
New Subassemblies Review



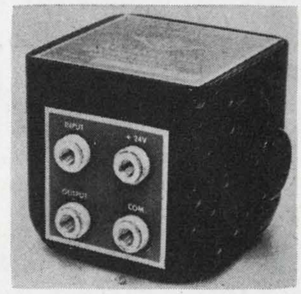
Digital-to-resolver converter for airborne use features a resolver output at 11.8 v, 400 hz. Logic levels are zero volts for logic 0 and +5 v for logic 1. The unit is accurate to 2 minutes of arc and accepts digital angle inputs from computers or peripheral devices converting them to resolver outputs for driving positioning servos. Astrosystems Inc., New Hyde Park, N.Y. **[381]**



Duty-cycle regulator DE208, in a 4 x 4 x 3 in. module, provides up to 160 w regulated d-c output. Efficiency of 85% is achieved by 5,000 hz duty-cycle operation. Relative low-heat generation is featured. Unit will supply up to 8 amps at an adjustable 10 to 20 v d-c output from a 24 to 40 v d-c, unregulated source. Diversified Electronics Co., San Lozaro Ave., Sunnyvale, Calif. **[382]**

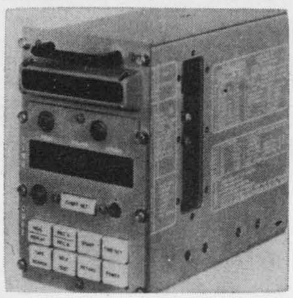


Differential data amplifier model 2615-V1 features 120 db common mode rejection and less than 4 μv of wideband noise. With a 3 db point of 40 hz, it has full-scale outputs of ±10v and 15 ma at selectable gains of 20, 50, 100, 200, 500 and 1,000. Units are suited for use in multiple-channel systems. Dana Laboratories Inc., 2401 Campus Drive, Irvine, Calif. 92664. **[383]**

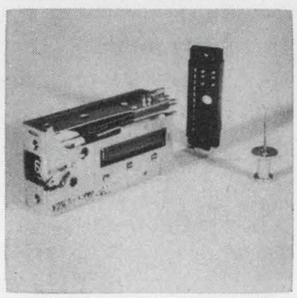


Solid state current amplifier provides a reliable interface between IC logic and d-c loads of up to 30 amps at 30 v d-c. It is available with a 0.2 sec output pulse or in a heat sink mounted configuration for continuous duty. It can be converted to a flasher that will operate within design parameters unaffected by load. All American Engineering Co., Wilmington, Del. **[384]**

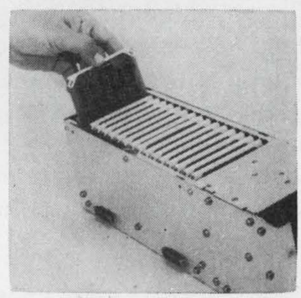
Versatile digital-to-analog converter model HS-2810 will decode 8-bit words at a word rate of 10 Mhz, to an accuracy of 0.1%. The desired minimum and maximum analog output is adjustable by two 10-turn pots. The converter automatically divides this range into 256 levels. Price is $1,690; delivery, 4-6 weeks. Computer Labs, 1109 Valley Park Drive, Greensboro, N.C. **[385]**



Airborne time code generator-decoder 3537A is a time correlation unit that generates an accurate time signal output for magnetic tape recording. A 6-digit Nixie display provides time-of-day readout of both real or tape replay time. System timing stability is better than 35 parts in 10° over a range of—20° to +50°C. C.A.W. Haydon Co., Ince Blvd., Culver City, Calif. **[386]**



Plug-in counting relay V23002 has a readout feature which counts in either the forward or reverse position. Over-all measurements are 2.6 x 1.32 x 0.53 in. The unit is an electromechanical 1-digit indicator that can be stacked to form counting arrangements with any number of digits. Price for 10 or more is $8.90 each. Siemens America Inc., 350 Fifth Ave., New York. **[387]**



A/D converter model 1200 features high speed (250,000 conversions per sec) and sharp resolution (15 bits). Accuracy is +0.01% of full range ±½ least significant bit at 0° to 50°C. There are 4 resistive inputs sampled sequentially, and sequences advance and reset and external inputs. Electronic Engineering Co. of California, 1601 E. Chestnut Ave., Santa Ana, Calif. **[388]**

New subassemblies

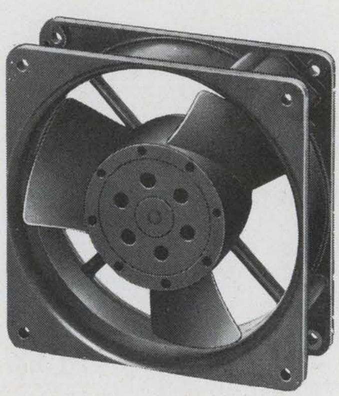
Low-cost supply has 1-ppm regulation

3½-inch high unit is controlled with thumbwheel switches; accuracy is 0.1% and drift over an 8-hour period is 10 ppm

One of three. The QHS comes in 20-, 40-, and 100-volt models.

Being one-up on other makers of power supplies is a matter of millionths. A change that small in regulation, accuracy, or stability is enough to put a company out in front in a very competitive race.

Engineers at the Sorenson operation of Raytheon Company say that their QHS supply will be the new frontrunner in the $350-supply derby. Available in 20-volt and 1-amp, 40-v and 0.5-amp, and 100-v and 0.2-amp models, the QHS has regulation of one part per million plus 30 microvolts for a 20% line change. This, the company says, is at least twice as good as the regulation in competitive supplies. Things are also steady at the other end of the QHS: a 100% load change causes an output change of no more



. . . inside the oven are amplifiers and zeners . . .

than 5 ppm plus 50 μv.

Five thumbwheel switches and a potentiometer are used to set the output. The pot, which handles the fourth decimal place, has a resolution of 11 μv.

Paul Muchnick, designer of the QHS, says that high internal gain and close attention to the characteristics of each component are the reasons for the high performance.

The reference zener diode and the first stage of the main amplifier and of the reference amplifier are in a sealed oven, mounted behind the supply's front panel. "The oven permits us to use lower-cost components," says Muchnick. "We could have built the supply without the oven, but the cost would have been too high. The one disadvantage is the warmup time, about a half an hour."

The QHS operates from 0°C to 50°C, and has a stability of 10 ppm plus 10 μv per/°C. Stability is 10 ppm plus 50 μv for 8 hours, 20 ppm plus 75 μv for 24 hours, and 25 ppm plus 100 μv for a week.

The power off-on repeatability is 100 ppm or 200 μv. The switch setting is accurate to within 0.1% plus 1 millivolt, and repeatable to within 0.003%.

Muchnick says the QHS, 3½-inches high, is the smallest among power supplies with comparable performance. It is 8¼ inches wide and its depth is 12¾ inches. The QHS weighs 12 pounds.

The standard model is priced at $345 and will be available from stock starting Nov. 15. Another version has 0.01% accuracy, and costs $395. "This supply has higher accuracy programing resistors and a little better calibrating system," says Muchnick.

Pots instead of thumbwheels are used in the low priced—around $280—version.

And a remotely-controlled model has neither wheels nor pots. The user provides his own programing resistors, besides the $280 it takes to buy the supply. This model has an extra circuit, an amplification loop that bypasses the rest of the supply. If the connection between the supply and the remote programer breaks down, this loop takes

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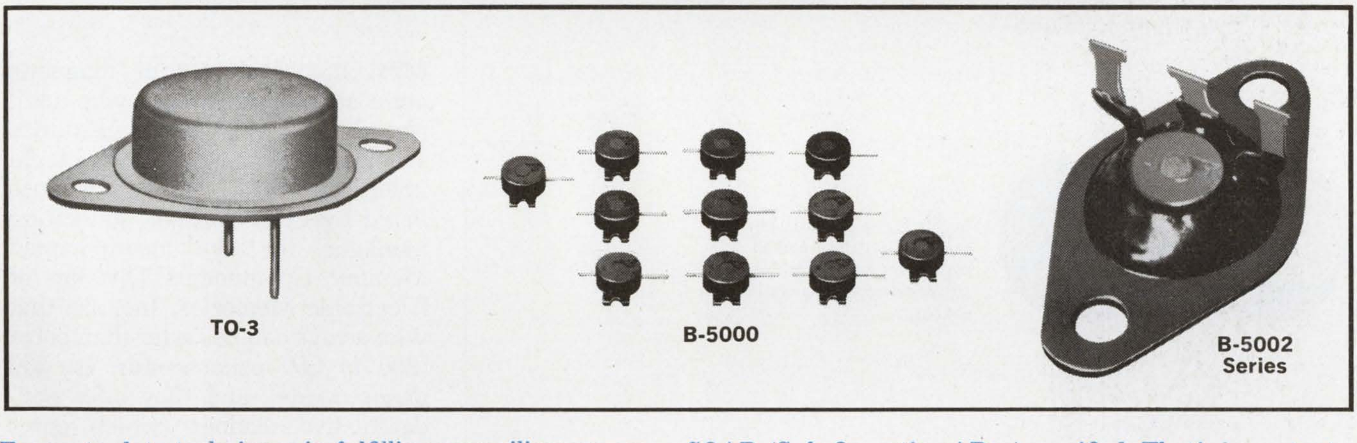

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over and delivers some predetermined voltage.

Specifications

Input range	105 to 125 v, 0.7 a 200 to 240 v, 0.35 a 48-440 hz
Current range	0% to 120%
Ripple	100 μv peak-to-peak
Input isolation	1,000 v d-c
Output isolation	300 v d-c
RFI	per Mil-1-16910

Raytheon Company, Sorenson Operation, Norwalk, Conn. **[389]**

New subassemblies

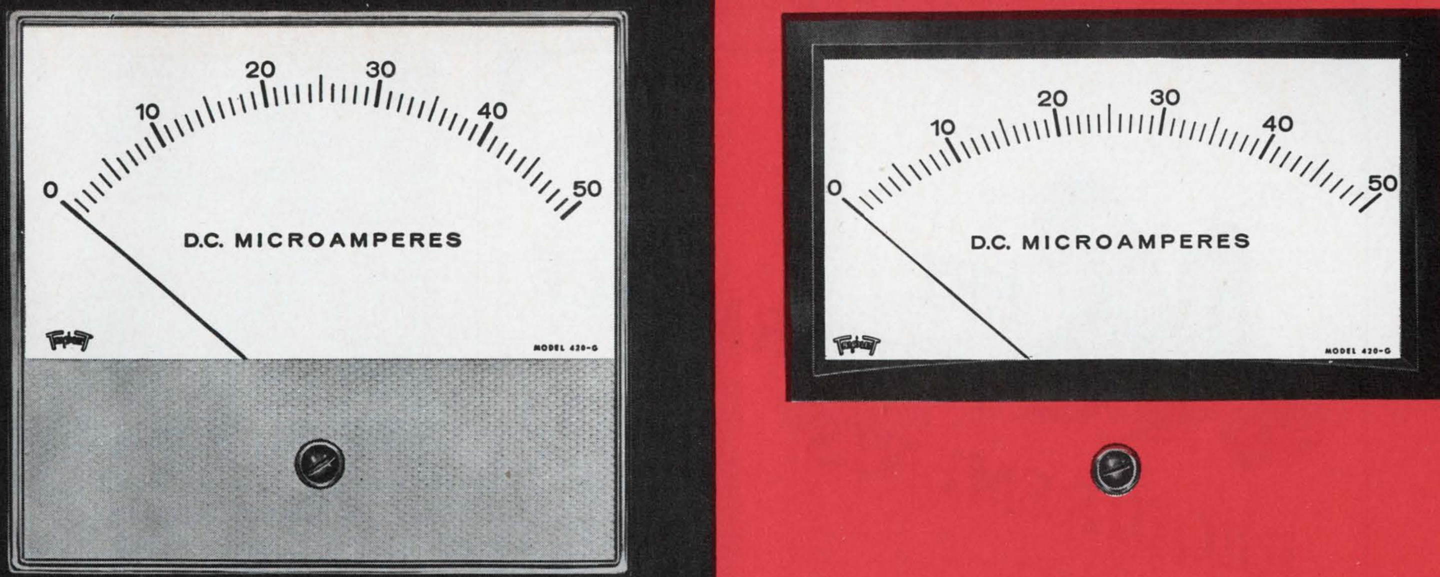
Cores challenged by plated wire

64-word memory is fast, has nondestructive readout; built for IC testers

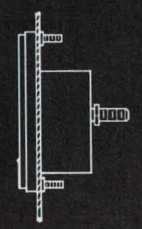
Most manufacturers of magnetic cores and core memories who don't already make plated-wire memories are taking a close look at wire technology for various reasons. Those listed by Peter Kuttner, marketing manager for the newly-named Memory Components Division of Electronic Memories, Inc. are that wire arrays can be faster than cores (200 to 300 nanoseconds vs. 500 nanoseconds), and they offer nondestrustive readout (which cores don't). He adds that there appears to be a trend toward plated wire for the main-frame memories of new computers.

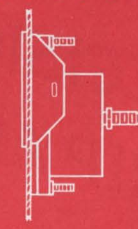
Electronic Memories embarked on an in-house research program in plated-wire technology two years ago. The first fruit of that effort is a 6-inch by 8-inch plated-wire plane containing 14 words of 36 bits each. Kuttner is quick to point out that the Hawthorne, Calif. firm will continue to expand its mainstay ferrite-core business, but confidence in plated-wire technology led the company to change the name of its Core Division to Memory Components Division.

Tunnel technique. The assembly consists of a plastic sandwich with tunnels between the word straps. Bonding of the word straps and



now you see it *now you don't*





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5½″ and 1½″ (Miniature)

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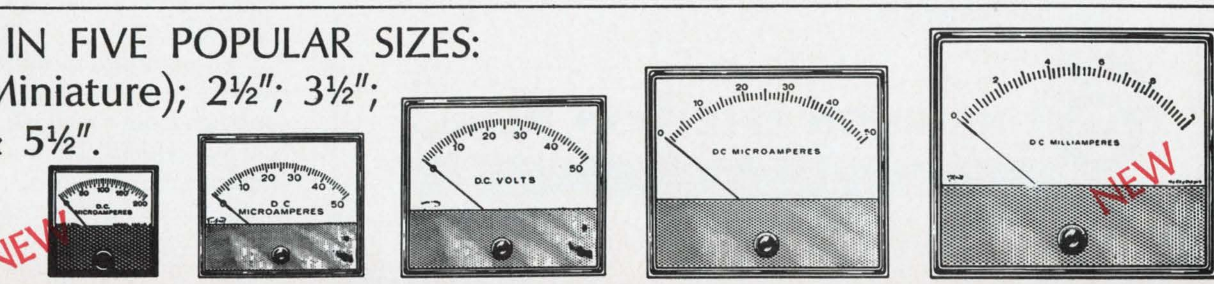
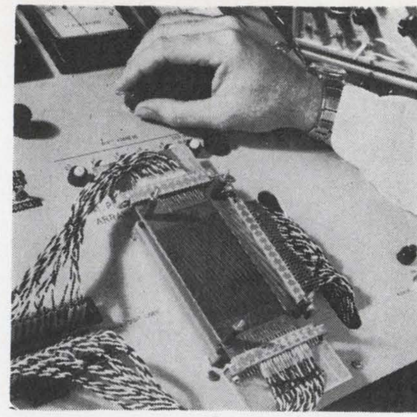
In five popular sizes: 5½″ DC and AC; 4½″ DC and AC; 3½″ DC and AC; 2½″ DC and AC; 1½″ (conventional flush mounting only) DC and AC rectifier type.

Circle 217 on reader service card

NOW IN FIVE POPULAR SIZES:
1½″ (Miniature); 2½″; 3½″; 4½″; & 5½″.



TRIPLETT ELECTRICAL INSTRUMENT COMPANY, BLUFFTON, OHIO



Quick time. Plated-wire memories like this run at speeds up to 200 nsec.

formation of the tunnels are done in one step. After the tunnel-forming wires are removed, plated wires are inserted into the tunnels. The single-turn wires have previously been formed into an elongated hairpin shape, and after their ends are inserted into the tunnels, the wire slides into place. The wire ends, which lie directly on top of connector pads, and the pads are solder-dipped to make the connection between wire ends and pads. The company says this eliminates stresses on the wire caused by handling in making individual terminations. The closed end of the hairpin remains exposed. The wire is beryllium-copper alloy electroplated with a permalloy coating, and it is a continuous strip with no solder joints.

The initial array is essentially a test product, but Kuttner emphasizes that it is a usable assembly. Although one of its chief functions is to serve as a demonstration vehicle for plated-wire technology, it is a fully-tested array that can function as a complete storage unit.

Judea Pearl, director of advanced memory devices, says the 64-by-36 plane was designed to function by itself. He foresees its application in the instrumentation field, possibly in integrated circuit testers and in testers for core and plated-wire memory elements themselves.

"These are devices in which you want to store a sequence of tests but need only a small storage capacity, which can be accessed at high speed," he says.

