Electronics®

Linear IC's—operational amplifiers: page 86
Broader use of scattering parameters: page 100
Using a scope for computer display: page 120

October 16, 1967
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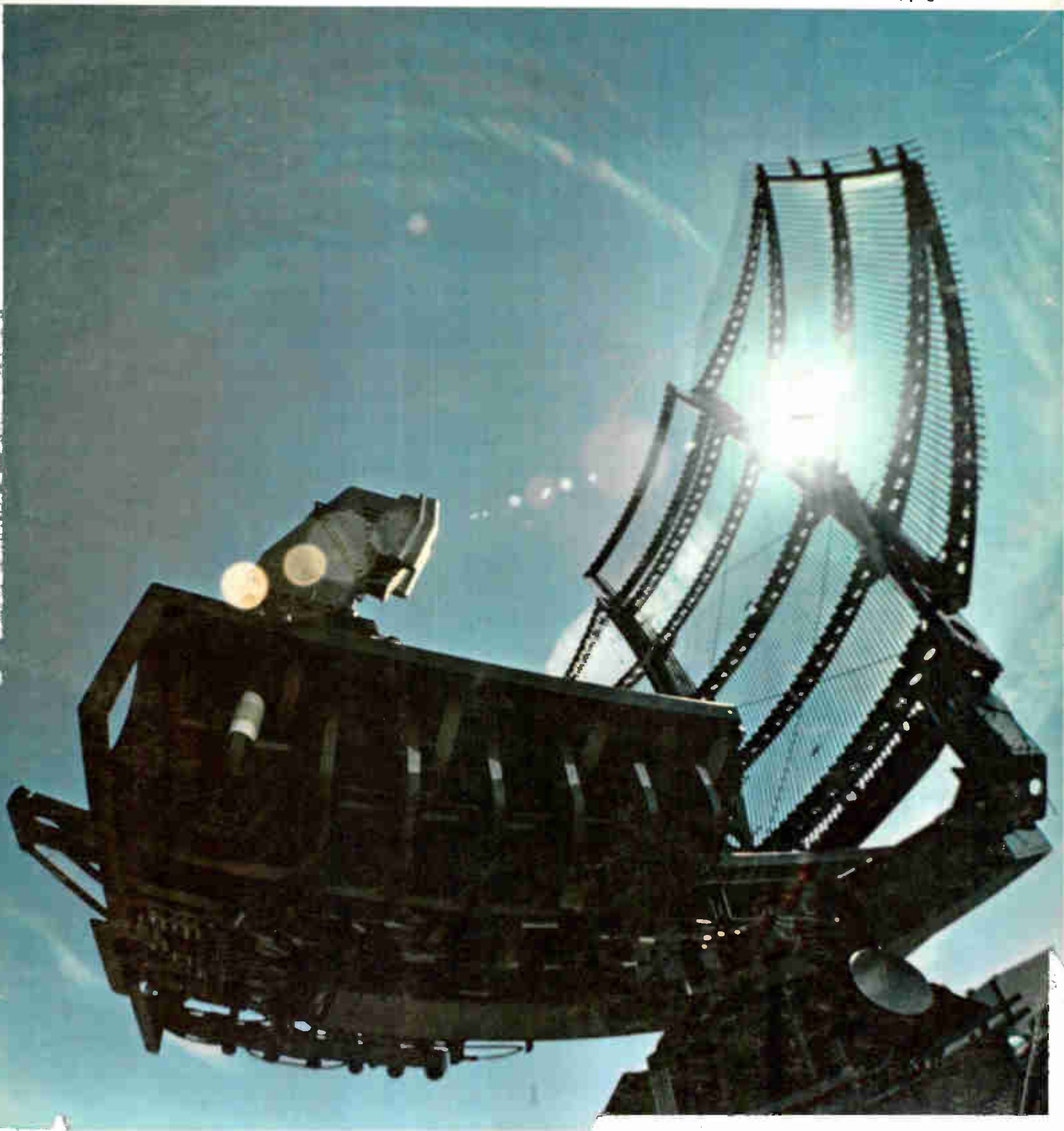
A McGraw-Hill Publication

Below: The military integrates a 3-dimensional radar, page 111



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User convenience and ease of operation were the chief criteria for the front-panel design of the Hewlett-Packard 8690 Series Sweep Oscillators; in fact, you can see the simplicity at a glance.

Features that make this sweeper simple to use include push-button function selection, plug-in RF units for your required frequency coverage, and a high-resolution, 13-inch snap-in frequency scale. Both frequency coverage and operation modes are presented quickly and logically. Independently adjustable START/STOP sweep lets you examine a broad span rapidly. Then, just push the MARKER sweep push button to bracket any portion of the frequency range. You also have calibrated Δ F sweep for high resolution with narrow sweeps.

Choose plug-in RF modules from 1 to 40 GHz and 0.1 to 110 MHz. PIN diode modulation leveling is available from 1 to 12.4 GHz. Model 8690 main frame is $1550, RF plug-ins start at $1575. Price depends on modulation and frequency range.

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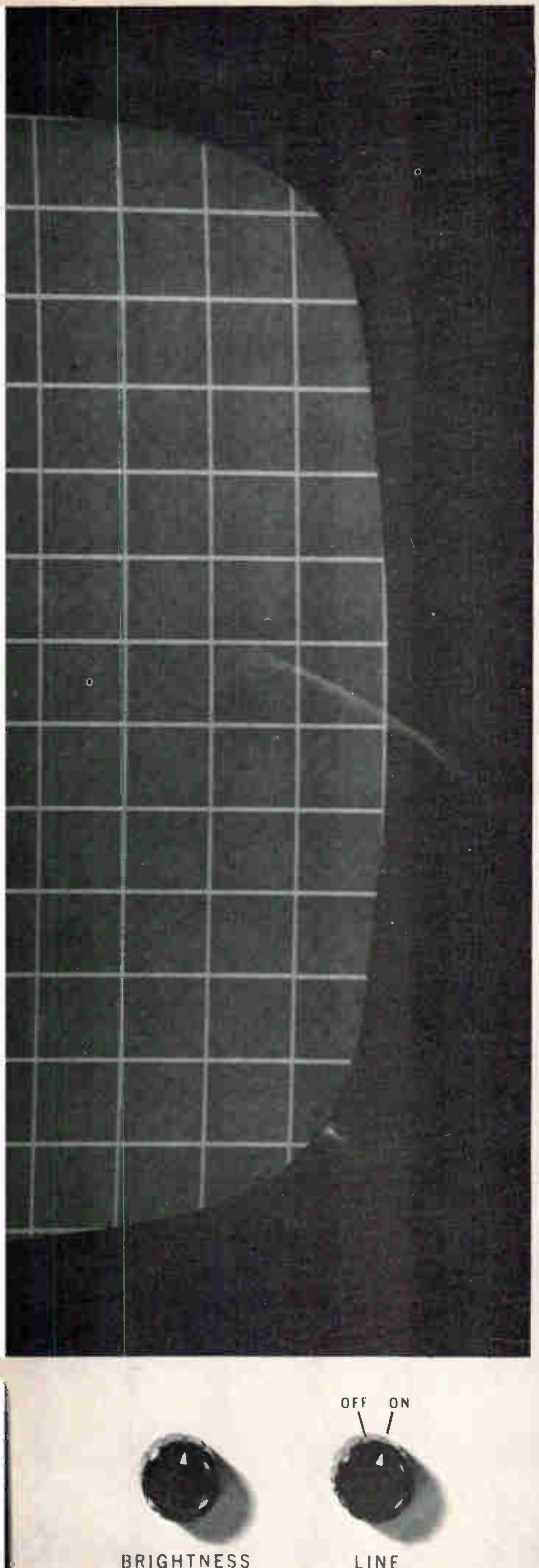
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Electronics

Volume 40, Number 21 October 16, 1967

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Electronics Abroad

New Products

Technical articles

I. Design

II. Application

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Readers Comment

Collision causes

To the Editor:

As a private pilot, a reader of Electronics since 1941, a student of air disasters, and an engineer who has tried several times to "sell" the FAA, I want to comment on your editorial "Frightening testimony" [Aug. 7, p. 23].

The Eastern/TWA collision near Westchester last autumn was not, as you imply, between two planes flying at the same altitude. The Eastern plane was at an assigned altitude 1,000 feet below the TWA craft, but climbed steeply upon seeing the other aircraft. The controller did not have false information.

Also, it was a similar panic climb, and not an "emergency maneuver" ordered by a controller that caused the prior Eastern accident at Kennedy Airport. In both cases the pilots had unreliable horizon information, and thought they were on collision courses.

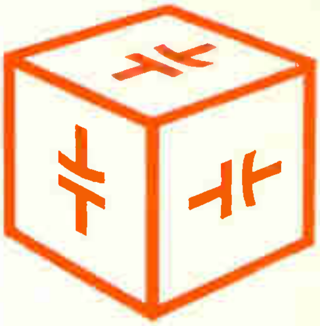
Electronic collision-avoidance systems are splendid for those who can afford them, provided, of course, that they work. But after 25 years of trying, we still don't have reliable radars, nav/com systems, omniranges, or even televisions. Perhaps it will turn out that anti-collision systems will serve only to give air crews a false sense of security, and to occupy them when they should be looking out the window.

The suggestion that air traffic control messages be acknowledged by pushbutton has several flaws. Chief amongst these is the obvious fact that there is no way of knowing that a clearance has been received correctly. Air traffic control procedures are based on an echo check routine, in which the acknowledging pilot states exactly what he is to do, and in what sequence.

Three-D radar is badly needed at major airports and in areas of high traffic density. The reason for not having it is budgetary. One wonders how many radars could be bought for the amount of the FAA's commitment in the unnecessary, unwanted, and unmanageable SST.

Also, one suspects, if the FAA

Obviously from Sprague Electric!



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For complete technical data, write for Engineering Bulletin 3536A to Technical Literature Service, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts 01247.

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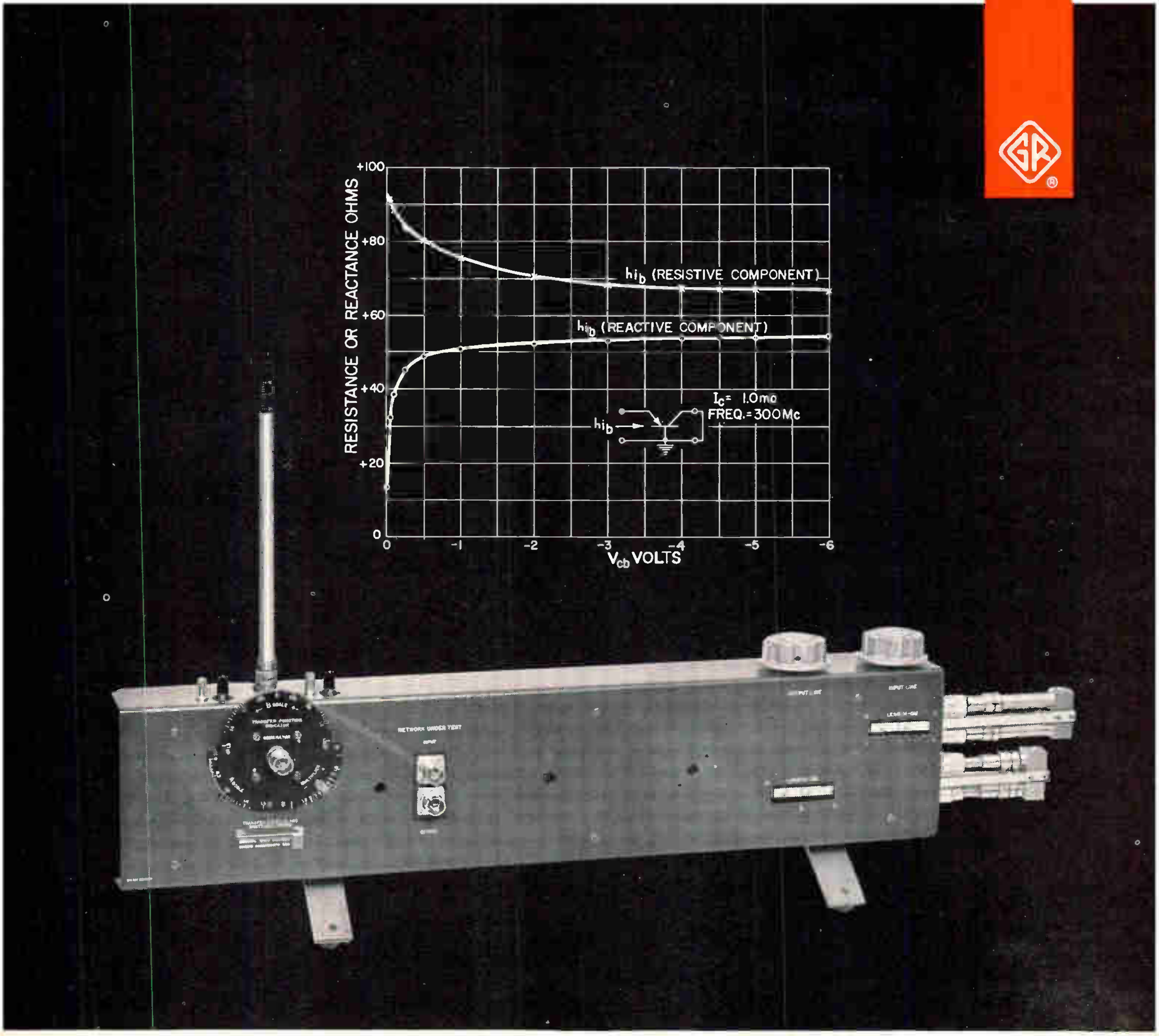

Measure transistor *h* and *y* parameters directly without resorting to the "New Math."

If you use *h* and *y* parameters in your design work, you can measure them directly with the 1607-A Transfer-Function and Immittance Bridge. You can measure h_{ob}, h_{oc}, h_{fb}, h_{fe}, h_{ib}, h_{ie}, h_{rb}, h_{re}, y_{ob}, y_{oe}, y_{fb}, y_{fc}, y_{ib}, y_{ie}, y_{rb}, y_{rc}, as well as all open-circuit impedance parameters directly, without using mathematical transformations that could degrade data accuracy. These measurements can be made over a broad 25-MHz to 1.5-GHz range.

Since the 1607-A uses adjustable lines settable to half and quarter wavelengths, both open- and short-circuit conditions can be easily established. Eight specially designed, electrically invisible mounts for almost all popular transistor configurations provide a readily defined reference plane for measurements. No measurement corrections need be made for the mounts. Even transistors with 2-inch leads can be measured without correction (the mount "swallows" the leads). The transistor can even be mounted with some of its lead length exposed to simulate its eventual connection in the circuit. In this way, the parasitic effects of the leads can also be considered.

Price of the 1607-A is $1995; transistor-mount prices range from $75 to $145. For a complete description of the 1607-A, request our Engineering Reprints E107 and E109. Write General Radio Company, 22 Baker Avenue, W. Concord, Massachusetts 01781; telephone (617) 369-4400; TWX 710 347-1051.

GENERAL RADIO

Circle 6 on reader service card

were to get seriously interested in computer control of air traffic some other Government agency might try once more to palm off the SAGE system on them, and this time it might work.

Richard Windels
Darien, Conn.

More on loops

To the Editor:

The article "Down-to-earth Army antenna" by Kenneth H. Patterson [Aug. 21, p. 111] describes an interesting and practical piece of gear. The article would have been even better if it contained more about why these loop antennas can be expected to perform as well as they do.

The tests conducted in the Alleghenies involved ionospheric skywave propagation. The conditions for the Vietnam tests are not stated, although high-frequency skyway is essential for getting out of mountain valleys and is probably the most efficient means of communicating out of a concealed jungle site. Thus, in its most important uses, this loop would radiate a high-angle skywave for communication out to a few hundred miles in the lower part of the h-f spectrum.

For short-distance skywave, polarization is horizontal (not vertical) insofar as reflection from the ground is concerned, exactly as in the case of the horizontal dipole. In fact, in all cases of skywave at any vertical angle for the loop and the dipole, the resultant of the direct and reflected waves is determined by the same plane-wave Fresnel reflection coefficients for the same height of radiating elements and involve the same reflection loss. In fact there is more nearly a null overhead when the loop is lower than the dipole.

What makes the relatively inefficient loop perform comparably as well as the dipole is the fact that the dipole as a circuit element, when near the ground, suffers ohmic losses caused by its near-field lines of force penetrating the surface of the earth. On the other hand, the near field of the small loop is closely contained and thus not subject to much ground loss. One can understand this by noting that in the limiting case of a small r-f inductor within an inch of a chassis its ohmic losses may be comparable to such losses for the coil in free space.

One possible disadvantage of the loop is its high Q. In some uses, broadband modulation would be attenuated at the edges of the passband. The necessity for tuning and matching for very small frequency changes is compensated by the use of automatic circuitry, leaving wide-band coverage as an advantage.

Loops are capable of receiving and transmitting ground waves. In communication over open country and especially from high sites or over sea water, a vertically polarized ground wave may be the best mode at short distances in the lower part of the h-f spectrum, depending upon interference and atmospheric noise. Here, vertical polarization is by far the best. The plane of the loop must be oriented to coincide with the plane of propagation. Performance should then be compared with that of a vertical dipole or monopole.

Richard Silberstein
Boulder, Colo.

People

Eighteen months ago the Fairchild Camera & Instruments Corp. combined its Instruments and Semiconductor divisions, moving the advanced research section from Clifton, N.J., to Mountain View, Calif.—an expensive and, as it turned out, somewhat shortsighted decision. Now it's returning the oscilloscope section of the Instruments division to Clifton and combining it with the Electron Tubes division. Named to head the operation is 44-year-old **Frederick Walzer,** a veteran of the Allen B. Dumont Labs, which Fairchild acquired in 1960.


Frederick Walzer

Corrective. Fairchild's decision is its latest move to bolster its instruments sales. Until the late 1950's, Dumont was a leader in the oscilloscope market; the emergence of Tektronix changed all that. In the last few years, however, Fairchild Instruments has made a small comeback—but mostly because of new instruments other than oscilloscopes.

In addition, the move unyoking the oscilloscope section from the Instruments division and moving it to Clifton is Fairchild's way of tacitly admitting that it blundered 18 months ago when it stripped the Tubes division of its advanced research personnel.

Under the new setup Walzer will be responsible for developing a new line of oscilloscope products and related equipment. Fairchild plans to market its new instruments through independent sales representatives.

Background. Walzer, who left engineering school to enlist during World War II, has an extensive background in quality control engineering. At Dumont since 1949, he has worked in all phases of the electron tube business. He moved into management in 1956 as head of the Technical Products division.

In 1961, following Fairchild's acquisition of Dumont, he was named quality control manager for all tube divisions. He took over the

the new name in high-performance, low-priced computers

This new computer is the easiest to program and interface of all high-speed computers. It has 16-bit words, 4K expandable memory, 2 microsecond cycle time, plug-in I/O cards, multichannel priority interrupt, relocatable software and both FORTRAN and ALGOL compilers. Plug-in options including direct memory access and hardware multiply and divide are available. Peripherals such as high-speed disc memory and magnetic tape are standard. The price, with 4K memory and ASR-33 teletype: $16,500.

To find out how easy the 2115A is to use—and its big brother, the 2116A, write to Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

06714

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People

Clifton operation two years ago and was made a corporate vice president of Fairchild last May.

For years a major subcontractor for military airborne antennas, Textron Inc.'s Dalmo Victor division is now scanning the industrial horizon for new applications because prime contractors now tend to make their own. To direct the technical sweep, the company has appointed **Michael Apcar Jr.**, 39, as vice president of engineering.

Michael Apcar Jr.

Dalmo Victor is looking into electro-optics, especially low-light-level television, and infrared sensing of toxic gases for air pollution control.

Peace move. "A few years ago," Apcar recalls, "one of the things we set out to do was to get out of the position we were in"—primarily that of a military subcontractor. Capitalizing on its automated checkout equipment for the military, the company developed similar gear for diesel-electric locomotives. In still another move, it also opened a plant in Grants Pass, Ore., to make wiring harnesses and switching matrixes.

Now the company sees commercial applications for its successful military-antenna business. "The trend," Apcar says, "is toward the use of electronic scanners." Because Dalmo Victor built antennas for the hypersonic B-70 program, Apcar thinks there might be a market in supersonic transports. Meanwhile, the company is making antennas for the Apollo program and the F-111A.

Although the company's figures are buried in Textron's ledgers, Apcar says sales have doubled in the last five years. He looks for them to double again in the next five years as the company reduces its contract mix from the present 90% military to 75%. "Hopefully, 10 years from now, we'll be able to spin off new self-supporting civilian lines," Apcar says.

MACHLETT

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	ML-8618	Conventional Triode	ML-8618	Conventional Triode
Power Output	6 megawatts	6 megawatts	200 kilowatts	200 kilowatts
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Filament Power	2.5 kilowatts	4.0 kilowatts	2.5 kilowatts	4.0 kilowatts

RESULT: ML-8618 reduces pulse driving power by a factor of 100 or better.

RESULT: ML-8618 reduces rf driving power by a factor of 10 or better.

Machlett's exclusive development, magnetically beamed tubes like the ML-8618 give you these advantages:

- By magnetically controlling the trajectory, electrons from the cathode bypass the grid structure so that nearly all emitted electrons reach the anode.
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For details, write The Machlett Laboratories, Inc., Springdale, Conn. 06879.

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TYPE SMDH 0 - 50 MHz

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Meetings

International Antennas & Propagation Symposium, IEEE; University of Michigan, Ann Arbor, **Oct. 17-19.**

International Electron Devices Meeting, IEEE; Sheraton-Park Hotel, Washington. **Oct. 18-20.**

Symposium on Switching and Automata Theory, IEEE; University of Texas, Austin, **Oct. 18-20.**

Conference of the Association of Data Processing Service Organization, Association of Data Processing Service Organization; Fairmont Hotel, San Francisco, **Oct. 19-20.**

Symposium of Adaptive Processes, IEEE; International Amphitheater, Chicago, **Oct. 23-25.**

Electronics Conference, IEEE; International Amphitheater and Sherman Hotel, Chicago, **Oct. 23-25.**

Meeting and Technical Display of the American Institute of Aeronautics and Astronautics; Convention Center, Anaheim, Calif., **Oct. 23-27.**

Business Equipment Manufacturers Association Exposition and Conference; New York Coliseum, New York, **Oct. 23-27.**

Conference on Effects of Diffuse Electrical Currents on Physiological Mechanisms with Application to Electroanesthesia and Electrosleep, Marquette University's School of Medicine and College of Engineering; Milwaukee, **Oct. 25-28.**

Symposium on Purposive Systems, American Society for Cybernetics and National Bureau of Standards; Gaithersburg, Md., **Oct. 26-27.**

Symposium on Hybrid Microelectronics, International Society for Hybrid Microelectronics; Somerset Hotel, Boston, **Oct. 30-31.**

Meeting on Electromagnetic Compatibility, Society of Automotive Engineers; Dallas Sheraton Hotel, Dallas, **Oct. 31-Nov. 1.**

Nuclear Science Symposium, IEEE; Statler Hilton Hotel, Los Angeles, **Oct. 31-Nov. 2.**

Asilomar Conference on Circuits and Systems, IEEE; Asilomar Hotel, Pacific Grove, Calif., **Nov. 1-3.**

Northeast Research and Engineering Meeting (Nerem), New England Section of IEEE; Sheraton-Boston Hotel, Boston, **Nov. 1-3.***

Product Assurance Conference, IEEE; Waldorf-Astoria, New York, **Nov. 2-3.**

Applied Superconductivity Conference and Exhibition, Atomic Energy Commission and University of Texas; Austin, **Nov. 6-8.**

Technical Conference, Society of Plastics Engineers, Nevele Country Club, Ellenville, N.Y., **Nov. 6-7.**

Reliability Physics Symposium, IEEE; Statler Hilton Hotel, Los Angeles, **Nov. 6-8.**

Short Courses

Institute on the transfer of technical information, the American University's Center for Technology and Administration, Washington; **Oct. 23-25,** $175 fee.

Infrared technology, University of Michigan's School of Engineering, Ann Arbor; **Oct. 30-Nov. 3; $175 fee.**

Theoretical developments in process control, Purdue University's Schools of Engineering; Lafayette, Ind.; **Nov. 6-17;** $250 fee.

Call for papers

National Aerospace Electronics Conference, IEEE; Sheraton-Dayton Hotel, Dayton, Ohio, May 6-8, 1968. **Nov. 15** is deadline for submission of abstracts to William Baker, technical program chairman, 2227 Springmill Rd., Kettering, Ohio 45440.

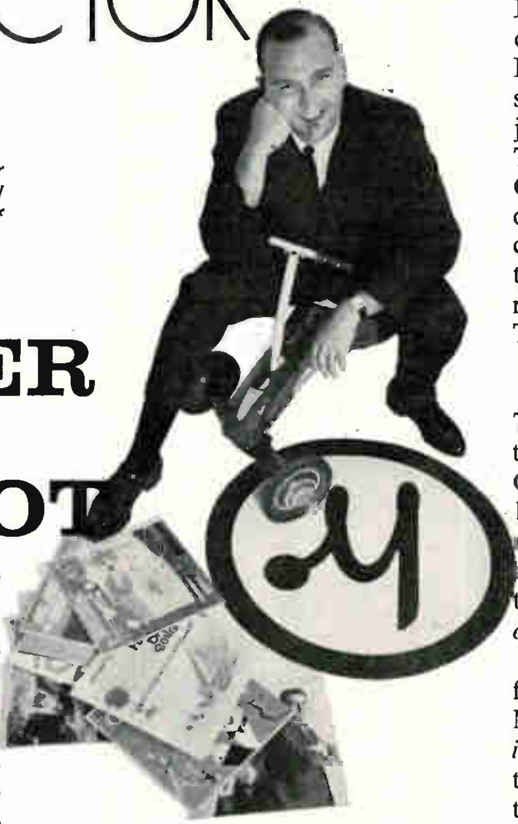
Symposium on Microwave Power, International Microwave Power Institute; Statler Hilton Hotel, Boston, March 21-23, 1968. **Jan. 1** is deadline for submission of abstracts to Symposium on Microwave Power, Box 342, Weston, Mass. 02193.

Region 6 Conference, IEEE; Sheraton Motor Inn, Portland, Ore., May 20-22, 1968. **Jan. 5** is deadline for submission of abstracts to Program Chairman, IEEE Region 6 Conference, P.O. Box 831, Portland, Ore. 97207.

* Meeting preview on page 16.

THE CONNECTOR THING

A periodical periodical, designed to further the sales of Microdot Inc. connectors and cables. Published entirely in the interest of profit.



DICK TRUMMER WINS MICRODOT

You've thrilled to the fabled romances of Damon and Pythias, Pyramus and Thisbe, Procter and Gamble. Now, grab a hankie and read the tale of Trummer and Microdot.

BOY MEETS CONNECTOR

Once upon a time, as they say, there was a young Wisconsin lad with two compelling interests—space technology and rowing. Richard Owen Trummer pursued both interests at the University of Wisconsin, where he received his B.S.M.E. and coached the rowing team. Later, as a components engineer at AC Electronics, part of his job was to recommend the right components for inertial guidance systems. But an equally important part of the job was helping the people who make those components to do a better job for AC.

One component category of concern to Dick was connectors. That's how Dick Trummer came to know of Microdot. But wait! Even more breathtaking is the saga of how Microdot came to know Trummer.

ALL-TIME CHAMPION CONTEST WINNER!

Our current series of ads is now more than two years old; and almost every ad offers an opportunity to enter some sort of contest. For example, our very first ad in the series asked readers to compete in assembling our Microcrimp connectors in record time. Winners received prizes such as a Honda, a Schwinn bike and an Irish Mail.

That's when we first heard of Dick Trummer. His speed in assembling our Microcrimp connector beat out all but two other contestants—and made him the proud owner of an Irish Mail. The fact that Dick didn't even know what an Irish Mail was, gave birth to a second contest in which we awarded lapel buttons reading "I know what an Irish Mail is."*

After that, Trummer was hooked. In a way, so was Microdot. Every contest brought a Trummer entry. Most of them were excellent. And since we're honest folk, we had to judge without partiality. Result: Trummer also won a whole stack of Capitol record albums for a new idea on what to do with our Twist/Con concept. And by June of this year, the word was out among our loyal readers and contest entrants: GET TRUMMER!

And that's what we did.

As of September 1, Richard Owen Trummer has been appointed Military Products Manager of Microdot's Connector and Cable Products. In this capacity, Dick will act as technical liaison man between Microdot and many of its most important customers. *(For one of Dick's new winners, see box on this page.)*

Most important benefit: as a bona fide permanent employee of Microdot Inc., Dick Trummer is now *ineligible* to enter any of our "Connector Thing" contests. Once again, there's room at the top! So take pen in hand with renewed hope. With Trummer out of the way, anything is possible. Who knows. If you win enough contests, we may hire you.

TRUMMER'S NEW WINNER: THE HIGH DENSITY MULTI-PIN MARC 53

Here's why Dick Trummer considers MARC 53 a winner: It's the smallest and most flexible high density multi-pin on the market. It meets MIL-C-38300 Rev. A (USAF) and is NASA approved for manned space flight applications. It features "Posilock," the finest blind mating coupling mechanism ever devised, and "Posiseal"—the best environmental seal. (Ask Dick what we mean by the floating interfacial seal concept.) Contacts are completely scuff-proof. Our new MARC 53 RMD gives you a genuinely field serviceable version that takes mass-produced pre-crimped wires and requires neither insertion nor extraction tools for assembly. A color-sound film that tells you all about the assembly of MARC 53 is now available.

RECENT CONTEST WINNERS
(Other than Dick Trummer)

CARY A. MATUSZAK, R&D Technician at the Republic Division of Rockwell Mfg. Co., is the winner of our "Great American Cable" Contest. Happy viewing on your new Sony TV.**

WINNERS of our "Let Microdot Take You To The Movies" contest:

1. Grand Prize: ROBERT H. AILOR, NASA Redstone Arsenal

2. Runner Up: MARVIN SENTER, Litcom Division, Litton Industries

Honorable mention awards in the form of imitation "Oscars" go to— R. H. KLEMM (Bethpage, N.Y.), G. E. FOGLEMAN (Washington, D.C.), PAUL KURLAND (Lansdale, Pa.), R. R. RIEBSAMEN (W. Palm Beach, Fla.), P. W. LANCASTER (Philadelphia), and—guess who—yep—RICHARD OWEN TRUMMER, *formerly* of Wisconsin. (That's it, Dick.)

*If *you* know, please write. We still have some buttons left.

**Winning slogan: "Microdot cable withstands the test of time."

MICRODOT INC.
220 Pasadena Ave., S. Pasadena, Calif. 91030

Meeting preview

Interest in millimeters

Boston, the center of the communications industry, will once again be host to the Northeast Electronic Research and Engineering Meeting (Nerem) Nov. 1 to 3 and, as expected, the main topic of the technical sessions will be communications. But this year, an unusual degree of interest is being focused on millimeter-wave technology. The interest in this area appears to stem from some researchers' belief that bulk-effect semiconductors will produce high powers above 30 gigahertz and the military's need for high-accuracy radar, wideband communications, and reconnaissance interferometers.

Wear and tear. In the session on millimeter waves, session six, F. J. Landkammer of Microwave Associates will unveil a 91.5-Ghz mixer using Schottky-barrier diodes. A 94-Ghz klystron local oscillator is used with the mixer to achieve a 3.5-Ghz intermediate frequency with about 12 decibels of conversion loss. This is higher than the losses encountered with physically delicate point-contact diodes, but Landkammer bets on his silicon devices for reduced conversion loss and shock and vibration resistance.

Ben Senitzky of the Polytechnic Institute of Brooklyn took advantage of millimeter waves' high rate of interaction with gases to build modulators, amplifiers, and power measuring devices. Using a radio-frequency pump source and a tube filled with hydrogen cyanide, Senitzky built a 238-Ghz parametric amplifier with a 21-megahertz gain-bandwidth product.

L. R. Wicker and J. E. Degenford of Westinghouse Electric and Ernest Wantuch of Fairleigh Dickinson University will describe latching ferrite phase shifters from 35 to 94 Ghz. Using nickel zinc ferrite, they've been able to build 35-Ghz shifters that can achieve 200 degrees phase shift per inch of length.

Diamonds for power. In session two, C. B. Swan of the Bell Telephone Laboratories will review the latest developments in high-power, continuous-wave Impatt oscillators.

Adlake Mercury Wetted Relay — Application Data

Measurement of "Dynamic Contact Noise" for Low Level Signal Applications

Adlake AWCS 26000 Series Relay— 2 Switch Form C

In small signal applications, such as computers, telemetric systems, strain gauges, etc. generated emf. within the system's relays must be taken into account.

Dynamic Contact Noise is a "coined" phrase used to indicate an undesired generated emf. upon contact closure. It is the result of mechanical oscillation of the armature—caused by the impact of the armature on the stationary contacts — sweeping the coil flux.

Typical illustrations of this noise are shown in the oscillograms, with the relay being driven at nominal voltage in the test circuit shown below. The frequency and amplitude are integral functions of system bandwidth and coil drive conditions.

The slight ripple seen at the end of each trace is not noise, but due to resolution of test equipment and test circuit.*

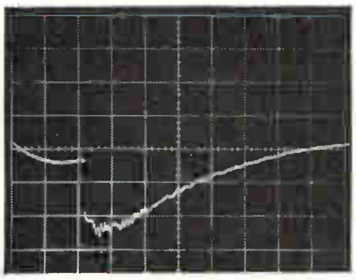


FIGURE 1

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	20 μV/cm
Systems Bandwidth	.06—60 Hz.

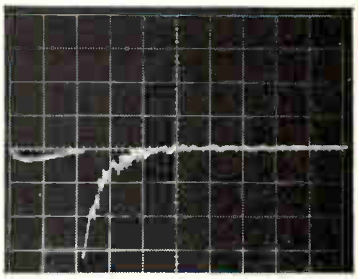


FIGURE 2

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	100 μV/cm
Systems Bandwidth	.06—600 Hz.

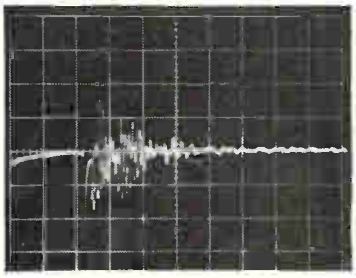


FIGURE 3

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	200 μV/cm
Systems Bandwidth	.06—6K Hz.

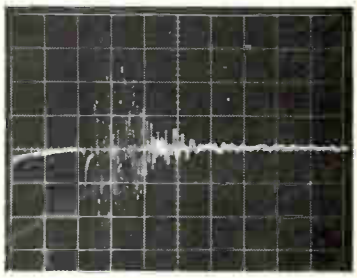
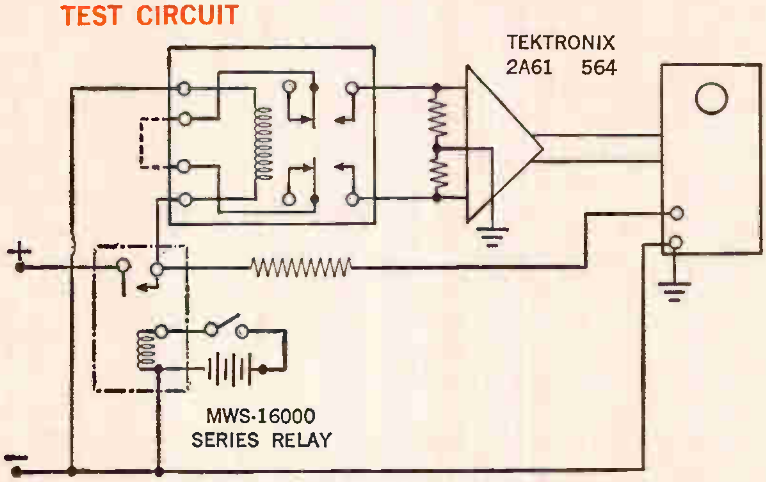


FIGURE 4

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	200 μV/cm
Systems Bandwidth	.06—60K Hz.

TEST CIRCUIT



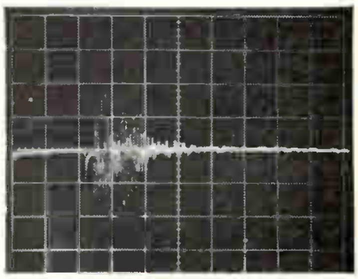


FIGURE 5

Horizontal Deflection	1.0 ms/cm
Vertical Deflection	500 μV/cm
Systems Bandwidth	.06—100K Hz.

* If you have a problem regarding relay applications to a particular system our engineering staff is ready to help you. Contact Mr. Le Roy Carlson, Chief Project Engineer.

Backed by sound research and disciplined engineering, Adlake applies the industry's broadest line of mercury displacement and mercury wetted relays to the creative solution of design circuit problems. However unique or special your application, Adlake can assist you in developing it. For prompt, personal and knowledgeable attention to your relay needs, contact the one source that is the complete source in the mercury relay field. Contact Adlake today for catalog and further information.

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RCA's MAX VALUE line now brings you the results of RCA's most successful silicon planar and epitaxial technologies at unprecedented savings... Performance/Hermeticity/Price. Contact your RCA Field Representative for more information. Or write RCA Commercial Engineering, Section CN10-1 RCA Electronic Components and Devices, Harrison, N.J. 07029. Check your RCA Distributor for his price and delivery.

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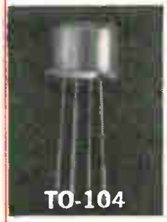
*RCA's MAX VALUE line offers military-type reliability control. For each type marked with the asterisk, production lots are subjected to and meet the mechanical, environmental, and life-test requirements of Military Specification MIL-S-19500.

2N5179
PHP Price 39¢†
LOW-NOISE UHF AMPLIFIER

20mW min oscillator output @ 500 MHz; 4.5 dB max NF @ 200 MHz; 15 dB min neutralized power gain @ 200 MHz; f_T = 1gHz min C_{cb} = 1 pF max.
Plus RCA Reliability Control



2N5180
PHP Price 29¢†
LOW-NOISE VHF AMPLIFIER

4.5 dB max NF @ 200 MHz; 12 dB min unneutralized power gain @ 200 MHz; f_T = 900 MHz typ; C_{cb} = 1 pF max.

2N5181
PHP Price 27¢†
HIGH GAIN RF AND IF AMPLIFIER

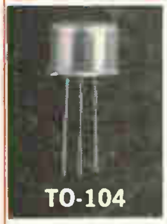
Max usable gain = 24 dB typ @ 200 MHz (neutralized); 3.5 dB typ NF @ 200 MHz; f_T = 700 MHz typ; C_{cb} = 0.34 pF max; new terminal arrangement for max isolation between collector and base terminals.

2N5182
PHP Price 24¢†
HIGH-GAIN RF AND IF AMPLIFIER
for low-current applications

Max usable gain = 24 dB typ @ 200 MHz (neutralized); 4.5 dB typ NF @ 200 MHz; f_T = 700 MHz typ; C_{cb} = 0.34 pF max; new terminal arrangement for max isolation between collector and base terminals.

2N5183
PHP Price 19¢†
1-AMPERE GENERAL PURPOSE AMPLIFIER

h_{FE} = 50 min @ V_{CE} = 1V, I_C = 300 mA; V_{CEO} = 18 V max; V_{CE} (SAT) = 0.5 V max @ I_C = 300 mA, I_B = 15 mA; f_T = 200 MHz typ; Planar epitaxial construction.



2N5184†
PHP Price 27¢†
HIGH-FREQUENCY HIGH-VOLTAGE AMPLIFIER

V_{CEO} = 120 V max; I_C = 50 mA max; f_T = 100 MHz typ; C_{cb} = 3.5 pF max.

2N5185
PHP Price 31¢†
HIGH-FREQUENCY HIGH-VOLTAGE AMPLIFIER

1 watt dissipation capability; V_{CEO} = 120V max; I_C = 50 mA max; f_T = 100 MHz typ; C_{cb} = 3.5 pF max.

2N5186
PHP Price 24¢†
HIGH-SPEED SWITCH

V_{CBO} = 10V max; t_{on} = 25 ns max @ I_C = 10 mA, I_B = 1 mA; t_{off} = 25 ns max @ I_C = 10 mA, I_B = 1 mA; V_{CE} (SAT) = 0.3V max @ I_C = 10 mA, I_B = 1 mA.
Plus RCA Reliability Control

2N5187
PHP Price 27¢†
MEDIUM-CURRENT HIGH-SPEED SWITCH

V_{CBO} = 25V max; t_{on} = 18 ns max @ I_C = 100 mA, I_B = 10 mA; t_{off} = 21 ns max @ I_C = 100 mA, I_B = 10 mA; V_{CE} (SAT) = 0.5V max @ I_C = 100 mA, I_B = 10 mA.
Plus RCA Reliability Control

2N5188
PHP Price 33¢†
HIGH-SPEED HIGH-VOLTAGE ½-AMPERE SWITCH

V_{CBO} = 60V max; t_{on} = 35 ns max @ I_C = 150 mA, I_B = 15 mA; t_{off} = 50 ns max @ I_C = 150 mA, I_B = 15 mA; h_{FE} = 20 min @ V_{CE} = 1V, I_C = 500 mA (pulsed).
Plus RCA Reliability Control

2N5189
PHP Price 39¢†
HIGH-SPEED HIGH-VOLTAGE 1-AMPERE SWITCH

V_{CBO} = 60V max; t_{on} = 40 ns max @ I_C = 1A, I_B = 100 mA; t_{off} = 70 ns max @ I_C = 1A, I_B = 100 mA; h_{FE} = 15 min @ I_C = 1A, V_{CE} = 1V.

Plus RCA Reliability Control

RCA'S MAX VALUE SAMPLER

22 PHP Transistors for only $3.95. (Optional distributor resale price). 2 evaluation samples of each transistor in RCA's new MAX VALUE line, packaged to let you check the outstanding performance of this economy line at your RCA distributors from Sept. 5, 1967 for a limited time only. Order your QK2100 Sampler today. This offer is limited to an evaluation quantity.

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Circle 19 on reader service card

1967

	VR-3700	VR-3400	VR-2600 PCM	VR-3300	VL-2810	DR-3000	VR-5000
TAPE SPEEDS	8 speeds to 240 ips	8 speeds to 240 ips	7 speeds to 120 ips (in two ranges)	6 speeds to 60 ips	6 speeds to 60 ips	up to 75 ips	8 speeds to 240 ips
TAPE SPEED ACCURACY	±.02% Phase-Lock Servo	±.02% Phase-Lock Servo	±0.2%	±0.25%	±0.20%	±0.3%	±.05%
REEL SIZE MAXIMUM	15 inch	15 inch	14 inch	10½ inch	Loop	IBM	16 inch
DIRECT FREQUENCY RESPONSE	400 Hz 2.0 MHz	300 Hz 600 KHz	1000 BPI	100 Hz 300 KHz	100 Hz 300 KHz	—	400 Hz 2.0 MHz
FM FREQUENCY RESPONSE	dc 500 KHz	dc 40 KHz	—	dc 20 KHz	dc 20 KHz	—	dc 500 KHz

VL-2810—Specifically designed for data reduction or data monitoring and storage where machine work-load is heavy.

- Accommodate tape loop runs from 2 to 75 feet at six tape speeds from 1⅞ to 60 ips.
- VL-2810 handles data in the range from dc to 20 KHz via FM techniques, and from 100 cps to 300 KHz employing direct techniques.
- Utilizes ½" tape for up to 7 channels, or 1" tape for up to 14 channels, using IRIG geometry.
- Accessories include selective erase equipment providing erasure of any combination of 7 to 14 tracks, without removal of the tape loop from the machine. Bulk erase equipment also available.


VL-2810


VR-5000

VR-5000—CEC's finest new recorder, the advanced VR-5000 2.0 MHz System has a flutter correction capability five times more effective than any other instrumentation recorder known today. The unique Dual Inertia* (DATALOCK™) tape drive provides the low flutter introduction advantages of high mass recording coupled with the flutter correction and low TDE (±0.4 μsec., 120 ips) advantages of low mass reproduce under wideband servo control. Consequently, the VR-5000 is the only recorder capable of translating the ideal system concept into a working reality—*high mass recording and low mass reproduce.*

- A 3% flutter component at 50 Hz will be reduced at least 20 db; a 1% flutter component at 200 Hz at least 16 db. Thus flutter components from dc to beyond 200 Hz are, for all practical purposes, effectively eliminated.
- Capstan servo phase-lock capture range is sufficient to lock on a ±30% recorded speed error occurring at a 5.0Hz rate or a quasi-static speed error of +50%—100%.
- Longer tape life, fewer "drop-outs", and better amplitude stability are assured by the VR-5000's unequaled servo system, which holds tape tension variations to such a low value they cannot be measured with gages presently available.
- Positive air pressure tape buffering (patent pending) prevents recording errors due to reel perturbations, while solving the contamination and "sticktion" problems normally associated with vacuum systems. This system, combined with closed loop reel servos, provides 40db of reel to head area isolation.
- A high inertia flywheel is inserted into the drive system during the record mode to achieve an absolute minimum of recorded flutter components.
- Tape speed accuracy of ±.05% with tape servo, machine-to-machine.

*PATENT PENDING

CEC DataTape® Accessories

The Monitor Oscilloscope is used with tape recorder/reproducers, or any multichannel instrumentation system to provide visual display of electrical signals ranging in frequency from dc to 3,000,000 cps. Unique features of this unit include up to 500 KHz sweep rate and modular construction.

The Type TD-2903 Automatic Tape Degausser is designed to erase data signals from magnetic tape wound on reels up to 14" in diameter and tape widths from ½" to 2". A reel of 1"-wide instrumentation tape recorded at saturation level is erased to a nominal 90 db below normal level.

The Dynamic Tape Tension Gage permits accurate tension measurements directly while the recorder is in operation ...helps keep your recorder in proper operating condition through routine maintenance adjustment.

CEC Computer & Analog Tapes
All CEC Computer Tapes are well within allowable tolerances of the reference tape used by the computer industry—and all are certified "drop-out free" for the first pass, and remain so for many more. Because of CEC's nation-wide field force and warehousing facilities, tape generally can be delivered within 24 hours. CEC Analog Tape is available in all frequency bandwidths, meets or exceeds the most critical specifications, and offers the same delivery advantages.

For complete information about any of these products, call your nearest CEC Field Office, or write Consolidated Electrodynamics, Pasadena, California 91109. A subsidiary of Bell & Howell. Bulletin Kit 320-X4.

CEC/DATATAPE PRODUCTS

BELL & HOWELL

Circle 21 on reader service card

Editorial

Who's to judge?

For years, the telephone companies have stoutly resisted the violation of their lines by so-called foreign attachments—devices of any kind made by companies other than themselves. The utilities have reasoned that any outside gear, no matter how well it performs alone in laboratory tests, could foul up telephone operations by introducing noise, crosstalk, unwanted voltages, or tiny faults that would be magnified as they traveled through the huge telephone system.

Until now, the Federal Communications Commission has supported the utilities in this view. The FCC has agreed that since a telephone company is responsible for operating its system, it should determine what equipment is used. Attempts by an outsider to get its gear into a telephone system usually involve a long and costly legal process: filing a complaint with the commission, appearing at a hearing before a trial examiner, and then fighting off court appeals if it wins. The procedure can take three to five years.

Last month, after just such a legal rigamarole, the FCC surprised everybody by radically changing its policy on foreign attachments. The agency had ruled against the phone companies before, so the shocker came not with the ruling—that the Carterphone, a device to facilitate the interconnection of telephones and mobile radios shouldn't be barred from telephone lines—but in the testimony. The Common Carrier Bureau, which rides herd on the utilities, offered the view that it was unfair to force electronics firms to go through this time-consuming and costly litigation every time a new device is invented. Now the FCC has gone on record that it wants tariffs changed so that ". . . customer-provided equipment may be attached so long as it is not hazardous or detrimental to telephone service . . ."

But wanting the change and bringing it about are two different things. The big question is: who is to say that the equipment is or is not detrimental?

Although AT&T insists that it will voluntarily and at no charge study any foreign attachment—and even recommend design changes to make the device acceptable to Bell System companies—inventors insist the phone company is not an impartial observer.

The testimony in the Carterphone case shows how disagreements develop. At the hearing, the telephone companies claimed:

- That the Carterphone inherently alters frequency response, thereby affecting the quality of sound in both directions, and that it would destroy the system's sidetone feedback, a factor that tends to keep speech outputs at desirable levels. But the examiner noted that users of the Carterphone had expressed no dissatisfaction with the quality of communications.
- That use of the device could cause crosstalk, which can occur when the system input reaches 100-104 decibels above reference acoustic pressure. The examiner concluded that this would not be a problem of great magnitude because misuses of the Carterphone that would cause the crosstalk were no more likely than the misuse of equipment supplied by the telephone companies.
- That the Carterphone might malfunction. The examiner held that any equipment could fail, but that the device had not shown itself to be prone to failure.
- That more frequent calls, longer times to complete connections, and the extension of telephone calls by private radio into distant toll zones would impose an unpredictable burden on the telephone system and bring a consequent increase in costs. This argument, according to the examiner, was purely conjectural.
- That uneven maintenance of Carterphones and the radio systems they connect into the telephone system would inevitably cause communication failures, and that initial complaints would be directed to telephone companies, who would then have to conduct expensive investigations to establish their innocence. A simple test call, not an expensive investigation, would probably suffice, the examiner suggested.
- That since the Carterphone is designed for use only with today's most common type of handset, it would be useless with handsets of other designs and could thus create consumer resistance to equipment innovations. Although this was the one point the telephone companies backed with concrete evidence, the examiner believed the evidence was too scanty to justify a finding that the Carterphone represented a threat to present or future phone service.

Although these are technical and economic arguments that seemingly can be resolved by evidence, a bias such as the telephone companies must have could easily alter the conclusion. So Electronics agrees with those who say the telephone companies cannot be the final judge of foreign attachments. Still, in its present understaffed condition, neither can the FCC.

But there are at least three other possible solutions.

1) Require the manufacturer of a foreign device to submit to the FCC complete test data on the performance and reliability of its gear as it operates on telephone lines, not as it worked in the manufacturer's engineering department. The test and report procedures would be similar to those the Food and Drug Administration requires of drug manufacturers before the introduction of a new drug.

2) Or, assign to a Government laboratory with a good technical reputation, such as the National Bureau of Standards, the responsibility for performing such tests and studies. An objection to this is that even the NBS is subject to political pressures in its evaluation of commercial products.

3) Or, expand the Common Carrier Bureau of the FCC, adding competent technical people and equipping a laboratory to perform the tests. FCC Commissioner Nicholas Johnson has already made such a proposal, and it makes sense since the bureau is intimately acquainted with both the technical and economic problems of operating the telephone system.

The FCC's newly declared policy is sure to spur a flock of new equipment developments. What's needed now are technical procedures to evaluate these developments outside the law courts.

Electronics Newsletter

October 16, 1967

Pontiac ready to tune in IC's

The Pontiac division of General Motors, which already has chalked up a first with its IC voltage regulator [Electronics, Oct. 2, p. 137], also will **be the first auto maker to put an IC into a car radio.** The silicon monolithic device, produced by Delco Radio, will be used as an i-f amplifier in Delco's am/fm receivers **to be offered to buyers as an option this winter.**

Philco-Ford, meanwhile, has finished tests of its IC car radio. The IC also is a silicon monolithic device used as an i-f amplifier in an am/fm set. But Philco, unlike Delco, has been stymied by the cost barrier. **The result, industry insiders predict, is that because of the higher cost of using IC's Philco won't be able to sell Ford** on switching and the Ford project won't get past the test stage for a while.

Trio of radars eyed for space tracking

The next generation of space surveillance sensors could come out of a new series of tests now being set up at the Air Force's Rome, N.Y., Air Development Center. Three new radars, including optical and super-high-frequency sensors, will be operated alongside each other in comparative tests.

First to be ready—before the end of this year—is a high-power, S-band (3,350 megahertz) radar that will attempt to get high range resolution by a pulse-compression technique. **The second sensor is an optical radar using a carbon-dioxide-nitrogen laser transmitting at 10.6 microns.** This infrared frequency is better in haze and fog than the 0.6- or 1.06-micron frequencies previously considered for this application. The carbon-dioxide tracker will be ready in two months for limited tests.

The third is S-band radar that will try for high resolution by using very-short pulses and brute-force power to get them to the target and back. The main problem has been generating sufficient power. Rome believes, however that a relativistic beam linear accelerator it has designed will provide up to 1,000 megawatts without difficulty. Operation of this radar is two years off.

New MOS IC's bar drift in linear jobs

A family of metal oxide semiconductor, monolithic linear integrated circuits that don't exhibit the drift problems typical of other prototype MOS linear devices has been developed at RCA Laboratories. Instabilities that usually crop up in MOS elements at higher operating voltages and temperatures are eliminated by an internal d-c feedback arrangement that uses an MOS element as a voltage-controlled resistor.

Included in the new IC line are seven-stage and 11-stage amplifiers. Over-all gain of the seven-stage unit is 60 decibels with a bandwidth of 1 megahertz—modest in comparison to the levels attained by bipolars but sufficient for many analog applications. An RCA engineer says yields and performance are running high enough to warrant a production go-ahead, but he wouldn't specify when RCA will market the new line.