In the IC tester example, Pearl says, each of the 64 words could constitute one test for one param-

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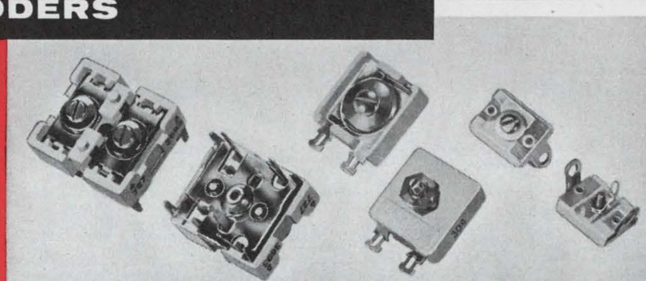

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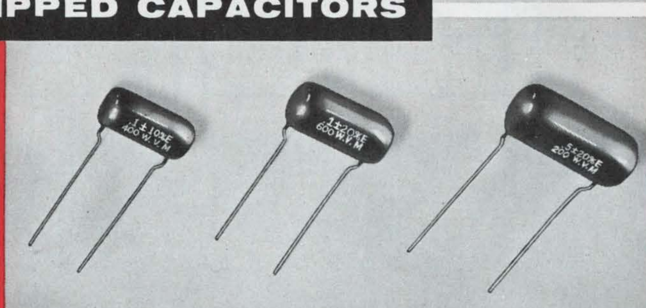

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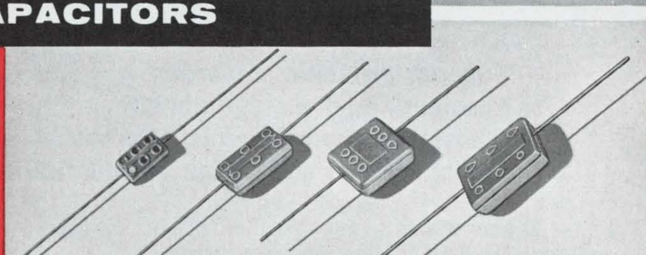

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. . . the array will operate from —25°C to +80°C . . .

eter. "The first two bits of the word could be the pulse amplitude, the next two could be pulse duration, and so on." Pearl says the array will have a cycle time of 150 nanoseconds as a read-write memory. Kuttner is more conservative. He puts the figure at 200 nanoseconds. The device has been tested at temperatures from 0°C to +100°C and Pearl maintains that it will operate reliably from —25° to +80°C.

Neither will compare the array with available plated-wire planes in performance because there are few comparable planes available commercially, they say. Kuttner maintains that just as in ferrite cores, there will be few standard products in plated-wire arrays. "We picked a size and worked out the techniques on how to put it together," he says. "We could have done other sizes, but we felt that potential customers who wanted to look at plated-wire arrays will buy this plane because it will stand by itself."

Narrow spacing. The company officials also say the array allows closer packing densities than do woven plated-wire arrays because of the wider spacing of the word wires dictated by the weaving technique.

Typical resistance for the word strap in the 64-by-36 array is 0.2 ohm; 1.35 ohms is the typical resistance of a digit pair. Word-strap and digit-pair inductance is 80 nanohenries. Typical word-to-word capacitance is 3.24 picofarads, word-to-digit capacitance is 0.23 picofarad, and digit-to-digit capacitance is 1.08 picofarads.

Electronic Memories is aiming initially at military users who like these arrays because of their NDRO feature, their ruggedness, and their low power requirements. The company is working on a memory stack for an aerospace application. Kuttner says he also has a commitment from a large computer manufacturer to buy plated-wire arrays, and a strong indication of interest from another large maker of digital processing equipment.

Electronic Memories, Inc.,
Chadron Ave., Hawthorne, Calif. **[390]**

90% of American TWTA's are overweight.

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The 1177 H series of traveling-wave tube amplifiers from Hughes.

Weight: Twenty pounds. (Some reduction.)

Measurements: 3½"x16¾"x11¼". (Some shape.)

The series covers the 2 to 18 gigahertz frequency range with a minimum power output of 10 watts CW. (That's power without any fat.)

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The 1177 H is perfect for bench or rack mounting in a lab. There's also a handle so you can carry it if you want to. (Try carrying most TWTA's.)

The traveling-wave tube is protected by a space age solid state power converter.

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New subassemblies

Laser's zap is at dead center

External mirrors permit yag unit to concentrate energy in middle of spot

A neodyium-doped yttrium alumninum garnet (yag) laser, built with external mirrors rather than with mirrors deposited on the ends of the crystal, will be sold by the Electro Optics Organization of Sylvania Electric Products, Inc.

Called the 610, the laser is rated at 1 watt for a 1.06-micron beam. But it can operate at 2 w, says Mahlon Fisher, manager of the component products department.

The use of external mirrors, says Fisher, enhances lowest-order temporal-mode operation and permits a circular aperture which slightly reduces the diameter of the spot. This has the effect of concentrating the highest power in the center of the spot.

There's space in the laser package to mount a mode-locking modulator or a Q switch. These options will be available in 1969.

The model 610 has interchangeable pump-cavity reflectors. Pitting, corroding and tarnishing of the gold surface may require polishing or replacing of the reflecting surfaces in the cavity. But, says Fisher, the double elliptcial reflector inserts can be removed and replaced in a two-hour operation. The tungsten-iodine lamps can also be removed and replaced without disturbing the alignment.

The Sylvania laser can machine integrated circuits films, trim resistors, and pump parametric oscillators.

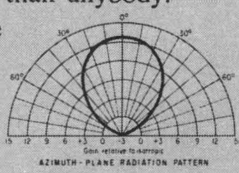
Its beam, 3-millimeters in diameter, has an amplitude variation of ±10%. The 208-volt, 60-hertz supply weighs 140 pounds and is 19 by 20 by 7 inches. The laser head weighs 25 lbs. and is 16 by 8 by 5 inches.

Price is $12,500 and delivery time is 120 days.

Electro Optics Organization, P.O. Box 188, Mountain View, Calif. 94040 [391]

an-ten'na 1. A wirelike growth on the head of a lobster. 2. An elevated conductor of electrical waves; that which in log-periodic designs Granger has more of than anybody.

az'i-muth The desired direction in which G/A antennas concentrate your signal.



ba'lun 1. An impedance transformer; connects 50 ohm co-ax to open wire lines. 2. A non-porous bag filled with hot air or gas.

cur'tain 1. Opening of a great performance. 2. An ordered arrangement of wires precisely engineered and factory fabricated for easy installation and long life as part of a G/A log-periodic antenna.

dec'i-bel (pronounced dee-bee) A measure of what G/A's h-f products can contribute to your system performance; usually in groups of 40 or 50 in the important characteristics of G/A receivers.

ex-cit'er Any of the new G/A h-f products; specifically, our new solid-state h-f unit with LSB, USB, CW, AM, and with FSK-ability.

fast-switch A rapid change between two pretuned frequencies (e.g. in 50 milliseconds); a characteristic of one of G/A's new transmitters.

gain 1. That which our products contribute to your communications system's performance. 2. A tage, benefit or profit to concerned.

h-f 1. Typically the from 3 to 30 MHz. 2. In G/A equipment the ban between 2 and 32 MHz.

im'age A reflection; t receivers don't have; t antennas use to fulle

i-on'o-sphere A fic layer used to bounc back to earth; its errati avior can be measured in real time (see *sounder*).

log per-i-od'ic The most versatile, compact precision h-f antenna design; available from Granger in many variations (e.g. rotatable, steerable, transportable, unidirectional).

mode 1. Ice cream on pie. 2. Method of doing (e.g. SSB, ISB, FSK, CW, AM); that which you have a full choice of in our equipment.

mon'o-pole 1. A game wherein you receive $200 for passing GO. 2. A compact reliable omnidirectional antenna offered by Granger Associates.

om-ni-di-rec'tion-al Going off in all directions; a capability of certain G/A antennas.

po-lar-i-za'tion di-ver'sit-y A combination of vertical and horizontal antennas to overcome fade; a space-saver.

point-to-point From here to there ith no wires; done with ionospheric irrors.

ra'di-o-tel-e-phone (pronounced TELETRANSCEIVER) A small but mighty G/A device that goes anywhere; specif. the Australian outback, remote Pacific islands, African veldt, etc.

ro-ta'ta-ble Capable of revolving; a new log-periodic antenna from Granger Associates offering reliable performance from 5.5 to 32 MHz.

re-ceiv'er A new solid-state G/A unit that selects your message from many others and renders it clearly intelligible.

se-lec-tiv'i-ty The quality of careful discrimination, as in G/A receivers; pert. to elimination of extraneous signals.

sound'er 1. A device used in early telegraphy. 2. A precise instrument for measuring the ionosphere; an efficiency expert in h-f communications.

SSB 1. In aviation, the supersonic balloon. 2. In radio communications, what nearly everyone will be using by 1971; we can help.

trans-mit'ter A microphone-antenna interface device; available from G/A in 1, 3 and 5 kw versions.

VSWR Abbr. for voltage standing wave ratio; less than 2.0:1 in almost all of our antennas.

ze'nith 1. A vertical take-off angle. 2. The name of another famous radio company.

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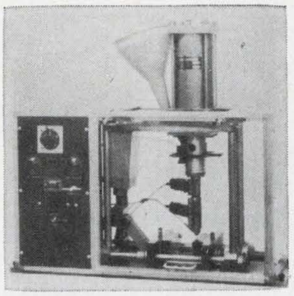
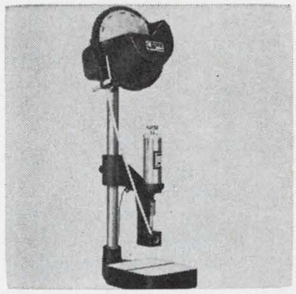
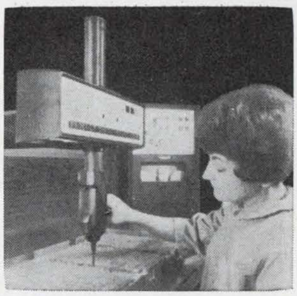
Automatic frequency plater FP-401 is essentially a 4-in. diameter basic high vacuum system packaged for production use, with automatic pumpdown and protection features. It operates at approximately 5 x 10^{-6} torr. Production rate is 1 crystal every 2 minutes for very precise frequencies, to many per minute for broader tolerance. Veeco Instruments Inc, Plainview, N.Y. **[421]**



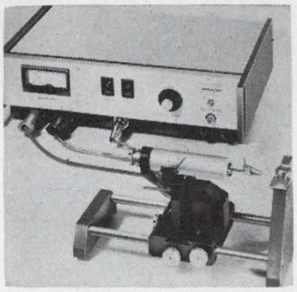
Semiautomatic, bench type injection molding machine SPIII features 3/4 oz shot capacity, 15-ton air-actuated toggle clamp and 360 shots per hour cycling. It injects all thermoplastics, including polystyrene, nylon, Delrin and PVC. The machine includes a two-zone heated plasticizing chamber. Price is $1,585. DCMT Machinery, 91 Commercial St., Plainview, N.Y. 11803. **[422]**



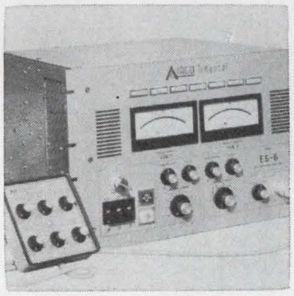
Four standard series of Pintrex machines speed the insertion of spiral pins, as well as other types of fasteners, solid, slotted-tubular or spring pins. Small and miniature pins down to 1/32 in. in diameter and practically any length can be handled at speeds up to 90 insertions per minute. The machines feed at any angle. C.E.M. Co., 24 School St., Danielson, Conn. 06239. **[423]**



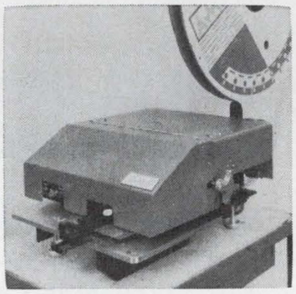
Semiautomatic, numerically controlled production consoles series 2000 P/2/P are for wiring complex electronic connector panels. The system automatically locates a wire-connecting tool over the proper pin or terminal permitting the operator to make connections from one pin to another at rates of 200 wires per hour. Product Improvement Corp., 150 Stevens Ave., Santa Ana, Calif. **[424]**



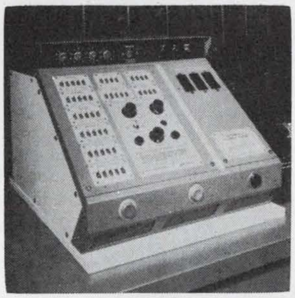
Percussive arc welder designated the Percus/Arc system consists of an arc welding power supply, model APS-105, and a holding fixture, model ABF-202. It provides a positive connecting method for butt-welding wires to wires, wires to connector plugs and wires to flat surfaces. Price of the system is $1,990. Protronic Industries Inc., 2415 S. Manchester Ave., Anaheim, Calif. **[425]**



Rack-mounted 6 kw electron beam power supply model ES-6 is for thin film deposition. It provides 100% overload protection, extreme beam stability during evaporation utilizing closed loop circuitry, automatic control from film thickness and rate monitors, and variable in-and-out beam sweep with wave form compensation. Air Reduction Co., 2850 7th St., Berkeley, Calif. **[426]**



Bench-top machine operating at a rate of about 2 terminations per sec, sequentially terminates each conductor of flexible flat cable and then stops automatically. The reel-fed machine is primarily for cables having up to 33 conductors that are 0.063 in. wide on 0.100 in. centers. It can apply connector contacts at any point along the cable. AMP Inc., Harrisburg, Pa. **[427]**



Filament winder ACW-10F may be electrically programed to provide successive coils having a different number of turns per inch, each of which is separated from the other by connecting legs of specific length. It will automatically produce up to 50 inches of filaments having as many as 5 different type sections. Eubanks Engineering Co., 225 W. Duarte Rd., Monrovia, Calif. **[428]**

New production equipment

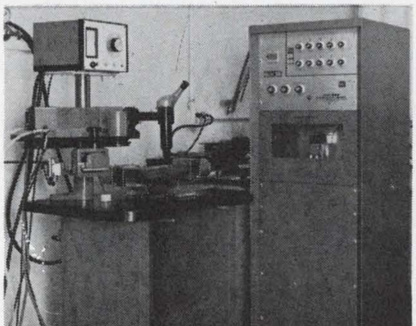
Yag laser cuts narrow swath in resistors

Trimming widths as small as 0.5 mil allow precision control of resistivity; system can be automated for complex patterns

Makers of yttrium-aluminum-garnet lasers are stepping up their bids for industrial jobs, particularly resistor-trimming and similar types of micromachining.

The Korad Department of Union Carbide Corp., in its latest entry, combines one of its Q-switched yag lasers with special optics to make a resistor trimmer which the company says is more accurate and less costly than competitive laser systems and other trimming tools.

Laser trimmers have been handicapped by speed limitations in the associated electronics, but Korad



Trim team. Laser, left, can be run by a numerical control system.

. . . rep rate is higher than ruby and CO_2 . . .

says its new trimmer, called the K-RT, compares favorably in speed with systems using abrasive or chemical techniques and with other laser assemblies.

Rod Waters, Korad applications manager, says the advantages of yag over other laser systems include narrower cut widths, lower average power, higher peak power, smaller size and higher repetition rates. Unlike abrasive systems, they cause no contamination or destruction of materials nearby.

Tight control. With narrower cut widths, the user can much more closely control resistivity characteristics in thick and thin-film resistors, hybrid integrated circuits and glass-encapsulated resistors.

"In our yag trimmer, we give the customer a cut width of 0.5 to 2 mils," Waters says, adding that carbon-dioxide lasers have minimum cut widths of 6 to 8 mils and that pulsed-ruby and continuous-wave argon laser systems furnish minimum cut widths of 1 to 3 mils.

Energy from the yag laser trimmer may be applied to a part of the resistor without fear of damaging any other portions of the device. The yag operates at 1200 pulses per second—and Waters says this compares with 1-10 pps for pulsed-ruby laser trimmers and 300 pps for CO_2 lasers. Average power of the yag laser is a half-watt, with a peak power of 5,000 watts. Gas lasers have an average power of 1.5 watts and a peak power of 10^4 to 10^5 watts.

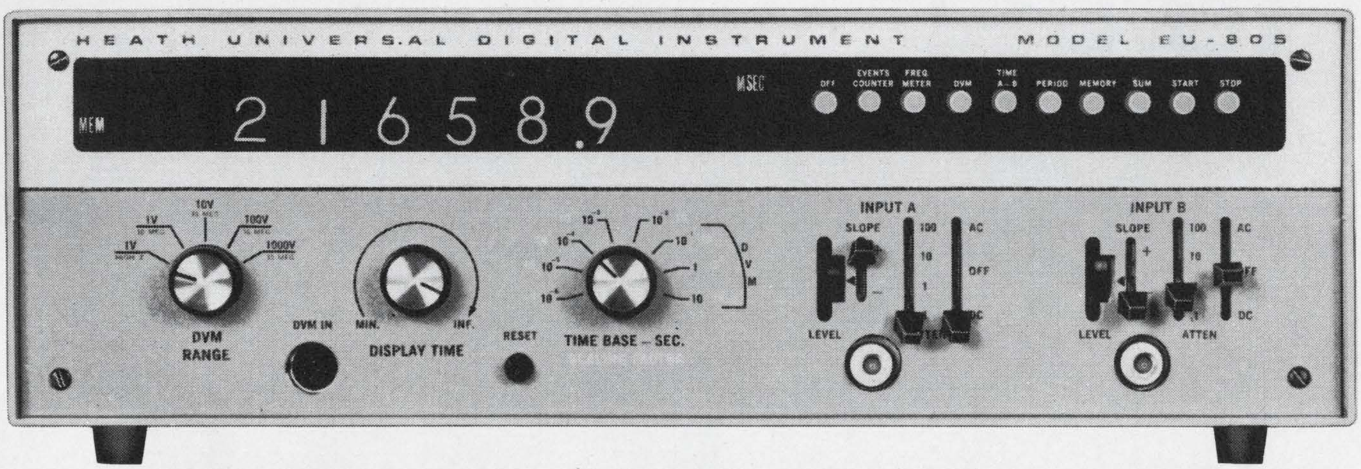
The difference between the yag's 1.06 and the CO_2's 10.6 microns operating wavelength gives the user a correspondingly smaller spot size and reduced beam divergence for greater precision trimming, Waters says.