Vidicon-laser camera system

A satellite camera system that can take pictures of the earth with almost seven times the resolution of present space cameras has been developed by the Radio Corp. of America's Defense Electronic Products division, Princeton, N. J. **The picture, from signals sent by a new type of vidicon**

tube, is reproduced with a scanning laser beam.

The tube, called a return-beam vidicon, differs from a normal vidicon in that, like an image orthicon, it uses a return scanning beam to generate a video signal. **System resolution now is 5,000 tv lines per picture, but the theoretical limit is 8,000. RCA notes that present space cameras have a resolution of 800 lines.** The picture taken by the vidicon is traced in a 9-by-9-inch format on photographic film by a continuous-wave, helium-neon laser. The recording spot, intensity modulated by the video signal, is moved across the film by a rotating lens assembly.

RCA is considering proposing the system for the advanced Tiros M weather satellite it's building for NASA. Or it could fit into the Earth Resources Orbiting Satellite (EROS) being contemplated by the Interior Department as a means of observing crops, forests, topography, and mineral resources.

Company jets land inertial navigators

Orders from the general aviation field—an unexpected customer—are giving new wings to the commercial inertial-navigator business. Prospects had seemed dim after Pan Am recently canceled its program to install Sperry SGN-10 units in its big jets.

But corporations, expected to pass up the inertial systems because of their expensive price tags, have started ordering them for company aircraft. Litton Industries has chalked up nine orders for its $100,000 LTN-51 system. Most will go on Grumman Gulfstream jets. One of the Litton customers is Canada's Home Oil Co., which is turning to inertial navigation because many of the airports it uses lack en route radio-navigation aides.

Industry organizes laser association

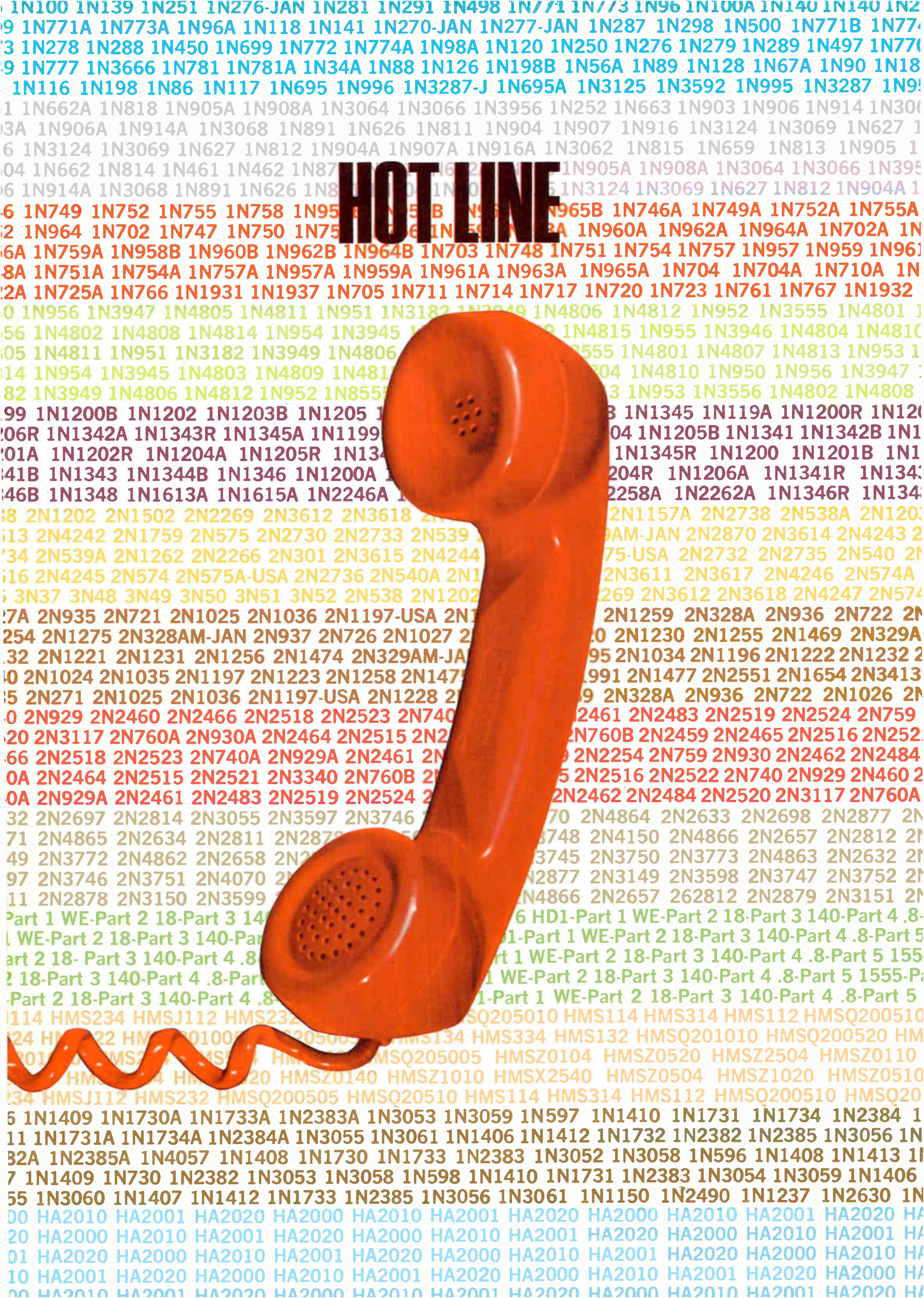
While the Electronic Industries Association spent months deliberating whether it should form a full subdivision on lasers or a committee on laser engineering, 31 laser manufacturers took action. They met in Washington to lay the groundwork for an organization that will be called the Laser Industry Association (LIA). **Its purpose: To serve as a focal point for the dissemination of information on laser technology and to change the public's image of the device as a "death ray."**

Many EIA members were at the laser group's organizational meeting but an EIA spokesman confidently predicted that the laser group his association eventually sets up will be able to lure back any members who defect to the newer association.

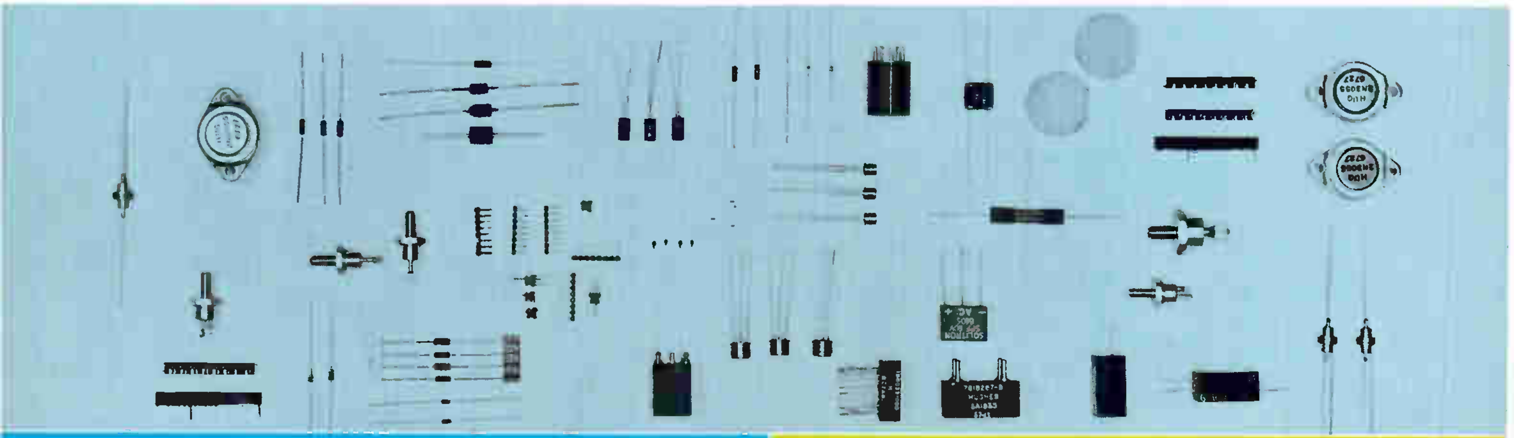
EIA faces a split over tariff, quotas

A battle is shaping up within the Electronic Industries Association over proposals to set import quotas on equipment and components and to boost the tariff on imported color television tubes. The clash, between the organization's "protectionist" parts division and its consumer products division, which includes importers, is expected when EIA groups meet in Los Angeles Oct. 25.

A bill has already been introduced in Congress to return the tariff on color tv tubes to 30% Jan. 1 from its present 12% level. And the parts division has prepared a bill for submission to Congress that would limit imports of consumer electronics products and components to 1966 levels. Despite opposition from EIA "free traders," the parts division is already looking around Capitol Hill to find a Congressional sponsor for the quota measure.


HOT LINE

HOT, YOU BET WE ARE..



1. Germanium Diodes:

All are featured in DO-7 glass packages; the same patented* subminiature diode glass package that was first introduced by Hughes Semiconductors in 1951. Included are a vast selection of standard gold bond and fast recovery computer gold bond germanium diodes from which to choose.

*Patent No. 2694168

2. Silicon Diodes:

Featuring the microglass pill or "pellet" (HMG series) – the smallest hermetically sealed diode in the industry. The devices in this category are primarily silicon computer and core driver diodes. They are also produced in the DO-7 subminiature glass package (HD series) and in the micro dual-stud 500 milliwatt packages (HDS series). Featured also are ultra high speed silicon diodes in the DO-7 package.

3. Silicon Zeners:

Two processes are available, alloy and diffused, and package sizes from DO-7 to DO-4 give the broad line of Hughes zeners a power range from 250 mW to 15 watts and a voltage range from 2.0 volts to 200 volts. Temperature compensated zeners are now available in the 1.5 – 3.0 watt range with voltages from 8.0 to 200 volts.

4. Silicon Capacitors:

In this category both silicon alloy and diffused processes produce a broad line of voltage variable capacitors in the DO-7, DO-14, and special molded packages covering a capacitance range from 3 pf to 1000 pf and a voltage range from 15 volts to 200 volts. "Q" ratings up to 1000 may be obtained.

5. Silicon Power Rectifiers:

This is the industry-famous Golden Line of Hughes rectifiers. The line features fast switch and standard types from 500 milliamps to 6 amperes and in voltages up to 1200 volts. Fast switch versions exhibit switching times as low as 75 nanoseconds.

6. Germanium Power Transistors (PNP):

Hughes now features a complete line of PNP power transistors from 3.5 to 200 amperes. These transistors feature low leakage, very low saturation voltages and compact packaging.

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lector. For "immediate ordering" call the Hughes HOT LINE (800) 85
714) 548-0671.

7. PNP Silicon Alloy and PNP Diffused Transistors:

PNP Silicon alloy transistors are available in military and industrial types in the TO-5 and in the coaxial 1 watt packages. Symmetrical V_{CB}, C_{CE} and V_{EB} characteristics up to 200 volts are uniquely available in these devices. PNP diffused silicon planar transistors are produced for high speed switch, general purpose, and small signal amplifier applications in both TO-18 and TO 5 packages.

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8. NPN Silicon Planar Transistors:

A family of NPN low-noise, small-signal transistors is available in TO-18 and TO-46 package configurations.

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9. NPN Silicon Power Transistors:

A broad line of NPN Silicon Power Transistors is introduced featuring single diffused, planar, planar epitaxial, and isotaxial processes. Collector current ratings from 2 amperes (in TO-46, TO-5 and TO-66 packages) to 100 amperes (in an MT-49 package) are available. Low saturation voltages and exceptional secondary breakdown characteristics are features of these lines. Power darlingtons with gains up to 10,000 are also available.

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10. R. F. Noise Diodes and Modules:

This category contains radio frequency noise diodes featuring performance from 20 cycles per second to 100 megacycles per second developing an output up to .5 microvolts per one cycle bandwidth of gaussian noise voltage. Modules incorporating these devices are effective white noise sources which may be energized by a D.C. voltage and can produce a noise voltage with a flat frequency spectrum across a 5 cycle to 500 megacycle bandwidth with up to 100 millivolts level of random white noise output.

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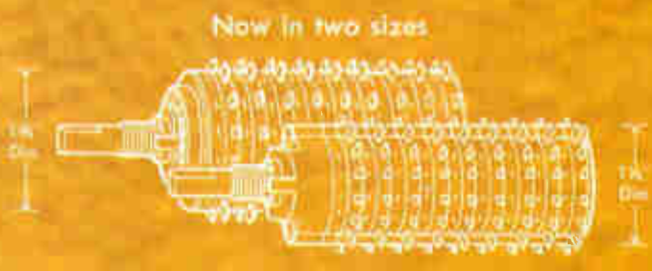

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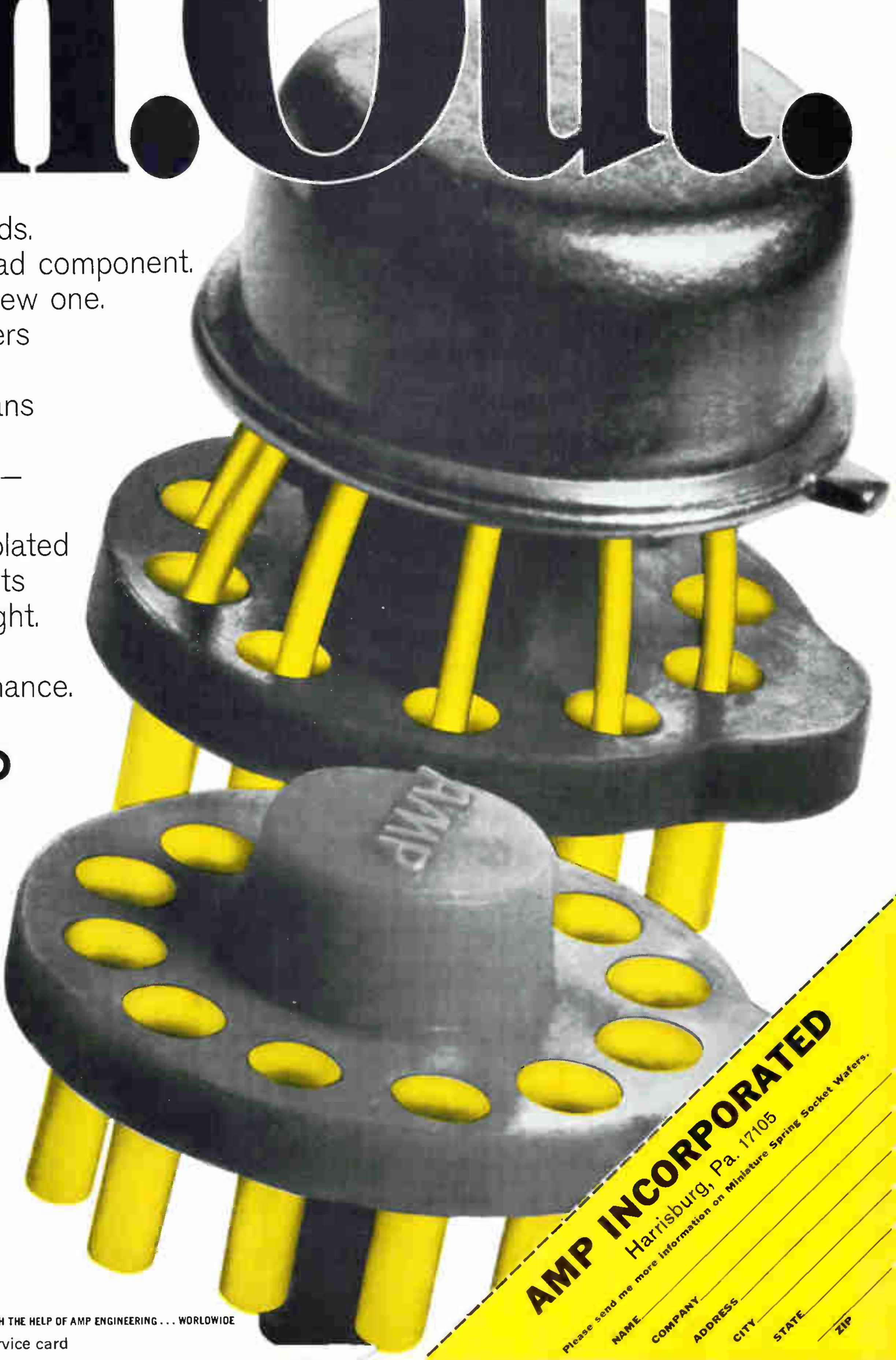

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Electronics Review

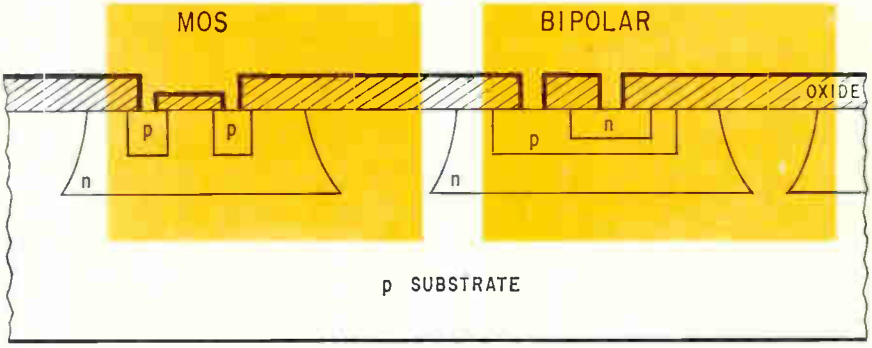
Volume 40
Number 21

Solid state

Best of two worlds

The two pillars of monolithic integrated circuits, bipolar and metal oxide semiconductor (MOS) transistors, have been successfully combined in a single structure. Designated the MOS-BI by its developers, Westinghouse's Molecular Electronics division, the new monolithic contains 8 MOS FET's, 4 bipolars, and 4 diffused resistors on a 40-by-40-mil substrate.

The report of the Westinghouse device follows by only a few weeks word that Fairchild Semiconductor had apparently achieved a way to produce a similar device [Electronics, Oct. 2, p. 25]. Although Westinghouse won't disclose when it will market its MOS-BI, it's been learned that Fairchild plans to offer its device soon.



Side-by-side. Active element mainstays of integrated circuits, bipolar transistor and metal oxide semiconductor field effect transistor, coexist on same monolithic substrate. Called the MOS-BI, the combination will be used to bring about digital and linear IC's with the best advantages of both devices.

New applications. Combining the two devices opens up an entirely new IC capability in both digital and linear applications. The MOS technology offers higher packing density, higher impedance levels, and better noise properties than bipolars. On the other hand, bipolars are more stable, operate faster, and are more rugged in terms of current-handling abilities, driving capabilities, and transient immunity.

Previous efforts to wed the two devices ran into severe problems because of the different diffusion steps required by each; simultaneous fabrication of the devices often resulted in poor isolation between the units and marked instabilities in the MOS elements.

Westinghouse engineers overcame these problems by wedding an enhancement-mode p-channel MOS with an npn bipolar, using modified resistivity epitaxies. These structures are more compatible than the other possible combinations—those involving depletion-mode MOS's, n-channel MOS's, and pnp bipolars, according to Karl K. Yu, a senior engineer at the Westinghouse division.

Yu indicated the configuration did not require any extra diffusion steps, or a need to invert the silicon surface to permit the isolation.

The initial MOS-BI circuit provides a triggering function. The p-type diffusion forming the base of the npn also forms the source and drain sections of the MOS FET. Turn-on voltage of the MOS elements ranges from 4 to 6 volts; current gain of the bipolars is modest, 10 to 30.

They're at it again

Watching the activities of the National Semiconductor Corp.—with its top staff of former Fairchild Semiconductor executives—has become an engineers' pastime on the San Francisco Peninsula second only to watching topless waitresses—and almost as breathtaking. National has already made bold forays into the linear and metal oxide semiconductor fields; next month it will invade still another growing semiconductor market by introducing a dual binary flip-flop utilizing transistor-transistor logic.

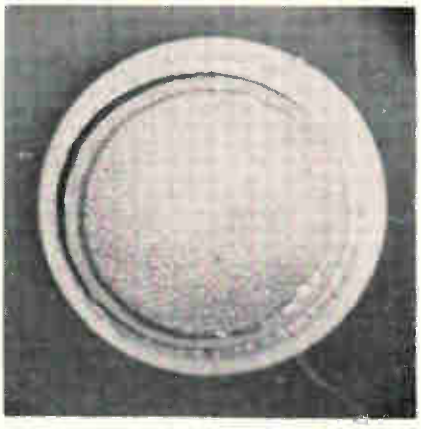
The circuit is billed as an improved version of what National believes is the fastest-selling TTL product made by Texas Instruments. By no coincidence, the designer of that circuit (TI's SN7473), Jeff Kalb, joined National several months ago.

Nod to Dallas. "We'll have a full line of TTL circuits," says Donald T. Valentine, National's new marketing manager. "We chose a complex circuit instead of a simple gate to start with in order to get on the current level of technology." Valentine adds that the company decided to make this particular line because it believes that TI has the best position in the TTL market.

Texas Instruments markets the dual binary in both commercial and military versions, and in both 14-lead and 16-lead dual in-line packages. National will follow suit, but its DIP will have a glass-to-metal seal that it claims offers better hermeticity characteristics.

Departures. The new circuit also incorporates two changes from TI's design. The operation of TTL circuits is so fast that the clock lines can go negative as they drop from positive to ground, which can cause the flip-flop to lose information. The National series will be clamped to avoid this problem. The company will also guarantee 15-nanosecond clock skew—the sum of the minimum propagation delay and the widest pulse that won't trigger a flip-flop.

To accommodate its integrated-circuit production, National has leased another 15,000 square feet of space across the street from its first Santa Clara, Calif., plant. Fabrication and diffusion will be carried out in the old plant, which has 20,000 square feet, while the new building will house final assembly facilities and executive offices.


Power pill. Disc-shaped laminated transistor offers low lead inductance, easy packaging.

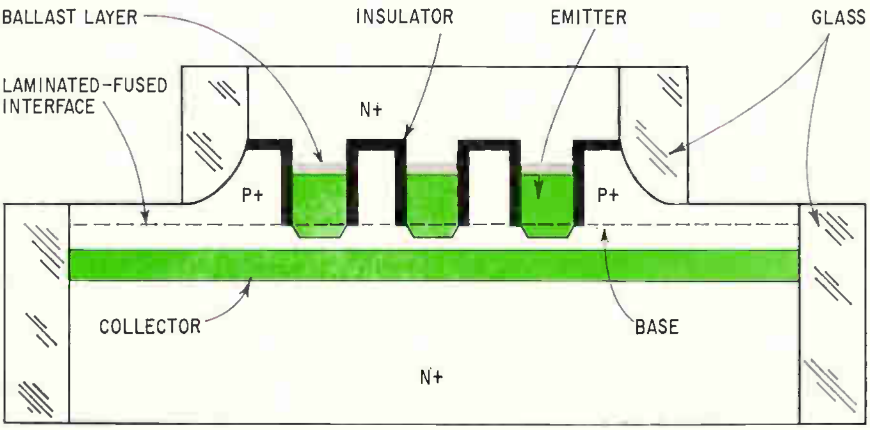
Laminated transistor

Two heat sinks are better than one—at least that's the approach being taken by transistor designers at the Radio Corp. of America in an Air Force-supported study aimed at developing a new way to build a high-power radio-frequency transistor. The transistors, formed on two separate slices that are then laminated, also include a ballast resistor in series with the emitter to reduce secondary-breakdown difficulties, and glass hermetic seals around the edges to protect the junctions. Lead inductance also is substantially reduced with the new design.

Still in the laboratory stage, the r-f transistors have yet to demonstrate better performance than RCA's standard overlay transistors, but they deliver in the 10-to-100-watt range into a load at frequencies from 10 to 100 megahertz.

In series. In one wafer of the transistor the n-type collector and the p-type base layers are formed over an n+ substrate. The other wafer holds the n-type emitter stripes, which are separated with dielectric isolation. An internal resistive layer is added in series with the emitter sites to act as the ballast resistor. The second wafer also carries a p+ region for use as the base contact, as shown in the diagram below.

The two wafers are then laminated and fused under temperature and pressure. The emitter-base junction is formed by diffusion of emitter impurities into the base region. Edges of the devices are then covered with glass. The use of hermetic glass seals on the sides of the transistor eliminates the need for a package. With this construction, the same size pellet can be used for high power, or the pellet can be made smaller for the same power as devices now available to users.



Two halves. RCA's laminated overlay transistor gives higher power at high frequencies because two sides are available for heat-sinking.

Avionics

Fly by the numbers

The first air-data computer developed for use in the Navy's Integrated Light Attack Avionics System (ILAAS) has just been delivered to Sperry Rand Corp.'s Systems Management division by Garrett AiResearch Manufacturing Co., Torrance, Calif. The design, the first all-digital unit available, will supply eight outputs for the ILAAS central computer.

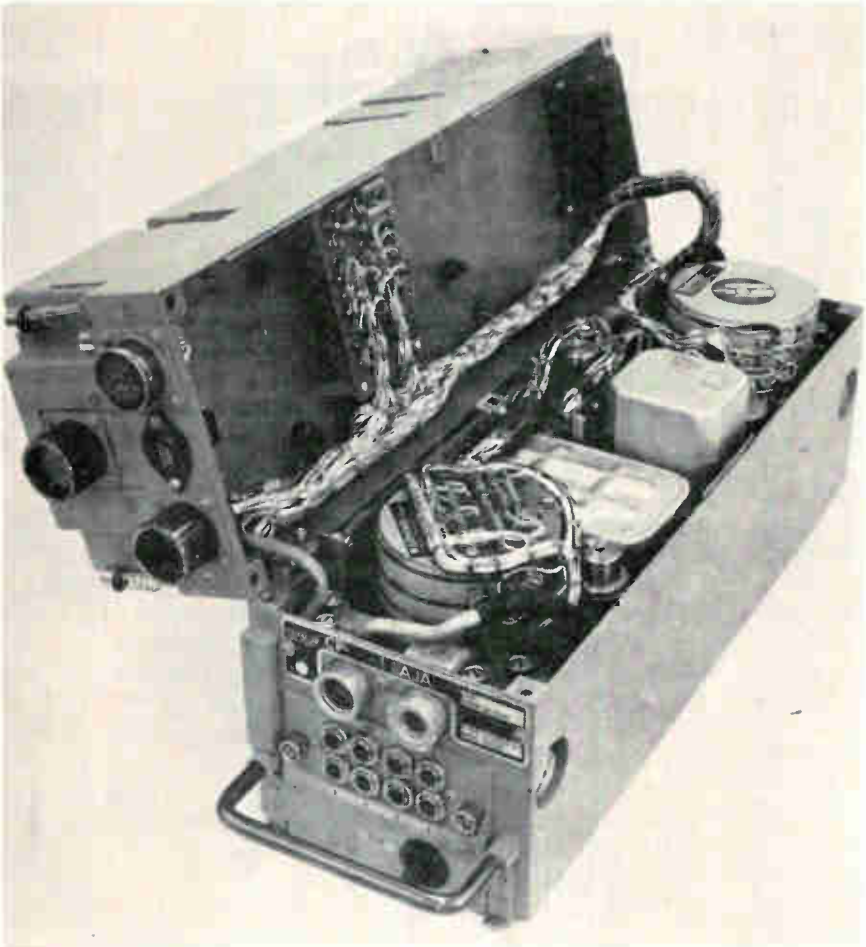
About 80% of the circuitry is made up of monolithic and hybrid integrated circuits (there are about 300 flatpacks in the system), and some of the circuit manufacturing and packaging techniques are unusual. The packaging and heat sinking design gets the entire computer into a box 8 by 5 by 15 inches that weighs 23 pounds. The system operates on about 75 volt amps.