Production-rated. The laser process can be automated and placed under computer or numerical control to allow the user to machine complex patterns. Waters says abrasive trimmers have operating rates up to 4000 devices per hour and that the yag trimming system can match this figure. The K-RT is priced at $20,000.

Korad Dept., Union Carbide Corp., Santa Monica, Calif. 90406 **[429]**

✱ Events Counter
✱ Frequency Meter
✱ Integrating DVM
✱ Time Interval Meter
✱ Period Meter
✱ Ratio Meter
✱ Voltage Integrator

all for only $1250



Heath Universal Digital Instrument

Now you need only one instrument, the Heath EU-805A to make any digital measurement you want. The UDI will measure all these functions: Frequency, Period, Ratio, Time-Interval, Events Count, Integrating DVM and Voltage Integrator. Combining in one standard rack package a DC-12.5 MHz Multi-Purpose Counter/Timer with a 0.05% accuracy Digital Voltmeter, the new Heath/Malmstadt-Enke EU-805A offers compactness on your bench and unmatched versatility. An original modular design based on plug-in cards with TTL IC's — cards stay in place for all 7 functions. And you can add new cards for other functions and protect the instrument from obsolescence.

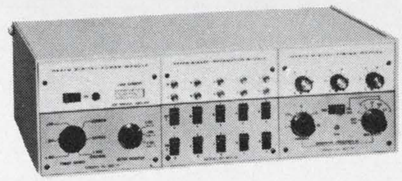
The UDI features convenient fast cycling on slow time bases, unique summing function for continuous summation without display reset, memory starts new count scaling before previous count has cleared, variable display time from 0.1 s to 30 s, 6 digit read-out plus over-range.

The two identical high-sensitivity (10 mV) input comparators provide 1 MΩ impedance, complete range of trigger controls (including Automatic Mode), oscilloscope monitoring of triggering point and four levels of input attentuation to accept up to 500 V. Input pulse resolution is better than 50 ns. Time base stability is better than 5 in 10^9 (short term) & 1 ppm (long term). Time bases range from 1 us to 10 s. Accuracy is ±1 count.

DVM section has Automatic Polarity Indication, 5 x 10^9 ohm input impedance on separate 1 V range (10 MΩ on the others) four ranges from 1 to 1000 V, 10 uV resolution, 0.1 second to 10 second integrating time and V-F output available at rear panel.

The EU-805A is obviously the instrument you need . . . and it is obviously priced right: $1250. Less DVM order EU-805D at $940. DVM conversion pack costs $340.

The UDI is part of the Heath Modular Digital System. Many of its cards may be used in the Heath/Malmstadt-Enke Analog Digital Designer EU-801:



The ADD permits investigation and design of various analog and digital circuits and instruments, by plugging-in circuit cards to its power, binary and timing modules. Connections are made with ordinary wire and component leads.

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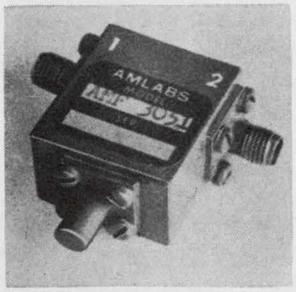
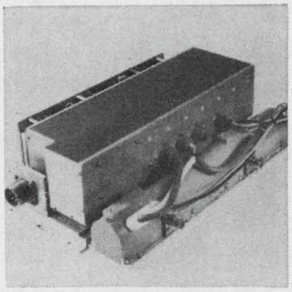
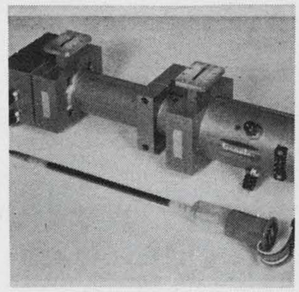
New Microwave Review



Miniature ferrite isolator AMF-3051 is for telemetry applications. It is rated for 2 w c-w, with power handling capabilities to 30 w c-w. Frequency range is 2.2 to 2.3 Ghz; isolation, 20 db minimum; vswr, 1.25 max.; operating temperature, −40° to +70° C; dimensions, 0.80 x 0.8 x 0.75 in. Advanced Microwave Laboratories, 611 Vaqueros Ave., Sunnyvale, Calif. [401]

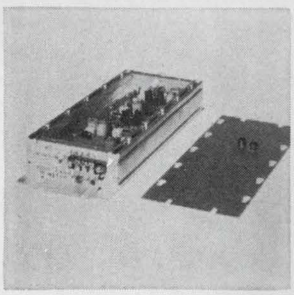


TWT amplifiers series A600-100 are solid state devices with complete arc and overload protection. They cover 1 to 2, 2 to 4, 4 to 8, 5.5 to 11 and 8.2 to 12.4 Ghz. Saturated power output is 100 w minimum. Small signal gain is 33 db minimum. Noise figure is 35 db maximum. Typical size is 8 x 5 x 12.5 in. Keltec Florida, P.O. Box 1348, Fort Walton, Beach, Fla. [402]

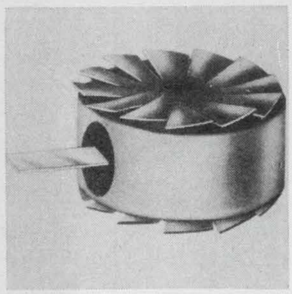


C-band TWT TWC21 allows the user two modes of operation to match his system to local attenuation conditions or interference restrictions. It operates in the 5.8 to 8.2 Ghz band and is designed to give 10 w or 5 w linear output at a gain of 40 db by adjusting beam current. Operating temperature is −10° to +70°C. M-O Valve Co. Ltd., Brook Green Works, London W. 6. [403]

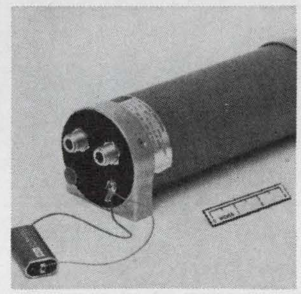
Balanced mixer model 70016 provides improved performance over former models in both vswr and isolation at the same time. At a frequency of 1 Ghz, vswr is 1.15 and l-o/r-f isolation is 40 db with a 9-db nominal noise figure. There is no need to trade one for the other. Advanced printed stripline circuitry is used. Anaren Microwave Inc., 478 E. Brighton Ave., Syracuse, N.Y. [404]



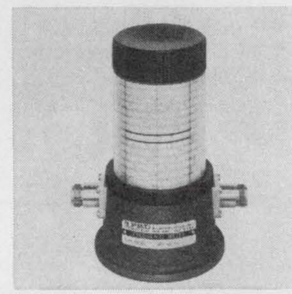
Adjustable equalizer is for 1800-channel, long-haul microwave radio relay equipment. It uses a wideband delay line hybrid transformer configuration at 70 Mhz i-f which allows adjustment of microwave radio group delay without unwanted variations in amplitude response and vswr. Raytheon Co., Communications & Data Processing, Boston - Providence Turnpike, Norwood, Mass. [405]



High-power strip transmission line terminations for 1/8 and 1/4 in. ground-plane spacings are available in the resilient pill-form design for up to 5 w dissipation. Vswr is limited to 1.35:1 at 12.4 Ghz and is below 1.21:1 max. for frequencies below 8 Ghz. Typical measurements are less than 1.24:1 at 12.4 Ghz. Filmohm Corp., 37-11 47th Ave., L.I.C., N.Y. 11101. [406]



Battery-operable, low-noise traveling-wave amplifiers models WJ-457 through WJ-461 cover 1 to 2, 2 to 4, 4 to 8, 8 to 12 and 12 to 18 Ghz. Power drain is 3 w. All units are self-contained and adjustment-free, requiring only 20 to 28 v d-c input for operation. Each is 3.4 x 9.5 in. and weighs about 6 lbs. Watkins-Johnson Co., 3333 Hillview Ave., Palo Alto, Calif. [407]



Coaxial frequency meter 518 is direct reading from 960 Mhz to 12.4 Ghz. It consists of a coaxial line coupled to an end-loaded reentrant cavity whose resonant frequency is set by means of a noncontacting plunger. Tuning is accomplished by adjusting a precision lead screw that is spring loaded to eliminate backlash. PRD Electronics Inc., 1200 Prospect Ave., Westbury, N.Y. [408]

New microwave

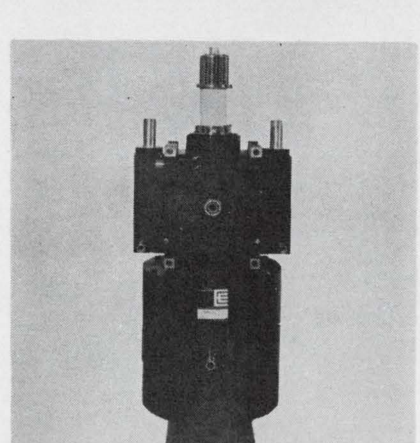
L-band magnetron delivers 2 megawatts

Vapor-cooled tube designed for surveillance radars at airports that will handle supersonic transports

Sometime in the mid-seventies when the supersonic transports start flying, airports will need more-powerful radars than they have now. The faster a plane flies, the farther out it has to be picked up.

For these long-range surveillance radars, engineers at English Electric Valve Ltd. have built an L-band magnetron that delivers 2 megawatts of peak output power. One model, the M5051, works from 1,250 to 1,310 megahertz. The M5052 runs from 1,305 to 1,365 Mhz.

English Electric expects that



Taking the heat off. The magnetron's condenser and boiler are built into the anode block.

magnetrons, like the 5051 and 5052, will replace klystrons in high-power radar systems. The company points out that magnetrons are smaller, less expensive and easier to tune.

A still approach. A designer using the new magnetron doesn't have to worry about fans or pumps. Instead of forced-air or water, the tube is vapor-cooled. The boiler and condenser are built right into the anode block. Heat from the tube is absorbed in the boiler by coolant which boils off into the condenser. From there the coolant flows back into the boiler for recycling.

Water or any other coolant, like antifreeze, can be used. And since the boiler and condenser are integral parts of the tube, there's no leakage problem.

Both models of the magnetron deliver a mean output power of 3 kilowatts and have a duty cycle of 0.0015. For both, the pulse width can range from 1.5 up to 5.0 microseconds.

Peak anode voltage is 35 to 45 kilovolts, and peak anode current is 150 amps. The tuning rate is 225 kilohertz per turn.

The magnetron is 9 by 9 by 25 inches and weighs 60 pounds. Its magnet weighs 150 pounds.

The tube is priced around $4,000 in the U.S. Delivery time is six months.

Calvert Electronics Inc., 220 East 23rd St., New York, N.Y. [409]

New microwave

Coaxial tube works in C-band

Pin-for-pin replacement for standard oscillators is rated at 3,500 hours

Conventional magnetrons have been around for a long time, but, one by one, the engineers at SFD Laboratories, Inc. are picking them off. A few years ago the company started making coaxial magnetrons that could replace the older units

Circle 231 on reader service card

. . . tube's minimum output is 250 kilowatts . . .

pin for pin. Now the Varian subsidiary has replacements for the seven most popular maggies, and coaxial magnetrons account for half the company's business.

The latest coaxial device, the 341, is designed to replace the 7156A and other conventional 250-kilowatt C-band tubes.

Like all coaxial tubes, the 341 has a cavity that gives the device frequency stability much better than that of the tube it's designed to replace. Pushing factor—the ratio of frequency change to anode current change—is 100 kilohertz per amp. John Martin, SFD's sales manager, says this figure is one tenth that of older tubes.

The newer device's pulling factor—maximum frequency change caused by changing the load's phase angle—is 6 megahertz, which Martin calls one fifth the pulling factor of the older magnetrons.

At $4,350, the 341 costs two to three times more than the 7156A. Martin is quick to point out that the coaxial tube lasts a lot longer—3,500 hours compared with 500 hours. The reason for the longer life is that all coaxial magnetrons have very large cathodes and anodes that don't burn out as quickly as smaller filaments.

The 341's minimum peak output from 5.450 to 5.825 gigahertz is 250 kilowatts, although Martin says output typically ranges from 260 to 275 kw in this band.

SFD expects its biggest customer for the new tube to be the Navy which uses tubes with similar specs in shipboard missile-control systems.

Specifications

Heater standby voltage	9.5 v
Heater standby current	11 amps
Maximum vswr	1.5
Dimensions	9 x 8 x 13 inches
Weight	33 lbs
Cooling	forced air
Minimum air flow	30 ft³/min
Warmup time	300 sec
Output flange	mates with UG-148B/U
Peak power input	600 kw
Peak anode voltage	25.5 kv
Rate of rise of voltage	120 kv/μsec
Peak anode current	24 amps
Temperature coefficient	—0.1 Mhz/°C

SFD Laboratories, Inc., 800 Rahway Ave., Union, N.J. [410]

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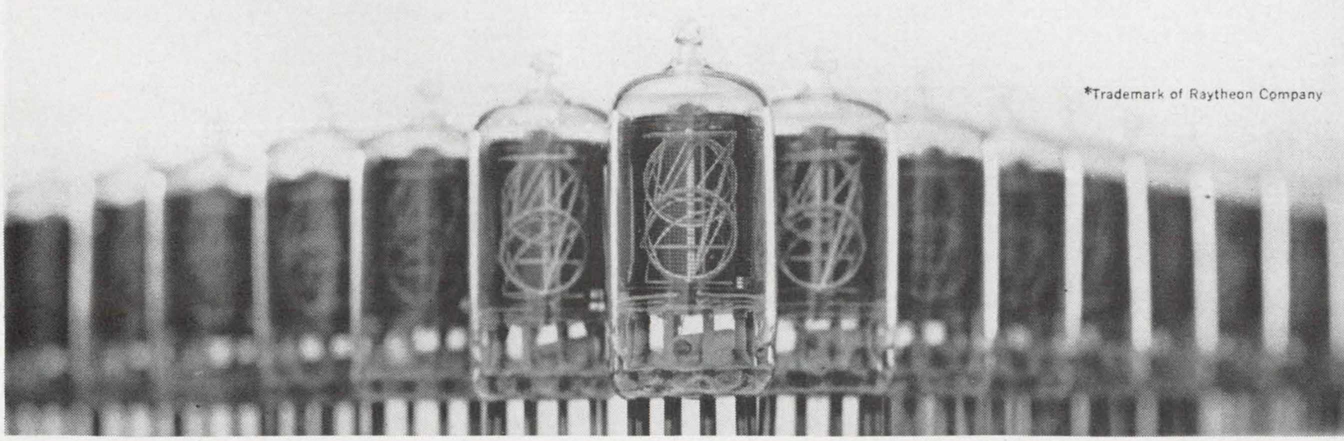
RAYTHEON



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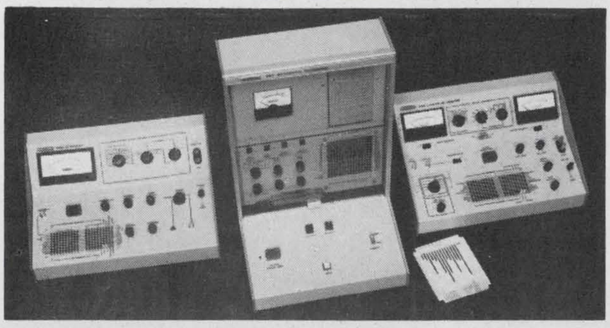

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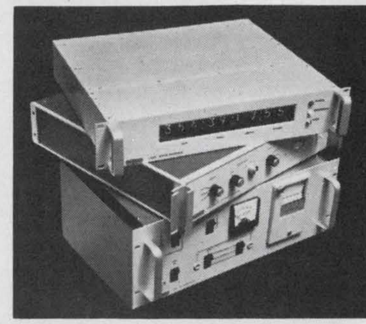

Presenting a complete line of electronic test instrumentation

High-Frequency IC Counter-Timers The Beckman 6300 Series are the fastest counters made – 200 MHz direct count! They are available as either six-, seven-, or eight-digit instruments with a choice of function, input and dual purpose modules to deliver all the capability needed in today's applications. And, a continuous development program lets you expand your counter/timer with added-capability modules rather than buying a new instrument.

100 MHz EPUT and Timer The Model 6148 is an IC unit built to accept Beckman 600 Series plug-ins. The basic instrument measures frequency, time interval, period, multiple period, ratio, multiple ratio, scaling, and counts random events. With plug-ins, you can measure frequencies to 12.4 GHz (or up to 120 GHz on request), voltages to 1000 volts, and increase input sensitivity to 1mV rms. For high resolution timing there is a 10 ns timer plug-in, ideally suiting Model 6148 for shock wave analysis, explosive burn timing, ballistics testing, time delay reflectometry, etc.

IC Industrial Counters In the 6200A Series, Beckman offers a complete line of 200 kHz industrial counters complete with magnetic proximity and photo electric pickups. A closed-box package design invites use under the most severe environmental conditions – dust, foreign matter, and excessive noise present no operational hazard. The series includes twelve models, from a basic accumulator to a versatile counter/timer which will measure frequency, period, time interval, ratio, and count random events all for less than $900. The Model 6246A Dual Limit Rate Controller provides an immediate indication of whether the actual frequency rate being measured is or is not within selected limits. A 6200B Series offers added display digits and increased frequency range to as high as 10 MHz.

IC Compatible Digital Printers The low-cost Model 1453 is designed to operate with a variety of digital instruments and will accept information in both 4-line BCD and 10-line decimal-code format. Local and remote red/black color control is standard. The Model 1455 is a high-speed, parallel-entry digital recorder and prints up to 12 characters a line at 20 lines per second. Provisions for local and remote input and output command signals are included to allow you to adapt the printer to various system configurations.

IC Testers Beckman offers integrated circuit testers designed to handle nearly all testing requirements. The Model 999 is designed for digital laboratory testing of all important dc parameters at a cost of only $595; the Model 998 Linear IC Tester handles amplifier evaluation for $945; and the $3995 Model 997 Automatic Digital Tester offers economical production IC inspection, and is available with automatic IC handling capability.

WWVB Time Standards Three WWVB Time Code Receivers, a Decoder, a VLF Phase Comparator Receiver, and related accessories are available for receiving, decoding and displaying time code transmissions from Station WWVB, Ft. Collins, Colorado. WWVB signals are maintained within 100 milliseconds of UT-2 (Greenwich or Universal Time). The instruments are extremely simple in operation, and, in essence, add a "time" dimension to the customer's capability.

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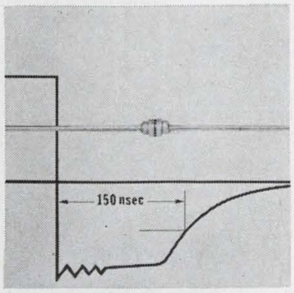
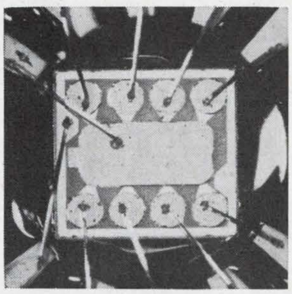
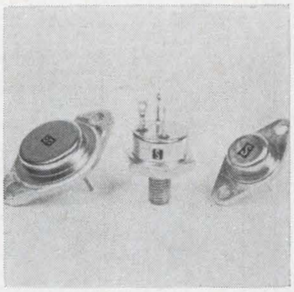
New Semiconductors Review



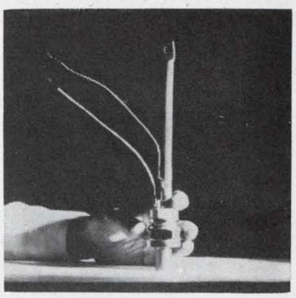
JAN and JAN TX 1N4942, —4, and —6 are 1amp 200 v, 400 v, and 600 v 150 n sec, fast recovery, controlled avalanche rectifiers. Fused - in - glass, metallurgically-bonded, voidless construction permits handling surges to 15 amps for 8.3 μsec and extremes in environmental conditions. Body size is 0.160 x 0.085 in. Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172. [436]



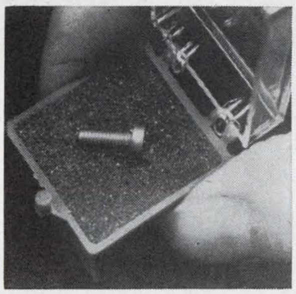
Monolithic 16-diode core driver array FSA2500M comes in a 1/4 x 1/4 in. ceramic flatpack mounting. Designed to drive core memories in military and nonmilitary computers, it features the formation of a two-layer metalization similar to that found in the most complex IC's. Price is $18 each in quantities of 100 to 999. Fairchild Semiconductor, 313 Fairchild Dr., Mtn. View, Calif. [437]



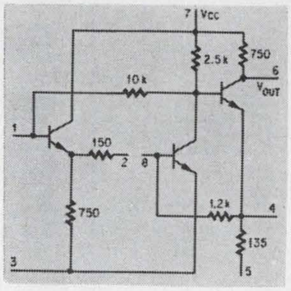
Triple diffused silicon transistors 2N5467 (TO-3 case) and 2N5469 (TO-66 case) have breakdown voltage of 700 v and a gain of 5 minimum at a collector current of 3 amps. Their collector saturation voltage is 0.5 v max. and base saturation voltage is 1.5 v max., both measured at a collector current of 3 amps. Solitron Devices Inc., Blue Heron Blvd., Riviera Beach, Fla. [438]



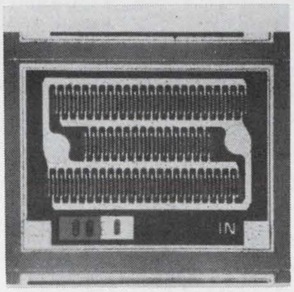
Thyristor model 270, with an average forward current of 350 amps, has applications in motor control, starters, and primary controlled power systems. Parameters include a forward blocking voltage of 1,500 v steady state and a 300 v/μsec minimum dv/dt to rated voltage. Surge current rating is 6,250 amps. Westinghouse Semiconductor Division, Youngwood Pa. 15697. [439]



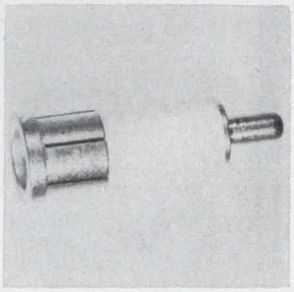
Single element, gallium arsenide laser diodes LD11 and LD12 are for operation at room temperature. Their package design permits operation approaching or exceeding 5 khz without decreasing peak power for pulse widths of 100 to 200 nsec, resulting in higher average power output. Price is $10.75 each in quantities of 1,000. Laser Diode Laboratories, Metuchen, N.J. 08840. [440]



Broadband amplifier linear IC model ULX-2103M has a 60 Mhz (—3 db) frequency response and 30 db typical voltage gain. It features two input connections: one a low-impedance 10-ohm input for current amplification, the other a 1,200-ohm emitter-follower. It comes in the 8-pin plastic dual-in-line package. Sprague Electric Co., Marshall St., North Adams, Mass. 01247 [441]



N-channel junction FET2N5432, for analog switches, commutators and choppers, has 5 ohms maximum "on" resistance. The 2N5433 and 2N5434 offer 7 and 10 ohms respectively. Guaranteed max. capacitance is 15 pf. Drain cutoff current is less than 200 pa. Leakage is 200 pa max. Switching times are less than 36 nsec. Siliconix Inc., 1140 W. Evelyn Ave., Sunnyvale, Calif. [442]



Bulk gallium arsenide diode CA4S2 provides 25 w pulse power at frequencies of 3 to 3.6 Ghz. Designed for using pulse lengths up to 2 μsec, the compact unit is fully compatible with standard, commercially available pulsers and may be operated at repetition rates of up to 5 khz without danger of diode damage. Cayuga Associates Inc., Parker Road, Long Valley, N.J. 07853. [443]

New semiconductors

Shift registers launch MOS standard line

Bit-addressable, read-only memories will expand family; devices designed for computer peripheral equipment

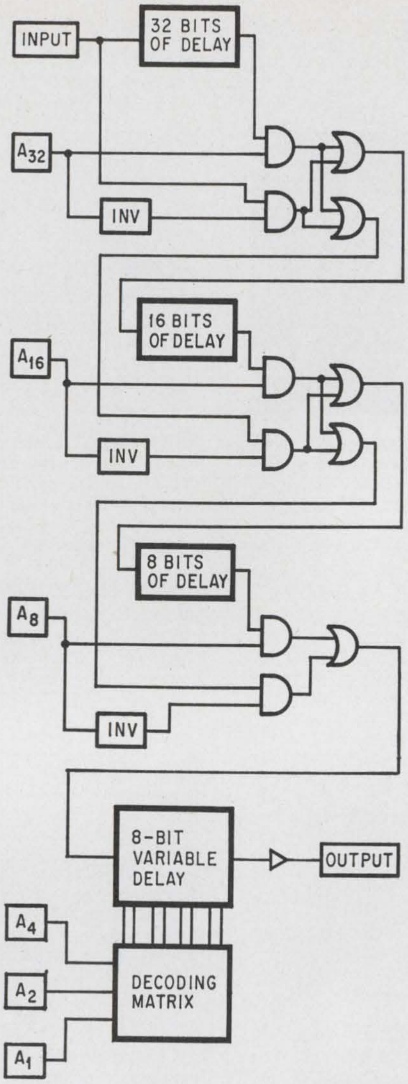
Unlike most small companies making metal oxide semiconductor integrated circuits, a new firm in Mountain View, Calif., is specializing in standard types rather than trying to fill gaps in the big companies' lines, or compete in the customized-circuit market.

After nearly a year of planning, Electronic Arrays Inc. will soon introduce its first four products, and all of them are standard shift registers.

"Custom work has its place, but to get MOS established, there must be standard products," says marketing director Earl Gregory.

The company's market approach is in contrast to that of its cousin, American Microsystems Inc. Both were formed by alumni of the old General Micro-electronics Inc.; American Microsystems, in business for two years, has achieved considerable success making customized circuits.

Most standard MOS products now on the market are modifications of custom circuits, and have a dismaying variety of characteristics: some are four-phase, some two-phase, some one-phase; some trigger on the leading edge of a pulse and some on the trailing edge; some op-



Adaptable. Any bit length from one to 64 can be obtained between fixed input and output leads by binary setting of six address code inputs

erate at one voltage level and some at another. Electronic Arrays, says Gregory, wants to establish a family of MOS devices, that have the same characteristics.

Taking aim. Exactly which devices to produce, and which market to explore, have been as important to the company in recent months as the development of its thick-oxide process. The company settled on the computer peripheral-equipment market after consideration of communications, telemetry, and numerical control. Since computer terminals generally work off transmission lines, Gregory notes, the speed requirements are compatible with MOS. So are functional requirements to take one type of information, such as ASCII code, off a line and convert it to Selectric or

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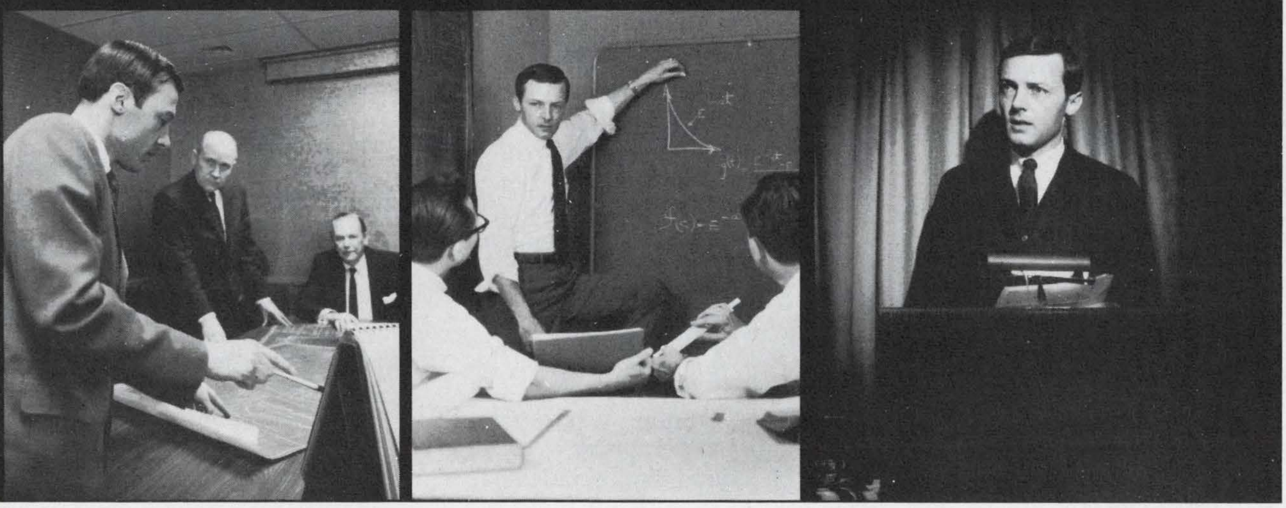

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. . . each of the registers has a one-phase clock . . .

extended binary code.

Equally important, Gregory adds, is the industry belief that the market will nearly double, from $475 million to $875 million, between 1967 and 1971.

Once the market was decided on, says product marketing manager Richard Eiler, the question was which circuits to start with. There are already more than 150 standard products available to peripheral-equipment manufacturers, Eiler says, but the availability of these circuits is almost as variable as their characteristics. Some are so old they are no longer really useful; some are so new that they are not available in bulk. What is selling, however, are shift registers, particularly in Japan.

The first four products from Electronic Arrays will be:

- a quad 32-bit dynamic shift register
- a variable length 64-bit dynamic shift register
- a quad 32-bit static shift register
- a 256-bit dynamic shift register.

The company will soon offer a bit-addressable random-access memory and a read-only memory of more than 2,000 bits as additions to its line of standard devices.

Few clocks. "Ease of use is extremely important in all of these circuits," Eiler says. "You don't give a small manufacturer something with a 10-megahertz, four-phase clock, with 27-volt swings, and tell him to implement it. We have gone the route of as few clocks as possible; almost all of our circuits will be available with one-phase clocks, and for anything over two-phase, the clock circuitry will be on the chip. That's why we limit our speed—but most applications are for under 1 Mhz anyway."

"The circuits will not need output buffering," Eiler continues. "They will drive bipolar circuits directly; the fanout may be only one or two, but the system will go." Eiler also plans application notes describing necessary voltages for hooking circuits up in various configurations.

The variable-length delay line is

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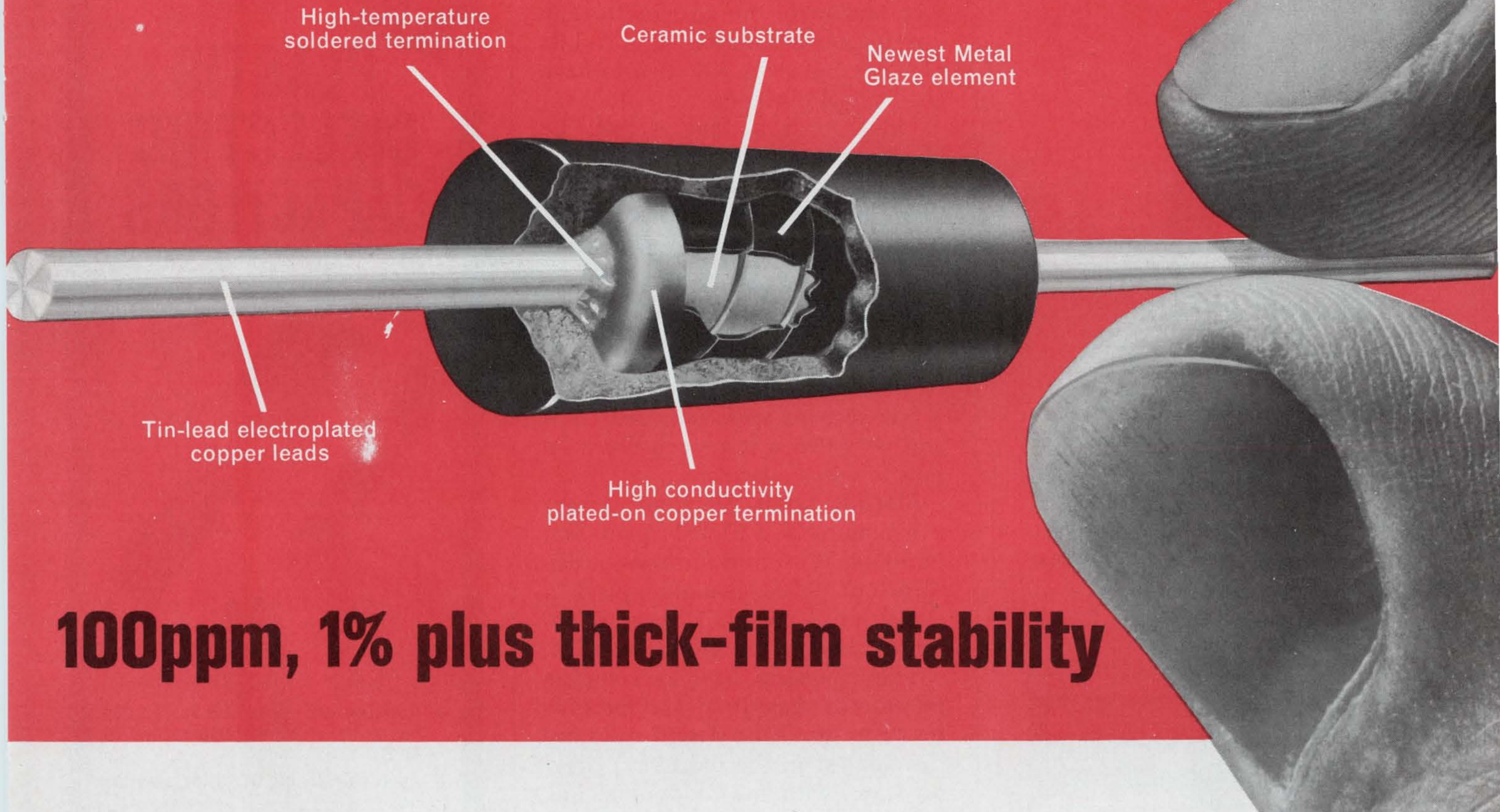

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TOLERANCE	±1%	±1%
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POWER	¼ watt @70°C ⅛ watt @125°C	½ watt @70°C ¼ watt @125°C

(derate to zero at 165°C, no load)

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the company's answer to a familiar complaint among MOS makers: each customer wants a different length. Six input control lines determine the length of the new circuit. Three control a 32-bit, a 16-bit, and an 8-bit delay; the other three determine the tap on a second 8-bit segment. Putting the circuits in series gives a delay line which is variable in very small steps. The company will also hard-wire the circuits for any customer who wants, say, 37 bits of delay but does not wish to have the control problem.

Gregory says that it will be cheaper for a customer to buy the standard circuit and use however many bits of delays he needs than to ask for a custom circuit—even though he may be wasting part of the standard chip. If a customer finds he needs a volume order, it may pay him to customize; in the beginning, however, he can build a few systems with standard chips and not incur a large expense if he fails to win a contract.

Starting small. Electronic Arrays is beginning in a 27,000-square foot building. With two furnaces, it can turn out 9,000 complex parts a month on a one-shift basis. Room for expansion has been provided.