It accepts inputs of static and total pressure, total temperature, and angle of attack. From these, it calculates altitude, altitude rate, differential pressure, air-density ratio, mach number, true air speed, true angle of attack, and dynamic pressure.

The Conrac Corp. has built a much smaller air-data computer system, which also makes extensive use of IC's and weighs about 3 pounds. But it only has six outputs, three of them analog and three digital.

High and fast. Since the Garrett system is designed for a high-speed, high-flying aircraft, it's much more sophisticated than the air-data equipment included in the Integrated Helicopter Avionics System (IHAS) being developed by Teledyne Inc. Teledyne uses a converter, which accepts three inputs (static pressure, total pressure, and indicated temperature outside the aircraft) and converts them to digital serial words that are supplied to the IHAS central computer upon interrogation. Also, the ILAAS system has to maintain an altitude accuracy of ±20 feet up to 50,000 feet, compared with 20,000 feet for IHAS.

Since one of the requirements of



High logic. This 23-pound air-data computer, developed for the Navy's ILAAS system, provides eight outputs for the central computer.

the ILAAS system is that there be no flight line test equipment, the air-data computer is made up of five modules, each of which can be easily replaced, and there is a self-check system that indicates a faulty module. The entire ILAAS system will check itself out at the push of a button in the pilot's cabin, the air-data computer indicating failures in any of the five modules by pop-out buttons on the front of the computer.

Garrett has a contract to deliver four systems to Sperry for bench testing. Flight testing is scheduled to get under way by year's end and will probably be done aboard an A-6 aircraft.

"One of the reasons we are using hybrids rather than monolithics is that we had to combine bipolar and unipolar transistors," explains Earl Blevis, of the Flight and Electronic Systems department. "For example, the multiplexer in the digital module uses a monolithic logic gate as the input and is then buffered by a pair of bipolar transistors. The output is a pair of field-effect devices (unipolar transistors). It wouldn't be possible to handle all this with monolithics alone."

Keep cool. Garrett has an interesting heat-sinking technique for the densely packed modules; each card has 24 IC DTL logic flatpacks (12 on each side), and there are five conducting layers on each card.

When all five layers have been laminated, the heat sinks are laminated in strips running from top to bottom on both sides of the card. The flatpacks are mounted so that they straddle the heat sinks, which are riveted to an aluminum rail on top of the card. This rail, in turn, is bolted to the outer case, making it possible for the heat to be transmitted from the circuits to the outer case.

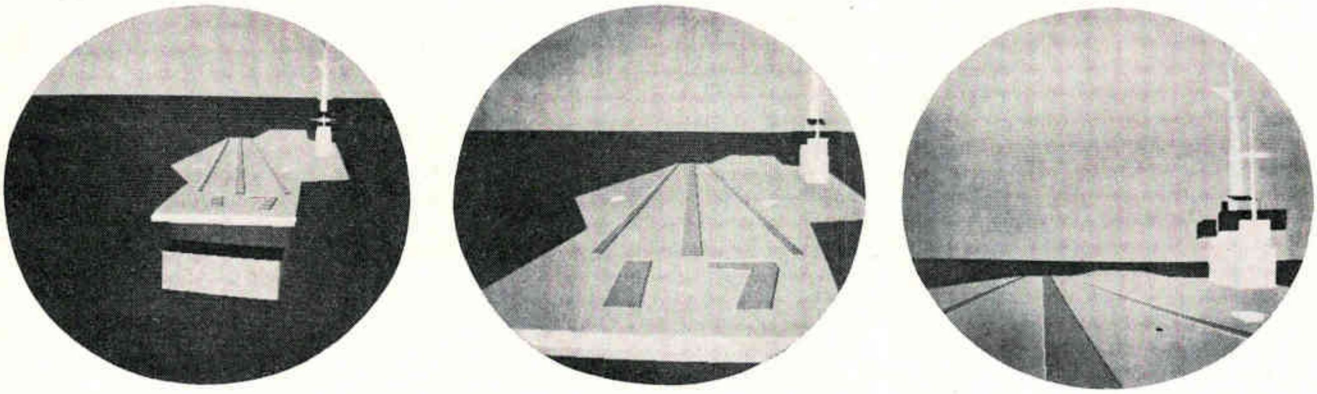
Right perspective

Visual flight simulators for training a pilot or astronaut must generate images that are as close as possible to what exists in the three-dimensional world. Most simulators do this by projecting films or slides, or televising a carefully constructed replica of the terrain that is to be flown over. At the Electronics Laboratory of the General Electric Co., Syracuse, N.Y., information stored in the memory of a digital computer is being used to generate scenes in color on a television display. There are no tv cameras, films, slides, models, or drawings in the system.

The scenes are accurate enough to be used for a variety of tasks. So far, the system can simulate, in proper perspective, a plane's approach to an aircraft carrier or to an airport, an enemy plane as seen by the pilot of an attacking plane during a dogfight, and objects such as NASA's lunar module, command and service modules for the Apollo program, and the surface of the moon. It has also been programed to simulate a street scene to demonstrate the system's usefulness in architectural training and urban planning.

Point of view. By manipulating an aircraft-type control stick, an operator can see the computer's visualization of a scene from any vantage point. For example, he can land on the carrier's flight deck, or fly past the carrier's superstructure, or pass beneath the carrier's flight deck. No matter what he does, the computer senses his instantaneous location and recomputes the exact perspective and size of the ship as it would appear to him at that point in space and time. This procedure is repeated up to 30 times per second, so that a smooth, continuous motion is presented on the screen.

The first system built by GE is being delivered this month under a $2 million contract to NASA's Manned Spacecraft Center, Houston. There it will be used by the Guidance and Control division primarily for evaluating the performance of control systems designed for the Apollo program,



Carrier landing. Plane's approach to carrier is simulated on display . . . . . . as computer calculates changes in position and perspective . . . . . . and pilot brings his plane safely down on the flight deck.

rather than for training astronauts.

Too close? NASA doesn't consider the imprecise nature of the pictures a handicap to its work. "We really don't have to see every nut and bolt on the vehicles when we're concerned with aligning and docking the lunar and the command and service modules," points out Donald C. Cheatham, assistant chief of the Guidance and Control division. "We just need enough detail to give us the proper visual clues for moving one vehicle relative to the other."

The GE system can generate up to 40 different objects in any one scene, involving up to 240 straight or convex edges. A numerical description of the vertices of the object are stored in a Raytheon 520 computer. A 4,000-bit core memory stores the mathematical relationships needed to make perspective calculations. Ten-megahertz, emitter-coupled logic is used to make the calculations rapidly enough for continuously updating the high-resolution color screen.

Advanced technology

Unchanging picture . . .

Drawing on lessons learned working with Xerox copy systems, two engineers at Electro-Optical Systems Inc., a Xerox subsidiary, have come up with an image display that can hold a picture for relatively long periods.

Image storage is nothing new. In the past 10 years, several experimental devices capable of retaining a picture burned into them have been developed. Most have employed two active layers—an electro-luminescent layer to produce the image and a photoconductive layer, either cadmium sulfide or cadmium selenide powder, to maintain the image. But storage panels of that type have a variety of shortcomings. For one thing, output brightness in most cases is limited because too high a voltage spoils the image contrast, causes self-triggering, or produces electrical breakdown. For another, viewing time is limited and brightness and contrast fade considerably during viewing. Finally, unless special measures are taken, the stored image has to be allowed to vanish completely—but slowly—before a new one is stored.

Better timing. Now the Electro-Optical team—Benjamin Kazan and J. S. Winslow—has applied the principle of field-effect conductivity control to produce a solid state image panel overcoming most of those shortcomings. The storage and control features of the panel are based on the special field effect properties of zinc oxide, which are also used in Xerox Electrofax copying.

The new device, like its predecessor, has a control layer and a phosphor powder layer to generate the image. But it's the zinc oxide in the control layer that makes the difference. The zinc oxide is first pulsed with a negative charge, which erases the old image without emitting light. The panel is then exposed to an image which produces a stored charge pattern on the zinc oxide surface. That pattern creates a conductive pattern, which in turn determines the luminescence level of the phosphor layer.

Brightness, say the developers, is as high as 20 foot-lamberts, compared with only a few foot-lamberts of the older methods. Maximum contrast ratio is about 100 to 1, with between 400 and 800 lines on the 12-by-12-inch panel. Best of all, an image can be retained for about an hour and then erased quickly, simply by recharging the zinc oxide with another negative-charged input.

. . . moving light

Most solid state light-emitting arrays require two sets of decoding circuits—one for each dimension—and the cost of such circuits often limits the size of the array. Such limitations have been eased by Basil W. Hakki and his team at Bell Telephone Laboratories. They have invented a light-emitting array that they call a SALS device (solid state acousto-electric light scanner) for alphanumeric image display or as a scanning light detector. Decoding circuits are needed for only one dimension.

The device consists of a glass substrate with a layer of n-type cadmium sulfide on it and rows of p-type cuprous sulfide on top of that. An acoustic domain—a con-

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For evaluation quantities and complete technical details, contact any TRW distributor or TRW Semiconductors, 14520 Aviation Blvd., Lawndale, Calif. 90260. Phone: 679-4561, TWX: 910-325-6206. *TRW Semiconductors Inc. is a subsidiary of TRW INC.*

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Circle 45 on reader service card

centrated vibration traveling at the speed of sound—generates the light as it scans the array.

Wireless. The moving acoustic domain does most of the work of the circuitry because only each row of cuprous sulfide, rather than each element, must be reached by an electric current from outside. All the circuitry that is needed is an amount equal to the square root of the total number of elements in the array. For example, one 141 x 141 array of p-n junctions (about 20,000) would require only the circuitry needed to reach each of the 141 rows.

The high-field acoustic domain is formed in the piezoelectric cadmium sulfide by pulsing the SALS device with an electric field strong enough to raise the electron drift velocity above the velocity of sound in the material. Such a high field forms an acoustic domain, with about 200 volts across it.

The domain moves through the cadmium sulfide and as it passes each p-n junction, its voltage causes reverse breakdown at the leading edge of the domain and heavy forward conduction at the trailing edge. The resulting current flow through the junction excites red light emission.

Hakki will report on the array this week at the International Electron Devices Meeting in Washington.

Transistor twosome

Efforts to develop higher-frequency transistors have always been handicapped by the necessity of using the same material for the base, emitter, and collector. But researchers at Carnegie-Mellon University in Pittsburgh are studying a promising method of fabricating so-called heterojunction transistors using germanium for the base and collector, and either gallium arsenide or zinc selenide for the emitter.

Moving holes. The heterojunction transistor is based on a 1951 patent by William Shockley, one of the original transistor developers, and later detailed by Herbert Kroemer, then of RCA Laboratories, in a 1957 paper in the Proceedings of the Institute of Radio Engineers. Kroemer showed that if the emitter material has a wider energy band gap than the base, then the emitter efficiency—the ratio of injected current from the emitter into the base to the total current crossing the emitter-base junction—can be significantly increased. With an npn transistor, for example, electrons injected into the base face a low potential barrier, while holes tending to cross back from the base into the emitter face a high barrier.

Thus, since the injection of holes from the base into the emitter is minimized, the base can be heavily doped to produce a low resistivity. A low-resistivity base enhances the frequency performance, since one of the basic frequency-determining factors in the operation of the transistor is the base resistance-collector capacitance time constant. In conventional transistors, the base could not be heavily doped—instead, the emitter is more heavily doped than the base in order to raise the efficiency level of the emitter.

The heavy base-doping also reduces chances of secondary breakdown, since it helps to reduce debiasing effects at the base-emitter junction.

Power pack. The wide band gaps offered by the two emitter materials, 1.43-electron volts for gallium arsenide and 2.6 for zinc selenide, are both significantly greater than germanium's band gap, 0.72, and account for the improved performance.

One of the problems with the gallium arsenide is that the arsenic, during epitaxial deposition of GaAs on the germanium p-type base region, tends to form a thin layer of n-type material over the base, since arsenide is one of the basic donor atoms for germanium. However, this is overcome with the heavy doping of the p-type base region, which tends to swamp out the n-type effects.

In preliminary tests, both the GaAs and the zinc selenide transistors have produced current gains of between 15 and 30.

Golden isolation

Designers of monolithic integrated circuits generally have to choose between low cost and high performance when selecting a method of isolating the various elements on the substrate. But a pair of International Business Machines Corp. researchers have come up with a process they say costs less than beam-lead and dielectric isolation techniques and outperforms that old standby, p-n junction isolation.

The new method, developed by Joseph Chang and Madhukar Vora at IBM's Hopewell Junction, N.Y., facility, calls for the deposition of a layer of lightly doped n-type silicon over the usual p-type substrate. Then, after the transistors are formed, gold is diffused into the extra layer to enhance its resistive characteristics and thus improve insulation.

Chang and Vora say the new process holds down parasitic capacitances between elements and substrate to 1/10th the level allowed by the p-n junction method, thereby keeping operating frequencies near their maximums and reducing unwanted feedback. The p-n "bathtub" junction around each element approximates an insulator when it's reverse-biased but has a high component-to-substrate capacitance.

The researchers also assert that the new method provides only 1/100th the substrate resistivity obtained with p-n junction isolation, and only 1/1000th the unwanted crosstalk.

Consumer electronics

Solid savings

What's holding back the design of all-transistor large-screen television sets is the lack of high-voltage transistors. So, makers of black-and-white tv sets use transistors in low-power signal functions and vacuum tubes for the high-voltage and deflection circuit functions. There is a way to get rid of tubes: add a power transformer and rectifier and

The Tektronix Type 547 is a 50-MHz, 7-ns sweep-switching oscilloscope that offers dual-beam measurement capabilities with most repetitive signals. A complete selection of plug-ins permits you to change your oscilloscope performance to meet your changing needs.

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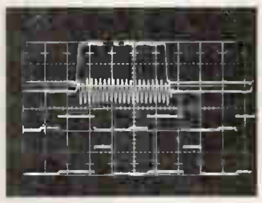
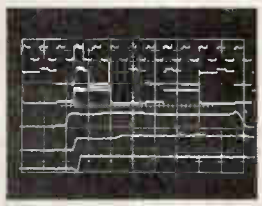


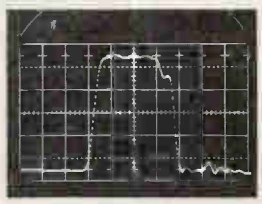
Four Signals—Two Sweeps

Using alternate vertical and horizontal display modes, Ch 1 and Ch 2 are locked to A Sweep (100 ns/cm) and Ch 3 and Ch 4 are locked to B Sweep (2 μs/cm). This provides dual-beam measurement capabilities with most repetitive signals.



Three Signals–Delayed Sweep

Increased convenience is provided with sweep-switching in the delayed sweep mode. You alternately view both the delaying sweep (2 μs/cm), intensified by the delayed sweep, and the delayed sweep (100 ns/cm). With the Type 1A4 Plug-in, eight traces can be displayed.



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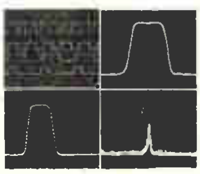

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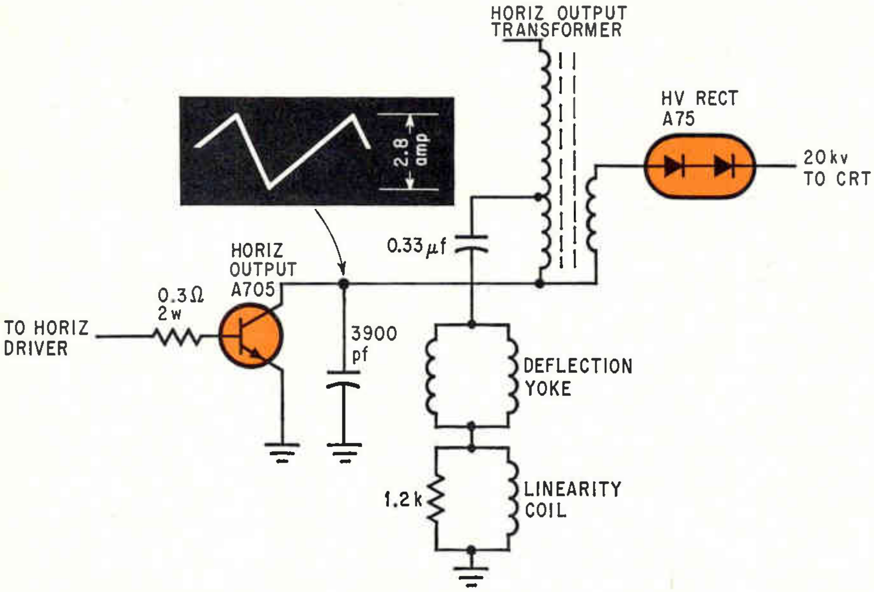

Horizontal output. The application of high-voltage transistor A705 and diode A75 simplifies solid state tv by eliminating power transformer.

filtering system—an effective but expensive alternative.

Boost. Last week, however, the Amperex Electronic Corp. demonstrated a transformerless solid state 23-inch tv set. The developmental receiver, containing 30 transistors and 10 diodes, operates directly from the line. Making this possible is a new high-voltage transistor, the A705, which operates with a collector-base voltage of 1,400 volts and will cost about $2.50. By contrast, the highest-voltage transistor commercially available now operates at 700 volts and costs about twice as much. Elimination of the transformer and rectifier and filtering system means an additional dip in manufacturing cost of $1.50 to $2 a set.

A silicon npn type, the transistor has a mesa collector structure and a planar emitter. It is used as a horizontal output amplifier and doubles as a damper, thus eliminating a separate damper diode across the collector circuit, without any deterioration in horizontal linearity.

The A705 has an extremely fast turn-off characteristic. When operated with an inductance of 25 microhenrys, the peak collector current switch-off time is about 0.8 microsecond. The A705 drives a tapped flyback transformer with a deflection yoke and linearity coil connected as shown in the schematic. The base-emitter diode is reverse-biased by the driver transformer (not shown) during the flyback period.

Another unusual feature of the receiver is that it employs an A75 silicon high-voltage rectifier which delivers 20,000 volts to a 23FPS4 picture tube. Most high-voltage rectifiers used in large-screen receivers are vacuum tubes, while small-screen solid state receivers generally have a large selenium rectifier stack. The A75 will be offered for sale when Amperex can make its price competitive with vacuum tube rectifiers.

Communications

New muscle for CATV

On the surface, the meeting of the National Cable Television Association at Philadelphia's staid Warwick Hotel last week was just another regional meeting of the trade group that represents the operators of community antenna television systems. What made it notable was the presence of Federal Communications Commissioner Nicholas Johnson. As recently as last June, the group had run into trouble getting a commissioner to appear before its more important annual meeting. Finally, Commissioner Lee Loevinger agreed to appear. But since then there's been a falling out at the FCC over CATV.

Johnson was at the meeting to blow the whistle on some of his fellow commissioners for a stalemate that has persisted almost all year on CATV litigation. For the first time, he publicly charged the commission with doing nothing to clarify the many complex problems involving CATV and with passing the buck to Congress.

What the majority of commissioners hopes is that Congress will pass copyright legislation that will put many CATV systems out of business and thus end the problem for the FCC.

Until this summer, Johnson was just another commissioner with no strong views one way or another on CATV. But he was angered in September when the commission turned down a proposal for a CATV test in Philadelphia—after the FCC had itself raised the question of a test in an area like Philadelphia 18 months before when it assumed jurisdiction for regulating CATV.

Rebuke. Johnson told the trade group that the long-run interests of CATV and the FCC should not diverge substantially. Almost as a rebuke to his fellow commissioners who voted down the Philadelphia test, he said: "We both want to see the future of CATV determined by research, analysis, and national planning, rather than by the present combine of emotional arguments, political squabbles, factual ignorance, obsolescing policy assumptions, and lawyers' speculations."

Johnson's switch to the side of CATV against the broadcasters may mean a lot more action out of the FCC because three commissioners are now considered friendly to the medium; four make a majority.

Until Johnson's change in Philadelphia, Loevinger and Robert Bartley had been the only commissioners who leaned toward helping CATV interests. Two others, Kenneth A. Cox and Rosel H. Hyde, feared that encouraging CATV would damage the status quo of broadcasting so they have consistently voted against it. Since neither of the remaining two com-new...

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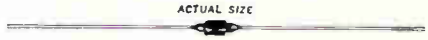

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missioners, Robert E. Lee and James J. Wadsworth, are committed strongly against CATV, either might be persuaded to support CATV.

Software

Late-late showing

Two years late in coming up with software for its System 360 computer line, the International Business Machines Corp. is now a year behind schedule in developing the time-sharing software package for its model 67. The company is releasing the first small software package that will give the 360/67 some time-sharing capability.

Until now, users of the 360/67 were confronted with two choices: develop their own software or run their machines as if they were model 65's. (The 360/67 is really two connected 360/65's with some added hardware.) Meanwhile, users of other 360 machines who rely heavily on the company's software continue to have problems when their specific requirements are slightly out of line with the software specifications.

For example, a customer whose system configuration includes devices that cannot tolerate even momentary delays or whose application requires real-time response under all kinds of adverse conditions may find that IBM's operating system—the supervisory program dubbed OS/360—won't quite do the job. Version 12 of OS/360 is now in the hands of IBM's customers; IBM plans to release version 13 in October; and, although IBM won't say, in all probability three or four more versions will always be in the works until the 360's successor is announced in 10 years or so. If enough customers begin having trouble with instant response, IBM will probably feel compelled to bring out versions that are better for their particular applications.

Can't keep up. A case in point is the Boeing Co's experience at its Simulation Center in Huntsville, Ala. Boeing has connected a Xerox Computer Adapter [Electronics, Dec. 12, 1966, p. 58] to its 360/67. With this machine, a Xerox LDX transmitter loads graphic data into a computer, and an LDX receiver prints computer-generated graphic data; the LDX equipment is the same as that used in transmitting graphic data over a telephone line. (LDX stands for long distance xerography.) Although the adapter is a commercially available product of the Xerox Corp., no units have been shipped except to Boeing because the manufacturer is refining the hardware development.

Boeing has experienced no serious difficulty with its hardware. But, lacking the IBM software designed for the 360/67, it is running its system partly as two 65's and partly with its own modifications to the standard OS/360. Boeing finds that OS/360 can't keep up with the demands of the LDX terminals. A single page contains approximately 144,000 eight-bit bytes of data, and the computer's main memory can't spare this much room at one time in the Boeing installation. Although the computer has over a million bytes of core storage, about half of this is occupied most of the time by a portion of the operating system. (The operating system itself occupies 8 million bytes, including compilers and other accessory programs, most of which at any one time are kept on a magnetic drum; segments of the system are sloshed in and out of main memory as needed.) The remainder is shared by four concurrently running programs plus a control program that supervises input-output for the four problem programs.

Hiccup. The computer handles the data being transferred to or from the LDX units only part of a page at a time, and busies itself with one of the other programs in between times. This works well as long as everything is running smoothly. But if an error occurs anywhere in the system, the operating system stops whatever it may be doing and tries to recover the lost data. This takes only a few milliseconds—the machine only hiccups—but it can throw the LDX adapter out of synchronism.

All input-output operations are independent of the central processor after they have once been initiated, because the input-output channels have direct access to the memory. When the operation is finished, the device interrupts the processor, which can then give another instruction to the device if desired—unless an error has been detected. If any other input-output operations are in progress, they continue undisturbed; but when they are finished, their interrupts are not honored until the error routine is out of the way.

Thus when the LDX adapter finishes reading or printing the first part of a page of data, it interrupts the processor to ask for more—while a motor in the transmitter or receiver keeps the paper moving. Ordinarily the operating system has another block of memory all set up, and need only tell the channel the starting address for that block, so that the flow to or from the adapter is continuous. But if the interrupt comes in the middle of a hiccup, it may not be answered right away and the output page will have a gap in it, or some input data will be passed over.

To overcome these difficulties, Boeing is trying to modify the operating system in two ways: it has to insure that the LDX adapter has the highest priority of all input-output devices; and it has to guarantee this priority even over that of the error routines. Any other input-output device can afford to wait a while—even if continuous motion is involved, as in the case of a magnetic disk or drum, the worst penalty is a 30-millisecond delay for a single revolution.