The company has been testing its process since June, and feels it's ready to go. "Our design rules are the tightest in the industry," Gregory says, "with line width of 0.2 mil, metal-to-metal spacing of 0.2 mil, and source-to-drain spacing of only 0.3 mil. Also, our design engineers are becoming clever at using the spurious capacitances that they used to fight. That has kept chip size down."

Gregory says that while a static shift-register cell is typically twice as big as that of a dynamic cell to allow space for the feedback that keeps the device on, his company's static cell is only 18% bigger than the dynamic cell. The result is a saving in power as well as costs. Chip size of the quad 32-bit static register is 80 by 84 mils.

Some shift registers will be available in production quantities by November, and the complete line by the end of the year.

Operating range is 0°C to 50°C

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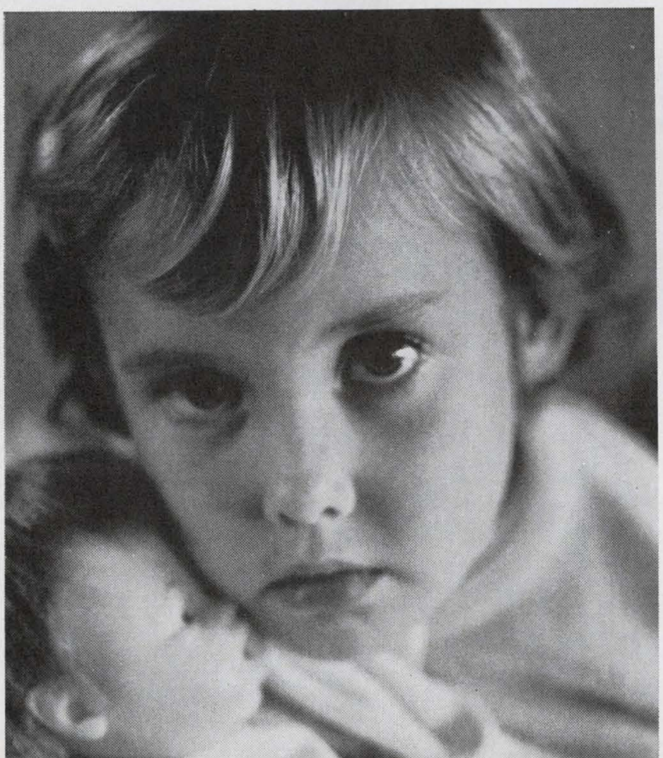

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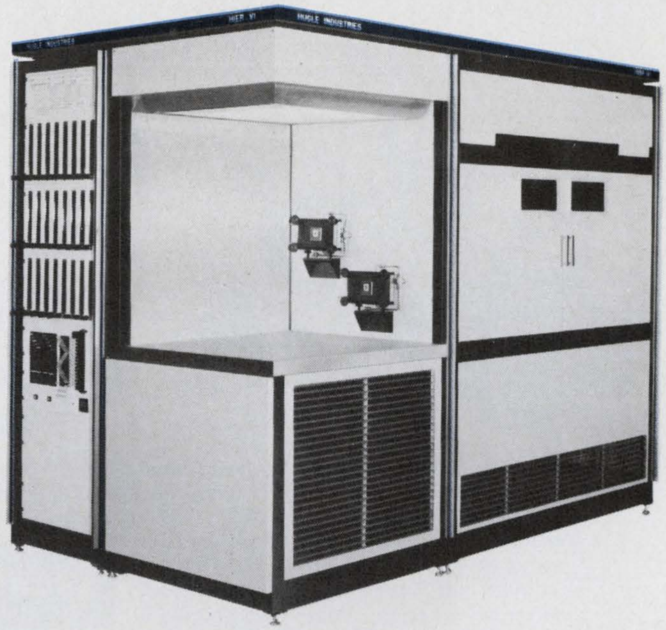

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for all devices.

Unit price of the quad 32-bit static register is $35, while the quad 32-bit dynamic two-phase register is $20, as is the quad 32-bit dynamic one-phase device.

The variable-length 64-bit register is $16 in either one- or two-phase form.

Also in either one- or two-phase form, the 256-bit dynamic register is priced at $30.

All registers are available in versions that work from —55°C to +85°C. On the average, having this broader temperature range doubles the price of the register.

Electronic Arrays Inc., 501 Ellis St., Mountain View, Calif. 94040 **[444]**

New semiconductor

Dopant diffusion done without gas

Film with suspended p-type or n-type impurity placed on wafer and then fired

When it comes to making semiconductor devices, Semi-elements, Inc. believes in laying it on, "it" being the company's new dopant film.

These films, a mixture of doping impurity and binder, are placed on top of a semiconductor wafer. When the wafer and film are fired, the dopant diffuses through the semiconductor.

Semi-elements is making both p- and n-type films in thicknesses from 0.0005 to 0.002 inch, and in a wide range of dopant concentration and material.

And for special applications, the company can make films that are over 0.01-inch thick.

Gaseous and ampule diffusion are the common techniques for making p-n junctions. Ralph Christensen, director of new product development at Semi-elements, says the film approach is better for several reasons.

First, he says, the film is easy to handle. It can be punched or cut into shapes that exactly fit the wafer. And since the fit is so pre-

. . . films are being used in making 25-watt diodes . . .

cise, there's little waste.

Firing costs can be lower, according to Christensen, because alternate layers of film and wafer can be stacked and then fired simultaneously. One side of the film acts as a diffusant source; the other as a passive non-sticking surface. And the device maker can do the firing in the same oven he now uses for gaseous diffusion.

The film has to be fired only once. Separate surface-diffusion and drive-in steps are not necessary.

Christensen adds that the film technique also is better than the paint-on diffusion method because with films it's much easier to get uniform surface distribution.

One junction. The films are suitable for making diodes with either simple p-n junctions or graded junctions, like a p-n, n^+ junction.

The smallest junction depth that can be made is 35 microns. Christensen says that Semi-elements engineers are developing films that will make one-micron junction depths possible, thus making the film attractive to transistor manufacturers.

All common p- and n-type dopants are available. "We offer most arsenic and phosphorus compounds for n-type doping, and boron compounds for p-type," says Christensen. "We hope to be able to offer our customers metallic dopants soon."

Semi-elements can also match the binder to the application. The most commonly used binders are Cyanocel and ethyl cellulose.

Usually during firing, the binder is burnt off.

The company says shelf life is a couple of months. "You don't have to be too careful handling the film either," according to Christensen. "And it won't oxidize."

He says Solitron Devices, Inc. is already using the film to make rectifiers that are rated from 25 watts down into the milliwatt region.

Price varies according to type of dopant and concentration. A typical boric-acid film costs $1 per square foot.

Semi-elements, Inc., Saxonburg Blvd., Saxonburg, Pa. 16056 [445]

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Born, not made

Antenna Engineering
Walter L. Weeks
McGraw-Hill Book Co.
370 pp., $13.50

Antenna design is one field, it seems, that demands total involvement. Antenna designers are a rare breed—even if they forget much of what they learned about circuits and active device operation, they seem to have an intuitive understanding of the real basics of electrical engineering—the behavior of electromagnetic fields. In fact, one wonders if antenna design can really be taught—it has enough empiricism to make it more of an art than a science.

Professor Weeks, of Purdue University, recognizes this by leading into the subject with a long chapter on small antennas. It can be read with little effort since there are few interruptions for mathematical statements. With this background, the reader moves on to the larger antennas, where other effects come into play, with a firmer intuitive understanding of their operation.

When it comes to antenna measurements, Weeks concedes that antennas are structures which are subject to environmental effects that are difficult to account for theoretically, since much of the design procedure must be based on experiment.

Weeks does a particularly good job on frequency independent antennas when describing the line of reasoning used in developing such structures. It goes like this: since length is the parameter that determines frequency, an antenna with no characteristic length should be frequency independent. A spiral, for example, has no characteristic length if it's made long enough so that current falls off rapidly, essentially disappearing at the point of truncation.

Certainly, this book alone won't make anyone an antenna engineer, but it's a good starting point.

Cross reference

Switching Theory
Paul E. Wood Jr.
McGraw-Hill, Inc.
390 pp., $13.50

Of the many books on switching theory published in the last decade, this is noteworthy because of its comprehensive treatment. It should be useful both as a text and as a library reference.

Sequential networks, for example, are covered in welcome depth. This subject must be completely understood by those applying digital systems in such areas as communication switching and control, telephone switching networks, and data processing.

Another plus is a chapter on

New Books

Boolean algebra that's better than those found in most books now used as references in probability, random processes, and statistics.

And the author employs some unusual methods for analyzing and minimizing switching networks—the application of matrixes instead of the conventional use of Karnaugh maps, for example. He uses matrixes for network analysis and simplification by setting up a matrix for the network and then bringing in the node removal technique. Since background material in this section isn't extensive, the reader must be familiar with matrix mathematics in order to fully appreciate the presentation.

There are cases where some excellent techniques are used that the reader won't be able to extract easily. Occasionally, minor points are over-explained or material with very significant implications is minimized. For example, in the second chapter four pages are used to derive equations for series and parallel resistors although only one line is used for deriving an equation that shows how matrix algebra can simplify a problem.

I.P. Magasiny
Paul Loeb

RCA
Camden, N.J.

Recently published

Modern Control Principles and Applications, Jay C. Hsu and Andrew U. Meyer, McGraw-Hill Book Co., 769 pp., $24.50

For engineers who want a reasonably detailed explanation of modern control theory. Takes a pragmatic approach, emphasizing two fundamental areas of automatic control—stability and optimization—and thoroughly describes both time and frequency domain techniques. Also covers various concepts of stability in nonlinear systems, exact techniques, such as Lyapunov's second method, and the basic premises in the formulation of some typical optimal control problems.

An Introduction to Random Signals and Communication Theory, Robert B. Lathi, International Textbook Co., 487 pp., $14.00

Aimed at graduate students, this book takes a physical rather than an axiomatic approach and wherever possible interprets theoretical results heuristically. It includes an introduction to signal analysis and the theory of probability, the concepts, analysis, transmission, and filtering of random signals. Other topics are the transmission of both analog and digital data, information theory, and the performance of various communication systems evaluated against Shannon's results.

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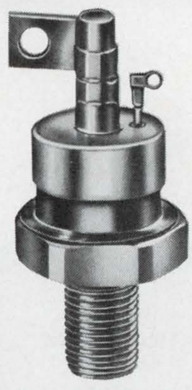

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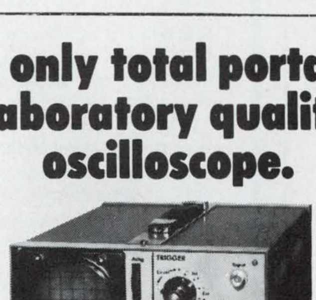

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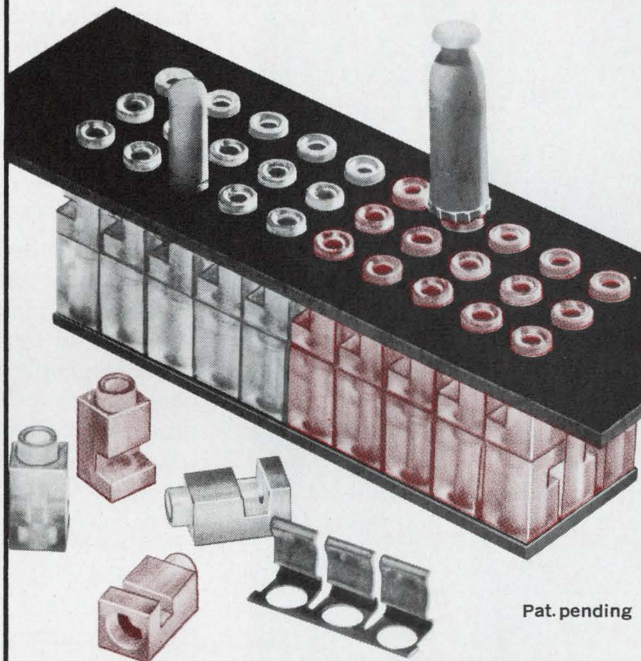

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Technical Abstracts

Get there first

Multiprocessor software lockout
Stuart E. Madnick
IBM Cambridge Scientific Center
Cambridge, Mass.

As the use of computers increases, every individual facility eventually becomes faced with the need to increase capacity. The solutions normally employed are either to replace the equipment with newer and faster models or to obtain additional independent systems. The latter solution, although possibly satisfactory for batch processing, is inefficient for time-sharing. Present trends indicate that future general-purpose computers will be smaller and less costly, but not significantly faster.

Many people see multiprocessor computing systems as the most promising technique for large-scale computer facilities. Projects such as MIT's Multics, IBM's TSS/360, GE's Gecos, and Univac's Exec-8 are developing operating systems for multiprocessor configurations.

To facilitate system scaling, reliability, and modularity, many multiprocessor operating systems are designed to treat the processors as homogeneous system resources. Hence, there is no "supervisor" processor; each schedules and controls itself. To prevent critical races and inconsistent results, only one processor at a time is permitted to alter or examine certain shared system data; all other processors are locked out.

Lockout isn't limited to multiprocessor systems. It's a familiar occurrence on multitask single-processor systems. If two tasks simultaneously request use of the same input-output device, one must be locked out, or blocked, until the device becomes available.

Several operational single-processor time-sharing systems have been estimated to spend up to 50% of their execution time performing supervisory functions. If these systems were adapted for multiprocessing by indiscriminately locking whenever they entered the supervisor state, their locked time (L) might easily exceed their unlocked time (E). However, a system de-

Technical Abstracts

signed with multiprocessor operation carefully planned to minimize lockout occurrences and duration might maintain low values of L/E.

It's difficult to predict how the L/E ratio will be affected by an increase in the number of processors. This depends upon the effectiveness of shared procedures and amount of main storage added. And, if more tasks are allowed on the system, the amount of time required by a locked priority scheduler would be expected to increase.

Presented at ACM National Conference, Las Vegas, Aug. 27-29

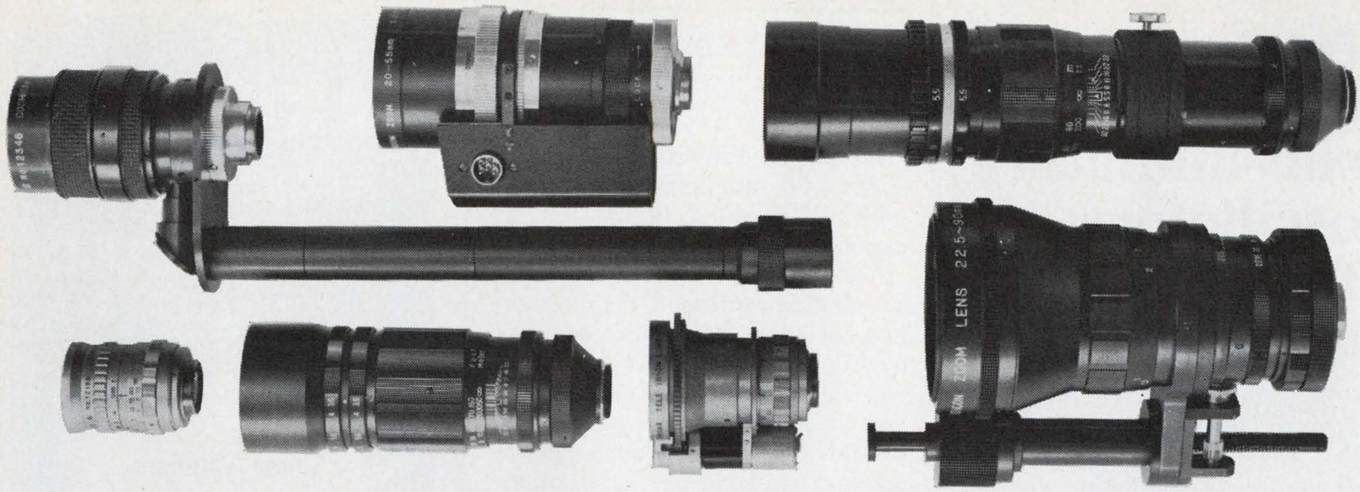
By cable

Solid state amplifiers for uhf cable distribution of tv signals
Brian L. Jones
Fairchild Semiconductor
Palo Alto, Calif.

Before deciding on equipment for a local cable distribution system for ultrahigh-frequency tv signals, the engineer should investigate all aspects of the problem in light of the operating characteristics of an amplifier at uhf frequencies. One important advantage of such a system is that it allows the use of a single frequency, 500 megahertz, in a single octave range from 500 Mhz to 1,000 Mhz to handle more than 80 6-Mhz-wide channels. Because all second-order harmonics fall outside of this band, less equalization is required, and thus the amplifier is somewhat easier to design.

But there are other problems to consider. For example, there is greater cable attenuation at uhf than there is, say, at vhf. Available transistors that provide good power gain at 1,000 Mhz are relatively small in size, requiring operation at low current levels. Thus, at uhf the output power for a given level of third-order distortion is considerably lower than the power obtained from larger devices operating at vhf.