Military electronics

Calling the shots

The military is now testing radars that can count near-misses on a rifle range and measure the accuracy of air-to-air missiles and antiaircraft fire and pilot strafing. Built by Sanders Associates Inc.'s Radar/Ordnance Systems division, Bedford, Mass., the systems have

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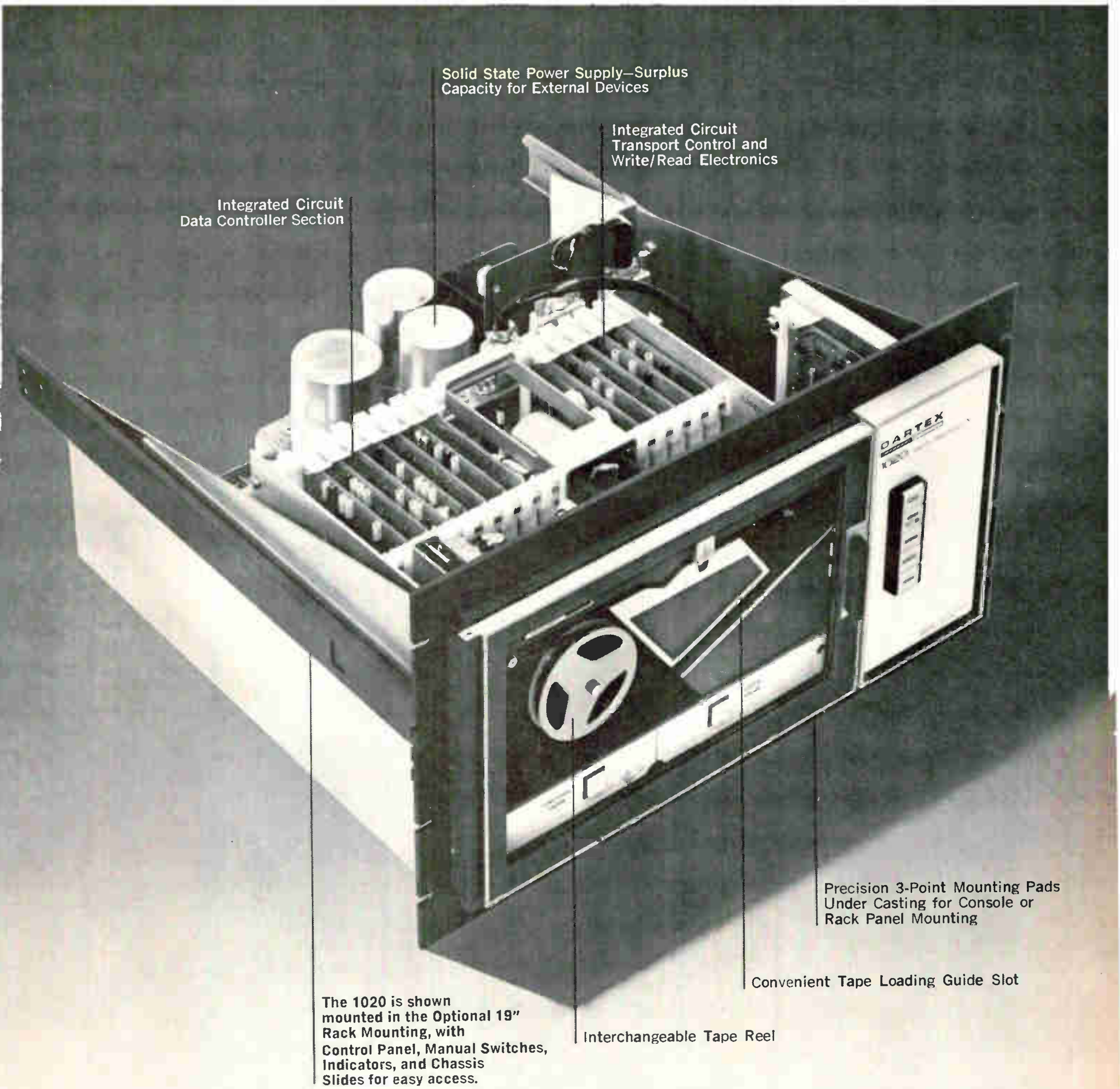

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been christened Rascore, for radar scoring system.

Rascores come in four varieties:

- Rascore-M, for installation aboard target drones to measure the effectiveness of air-to-air, surface-to-air missiles, or for pilot training.
- Rascore-AA, which would perform the same function for conventional ground-based antiaircraft fire.
- Rascore-S, a pilot-training system that gives real-time measurements of a pilot's strafing accuracy.
- And Rascore-AP, which would be installed near target dummies and used to gauge the effect of infantry rifle fire.

All four are short pulses (as short as 10 nanoseconds), high repetition rate (as high as 12.5 megahertz) coherent radar systems.

Rascore-M is the most complex, and after three years in development is about one year away from operational status, according to Sanders. Two units are about to be tested at the Naval Missile Center, Point Mugu, Calif.; two more are scheduled for delivery within 60 days.

Know the enemy. Rascore-M must compete in the market with tracking cameras and drone-borne continuous-wave radar systems already developed. But Sanders' Nicholas Senio, ordnance section manager, believes that Rascore will be able to offer better sensitivity than c-w radar and that Rascore's real-time telemetered readout will outclass the optical systems, which require film processing and interpretation.

Aboard a target drone, Rascore-M provides near-spherical coverage with a radius of about 275 feet. Within this sphere, it can measure range to intercepting missiles to within ±2.5 feet at its maximum range and to ±1.25 feet at ranges below 35 feet.

The system requires no transponder or corner reflector aboard the intercepting missile. Some miss-distance indicating systems usually require these added devices, which can degrade missile performance. This ability to work with noncooperative targets gained the interest of Hughes Aircraft Co., which planned to purchase Rascore-M to evaluate its version of Sam-D, but Hughes lost that contract.

Spotting rounds? Though developed in-house, Rascore-AA is being evaluated now at Point Mugu for the Defense Department's Joint Task Force 2 and the Sandia Corp. It's capable of spotting antiaircraft rounds of the standard NATO rifle caliber to 57-mm antiaircraft shells —and scoring them at the rate of 3,000 rounds per minute as they whiz past at up to 3,800 feet per second.

Both Rascore-M and AA operate at about 1.78 Ghz and have peak output powers of only 1.5 to 2 watts. Pulse compression in the receiver adds the power in each group of 255 pulses to achieve effectively higher output power. In both, real-time data is relayed to the ground using IRIG telemetry coding.

Rascore-S is the highest-powered system of the lot and uses the only non-solid state component in the line, a 4-watt magnetron. Its dish antenna is aimed at strafing targets and the pilot's hits are recorded and printed out in real time. Its prime application would be for ground-support pilot training. Accuracy is ±1 foot and special circuitry eliminates ricochets from a pilot's count.

Antipersonnel. Rascore-AP, another in-house development, has already met requirements set by the Army's Combat Development Command at Fort Ord, Calif., and should find its way into obstacle courses for advanced infantry training. Four units are due for November delivery. The Army is most interested in Rascore-AP's ability to spot rounds that miss the target but come close enough to make a soldier dive for cover. This is called suppressive fire and Rascore-AP is the first system capable of measuring it in real time. Rascore-AP's prime competition is acoustic detection—but these systems spot only supersonic rounds—Rascore can locate subsonic ones as well.

Coupled with a computer, Rascore-AP would trigger stand-up or falling motions among a series of targets, even though the targets themselves were never touched. Computer readouts would also measure the effectiveness of squads or platoons in combined action, another first, as well as giving insight into the best weapons mix for a unit.

Rascore-AP is the lowest-powered of the four systems, operating at 70 milliwatts peak power at a 3-Mhz repetition rate. Its maximum range of two yards allows the units to be used close together, simulating groups of enemy infantry. Twin dipole antennas give the system a half hemispheric coverage facing incoming fire with the target dummy in the center of the sphere.

Though all four Rascores are based on the same general engineering approach, Rascores-M and -AA are the most complex, and required a solution to a tricky problem—range ambiguity.

Where am I? Long-range radar systems with low repetition rates can transmit a relatively long pulse, time return, then transmit again; they always know what pulse they're working on. But the short-pulsing, high-repetition rate Rascore systems must operate at very short ranges, and without extra signal processing could get pulses confused and generate false information.

Sanders got around this by dividing the radar system's pulse stream into sections 255 pulses long and then applying a binary code to each of these sections—each pulse either begins with 0 degrees phase or at 180 degrees, indicating either a binary 1 or 0.

In the transmitter, a single transistor oscillator is followed by a varactor tripler to generate the 1.78-Ghz output frequency. This is then passed to a coding and pulsing switch controlled by a shift register. The shift register also feeds its code to digital correlators in the receiver.

Successive pulse sections will match in only one of the receiver's correlators at any given time. Thus the sequence of incoming pulses and the range from which they returned can be determined without ambiguity. Fine range determination is given by a set of range gate

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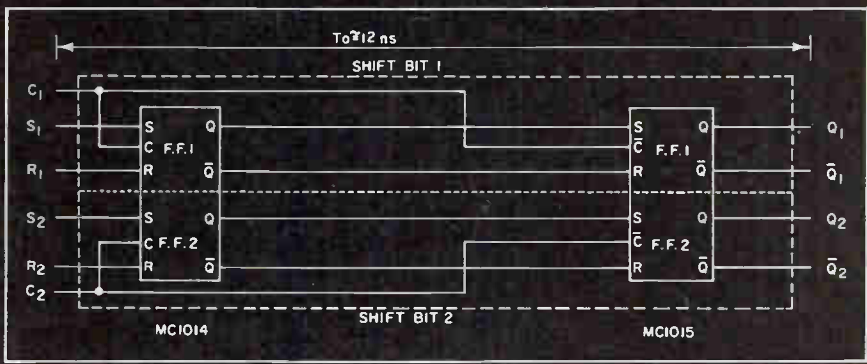

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Two new additions to the growing MECL II line of integrated circuits, MC1014P and MC1015P, can be used as positive-gated and negative-gated R-S flip-flops, respectively. Two levels of gating are accomplished with only 2 ns increase in propagation delay. As a result, a single phase, clocked Master-Slave type of shift register with a 6 ns total propagation delay may be obtained as shown.

The MC1014P, in addition to teaming with MC1015P for shift register functions, is also useful as a dual storage element. It contains two dc Set-Reset flip-flops with a positive clock input provided for each flip-flop. MC1015P operates with a negative clock input.

Both new circuits exhibit typical propagation delays of 5.0 ns, operating over the 0 to +75°C temperature range. Both provide typical power dissipation of 125 mW at an operating frequency of 80 MHz. Minimum dc fan-out of 25 for each output is guaranteed!

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Rascore-M offers doppler as a growth feature. With moving targets the binary pulses won't quite line up in the correlators and the output will be a series of amplitude-modulated pulses. By demodulating these, range information is derived. To get velocity, the frequency of the demodulated signal would be measured.

Coming up. Sanders' staff engineer, Eugene Heft, believes that Rascore-AA and -M could make good ground-fire detectors for helicopters, and that Rascore-S could score artillery fire. Most interestingly, he says, Sanders has had nibbles from several Nike-X subcontractors. This could mean that Rascore could be used in evaluation of the upcoming thin missile-defense system. But if so, it would take a complete redesign of Rascore-M.

For the record

Testing. Mariner 5, which is expected to pass within 2,500 miles of Venus on Oct. 9, will carry a payload of scientific instruments designed to determine the planet's atmospheric and ionospheric conditions. Three ultraviolet photometers will determine the gaseous composition of the atmosphere from the top of the clouds to an altitude of several thousand miles. In another experiment, a dual-frequency radio signal emanating from the Palo Alto, Calif., earth station will provide the spacecraft's sensors with occultation data on the ionosphere's altitude, thickness, and day-night variation. A similar experiment, using an S-band radio contained in the craft, will measure the atmospheric density.

Third down. Texas Instruments Incorporated, which predicted earlier this year a rise in earnings for the autumn, now says that third quarter and total 1967 earnings will be "down significantly" from last year's. Mark Shepherd Jr., TI president, blamed the troubles on semiconductor business. Specifically, earnings were hurt by smaller-than-expected profits in the integrated circuit field, and a TI decision not to cut back on expenses for future IC programs.

Wide, wide world. During the next six months two satellite systems, which are expected to collect data on everything from animal migration to worldwide meteorological patterns, will be tested by the Goddard Manned Spaceflight Center. The systems—Interrogation Recording and Location System (IRLS) and the Omega Position Location Equipment (OPLE)—both use remote ground or airborne platforms, ground stations, and satellites. The IRLS satellite, which travels in a 90-minute earth orbit, will use triangulation with known orbital parameters to locate the platform positions, while the OPLE satellite, which travels in a synchronous orbit, uses the Navy's Omega navigational system. IRLS, which has just been given the green light by NASA for a second model to be launched in 1970, is expected to be used primarily for studying weather patterns, animal migrations, and other natural phenomena. OPLE, on the other hand, will be used more for navigation, air traffic surveillance, and space flight reentry positioning.

Operational. Braniff Airlines is now using Bunker-Ramo's cathode-ray tube visual display reservations system at strategic sites with tie-ins, from its Dallas headquarters, to three other participating airlines—Central, Southern, and Trans-Texas.

All set. The world's fastest typesetting machine, Linotron [Electronics, April 3, p. 113], a joint effort by CBS Labs and Mergenthaler Linotype, has been put to work in the Government Printing Office.

Vacancy. NASA's Deputy Administrator Robert C. Seamans Jr. will step down at the first of the year to return to industry. Seamans, who agreed to take the job for two years but stayed for seven, has not announced where he will work next nor has the agency appointed his successor. NASA watchers say the odds-on favorite for the post is Homer E. Newell, who stepped into the No. 3 spot as associate administrator the day before Seamans announced his resignation.

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Single-Gate Types	Typ 200MHz G_{ps}	Typ 200MHz N.F.	Typ g_{fs} (μmho)	Max C_{rss}	Max I_{GSS}	Min V_{DS}	Case	Price (1000+)	Applications
3N128	18dB	3.5dB	7,500	0.2pF	50pA	20V	TO-104	.88	RF Amplifier, Mixer, Osc. High Input Impedance Timing Circuits, Electrometers, Instrumentation & Controls
3N138	(Zero offset)		6,000	0.25pF	10pA	35V	TO-72	2.00	Chopper and Multiplex Equipment, Transmission Gates
3N142.	17dB*	2.5dB*	7,500	0.2pF	1nA	20V	TO-104	.65	RF Amplifier, Mixer, Osc. and General Purpose Amplifier
Dual Gate Types									
3N140	ᵘ18dB	3.5dB	10,000	0.03pF	1nA	20V	TO-72	.98	200MHz RF Ampl.
3N141	18dB	—	10,000	0.03pF	1nA	20V	TO-72	.94	200MHz Mixer and Product Detector

ᵘ unneutralized power gain
* 100MHz

The new RCA 3N142 N-channel depletion type insulated-gate (MOS) FET offers complete versatility from DC to 100 MHz and beyond. Its high input resistance (10^{12} typ.) and low gate leakage current make it ideal for low frequency timing circuits, industrial controls and instrumentation equipment. High transconductance and low feedback capacitance, coupled with excellent thermal stability, provide outstanding performance in RF amplifier, mixer and oscillator applications up to 175 MHz. Because it features low cross modulation, reduced spurious responses, minimum oscillator feedthrough and large signal handling capability without diode-current loading, the 3N142 offers today's greatest value in MOS transistors.

Why not get the complete story of the price and performance advantages of the RCA 3N142 (MOS) FET? Your RCA Field Representative will be glad to answer your questions and supply information on other single and dual-gate (MOS) FET's. For additional technical data, write RCA Commercial Engineering, Section EN10-1, Harrison, N.J. 07029. See your RCA Distributor for his price and delivery.

RCA Electronic Components and Devices

RCA

The Most Trusted Name in Electronics

Circle 55 on reader service card

Look who's now

big in MOS.

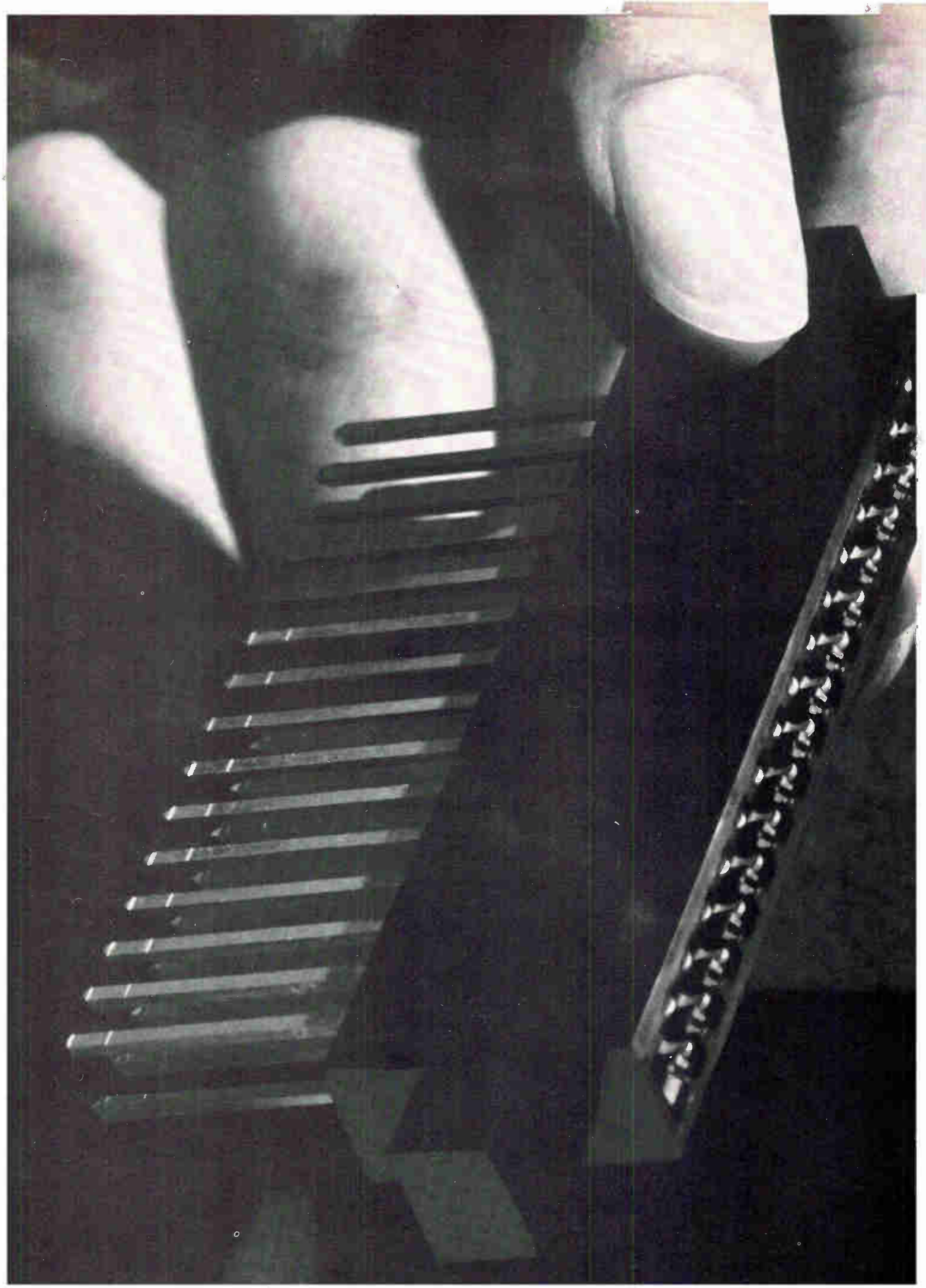
Prodded by Dan Izumi, we now make the fastest, lowest-powered two phase shift register in the whole wide world.

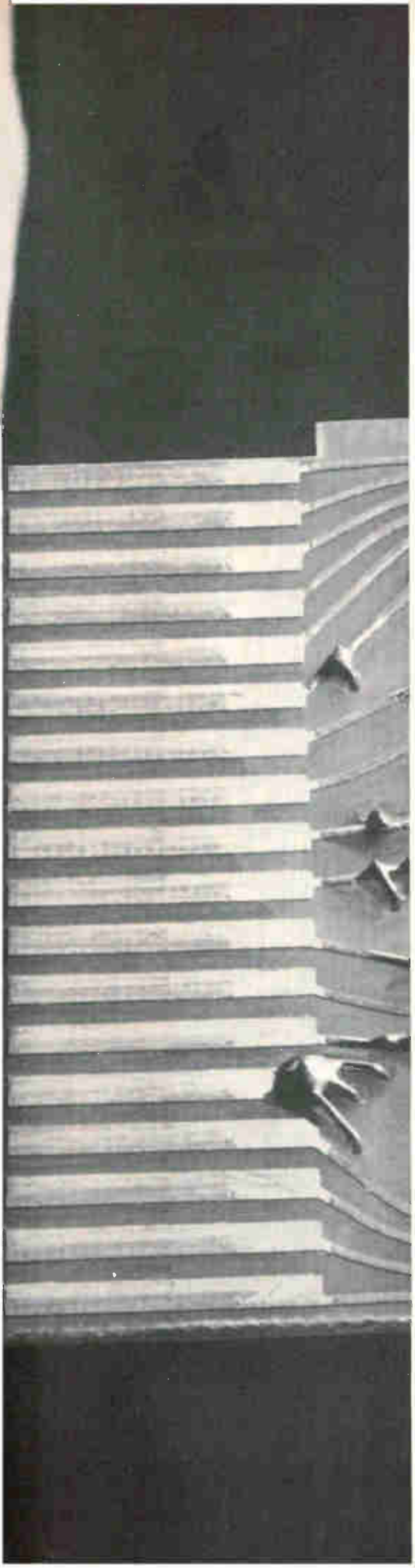
We call it the MM400. He calls it the Izumi 400. Call it what you like, it's still the world's best dual 25 bit dynamic register. Primarily because it uses only −10 volt VDD and −16 volt clock voltage. That's at least a good 11 volts under any other. And guaranteed operation is at 1MHz over a temperature range that goes up to 125° centigrade.

There's also very little power dissipation — typically 40mw at 1 MHz operation — making it just perfect for ground systems, instrumentation, airborne computers and a variety of other applications. Price is an inscrutable $40 in 100 lots. Send for details or get them off the shelves of our distributors. Ask for the Izumi 400. See if they know what you mean.

National Semiconductor Corporation, 2950 San Ysidro Way, Santa Clara, California 95051, (408) 245-4320.

National Semiconductor





Off-the-shelf PMT from Amphenol

PMT means Precious Metal Tip, a wrought gold dot welded to printed circuit connector contacts. PMT is 100 times thicker than ordinary contact plating. We have 22 different PMT connectors that will work for 20 years, and they're all standard production items. Pre-tensioned contacts spring back to position insertion after insertion —without damaging P.C. boards. You'll pack about twice as many contacts in the same space, too: 56 in a No. 28 connector, 36 in a No. 18. PMT could be your best printed circuit connector buy. Call your nearest Amphenol Sales Engineer or write to **Amphenol Connector Division,** 1830 S. 54th Avenue, Chicago, Illinois 60650

Cut-away Amphenol PMT connector shows welded gold dots on contacts

AMPHENOL

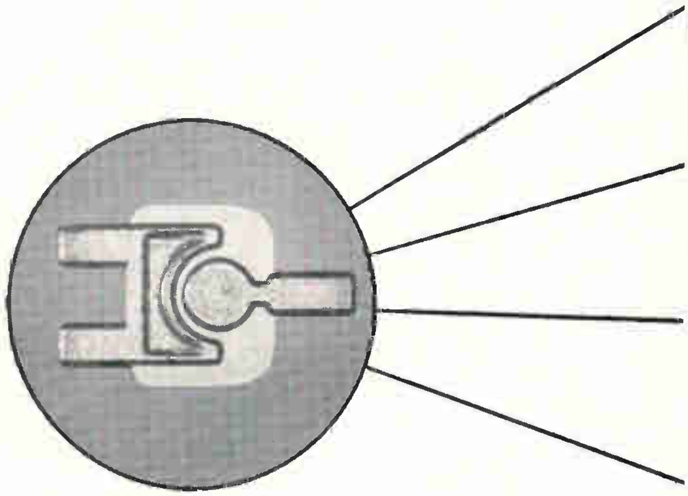
TM

Circle 59 on reader service card

now...
BEAM LEAD DIODES
in flip-chips, axial-lead microdiodes and multi-diode modules

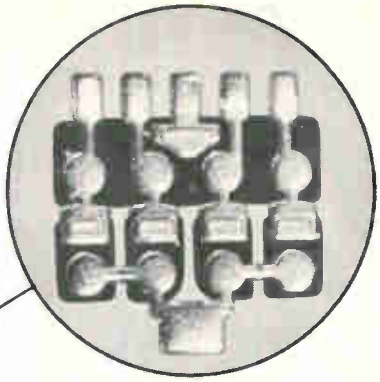
You can now select from General Instrument's line of Beam Lead diode products, flip-chips, axial-lead microdiodes, and a complete line of multi-diode modules—all providing the extreme reliability of the Beam Lead structure.

The Beam Lead Technology:
General Instrument's Beam Lead devices consist of gold bonding leads extending beyond the edges of the chip—in cantilever form. Securely bonded to the silicon and its passivating layer, Beam Leads make ohmic contact through a highly stable and low resistance platinum alloy. Beam Leaded devices are prepared on the slice in a batch process, thereby lowering costs and providing the utmost uniformity between Beam Lead interconnected devices. Beam Lead technology creates a total chip/bond system which is unusually rugged and yields extremely reliable package bonds by a variety of techniques.



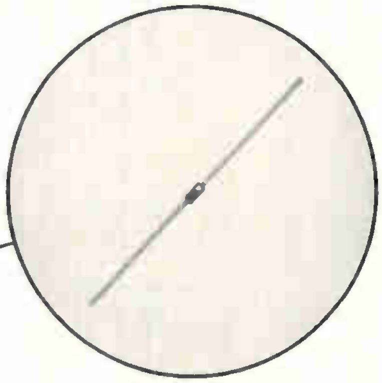
only from General Instrument

For information in Europe, write to: General Instrument Europe, Via Turati 28, Milano, Italy.



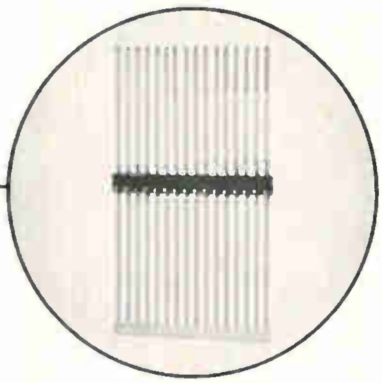
now available in...

Chips and Chip Arrays—for use in flip-chip bonding in a wide range of electrical parameters and circuit configurations. The cantilevered Beam Leads permit economic assembly to substrates without the use of eutectics, aluminum or thermal wire bonding. No bonding energy need be transmitted through the chip itself and, once formed, the bond is <u>visually available</u> for inspection. Discrete diode chips as well as diode arrays containing two to eight air isolated junctions are available.



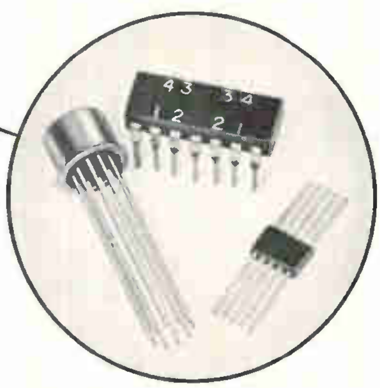
and in...

Beam Lead Microdiodes—in a small plastic axial-lead Microdiode which exceeds MIL moisture specifications. The Microdiode body measures only 40x40x80 mils. It has half inch long gold plated Kovar ribbon leads (5x20 mils). Life tests performed on General Instrument's Microdiode indicate a typical ΔI_r less than $1.5 x I_{r\,(orig.)}$ at PRV and 25°C after 2000 hours at 150°C operating conditions.



and in...

Beam Lead Microdiode Strips—as modular diode strips on 50 mil centers. The strip may comprise from two to twenty diodes in any combination of common anode, common cathode or discrete interconnections. They can be easily used to form large diode matrices for switching applications.



and in...