In a typical vhf cable distribution system using 12 channels to drive a cable at a power level of about —10 dbm per channel, the signal



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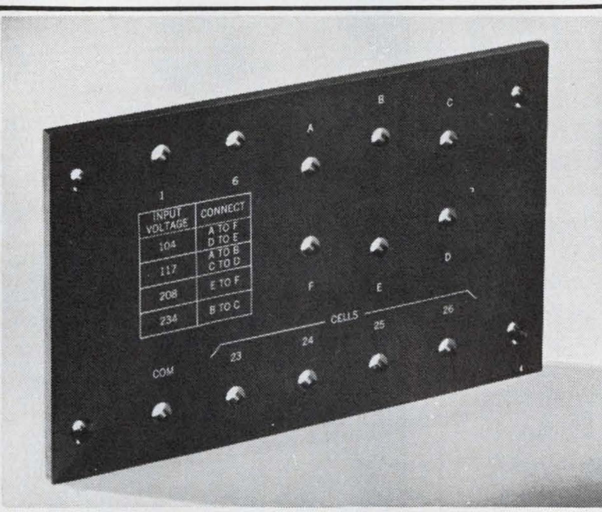

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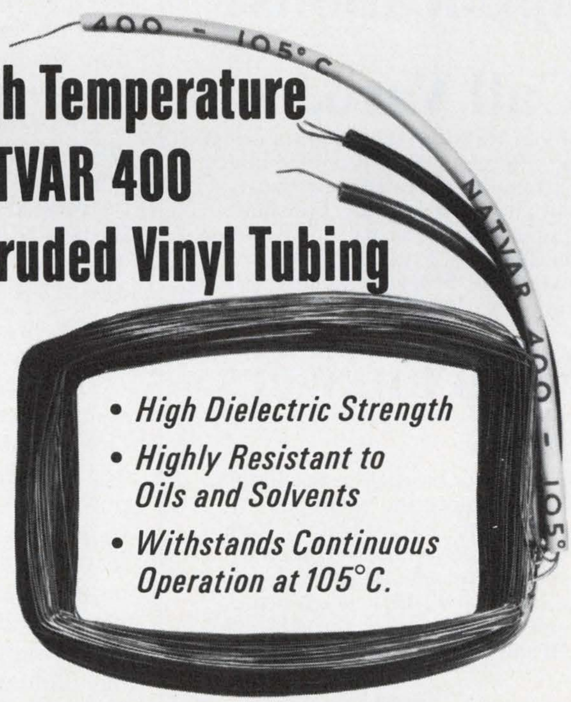

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level can be allowed to decline to about −30 dbm before another amplifier is inserted in the line to maintain the desired signal-to-noise ratio. About 10 db out of the 20 db attenuation represents the through-loss of the directional couplers feeding the subscribers' receivers.

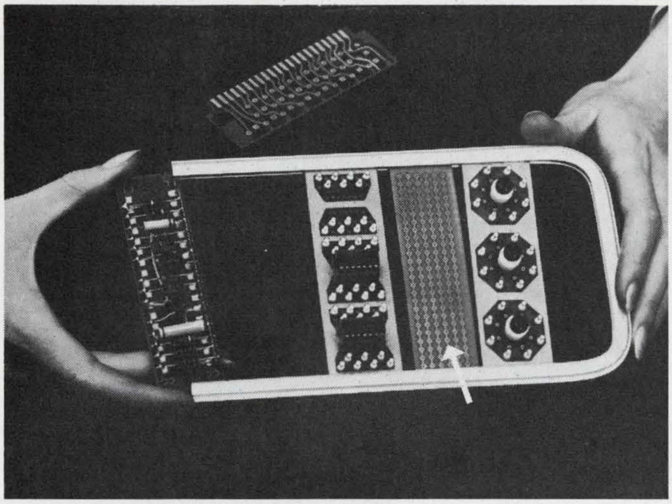
A cable having 10 db of attenuation at 200 Mhz will have a 30-db loss at 1,000 Mhz. Unless special low-loss cable is used, the amplifier must overcome an attenuation of about 40 db. If a single amplifier is used, the output capability would have to be +10 dbm.

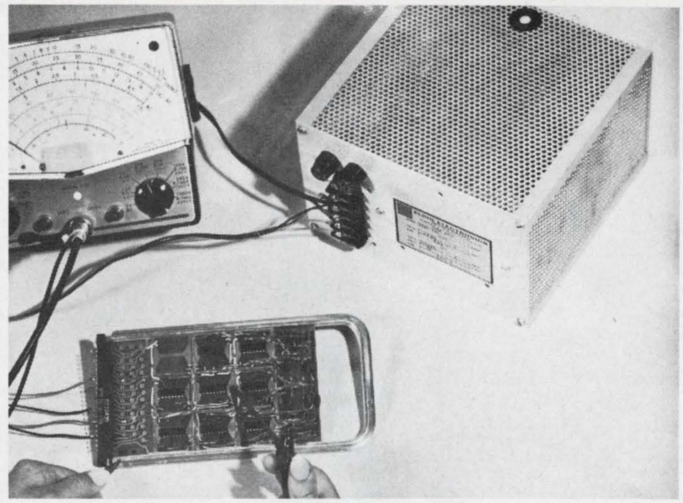
A broadband uhf amplifier designed with presently available transistors can provide the required +10 dbm low distortion signal to a limited number of channels only. This conclusion is based on test results obtained from a common-base, single-stage test circuit. The circuit noise figure was 6 db minimum from 500 Mhz to 1,000 Mhz. The test frequencies used were 600 Mhz and 700 Mhz, providing intermodulation frequencies of 500 Mhz and 800 Mhz. The output levels for −60 db intermodulation were −6 dbm for the lower frequencies and −8 dbm for the higher frequencies.

The test results indicate that in order to maintain the distortion at low level, the signal power must be reduced approximately in proportion to the number of channels. Thus for, say, 50 channels, this would be −17 db or a power per signal of −25 dbm. This is obviously unacceptable.

This limitation can only be overcome by: reducing the bandwidth of the system and hence the number of channels and improving the power handling capability of the transistor. It is feasible to manufacture amplifiers for cable distribution of uhf tv signals using currently available integrated circuit technology. However, because of the high cable attenuation at uhf, many more amplifiers are required in the system than would be needed for similar vhf systems. But the use of IC's should reduce the cost of the amplifiers to acceptable economic levels.

Presented at the International Broadcasting Convention, London, England, Sept. 9-13.





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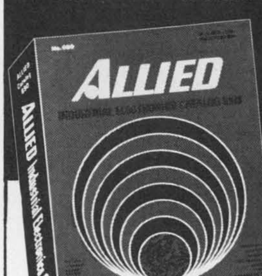

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New Literature

Coaxial attenuators. Weinschel Engineering, Gaithersburg, Md. 20760, has published a data sheet covering model 693 coaxial attenuators, which handle 20 to 30 watts c-w average, 10 kilowatts peak.
Circle **446** on reader service card.

Serial character generator. National Semiconductor Corp., 2950 San Ysidro Way, Santa Clara, Calif. 95051. Application note AN-14 discusses the MM420/MM520, a 256-bit serial character generator. **[447]**

Nickel alloys. International Nickel Co., Huntington, W. Va. 25720, has available a 28-page booklet on commercially pure nickel alloys. **[448]**

Computer-designed motors. McLean Engineering Laboratories, Princeton Junction, N.J. 08550. A six-page short-form catalog presents a line of computer-designed fractional horsepower motors. **[449]**

Relays. Kurman Instruments Corp., 15 Burke Lane, Syosset, N.Y. 11791. A 28-page catalog includes all the in-stock and standard relays available from the company's general-purpose, sensitive, and military lines. **[450]**

Photofabrication products. Eastman Kodak Co., 343 State St., Rochester, N.Y. 14650, offers a catalog covering photosensitive resists, film, plates, chemicals, and equipment used in photofabrication. **[451]**

Plane and stack tester. Honeywell Inc., Computer Control Division, Old Connecticut Path, Framingham, Mass. 01701, has available a brochure on the model 3702 memory-plane stack tester. **[452]**

Cold cathode switch. EG&G Inc., 160 Brookline Ave., Boston 02215, has issued an application note describing the characteristics and operation of the cold cathode KN-22 Krytron to switch pocket cell crystals. **[453]**

Electric soldering oven. Fostoria-Fannon Inc., 1200 N. Main St., Fostoria, Ohio 44830. Model 68-080 electric infrared soldering oven for the electronic production shop is described in bulletin 50-551-68E. **[454]**

Ultrasonic point level system. Brooks Instrument division, Emerson Electric Co., Hatfield, Pa. 19440, has published a technical bulletin on an ultrasonic point level system that measures all dry solids. **[455]**

Digital data equipment. Braincon Corp., Marion, Mass. 02738, offers data and

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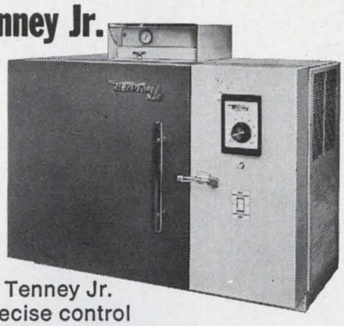

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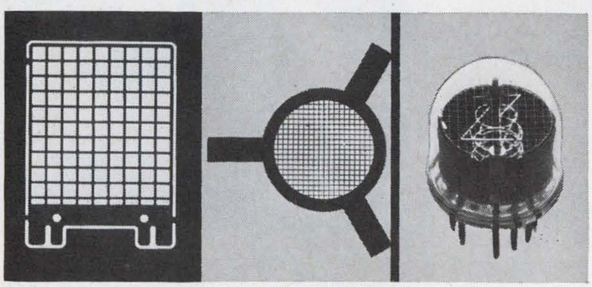

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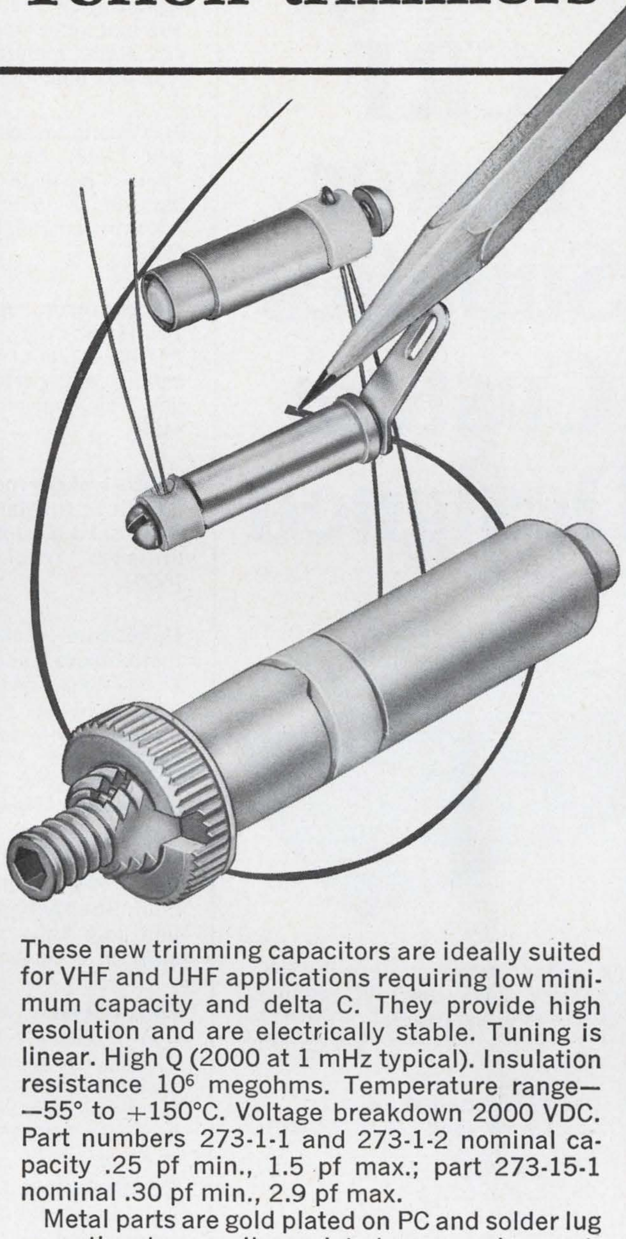

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New Literature

specification sheets describing its type 595 magnetic tape data processor, type 407 digital magnetic tape recorder, and type 463 analog-digital converter. **[456]**

Relays and switches. ITT Jennings, P.O. Box 1278, San Jose, Calif. 95108, offers a six-page product-line summary featuring a comprehensive selection of electromechanical relays and switches. **[457]**

Ferrimagnetic components. I-Tel Inc., 10504 Wheatley St., Kensington, Md. 20795. Bulletin 1929-23 gives specifications and performance curves for a line of ferrimagnetic components. **[458]**

Punch and die manual. Sealectro Corp., 225 Hoyt St., Mamaroneck, N.Y. 10543, has issued a punch and die manual for Press-Fit Teflon-insulated terminals. **[459]**

Light-beam oscillographs. Midwestern Instruments Inc., 6422 E. 41st St., Tulsa, Okla. 74135, offers a 16-page catalog listing six models of general-purpose, direct-recording, light-beam oscillographs, their specifications, optional features, accessories, and galvanometers. **[460]**

I-f strip. National Semiconductor Corp., 2950 San Ysidro Way, Santa Clara, Calif, 95051, has published an application note on a complete monolithic i-f strip for a-m/agc applications. **[461]**

Polycarbonate resin. General Electric Co., 1 Plastics Ave., Pittsfield, Mass. 01201. The many uses of Lexan polycarbonate resin in the electronics industry are discussed and illustrated in brochure CDC-469. **[462]**

R-f attenuators. Daven division, Thomas A. Edison Industries, Grenier Field, Manchester, N.H. 03103. Precision r-f attenuators and special devices are the subject of a 16-page catalog. **[463]**

D-c/d-c converter. Microtran Co., 145 E. Mineola Ave., Valley Stream, N.Y. 11580, has available a d-c/d-c converter technical application bulletin. **[464]**

Laser data. Laser Nucleonics Inc., 123 Moody St., Waltham, Mass. 02154, has available a 22 x 24 inch laser data compilation chart. **[465]**

Infrared spectrophotometers. Beckman Instruments Inc., 2500 Harbor Blvd., Fullerton, Calif. 92634, has released a six-page bulletin describing the IR-18 and IR-20 infrared spectrophotometers. **[466]**

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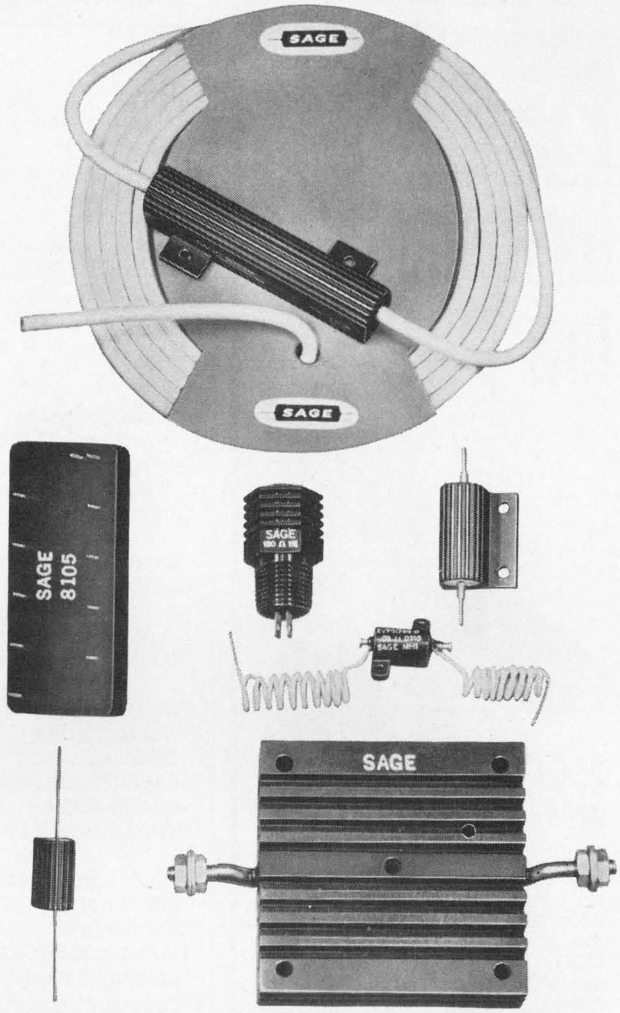

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New Literature

Relays. ITT Components, 14 rue du Gouvernement Provisoire, Brussels 1, Belgium. The "1968-69 Relay Summary" is an 80-page booklet covering more than 150 relay types. **[467]**

Tantalum Capacitors. Components Inc., Biddeford, Maine 04005, has released a general catalog listing a broad line of subminiature and microminiature solid tantalum electrolytic capacitors. **[468]**

Timers. General Time Corp., Torrington, Conn. 06790. Catalog HD12A presents dimensions, adjustable time ranges and detailed specifications for a full line of timers. **[469]**

Ceramic capacitors. Southern Electronics Corp., 150 W. Cypress Ave., Burbank, Calif. 91502, has issued a 10-page catalog covering microminiature ceramic capacitors. **[470]**

Glass memory modules. Corning Glass Works, Corning, N.Y. 14830. Data sheet CE-5006 describes digital glass memory modules that permit storage of 200 to 200,000 bits at a bit cost as low as five cents. **[471]**

Mixer preamplifiers. RHG Electronics Laboratory Inc., 94 Milbar Blvd., Farmingdale, N.Y. 11735, has issued bulletin MP-102A describing its mixer preamplifiers. **[472]**

Silicon power transistors. Silicon Transistor Corp., East Gate Blvd., Garden City, N.Y. 11530, announces three data sheets, each of which fully describes two 50-Mhz npn silicon planar power transistors with gain specified at 5 amps. **[473]**

Reed switches. Hamlin Inc., Lake & Grove Sts., Lake Mills, Wis. 53551. Magnetic reed switch selector brochure No. 7 is now available. **[474]**

Adjustment potentiometers. Bourns Inc., 1200 Columbia Ave., Riverside, Calif. 92507. An eight-page brochure features the nomenclature, specifications, price listings, and detailed photos of more than 50 adjustment potentiometers. **[475]**

Solid state choppers. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343, has available a 62-page catalog describing its complete line of 30 solid state choppers. **[476]**

Integrated semiconductor modules. Alpha Industries Inc., 381 Elliot St., Newton Upper Falls, Mass. 02164, has published an eight-page brochure on a line of integrated semiconductor modules for use in all types of stripline and coaxial r-f structures from d-c to 18 Ghz. **[477]**

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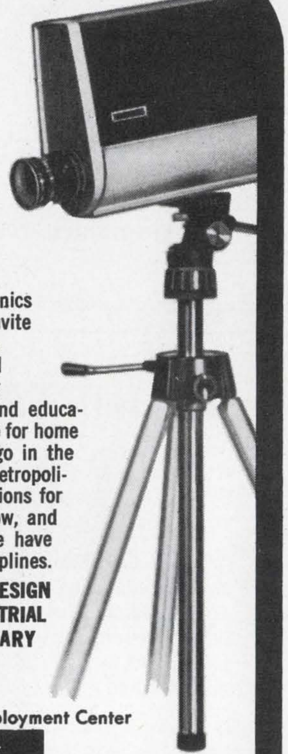

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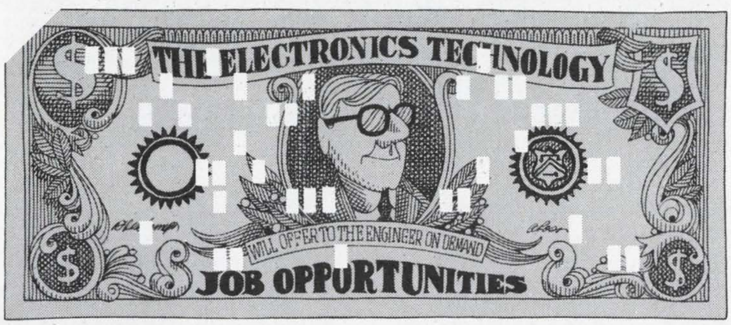

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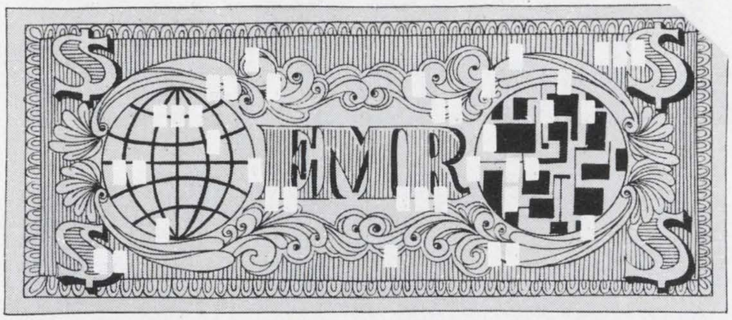

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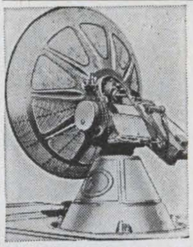

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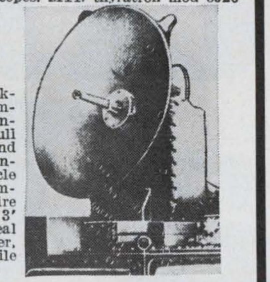

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International Newsletter

October 14, 1968

Japan to test pcm for Intelsat use

Since Intelsat will probably switch from frequency-division to time-division multiplexing for part of its satellite communications band, **the Japanese are preparing a pulse-code modulation time division system for use with the satellites.**

Kokusai Denshin Denwa Co., which operates Japan's overseas comunications system, including satellite transmission, has let a $208,000 contract to Fujitsu to build an experimental pcm system for the existing Juo Machi earth station in the Ibaraki prefecture.

The system, to be delivered by the end of next August, is designed for a maximum of 300 channels in either direction, although all 300 will not be equipped for the experiments. The transmission rate is 50 megabits per second.

KDD will test the system by transmitting from the earth station to the satellite, then back to the same earth station. The system will also be used for transpacific tests with a similar system now being built under Comsat auspices.

GE sells interest in French combine

Now that GE has finally agreed to sell its 49% of Societe Europeenne des Semiconducteurs (Sesco) to its partner, Compagnie Francaise Thomson Houston-Hotchkiss Brandt, **the next step probably will be the merger of Sesco with Cosem, component-making subsidiary of Compagnie Generale de Telegraphie Sans Fil.** In the works since spring [Electronics, April 15, p. 268], GE's move comes on the heels of Fairchild's termination of its partnership with Olivetti and further shrinks U. S. participation in the European semiconductor industry.

GE had offered to take control of Sesco by buying Thomson Brandt's 51% in an effort to reverse the company's string of losses ($1 million last year, with a like amount expected this year), but France's nationalistic government balked. **Instead, the de Gaulle regime persuaded Thomson Brandt to buy out GE and merge Sesco with Cosem. Industry sources say Thomson Brandt agreed only after the government offered to lend it the $2.5 million the transaction is expected to cost.**

Cosem is the prime beneficiary of the government-subsidized Plan Composants, which aims to develop all-French integrated circuits and other components, freeing France's electronics industry from reliance on American technology. French authorities are apparently banking on a Cosem-Sesco merger to bring this top-priority goal closer. With details to be announced within a few weeks, it's understood that the deal calls for GE to continue to give Sesco technical aid. **Cosem, too, is getting American help—notably from National Semiconductor—in designing its "all-French" components.**

Sesco, founded in 1961, had 1967 sales of $12.3 million. Cosem had 1967 sales of $14 million.

Hitachi makes laser to track satellites

Japan, keeping pace with U.S., French, and Russian technology, has developed a laser system for tracking satellites. **Capable of homing in on satellites from 185 to 930 miles away, the system, developed by Hitachi Ltd., uses a ruby laser with a peak output of five megawatts and a repetition rate of one pulse per second for up to six minutes.** Beam spreading is less than one milliradian; Hitachi says its accuracy of one part in a million is 10 times better than radar's.

The Cassegrain-type receiving telescope has a filter to keep out light wavelengths other than those emitted by the laser, an effective diameter of 2.60 inches, and a focal length of 16 feet. A photo-multiplier tube converts the optical signals into electrical impulses.

Tracking by Hitachi and Tokyo's Astronomical Observatory will begin within six months. There are now at least six satellites in orbit with reflectors suitable for laser tracking.

Philips seen shifting to IC's in tv sets

Some U. S. semiconductor makers are convinced that Philips Gloeilampenfabrieken, Europe's largest electronics firm, will start phasing integrated circuits into its television sets next year. **The move could trigger a European rush to get on the market with IC sets.**

According to these sources, Philips will begin the switch during the first quarter of 1969 by putting a monolithic, 1-watt audio amplifier into some sets. **Toward the end of the year, they say, the company will shift to a monolithic circuit for the i-f amplifier as well.** By 1970, it's estimated, every Philips television set produced in Europe will have at least one IC in it.

U. S. and Japanese set makers have been using IC's for several years.

Siemens adds pair of computers to line

Siemens AG, moving to strengthen its foothold on the West European computer market, is about to introduce two new models for its 4004 line—the 4004/16 and the 4004/26. **The West German firm says production of the new machines will start before the end of the year at Augsburg; first units will be on the market early in 1969.**

The series is a version of RCA's Spectra 70. The 16 and 26, like the bigger 4004 models, use monolithic integrated circuits. **They're intended primarily for real-time commercial and administrative applications.**

The 4004/16 has a maximum storage capacity of 16,384 bytes; the 4004/26 has 65,536. The store cycle time for both machines is 0.880 microsecond per byte.

Workers scarce in West Germany

Now that West Germany's electronics industry has begun to recover from the 1967-68 slump, it's facing a new problem: a labor shortage that the industry association has labeled serious. Moreover, all signs seem to indicate that the lack of workers will become more acute, particularly where automatic production techniques can't be used. **The result is that many firms, primarily in the instrument, control, and communications areas, are working overtime to cope with an ever-growing order backlog.**

But especially affected is the entertainment sector, now bracing for a pre-Christmas sales rush. Color-tv sales, running behind predictions for most of this year, are up again; some observers believe they may top the quarter-million mark for 1968.

Addenda

Greece plans to slash television set imports by as much as 50%. The move comes when the Greek market is expanding rapidly. **During the first quarter of 1968, imports reached 10,500 sets; the total for all last year was 12,500.** . . . Standard Telephones & Cables, ITT's British subsidiary, has landed a $36 million contract to supply a microwave transmission system to Brazil's state telephone company.

Electronics International

Japan

One to make ready

Ten years ago, Junichi Nishizawa, a professor at Tohuku University, proposed a solution to a problem that didn't exist yet but was certain to come up in the near future: how do you build a high-efficiency low-noise diode oscillator to be used as a frequency generator in the millimeter and submillimeter wave regions?

Impact-avalanche and transit-time (impatt) diode oscillators, using both avalanche and transit-time effects in a p-n junction to provide negative resistance, had been proposed independently by Nishizawa, Yasushi Watanabe, and W.T. Read. At lower frequencies, these diodes are quite efficient. But as frequency is increased, efficiency drops because of the transit time in the avalanche region. And the avalanche region can't be narrowed because that would yield a poor injection effect and the diode wouldn't oscillate. Why, hypothesized Nishizawa, couldn't negative resistance be obtained from the transit-time phase delay of carriers injected by tunneling?

Eureka. So Nishizawa and his team at the university's Research Institute of Electrical Communications did just that. The result is a diode oscillator generating frequencies as high as 134 gigahertz. It uses gallium arsenide p-n junctions with both tunnel and avalanche electron injection; the phase shift necessary for oscillation depends primarily on the transit time of the injected electrons in the semiconductor bulk. Laboratory measurements indicate that tunnel current coexists with avalanche current; what's more, says Nishizawa, extrapolation of that data shows that diodes with still thinner junctions will break down by tunnel injection only and will oscillate at still higher frequencies.

Tunnel injection has several advantages over avalanche breakdown:

- Breakdown voltage is low, making possible millimeter-wave oscillators that consume little power and are highly efficient.
- Less noise is generated.
- Perhaps most important, the time constant of tunneling is much lower.

Second life. The diodes used by Nishizawa's team were mostly laser types that were too highly doped for laser operation. The substrate was p-type GaAs. Using liquid-phase epitaxial techniques, the lab team grew an n-type layer. Junctions were plated with nickel and gold to obtain ohmic contacts, diced into pellets with areas of 0.1 to 3 square millimeters, then soldered to copper plate to produce devices to be mounted in a waveguide or waveguide resonator.

Oscillations were at frequencies ranging from 21 Ghz up to the 134 Ghz; output power at the higher figure was about a milliwatt. As frequency increased, breakdown changed from mainly avalanche to mainly tunnel; the temperature coefficient beta of the bias voltage at which avalanche breakdown occurred was positive, but was negative at the tunnel breakdown point.

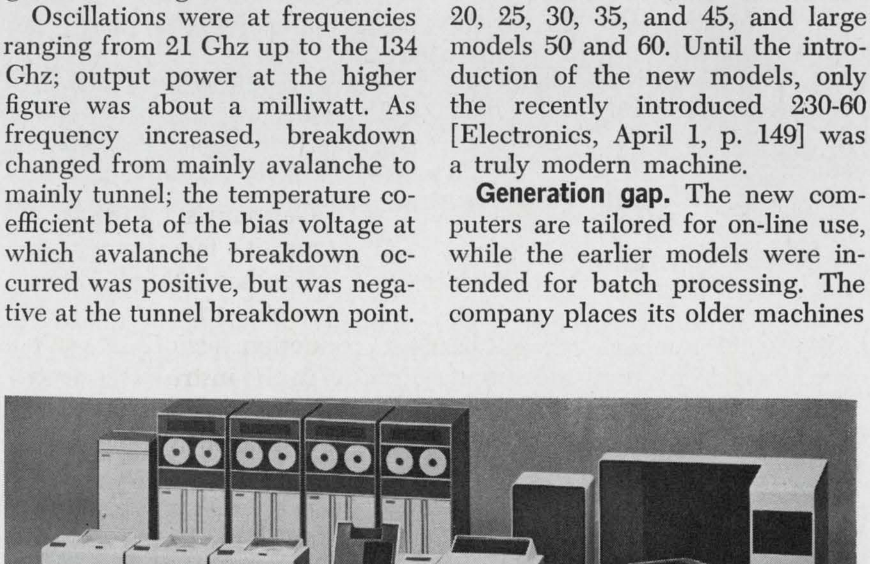
Nishizawa will describe his work at the International Electron Devices meeting in Washington, D.C., October 23-25.

Calculated move

Most anyone in the U.S. who thinks about shopping for a computer thinks first of the International Business Machines Corp., with the result that IBM has about three-quarters of the market. But in Japan the picture is quite different. There, three manufacturers run neck and neck with about 20% of the market apiece, while three others compete for the rest.

Fujitsu Ltd., one of that top trio, has added to its stable in hopes of opening some daylight between itself and the rest of the pack. Three models—the 25, 35, and 45—have been added to the Facom 230 series, which now stacks up this way: the small model 10; medium models 20, 25, 30, 35, and 45, and large models 50 and 60. Until the introduction of the new models, only the recently introduced 230-60 [Electronics, April 1, p. 149] was a truly modern machine.

Generation gap. The new computers are tailored for on-line use, while the earlier models were intended for batch processing. The company places its older machines



Just around the corner. Mockup of the Fujitsu Facom 230-25, one of three new models introduced by the company to fill out the series 230. First 25's will be ready by next spring.

midway between the second and third generations and the newer ones between the third and fourth.

The control memories, which use medium-scale integrated circuits made by Fujitsu, work on a cycle time of 125 nanoseconds, and have a stored monitor program for multiprocessing. The 25 and 35 have the same logic, but the 35 is faster and has more memory capacity. The 25 has a memory cycle time of 750 nsec per byte, and a main memory capacity ranging from 8,000 to 64,000 bytes, with a basic addition time of 3 microseconds for 16 bits and a multiplication time of 17.2 μsec; there are six data channels. The 35, by contrast, has a cycle time of 250 nsec per byte and main memory capacity of 32,000 to 128,000 bytes; basic addition time is 1.5 μsec for 16 bits, multiplication time 8 μsec, and there are eight data channels.

The 45's credentials: memory cycle time of 250 nsec per byte, capacity of 64,000 bytes to 1,024 kilobytes, basic addition time of 1.2 μsec for 16 bits, multiplication time of 5.8 μsec, 32 data channels.

Options. The 25 and 35 give the user a choice of real-time or batch operating systems, or both, while the 45 offers only real-time operation. In practice, though, the 25 is most useful for up to three batch tasks. The 45 is a true multiprocessing real-time computer in which two main frames can be used together.

The first units of the 25 will be ready next spring; they'll rent for $2,700 a month. The 35's will be ready for delivery in the fall of 1969; rental will range from $4,000 to $19,500. The model 45 won't be ready for delivery until the spring of 1970, and will rent for $8,000 to $55,000.

Tooling around

How does a firm with 90% of the Japanese market for numerically controlled machine tools keep that lion's share? Fujitsu Ltd., which claims just such a lead, thinks it has an answer—a computerized numerical control system.

Fujitsu's system—dubbed Fanuc (for Fujitsu automatic numerical control) 250—can control a milling or drafting machine, for example, and also can automatically inspect and measure the first product of a particular run, using input from either a mechanical probe or an optical system, such as a vidicon pickup or laser.

Something borrowed. The system, which will cost around $84,000 depending on options, is built around a computer that uses the same electronic hardware as the company's Facom 230/25, set to go on sale next spring [see story above].

The Fanuc 250's computer has a cycle time of 1.5 microseconds per 2-byte word, making it faster than Fujitsu's Facom 270/20 medium-size control computer. However, memory size for the system's computer is limited to options of 8,000 or 16,000 words of 2 bytes each. Software for the system includes an assembler but not a compiler, because the memory isn't large enough.

Like most other Fujitsu numerical control systems, Fanuc 250 is designed for open-loop drive of the company's electric or electro-hydraulic pulse motors. Response for these motors, which step up one position for each pulse received, ranges up to 16,000 pulses per second.

The computer greatly increases the number of automatic operations, such as adjustments for the diameter of the cutting tool. It isn't necessary to alter the program for each diameter.

Neither is it necessary to specify a cutting speed in the program; the computer automatically adjusts to the most efficient speed on the basis of data from transducers that measure cutter temperature, deflection, and other factors that have a bearing on cutter performance and durability.

Something new. Fanuc 250 can effect four- and five-axis control, meaning it can translate along three axes as well as rotate around two of them.

Finally, Fujitsu has developed its own version of the APT (automatic programed tool) language, which, not surprisingly, it calls FAPT.

Used for automatic inspection and measuring, Fanuc 250 can give coordinates in either two or three dimensions; the output can be typed or punched on tape.

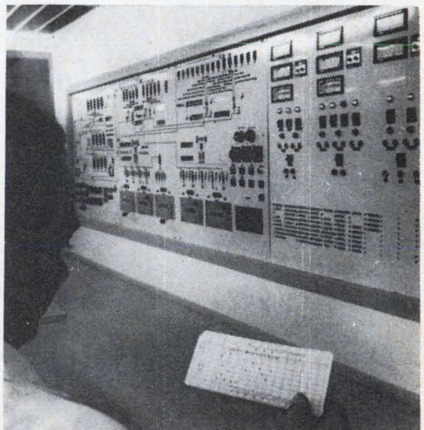
The system can produce a full-scale part directly from reduced or enlarged drawings or models or scale parts from measurements of life-sized drawings or models. It can rotate the axes of a drawing, generate isometric or perspective drawings, and can be made to automatically produce dashed and center lines.

Fujitsu expects to be able to deliver six of the Fanuc 250 systems by next April and another 20 to 30 units in the next 12 months.