Beam Lead Diode Modules and Arrays—in any circuit configuration and in plastic or hermetic packages—both flat pack and dual in-line. The extreme stability and long life provided by Beam Lead bonding is assured. The use of Beam Lead isolation between junctions allows the production of switching and core driver modules with faster response times than obtainable by the usual monolithic approaches.

GENERAL INSTRUMENT

Write for full information.

GENERAL INSTRUMENT CORPORATION · 65 GOUVERNEUR STREET NEWARK, NEW JERSEY

Circle 61 on reader service card

Meet Trygon's Jolly Clean Giant

Trygon's New EAL Series Laboratory Power Supply

■ This is Trygon's new EAL wide-range laboratory power supply —four models in the most commonly used laboratory voltage ranges. At $99, it's a giant.

■ And it's a clean giant. Clean output, with ripple less than .5mv rms, plus rock-steady .01% regulation, .05% stability.

■ Clean, compact all-metal case, too, that doesn't waste an inch of bench space. The switchable volt/ammeter, concentric coarse and fine voltage controls, pilot light and output terminals (fully floating output) are all on the front panel.

■ Put our jolly clean giant to work for you. Just write your order neatly on the order blank below. We'll take care of the rest.

TRYGON

TRYGON ELECTRONICS, Inc.
111 Pleasant Ave., Roosevelt, L.I., N.Y. 11575*

I need the following EAL unit(s).

Qty.	Model	Rating
....	EAL 10-1	0-10 VDC @ 1.0 Amp
....	EAL 20-500	0-20-VDC @ 500 ma
....	EAL 32-300	0-32 VDC @ 300 ma
....	EAL 50-250	0-50 VDC @ 250 ma

Name ______ Title ______

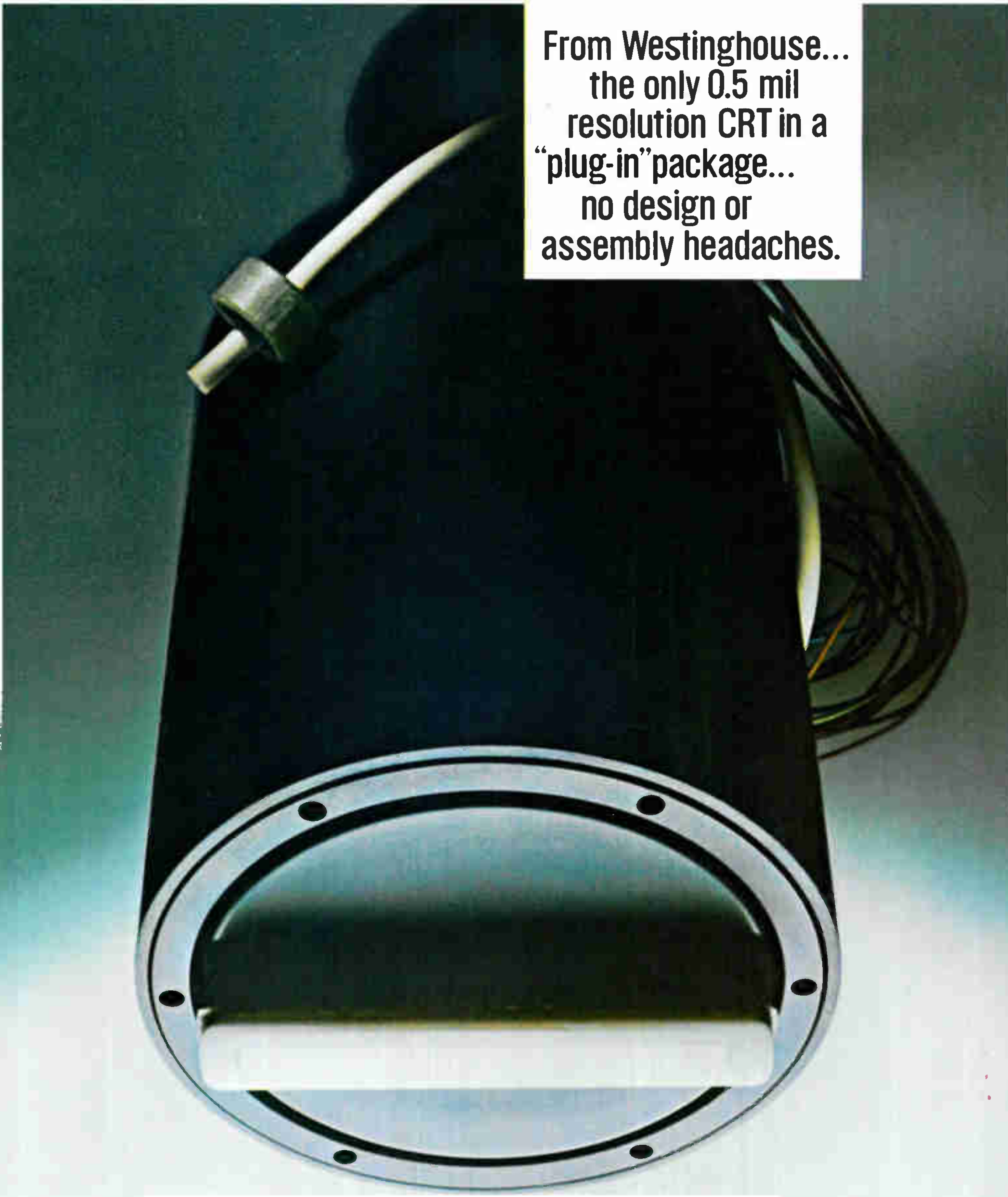
Firm ______

Address ______

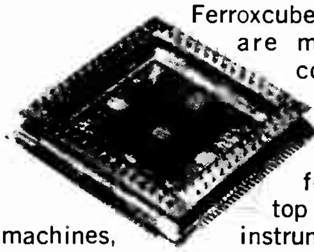
City ______ State ______ Zip ______

☐ Purchase Order Attached. ☐ Contact us for Purchase Order.
☐ Please send Trygon Power Supply Handbook.

*Prices slightly higher in Europe: Trygon GmbH, 8 Munchen 60, Haidelweg 20, Germany.



Now an instant Core Memory ...just plug in and solder



Ferroxcube Platrices are magnetic core matrices specially designed for desktop business machines, instrumentation and industrial control equipment. Not only are they priced far below conventional core memory planes; they save you even more money on assembly costs.

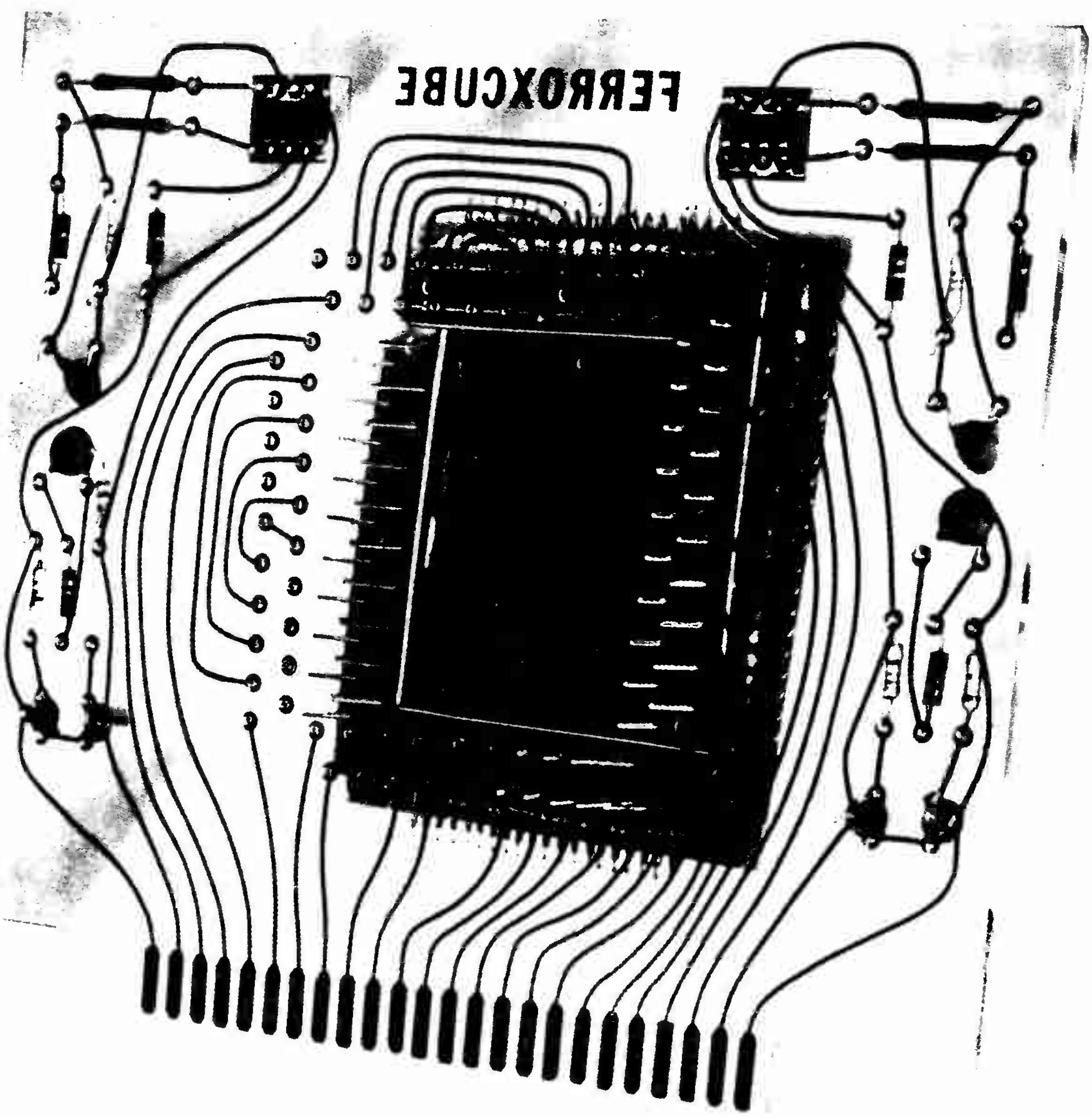
Platrices are provided with plug-in connection pins for quick and simple direct mounting on printed circuit boards. You mount a Platrix as you would a transistor: push the leads through the board and solder. To illustrate, we built this mockup out of clear plastic so you can see both the pins and the Platrix itself.

The expensive cut frames of conventional planes are eliminated by a simplified yet rigid frame of glass-epoxy laminate. For high resistance to shock and vibration, the cores are fixed to a base plate of this material by a special lacquer.

Stacks of up to four Platrices can be supplied with series connected drive lines terminated at the bottom of the stack. Low drive currents allow use of simple drive and selection circuits. Platrices are available in 8 standard configurations with bit capacities from 256 to 1,024, but we can be persuaded to make other sizes if you really need them.

Platrices. Reliable. Simple. Inexpensive. Bulletin 6007 tells all. Write for it today.

Ferroxcube



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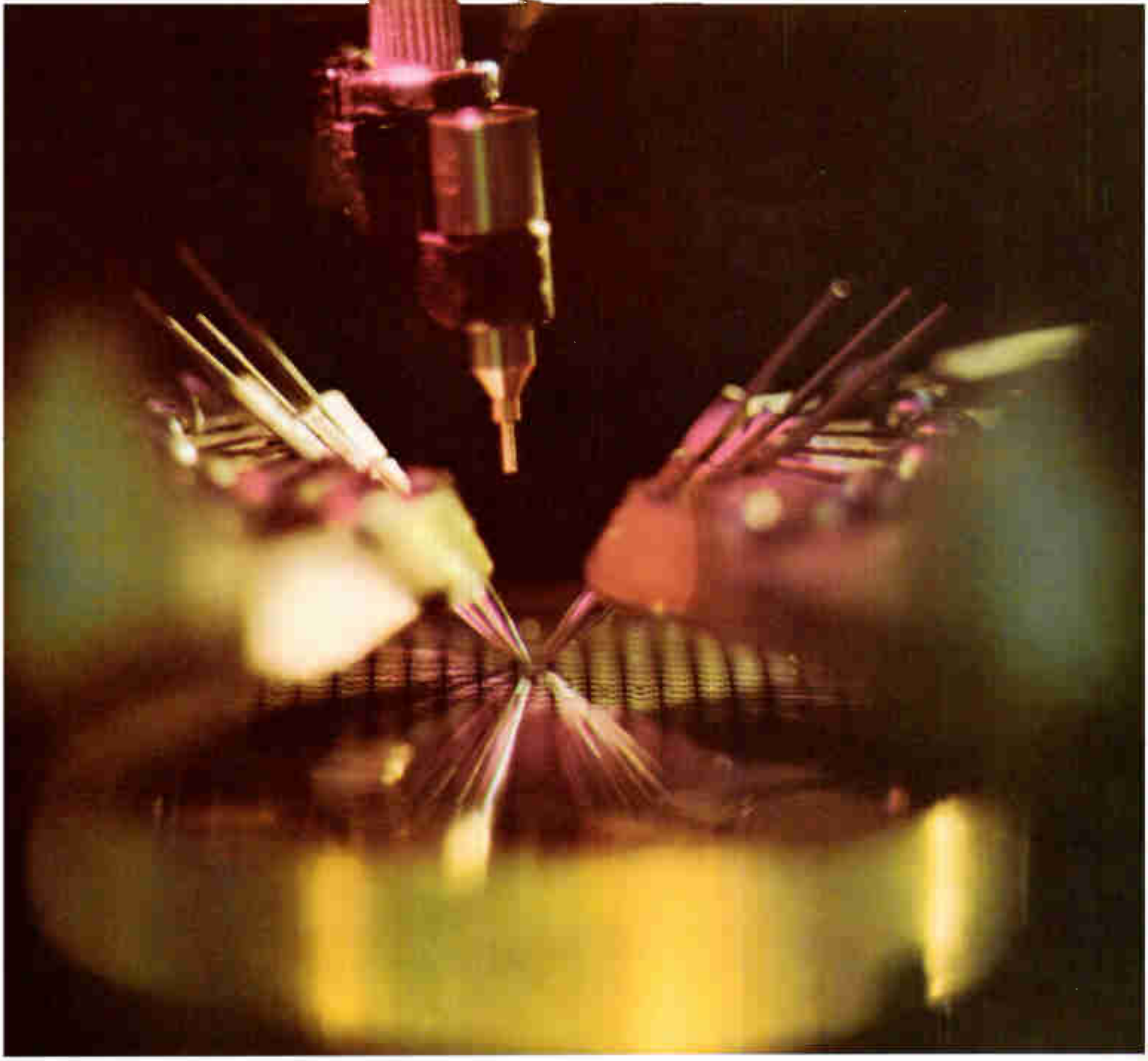
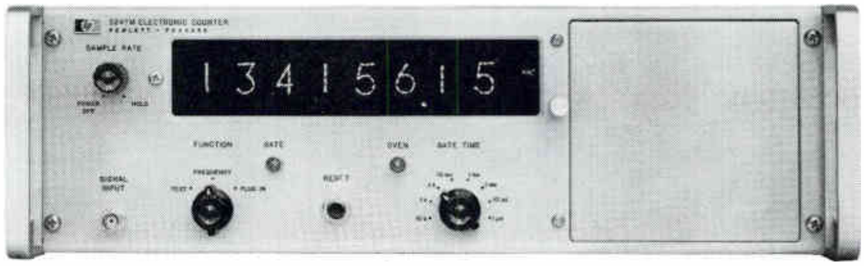


NON-STOP TO 135 MHz!



PLUS—ultra-stable, fast warm-up time base
PLUS—plug-in measurements to 18 GHz
PLUS—versatility as a frequency standard
PLUS—100 mV to 10V input range without adjustment

The new Hewlett-Packard 5247M Electronic Counter makes direct frequency measurements 10 Hz to 135 MHz with no tuning, changing of accessories or adjustments of any kind. Further, it accepts signals over the wide input amplitude range of 100 mV to 10 V rms without any level adjustment. Additional plug-ins let you measure frequency to 18 GHz. Ultra-stable, fast warm-up time base increases accuracy of your measurements and extends the time between calibrations.

Typical warm-up is one hour to reach 5 parts in 10^9; aging rate is < 5 parts in 10^{10}/24 hours. The spectrally pure 5 MHz time base output is available whenever the line cord is plugged in and serves as an excellent secondary frequency standard well buffered against line and load changes. Price: $3000.

The 5247M is another addition to the popular HP plug-in electronic counters. For information on the 5247M call your local HP field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

HEWLETT hp PACKARD

ELECTRONIC COUNTERS

02718

THIS IS THE ONLY SYSTEM/360-COMPATIBLE DIGITAL INCREMENTAL MAGNETIC TAPE RECORDER YOU CAN BUY. (THE REASON IS CBD.)

Why is CALMA's Model 800 the only 9-channel, 800bpi, SYSTEM/360-compatible digital incremental magnetic tape recorder currently available? Because no other recorder manufacturer can meet the maximum character spacing variation specifications of the major computer makers.

CALMA's unique CBD (Constant Bit Density) controller guarantees character spacing variations of less than 2%.

The Model 800 will collect your sporadic (0-500 characters per second) digital data on SYSTEM/360-compatible magnetic tape.

Those of you without SYSTEM/360 can have all the advantages of CBD in our Model 600 (7-channel, 556bpi, 0-500cps) and Model 200 (7-channel, 200bpi, 0-500cps) digital incremental recorders.

Detailed technical information is available. Write, phone, or circle our number on the reader service card for your copy of CALMA Bulletin DR.

CALMA COMPANY

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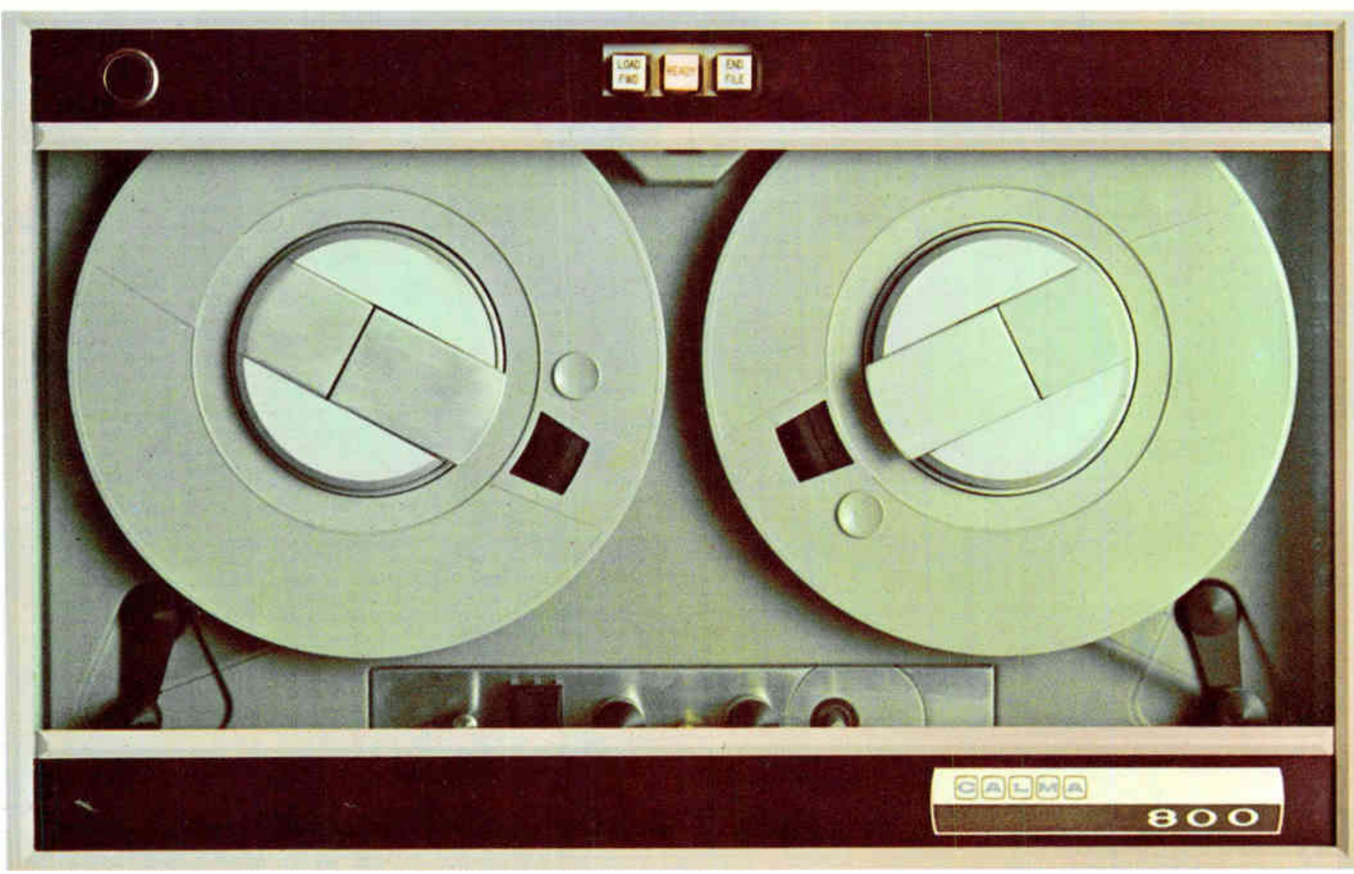
Santa Clara, Calif. 95050
Phone: (408) 244-0960



Washington Newsletter

October 16, 1967

Weigh miniaturized electronic-warfare system from TRW

The Pentagon is evaluating TRW Systems' unsolicited proposal to build an electronic-warfare system small enough to fit in any attack or fighter aircraft. Existing equipment is so large that it usually requires a separate electronic-warfare plane to accompany attacking aircraft on combat missions.

TRW's bid is typical—most electronic-warfare designs originate from unsolicited proposals. Company-funded thus far, the proprietary TRW system already has been breadboarded. In production, the vhf system would cost from $20,000 to $35,000.

Fully automatic, the system employs high-powered miniaturized transmitters—packaged in a 35-pound, 1 cubic-foot box—that deliver up to 500 watts. The system would scan its frequency, recognize and identify a signal from a hostile source, discard other signals, turn on its power, and jam the sensor—after the pilot flips a single switch.

TRW has recently established a 200-man laboratory in Redondo Beach, Calif., to research and produce electronic-warfare equipment. **The annual market for this gear is estimated in excess of $300 million.**

Still no date set For FAA briefing

The Federal Aviation Administration still has problems fixing a date for its first conference to brief electronics firms on future requirements for terminal air traffic control [Electronics, Aug. 21, p. 59]. The FAA this spring planned to have the conference in August; and then it was hoped for September. **Now the FAA is shooting for November, but is still not definite.** Biggest hold-up is the fact that the FAA itself isn't positive what its future needs will be and is having problems trying to figure out what to tell the electronics firms.

Freeze on spending cools Omega outlook

Navy officials seeking a go-ahead for full-scale deployment of the Omega navigation system now fear that the Administration's military spending freeze may push the operational date deep into the 1970's. Omega advocates have been pressing for top-level Pentagon approval of the system for more than two years, but their formal request reached the desk of Defense Secretary McNamara at the same time as did orders for the deferral of outlays not related to the Vietnam war.

Even if McNamara approves the Omega concept—and he may this week—he isn't likely to request money for its implementation until Vietnam spending subsides. The Navy had hoped that an approval would mean $40 million in the fiscal 1969 budget to improve the system's very-low-frequency transmitter network and to equip ships with the receivers. With the transmitters fully operational, the door for a $1 billion receiver market would be opened [Electronics, March 20, p. 50].

IBM studies future flying 'war room'

The Pentagon has awarded IBM's Federal Systems division a $230,000 contract to study the first element of an advanced strategic military command and control system for the post-1975 era. **The order calls for a design study of an airborne emergency command post for the projected world-wide military command system.**

Such a command post—probably installed aboard a giant C-5A Galaxie aircraft—would replace the one now in a Boeing 707 based at Andrews Air Force Base, Md. Other emergency command posts are in a hardened site in a Maryland mountain and aboard two Navy ships operating off the Virginia coast; all could take over "war-room" functions if the primary command center in the Pentagon were destroyed.

IBM is just starting the study, but indications are that the design will include larger and faster data processors.

Riding a moonbeam

An S-band beacon on the moon will be used to calibrate the antennas of U.S. telemetry terminals on earth. **Researchers have given up on a range-calibration satellite because of problems in stabilizing it with necessary precision.** Astronauts will set up the beacon during their first lunar landing. It will have sufficient power to send out signals for two to three months.

Law groups framing new patent bills

The controversial "first to file" tests in the Administration's patent reform bill [Electronics, May 29, p. 60] have held up that bill and will undoubtedly keep it from being passed this session. **However, two alternatives will be posed in the separate bills being framed for presentation by the American Bar Association and the American Patent Law Association.** The two bills, expected to be unveiled before winter, for the most part duplicate the Administration bill, but will have provisions for filing which are closer to the existing patent office "first to invent" rule.

Wanted: New ground communications link

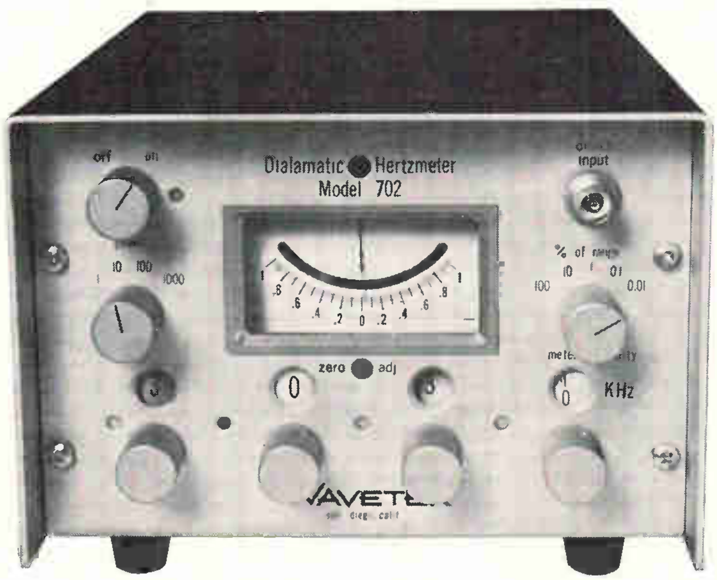
Conventional communications have been ruled out as links between vehicles and control centers of the high-speed ground transportation system planned by the Department of Transportation. **The reason: An overcrowded frequency spectrum.**

DOT is looking into surface wave transmission lines, leaky waveguides and modulated laser beams for links to the automatic controls. Studies of the surface wave transmission lines have gone farther than the other systems so far. Government researchers are investigating field configuration, transmission line design, the effects of supporting structures, methods of coupling between vehicles and control centers, and ways to increase the data capacity.