West Germany

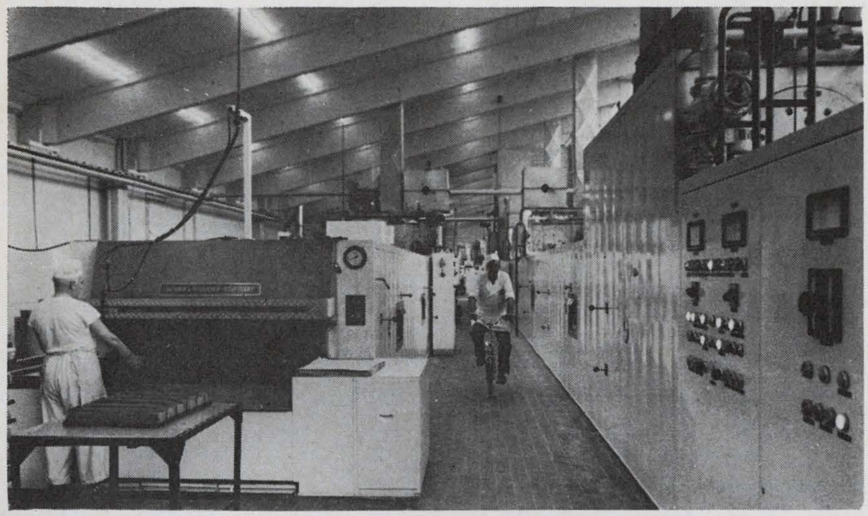
Meeting a knead

A curious leftover piece of Nazi legislation is a West German law that forbids commercial baking between 9 p.m. and 4 a.m., leaving little time for bakers to deliver fresh bread to breakfast tables.



It goes in here . . . Harry-Brot bakery is controlled by punch cards and an IBM 360/20 computer.

So great is the demand for freshly baked breakfast delights that one enterprising West German businessman has negotiated a deal with authorities in East Germany, where the no-bake law has been repealed, by which thousands of freshly



. . . and comes out here. View of the West German baking firm's main floor, with control equipment at right and ovens at the left. Harry-Brot is the first baker in the nation to use computers. Now it will be able to deliver fresh bread in time for breakfast despite a law forbidding commercial baking from 9 p.m. to 4 a.m.

baked rolls are sent across the border each day for early-morning delivery to households in the border area.

No help. But such a scheme by no means satisfies West Germans in other parts of the country, nor does it make the large commercial bakeries (small bakeries for the most part ignore the restriction) very happy.

So, most large bread and roll factories are turning to automation as a means of baking more in less time, and way out in front of the pack is Harry-Brot, a 280-year-old baking firm with several plants in northern Germany.

In the firm's new $3.25 million plant on the outskirts of Hanover, electronics is used to control all major phases of the baking process. While computer control of bakeries is not new—for instance, the Kitchens of Sara Lee outside Chicago put its facility under the direction of a Honeywell 610 in 1964—this is the first time a German bakery has gone this route.

It's been estimated that Harry-Brot has spent $250,000 on electronic equipment at the Hanover plant, whose daily output is about 120 tons of bread, rolls, and cake. Now, the firm is planning to automate operations at its Hamburg facility as well.

Pinch of data. An IBM 360/20 computer processes and stores all data pertinent to the baking process. At a signal from the master baker, the computer initiates the weighing of solid ingredients at a weigh station. When the scales, which have a digital output, reach a specified weight, the computer starts the flow of ingredients through a pneumatic flow system to a mixing and blending station. There, the liquid ingredients—salt and yeast solutions and water—are added to the batch for preparing the dough.

Rise time, baking time, and cooling time are controlled by the line frequency applied to the motors that feed the conveyor belts through the ovens and the cooling and rise chambers.

In the ovens, some of which are up to 750 feet long, temperatures are regulated by conventional means.

Fixing the brake

You hit the brakes hard. They lock. The car goes into a skid. Every driver who has ever operated an auto on wet, snowy, or icy pavement can recite that litany—and he knows he should pump the brakes gently to avoid a skid. But the instinct is to step on the brake pedal, no matter what the condition of the road, and instinct dies hard.

Auto makers would like to replace instinct with electronics. Earlier this year, for example, the Kelsey-Hayes Co. of Detroit brought out a braking system, controlled by what it called a small computer, designed to prevent wheel lock by taking over the job of applying varying pressure to the brakes. Ford is including it in some models. Now Teldix GmbH, a joint venture of AEG-Telefunken and the Bendix Corp., has developed an electronic antiskid system it touts as providing the answers to the three major drawbacks of existing automobile braking systems. Those are, says Teldix:

- Little brake pressure is transmitted to the wheels for relatively long periods.
- Present systems don't perform equally well on dry, wet, and icy surfaces. American engineers, however, point out that they can't be expected to.
- Response time is slowed, and size is added to the unit, because vacuum principles are used to actuate valves.

Added edge. The Teldix system, instead of responding to a certain skid value, senses wheel acceleration and determines the braking force needed for any road condition. Moreover, signals go directly to the valves, considerably reducing response time from that of vacuum systems.

Unlike the Kelsey-Hayes system, Teldix's is designed for four-wheel brakes. The electronic unit—about 1 x 3 x 5 inches—is mounted on a pressure regulator and contains a discrete-component logic circuit for each wheel. There are four sensors —one for each wheel—and a brake-fluid return pump.

Brake fluid in the master cylinder goes to the pressure regulator and then to the individual wheel brake cylinders. The sensors detect periodic changes in acceleration and deceleration, and control the pressure regulator.

Slows fast. The sensors develop signals that vary as a function of acceleration. The signals are powerful enough to handle braking up to 40 G's on an icy surface within a fraction of a second.

The sensor signals are fed to the electronic unit whose logic circuitry evaluates their sequence and produces pulses for controlling the valves in the pressure regulator.

Several German car manufacturers, among them Daimler-Benz AG, maker of the Mercedes, are testing Teldix prototypes. Once production starts, says Teldix, cost will be around $150 per car. Also, Bendix will incorporate some Teldix principles in an antiskid system for U.S. cars.

Soviet Union

The Italians are coming

Despite—or perhaps because of—the invasion of Czechoslovakia, the Russians, wanting to show that it's business as usual, are on the verge of signing another major industrial contract with the Italians.

This time it's with Ing. C. Olivetti & C. S.p.A. for a plant that would produce a variety of computer peripheral equipment, including electromechanical desk calculators, accounting machines that can read and punch paper tape, and quantity-control production registers that can interface with computers.

Mission to Moscow. Representing Olivetti in the negotiations is Bruno Jarak, one of the company's two managing directors, who recently spent a week in Moscow discussing a detailed proposal for a factory at Oryol, 200 miles south of the Soviet capital. Reportedly, Jarak invited a Russian delegation back to Italy shortly for what might turn out to be the final meeting. From all indications the deal is expected to be concluded at the latest by January, and possibly sooner—maybe next month.

The major delaying factor is money, and consequently the size of the factory. Olivetti has offered the Soviet blueprints for plants costing $50 million to $92 million.

Yugoslavia

Number game

To telephone, say, Toronto from Belgrade, a caller needs, among other things, time, patience, and a finely honed sense of Rube Goldberg. First he contacts the Belgrade international operator, who calls the Vienna operator. The Vienna operator then relays the Belgrade request to the Paris or Frankfurt operator, who then uses the Atlantic cable to get in touch with the Toronto operator.

And then, finally, assuming the link hasn't been broken—not always a fair assumption—the Toronto operator can connect the Belgrade caller with the number in Toronto. If, on the other hand, the link has been broken, the whole process must begin again.

Hello, central. However, all this may go the way of the horse and buggy by the end of 1970. Yugoslavia is planning to build a $6 million ground station designed to link it with a communications satellite, presumably Intelsat. Then, its citizens will be able to dial directly any number in Toronto—or New York or a host of other cities in the Western Hemisphere—and get their parties within seconds.

The Yugoslavs expect the ground station to pay for itself in about 10 years.

Whether Yugoslavia will apply for membership in Intelsat (International Telecommunications Satellite Consortium) is another question. While membership isn't a prerequisite for use, rumors have been circulating in Washington for months that Belgrade is about to provide Intelsat's first chink in the Iron Curtain.

Around the world

Taiwan. Motorola Inc. is joining the build-a-plant-in-Taiwan-and-prosper club. The Chicago company says the new plant, to be built near the capital city of Taipei, will start turning out subassemblies for consumer electronics products toward the end of next year. Motorola insists that "this production facility will not replace any production capacity presently operating or planned for location in the U.S."

Portugal. Now that Marcelo Caetano has succeeded Antonio Salazar as Premier, the major question among Portuguese businessmen is what will happen to the third five-year plan? Under it, among other provisions, all the major electronics firms in the country—Standard Electric Portuguesa, and the local affiliates of Philips Gloeilampenfabrieken, Britain's Plessey Co., and West Germany's Grundig Werke GmbH—were slated to make big investments. The feeling seems to be that Caetano is a liberal, international-minded man with expansionist ideas who will encourage business to push the gross national product—only $5.5 in 1966—upward. In short, the outlook is bullish.

Austria. Oesterreichischer Rundfunk GmbH, the Austrian broadcasting authority, has signed a $2 million contract with the Radio Corp. of America under which RCA will design and build a color television production center in Vienna and provide it with about $2 million worth of equipment. The new facility, whose completion date has not been set, will be one of the largest and most modern in Europe.

Canada. The Bouchette, Quebec, earth station is in its final stage of construction and should go operational any day now. It's intended for Canada's first domestic communications satellite, which is still in the study-contract stage [Electronics, Sept. 16, p. 239]. The station, designed for unattended operation, will undergo extensive testing to determine its ability to withstand weather conditions. It has a 30-foot parabolic antenna. The station is being built by Northern Electric Co., which, along with RCA Victor Co., has a study contract for the proposed satellite.

Electronics advertisers October 14, 1968

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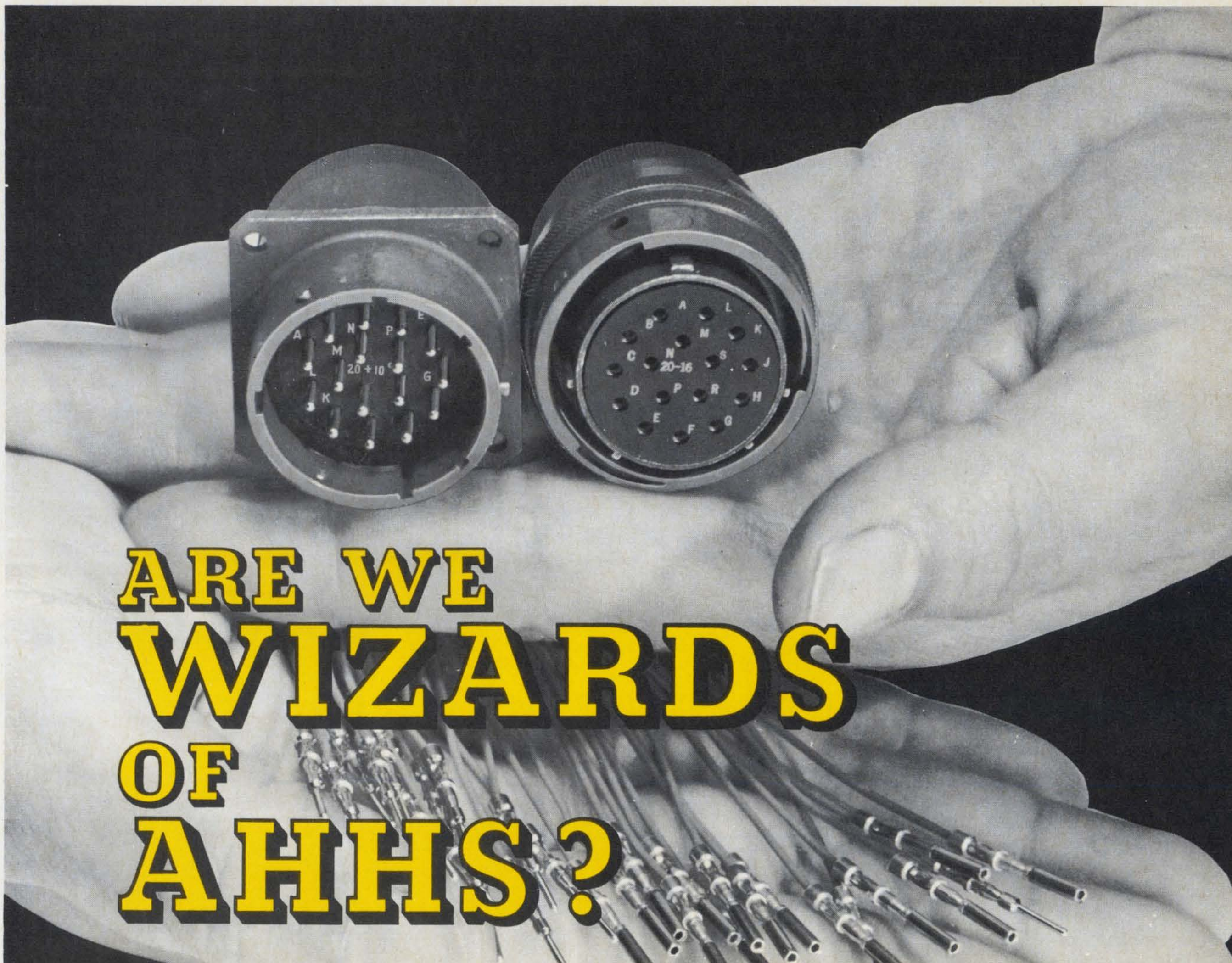

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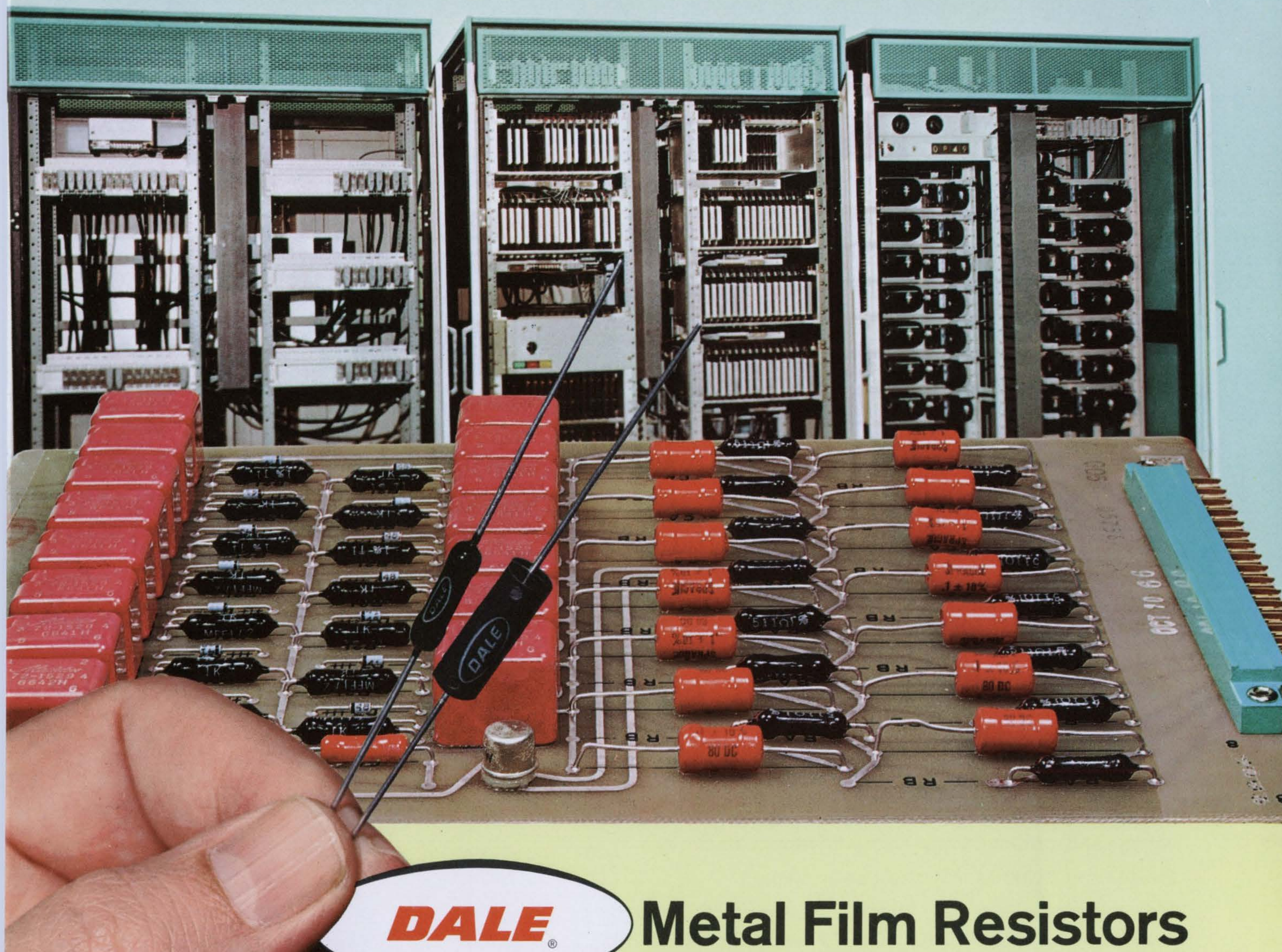

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MF-1/10	RN-55	1/10 w	1/8 w	30.1 to 301K
MF-1/8	RN-60	1/8 w	1/4 w	10 to 1MΩ
MF-1/4	RN-65	1/4 w	1/2 w	10 to 1 MΩ
MFS-1/2	RN-70	1/2 w	3/4 w	10 to 1.5 MΩ
MF-1	RN-75	1 w	—	25 to 2.6 MΩ
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