Addenda

Robert M. Lowe, a lawyer, has been named to head the Transportation Department's office of telecommunications. His group's first assignment will be to study transportation communications and satellite navigation. The department is still searching for a research and development chief . . . Air Force research and equipment needs for the Vietnam war are going to get more attention. Brig. Gen. William S. Charsell will head a new office that will take over many of the tasks previously assigned to the limited war offices of the Air Force Systems Command divisions . . . The first mechanically despun satellite antenna will get its initial flight test aboard the ATS-C spacecraft scheduled for launching into a stationary orbit Nov. 7. The Sylvania-built antenna is designed to provide an 18-decibel gain, compared with the 13-db gain being registered by the electronically despun antenna aboard the ATS-1. Sylvania is also developing a more sophisticated mechanically despun antenna for Comsat's Intelsat 3 global satellite system.

We call it a Hertzmeter.



Hertzmeter?

That's right. Hertzmeter.

When you invent a unique instrument, you give it a unique name. Here's what's so special about it.

The Hertzmeter can measure, monitor and tune frequency. Easily and accurately. It combines the advantages of digital precision with analog continuity.

We were going to call it a Differential Frequencymeter because it's a lot like a differential voltmeter. Only it's more so. The Hertzmeter is fast, because it uses Wavetek's Transfermatic Switch* and non-saturating null amplifier. Measurement of low frequencies is particularly fast. Incidentally, the frequency range is 5 Hz to 100 MHz, with accuracy of ±0.01%.

The Hertzmeter also has a recorder output for monitoring deviations from 100% full scale down to a maximum resolution of ±1 ppm.

You can get yourself a Hertzmeter for as little as $795. Or you can get a more versatile instrument that measures dc voltage in addition to frequency for $1,095. We call this one a Voltmeter/Hertzmeter.

If you buy one, you can call it whatever you like.

*Patent applied for.

WAVETEK®

8159 Engineer Rd., San Diego Calif. 92111, Tel. 279-2200
P.O. Box 651, San Diego Calif. 92112, TWX 910-335-2007

The new Bourns units are available in 7/8", 1 1/16" and 2" diameters with either bushing or servo-mount lids. Standard linearity is 0.5% with special linearities on request. Rotational life of the new conductive plastic units is 50,000,000 shaft revolutions and temperature range is —55°C to +125°C. All have outstanding resistance to humidity and exceed the moisture resistant requirement of MIL-R-39023. Most are available in ranges of 100 to 1,000,000 ohms. All models are manufactured to the stringent quality specifications you have come to expect from a Bourns product line. As with all products manufactured by Bourns, every single INFINITRON unit is guaranteed by the Bourns Reliability Assurance Program, which includes individual inspection to published electrical and physical characteristics. Standard units are ready to ship off-the-shelf to fit your production or engineering requirements. . . special resistance values, taps, electrical angles and mechanical stops are available upon request.

Don't gamble in down-time, extended deliveries, etc., and don't speculate on quality and specifications! Investigate all the outstanding specs offered by the six new INFINITRON conductive plastic precision potentiometers from Bourns! For complete technical data contact your nearest Bourns office, representative or write the factory direct.

BOURNS

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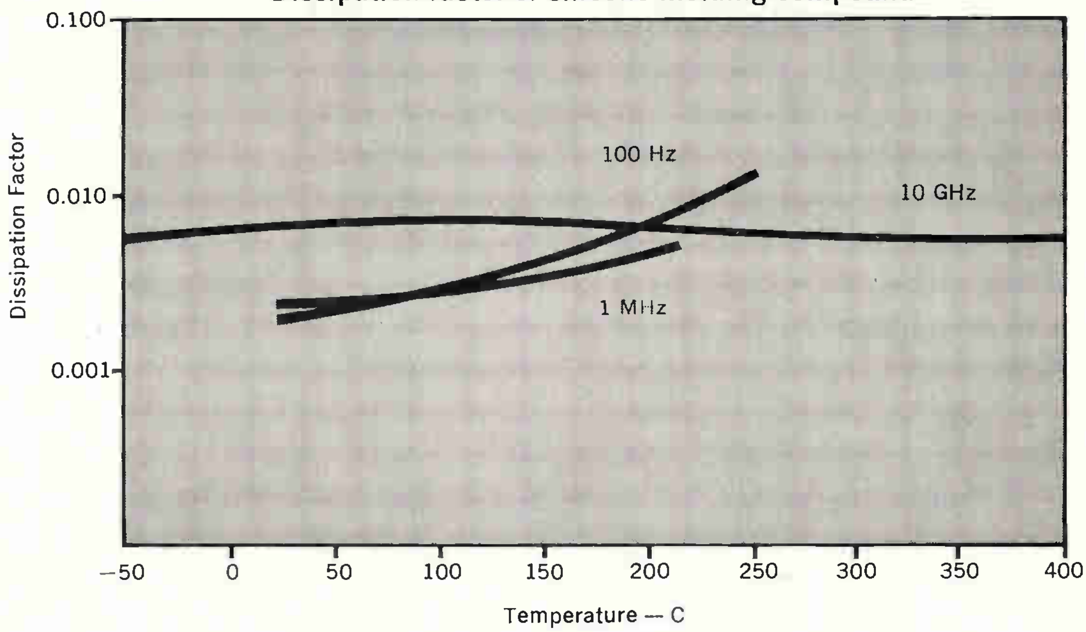
Why the big swing to silicone molded devices?

Dissipation factor of silicone molding compound



Why the big swing to silicone molded devices? . . . Electrically stable materials over a wide range of temperatures from low to high frequencies—as shown graphically above. Silicone molded packages do not limit the design or performance of high frequency semiconductor devices. Design characteristics will not drift due to changing electrical properties of the molded package.

That's why the rapid growth in the number of devices—from simple diodes to integrated circuits—packaged in silicone molding compound. Of course, there are other important reasons.

No derating necessary. Devices packaged in silicone molding compounds can be operated at their full power potential. This enables designs with a higher device density per given volume. For example, one manufacturer reduced the size of a power diode to 1/30th of its glass packaged counterpart. Compared to other plastic materials, the package size is from 1/5th to 1/3rd smaller, since derating due to package stability is not required.

No cracking — Dow Corning silicone molding compounds—unlike other organic thermal setting plastics—are virtually unaffected by heat and thermal shock. For example, a power resistor molded in Dow Corning® 307 molding compound was subjected to repeated cycling from −65 C to 350 C without damage to the packaging material or the device. Dow Corning® brand molding compounds subjected to 1000 hours at 300 C (572 F) show no significant change in physical and electrical properties.

Will not burn. Silicone molding compound is inherently non-burning. Thus components packaged in silicone molding compound will not constitute a fire hazard. No flame snuffers are needed . . . a source of ionic contamination for devices packaged in organic plastic materials. With silicone molding compound there are no ionic or polar constituents when properly used, to affect junction performance.

Low water absorption—Dow Corning silicone molding compounds have low water absorption even after long aging at maximum operating temperatures.

Competitive Price. Silicone molding compound costs only a fraction of a cent per device. Thus, it enjoys a substantial price advantage over metal cans and glass packages.

Manufacturing Economies. Transfer molding enables devices to be packaged with minimum of manual labor and supervision. Good mold release and minimum flash assure high production rates and reduced deflashing costs.

For technical data on why the swing to Dow Corning silicone molding compounds in device packaging, write Dept. 3734, Electronic Materials Division, Dow Corning Corporation, Midland, Michigan 48640.

Circle 75 on reader service card →

200,000 OHMS PER VOLT

TRIPLETT

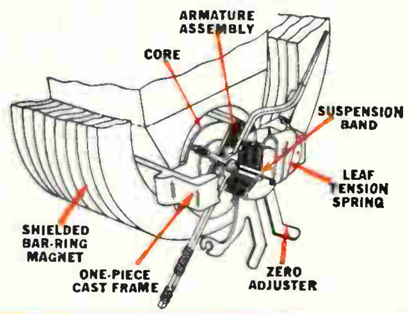
Model 630-NS

VOLT-OHM-MICROAMMETER

$105.00
SUGGESTED U.S.A. USER NET

TRIPLETT SUSPENSION MOVEMENT

no pivots . . . no jewels . . . no hair springs . . . thus NO FRICTION.



FACTS MAKE FEATURES

1 200,000 OHMS PER VOLT D.C. for greater accuracy on high resistance circuits. 20,000 OHMS PER VOLT A.C.

2 5μa SUSPENSION METER MOVEMENT. No pivots, bearings, hairsprings, or rolling friction. Extremely RUGGED. Greater sensitivity and repeatability.

3 62 Ranges, usable with frequencies through 100 Kc. Temperature compensated. 1½% D.C. ACCURACY, 3% A.C.

Low voltage ranges and high input impedance make the 630-NS especially useful in transistor circuit measurement and testing. Input impedance, at 55 volts D.C. and above, is *higher than most vacuum tube voltmeters.*

The unit is designed to withstand overloads and offers greater reading accuracy. Reads from 0.1μa on 5μa range. Special resistors are rigidly mounted and directly connected to the switch to form a simplified unit. Carrying cases with stands are priced from $11.00.

TRIPLETT ELECTRICAL INSTRUMENT COMPANY, BLUFFTON, OHIO

62 RANGES

D.C. VOLTS	0-0.6-3-12-60-300-1200 at 100,000 Ohms/Volt. 0-0.3-1.5-6-30-150-600 at 200,000 Ohms/Volt. 0-0.150 at 60μa
A.C. VOLTS	0-3-12-60-300-1200 at 10,000 Ohms/Volt. 0-1.5-6-30-150-600 at 20,000 Ohms/Volt.
DB	-20 to 77 in 10 ranges.
D.C. MICRO-AMPERES	0-5 at 300 MV. 0-60-600 at 150 MV. 0-120 at 300 MV.
D.C. MILLI-AMPERES	0-6-60-600 at 150 MV. 0-1.2-12-120-1200 at 300 MV.
D.C. AMPERES	0-6 at 150 MV. 0-12 at 300 MV.
OHMS	0-1K-10K-100K (4.4-44-440 at center scale)
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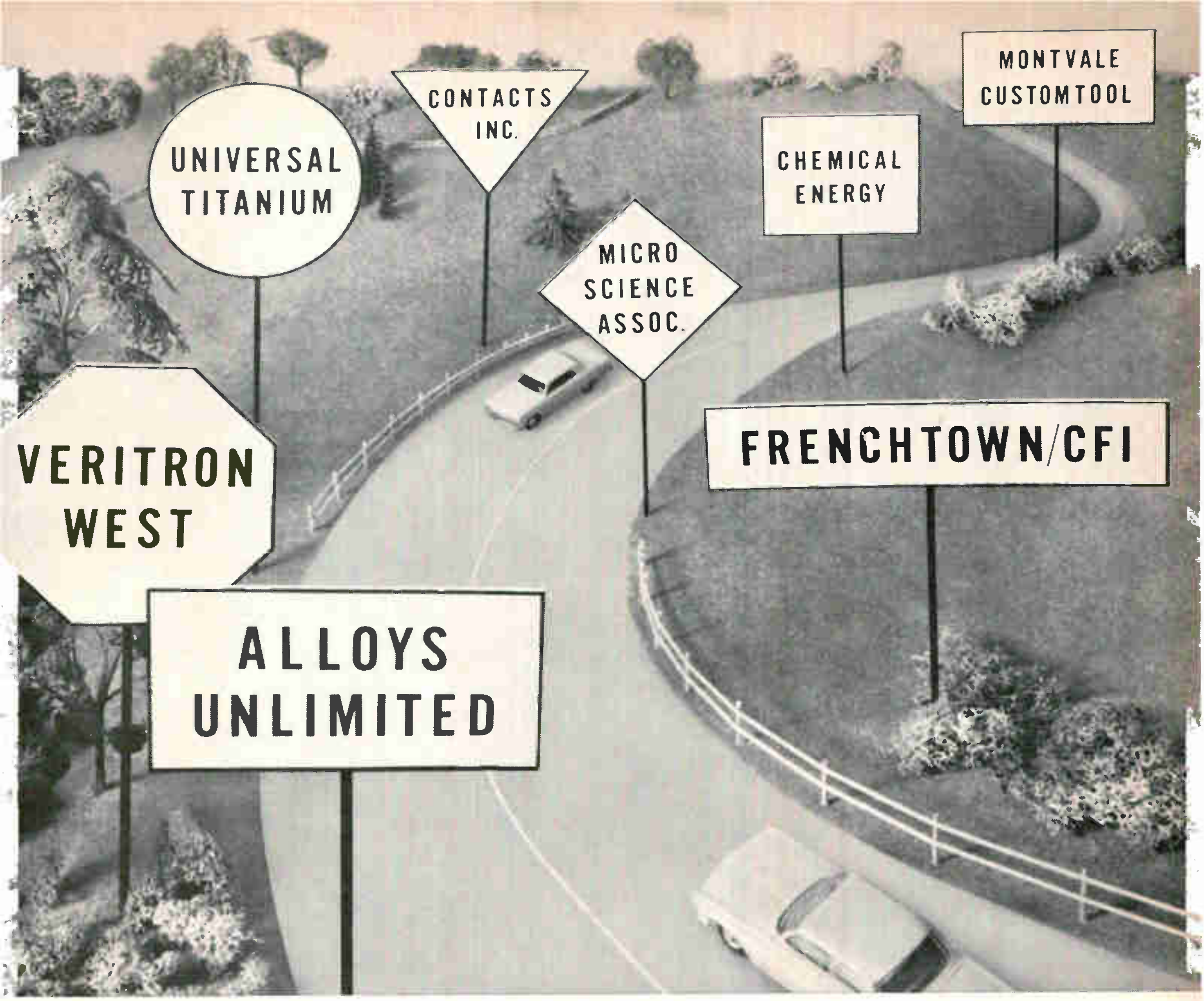

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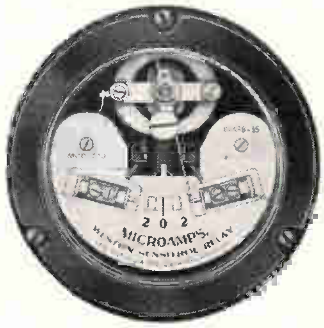

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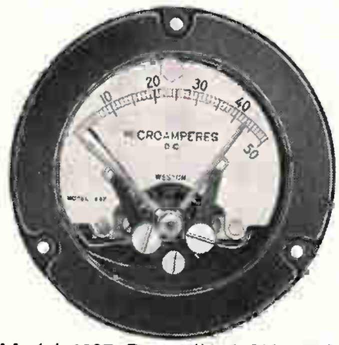
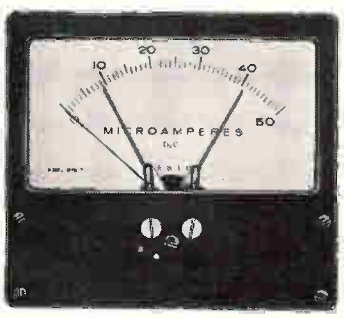


Model 1097 Ruggedized 3½" Relay—Load Current Contact Aiding type fully meets applicable portions of military ruggedized spec; sealed; long scale; shielded; solder terminals; single or double adjustable contacts.



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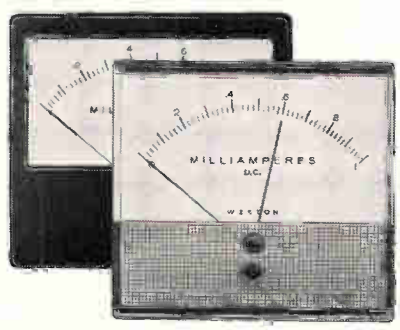

Model 1930/1940 Photronic Relay—3½" and 4½" in either bakelite or plastic front; low cost; add-on power supply and solid state switching circuit; shielded; non-physical, adjustable contact.*

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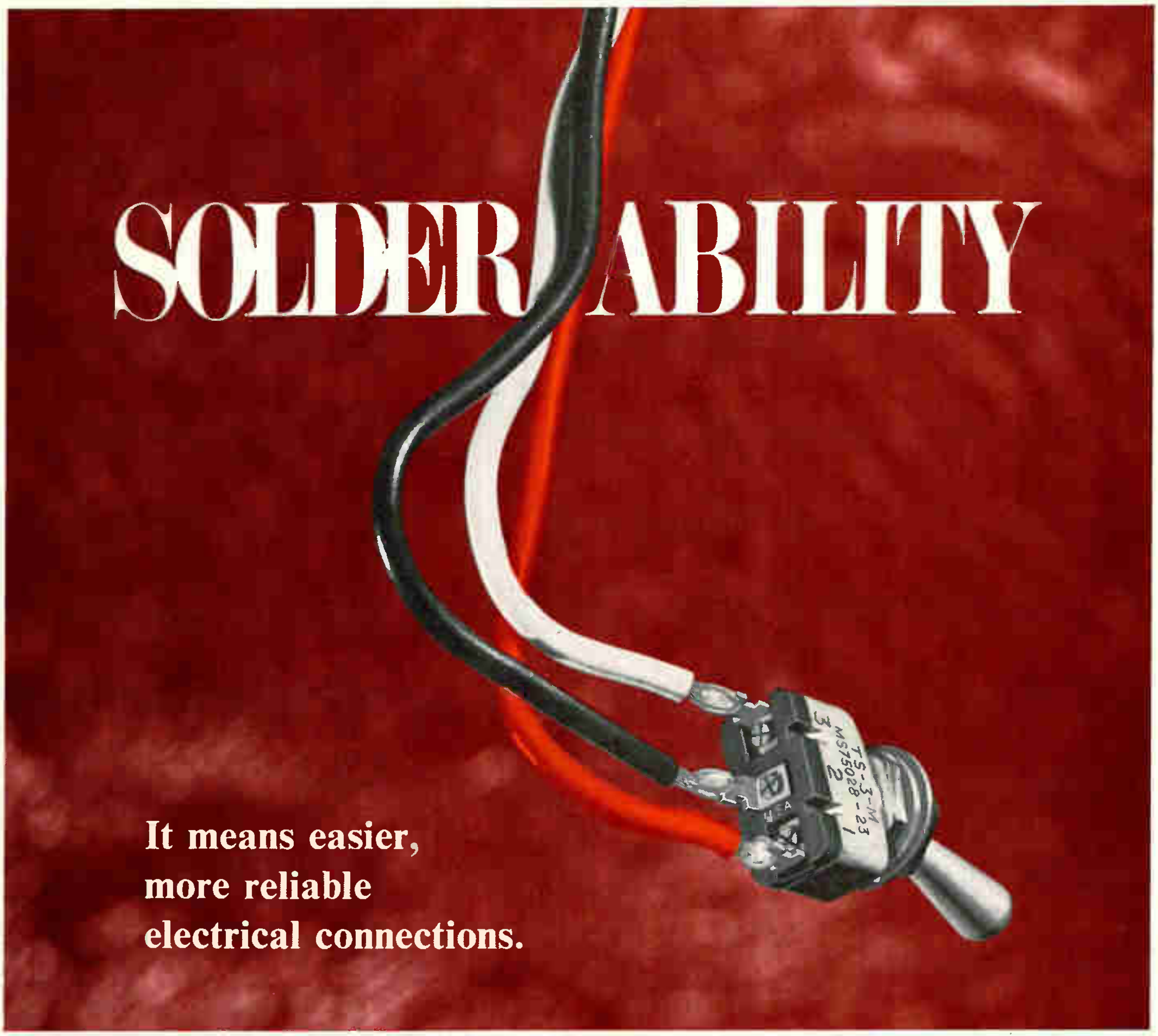

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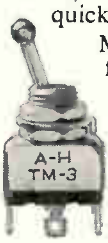
Oversized, gold-plated terminals make soldering these Arrow-Hart subminiature switches a snap.

You also get exceptional versatility of installation, because these are combination solder, quick-connect and single-turret terminals. Movable contacts are rhodium plated for long mechanical life. Stationary contacts are gold-plated silver for long shelf life and superior performance on low-energy circuits. Contacts are rated 5 amps at 125 volts AC and 29 volts DC. For design versatility, you get a wide choice of bat and ball levers, including seven colored types. Two or three position. Maintained or momentary contacts. Arrow-Hart subminiature switches are available to meet MIL-S-3950-C, MS-75028 and MS75029 specifications.



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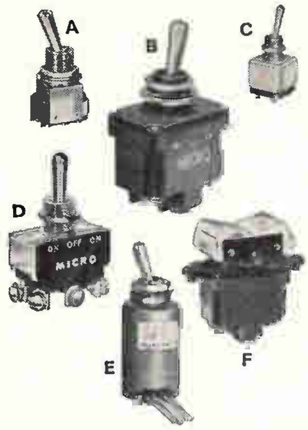
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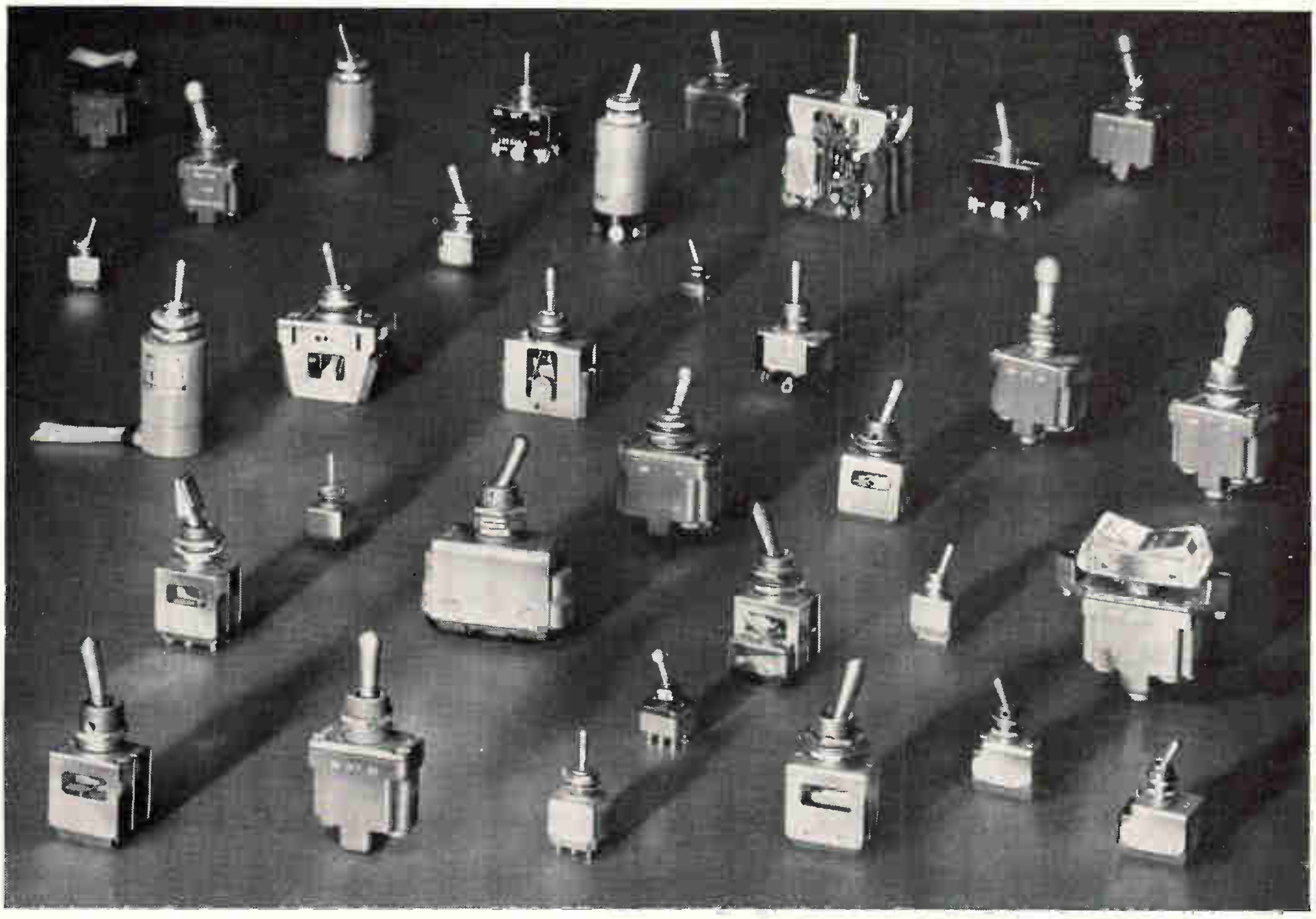

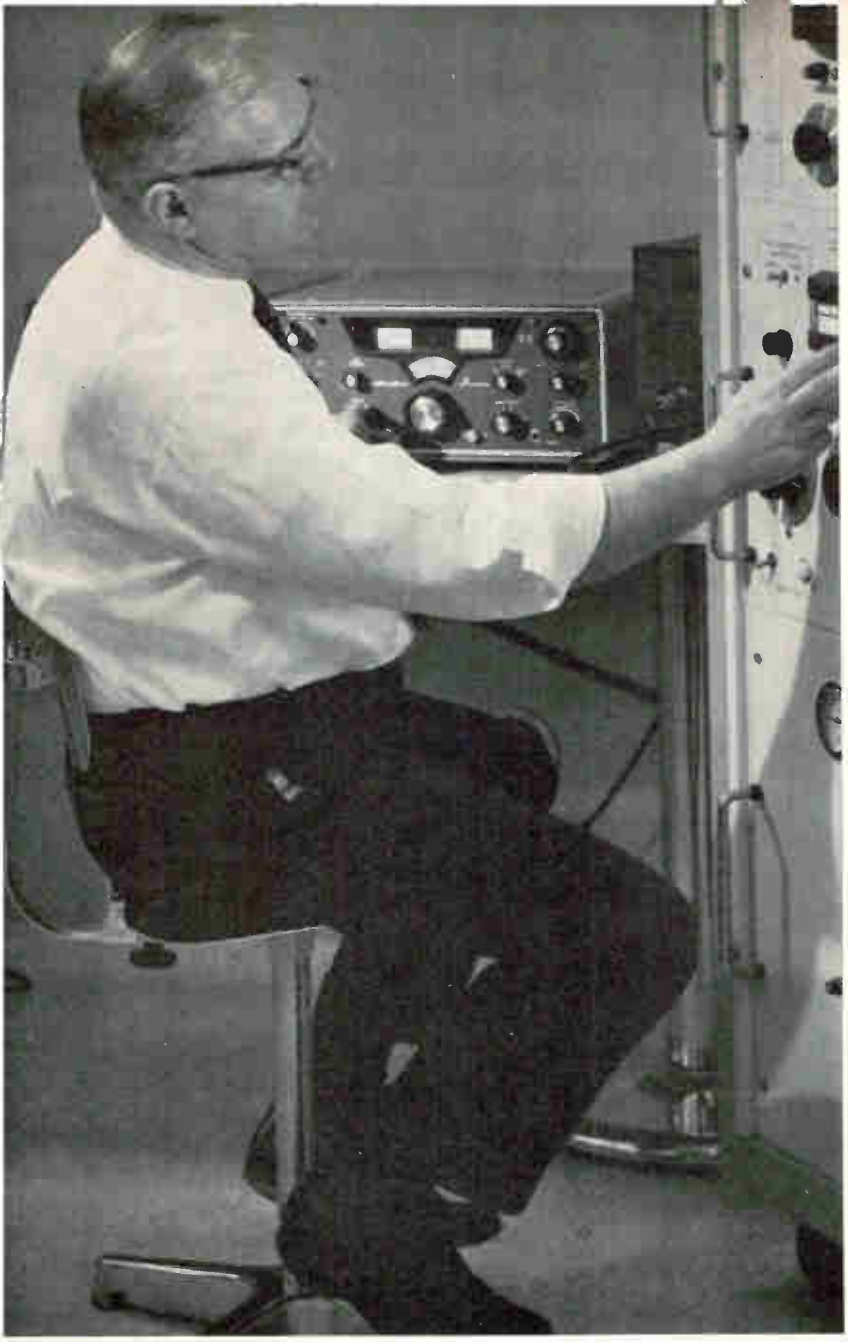

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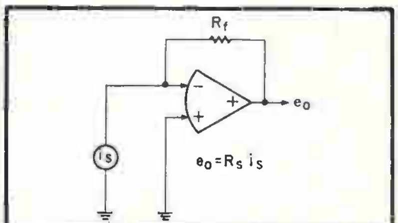
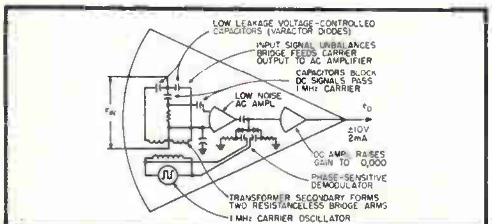


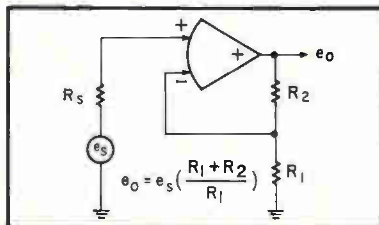
Measure Picoamp Current Signals

With bias current drift of only 0.05 pA/°C and noise of 0.01 pA the 302 can resolve signal currents as low as 10^{-14} amps. Applications include flame detectors, phototubes, nuclear detectors, semiconductor testing, measuring insulation resistance and capacitor leakage, ion gauges, and ion chambers.



How Model 302/303 Works

Amplifier input, e_{IN}, varies varactor capacitance, unbalances bridge and developes carrier voltage output proportional to bridge unbalance. After AC amplification, carrier voltage is phase sensitively demodulated to restore correct polarity, then further boosted by DC amplifier. Matched varactor diodes operated with low level carrier signal give extremely small bias current (0.5 pA). High quality capacitors and high transformer insulation gives 10^{13} ohms common mode impedance.



Measure Voltage Signals from Megohm Sources

Model 303 achieves input impedance of 10^{13} ohms for measuring voltage signals from source impedances (Rs) as high as 10^{10} ohms. Low bias and noise currents give negligible errors with large source impedance. Applications include measuring potentials from pH electrodes, electrochemical cells, vacuum tubes, piezo-electric crystals and high resistance potentiometers.

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The varactor bridge circuit provides the only solid state amplifier which approaches the performances of vacuum electrometer tubes and yet does not suffer the excessive voltage drift and noise, aging, microphonic and overload recovery problems usually associated with these tubes.

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Specifications

Bias Current, max.*	0.5 pA
Current Drift, max.*	0.05 pA/°C
Current Noise, p-p, dc to 1 Hz	0.01 pA
Input Imepance, CM.	$10^{13}\Omega$
Voltage Noise, p-p, dc to 1 Hz	2μV
Voltage Drift, max.	60μV/°C
Rated Output, min.	± 10V@ 2 mA
Open Loop Gain, min.	10,000
Unity Bandwidth	20 k H z
Price (1-9)	$110.00

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Resistance Range, ohms	10 - 2 meg	50 - 20K	20K - 1 meg
Resolution	Essentially Infinite	1.7 (100) to 0.3 (20K)	Essentially Infinite
Sealing	Yes	No	No
Power Rating, watts	0.75	0.5	0.2
Maximum Operating Temp. °C	105	85	85

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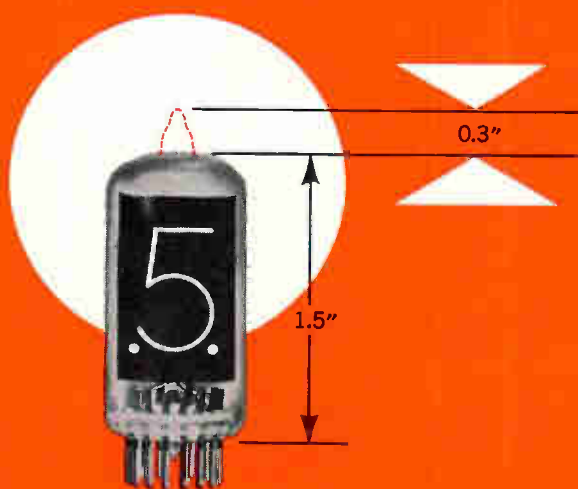

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Technical Articles

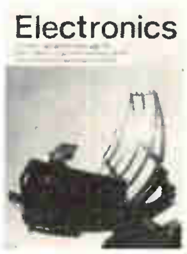
Linear IC's: part 4
Inside the operational amplifier
page 86

The most popular of the linear integrated circuits is the operational amplifier—about six of every 10 linear IC's designed into systems are operational amplifiers. They perform just about any kind of computing function, and can also compare, regulate, control and even process communication signals. The IC operational amplifiers are more useful than their discrete component forerunners because of a more complex makeup that gives excellent balance and versatile differential inputs.

Quick amplifier design with scattering parameters
page 100

In designing transistorized circuits for use above 100 megahertz, an engineer almost has to turn to s-parameters and the Smith chart instead of conventional transistor parameters. In the September 5, 1966 issue, Electronics published one of the first articles on the use of s-parameters in amplifier design, but it considered the special case of an input impedance matched to a load. This article describes how to use the s-parameter technique for the general case.

Air traffic cop watches out for 'bandits' too
page 111



The Air Force's newest 3-D radar uses digital signal processing to zero in on a plane's range, bearing and altitude. Among its unusual features is a computer-designed beam-sharing system that will make the radar exceptionally accurate. Designed so the transmitting and receiving circuitry can be transported by helicopter, the system is the first solid state 3-D tactical radar; it contains about 3,000 integrated circuits. For the cover, Vincent Pollizzotto photographed the antenna of the new 3-D radar as it searched the skies in a practice run at the Baltimore facility of the Westinghouse Electric Corp., where it was designed and built.

Do-it-yourself display brightens the outlook for low-cost computer-aided design
page 120

A simple interface unit turns a conventional laboratory oscilloscope into an effective display for a computer—and costs only about $1,500. To simplify both designing and programing, the equipment uses an elementary form of digital-to-analog conversion, a network of resistances scaled in powers of 2. With incremental conversion, the picture is built up on the oscilloscope screen by a series of small, overlapping spots of light.

Coming October 30

- Conversational approach to pattern recognition
- More on hardening circuits against radiation
- Computer aid on the ocean floor

Linear IC's: part 4
Inside the operational amplifier

With component restrictions offset by radical designs, this jack-of-all-trades is by far the most popular analog circuit

By Mark B. Leeds
Solid state editor

About six of every 10 monolithic linear integrated circuits designed into systems since 1965 have been operational amplifiers. It was the advent of the operational amplifier that year, in fact, that picked the whole field of linear monolithics out of the doldrums and set it on the road to success.

The popularity of the circuit is easily explained. It performs just about any kind of computing function—addition, subtraction, integration, differentiation, sign and scale changes, calculation of fractional and higher-order powers—and can control, compare, process, regulate, and detect both linear and nonlinear signals.

In addition, the operational amplifier is suitable for communications applications. By appropriate choice of feedback components, the circuit can provide the peaked response required by various types of shaping amplifiers, or the flat, wideband response of video amplifiers.

The IC op amp is more complex than its discrete semiconductor counterpart, is at least its functional equal, and offers some fundamental advantages—superior tracking, for one. As with most amplifier circuits, the monolithic linear IC has a finite and negative feedback characteristic. This feedback—from the output to the input through a resistor, diode, or complex network—improves gain stability and reduces frequency distortion and output nonlinearities.

This is the fourth installment in the linear integrated circuit series. Previous articles have covered an overview of the field, evolution, differential amplifiers, and gating circuits for power control. In future issues the series will focus on communications applications, putting operational amplifiers to work, and comparing various types of amplifiers.

It's also the key to the circuit's response. If the amplifier has a gain of 5,000 or more and an input impedance greater than 50 kilohms, signal processing is a function solely of the feedback and the external source impedance. The user's choice of feedback or source components, therefore, determines whether the amplifier adds signals, compares them, generates new ones, or performs any number of other tasks.

Outside job

As a black box, the circuit has two input terminals and a single-ended output. The input configuration is the familiar differential arrangement, the basic building block of most linear IC's [Electronics, Sept. 18, p. 96]. Most monolithic operational amplifiers contain at least two differential stages, and display the balance, tracking, selectivity, and other features imparted by a differential network. Functionally, such an amplifier magnifies the differences between signals applied to its inputs. The amplifier's input impedance is, for all practical purposes, infinite with respect to both the impedances of a signal source and the feedback element. Thus, any number of input signals can be applied simultaneously without causing interaction between external generators.

Of the circuit's two input terminals, one inverts a positive voltage, causing a negative output; inputs at the other terminal aren't reversed. When voltages are applied to both terminals, the output is positive or negative depending upon the relative magnitudes of the input signals.

The input terminals are designated inverting and noninverting, respectively (see schematic on p. 87). The differential inputs complement one another, thereby enhancing some applications, and making the over-all circuit that much more versatile.

The maze

To the uninitiated, the schematic of any linear IC appears awesome in comparison with that of a comparable discrete unit. This complexity stems from the designer's attempts to provide functions within the limitations of IC components, and performance features beyond those of discrete semiconductors.

Integrated-circuit elements are limited both in type and value, a drawback particularly acute in linear IC's. There are no workable inductors, resistor and capacitor values are restricted, individual tolerances are wide, and truly complementary devices are rare.

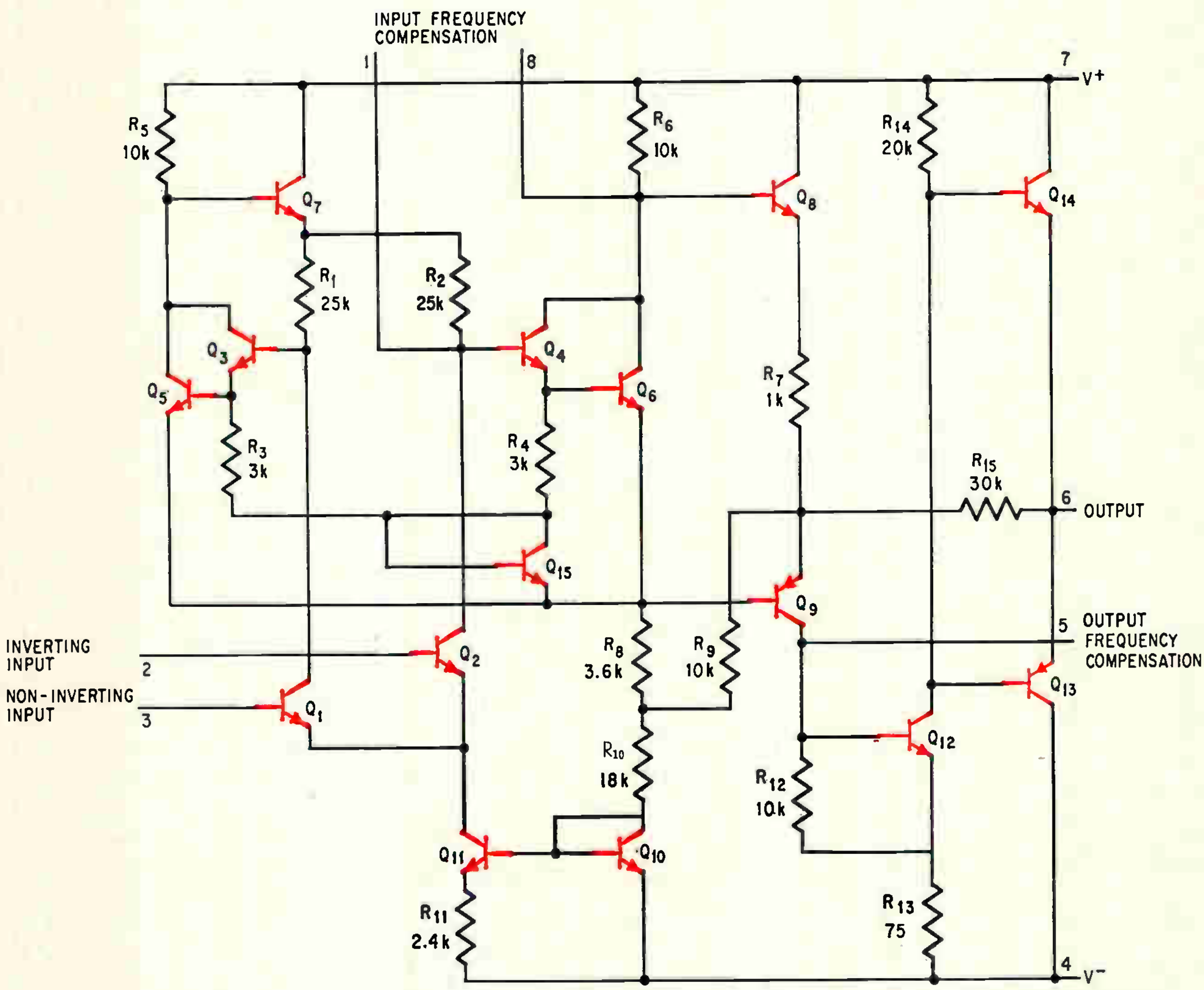
Designers have therefore been forced to evolve special design techniques [Electronics, Aug. 7, p. 100] to circumvent these limitations. Typical of these methods is the use of active current sources in place of large resistors, of differential and emitter-coupled amplifiers in place of large by-pass capacitors, and of npn-element cascodes in place of zener diode and complementary-transistor level-shift stages.

Of course, such unique advantages of monolithic IC's as close matching of active and passive elements, excellent thermal coupling, and economy of active devices, go a long way toward offsetting component restrictions. Linear IC's have better over-all balance and lower offsets than their discrete counterparts, greater uniformity of response to temperature changes, and fewer and smaller parasitics.

Framework

A popular IC op amp, the μA709 shown below, has three stages—input, coupling, and output—and contains 14 transistors and 15 resistors, about three times the number of components in a comparable discrete amplifier.

Matched transistor elements Q_1 and Q_2 form the differential input circuit and are driven by the current source Q_{10}–Q_{11}. Q_{10} is identical to Q_{11} but is connected as a diode. The 2.4-kilohm resistor in the emitter of Q_{11} establishes the magnitude of the current source. Because the entire source circuit's temperature response is equal and opposite



Complex. Monolithic operational amplifiers have more components than their discrete counterparts in order to meet functional requirements within chip limitations (such as the lack of large resistors and capacitors), and to provide extra performance benefits. Schematic here is that of the widely used μA709.

to that of the differential stage, the gain of the first stage remains constant as temperature varies.

The second stage, a differential amplifier formed by the Q_3–Q_5 and Q_4–Q_6 Darlington pairs, converts the double-ended output of the first stage to single-ended, and buffers the output stage. The Darlington connections, which help prevent loading of the input stage, are supplied by a constant-current source, Q_{15}, that connects to the same voltage divider chain that feeds the current source of the first stage. Emitter-follower Q_7 isolates the Q_5 balanced-biasing side of the amplifier from the first stage; Q_8, another emitter-follower, prevents loading of the second stage by the output stage. Resistors R_5 and R_6, the collector loads for the second-stage differential pair, smooth out power-supply variations.

In the four-transistor output stage, Q_9 is a pnp level-shifter that restores the d-c level of the output driver that feeds the complementary class-B output stage formed by Q_{13} and Q_{14}. The current-gain of these last three transistors is limited by injection efficiency so that chip current is held down if the output is momentarily short-circuited. Resistor R_{12} limits current leakages from Q_9 and Q_{12}, and R_{13} reduces the gain of the output stage to stabilize its internal feed-back. The gain of the last stage is principally established by the ratio of R_{15} to R_7.

Any amplifier, monolithic or discrete, tends to oscillate under high-gain, feedback conditions, but this tendency is easily overcome by two external frequency-compensating networks. The best points in the circuit to apply the compensation are those where a high transfer resistance exists and where small, external capacitors can thus be used.

Simple RC networks establish external off-setting feedback loops that maintain less than unity gain at the critical 180° phase-shift point, and stabilize the IC by causing the gain to roll off with frequency at a low and uniform rate. Each of the two networks can provide as much as 60 decibels of roll-off, sufficient to handle the most severe oscillation the circuit might experience. In addition, the second network offsets the parasitics of the output stage.

The exact compensating resistor and capacitor values can be optimized for a particular case so that both over-all gain and bandwidth can be maximized. Integrated-circuit makers provide optimum-value curves that are based on various gain-bandwidth conditions and that take the chip's parasitics into account.

With discrete designs, compensation networks have to be determined experimentally—a lengthy procedure, especially if optimial values are sought. Also, the best temperature-tracking performance is at least an order of magnitude poorer than that of monolithics.

Best case

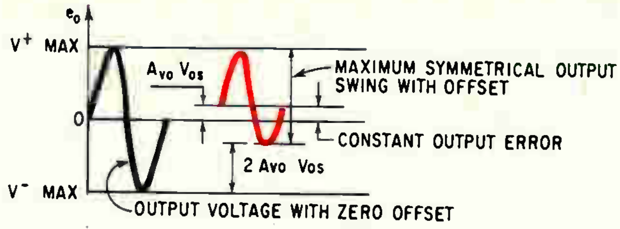
The ideal operational amplifier would have infinite voltage gain, input impedance, and frequency response, and no output impedance or noise. There would be no output voltage when there was no input voltage, and input and output voltage ranges would be unrestricted.

This ideal doesn't exist, of course, but departures from the ideal are predictable, and can be offset in most cases.

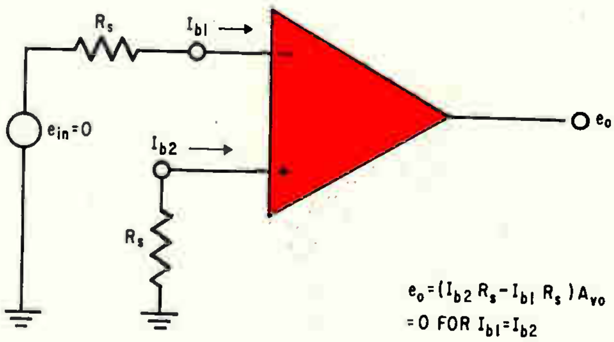
For example, one of the most significant operational-amplifier characteristics is input offset voltage; it can be a source of errors in the output signal and a factor in limiting the output signal swing. When biasing potentials are applied to the amplifier, a finite output appears even though the input terminals are shorted together.

This output is caused by imbalances in the differential stages [Electronics, Sept. 18, p. 97], plus finite tolerances and changes in component values with temperature variation. But since the error typically amounts to only a few millivolts or less, it can be easily offset. In some recent IC's, the compensation is built into the chip; with most devices, though, the correcting offset is externally applied.

The small input signal, designated V_{os}, that causes the output to go to zero is called the input offset voltage. Its value at room temperature appears on IC data sheets; for other environments, it has to be determined experimentally. The application of this offset signal overcomes circuit imbalances and centers the quiescent d-c output point.



Excursions. Output of an IC op amp is nominally limited by the saturation and cutoff levels of the output stage. But if the error-inducing offset voltage isn't compensated for, maximum output swing is lessened. The magnitude of error is the product of open-loop gain, A_{vo}, and the amplitude of offset, V_{os}.



Balance. Finite outputs are produced by base current imbalances, even when an input voltage isn't applied. Curent offset, the average of the two base currents, can be nullified by an equalizing source resistor or an external, oppositely applied, signal source.

The amplifier's finite input impedance is another potential source of error. Each input of the differential stage requires a small bias current that flows through the resistances of the signal sources.

Source resistors are rarely the same; in some cases where single-ended inputs are used, only one source resistor exists. In any case, the bias currents aren't nominally equal, and the potential drop they induce—in series with input signals to be processed—causes output errors. Because of the differential input, the error is expressed on data sheets as the average of the bias currents with no input voltage applied before equalization.

The effect can be canceled by inserting an equalizing resistor in the appropriate input lead to make the two bias currents match. Or an external current, designated the input offset current, I_{os}, can be made equal to the difference between the base currents, and applied to nullify their imbalance.

Of all the deviations from the ideal, the most important to compensate for is drift—changes in voltage, current, and gain levels with temperature. There are four major types of drift in the IC—the voltage and current offsets, the base-to-emitter drops of the transistor elements (V_{BE}'s), and the transistors' current gains, (h_{FE}'s)—and, happily, they can be handled fairly easily. Both V_{os} and I_{os} are functions of the entire chip; V_{BE} and h_{FE} involve individual chip elements. The answers to all four come merely from experimental determination of the offsets needed for the temperature swings encountered.

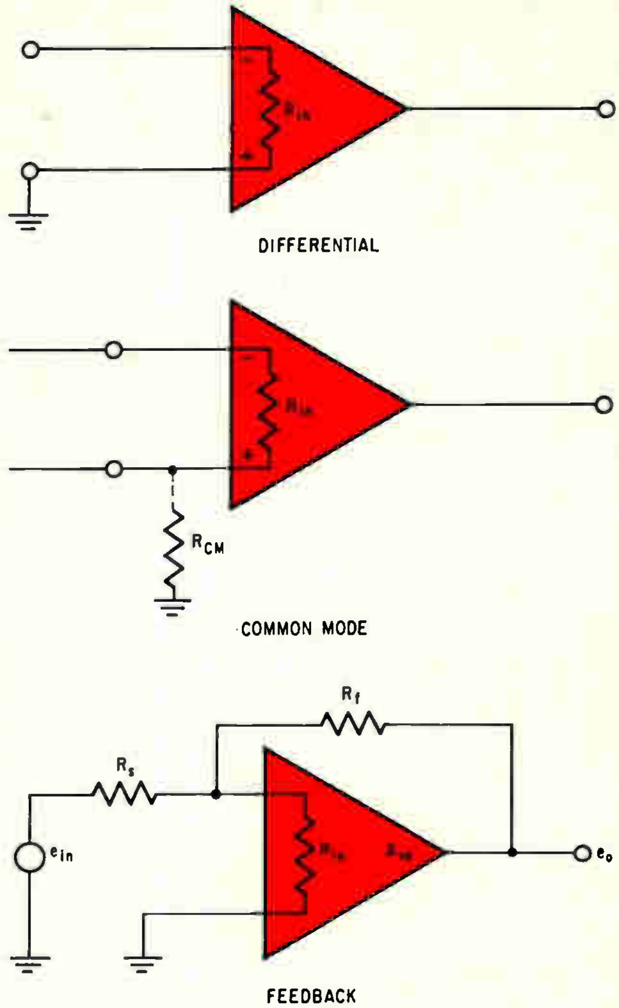
Resistance

Though IC operational amplifiers have a nominally high input impedance, loading problems cannot be ignored as there are two input resistances—differential and common mode. Differential input resistance is defined as the resistance into either input terminal with the other input grounded; common-mode type is the resistance between inputs and ground with both inputs shorted together.

Common-mode input resistance is usually high, typically 20 to 100 megohms. Compared to source resistors, it's essentially infinite and has little effect on circuit operation. But the differential input resistance, which may be as low as a few thousand ohms or as high as hundreds of megohms depending on the amplifier type, does affect closed-loop gain. Since it is in parallel with the source resistance, it can reduce the feedback factor by as much as 50% when it is of the same order of magnitude.

Output resistance, designated R_o, is the resistance seen looking into the output terminal with the output voltage at null. A finite value usually a few hundred ohms in magnitude, R_o comes into play in open-loop applications—comparators, for instance, When capacitive loads are being driven, the load and R_o together establish a time constant that limits the rise time of the output signal; the larger the R_o value, the slower the rise time.

For any kind of load, finite R_o restricts the magnitude of the output current. It's not important



FACTORS

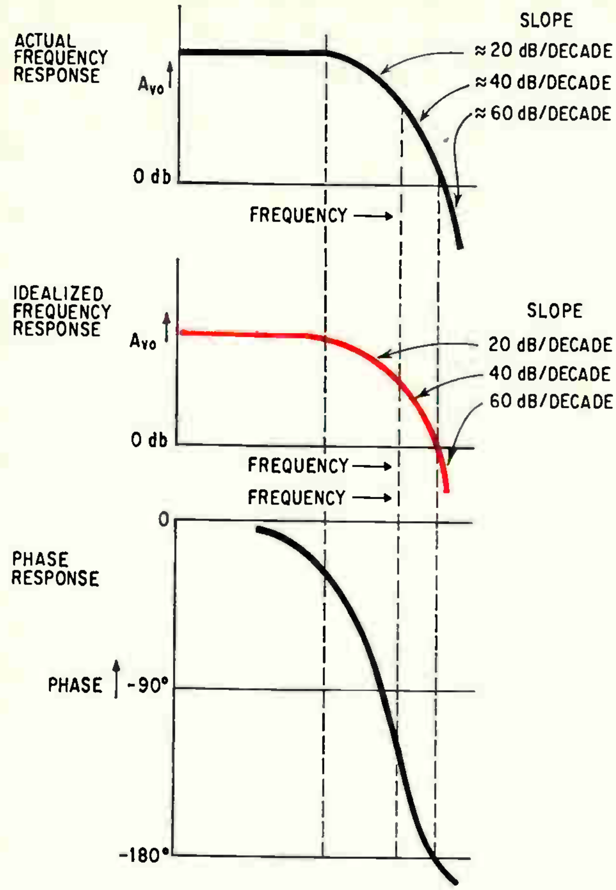
	$R_{in}=\infty$	$R_{in}\neq\infty$
ATTENUATION FACTOR	$\frac{R_f}{R_s+R_f}$	$\frac{R_f \parallel R_{in}}{(R_f \parallel R_{in})+R_s}$
FEEDBACK FACTOR	$\frac{R_s}{R_s+R_f}$	$\frac{R_f \parallel R_{in}}{(R_s \parallel R_{in})+R_f}$

Modes. Differential input resistance (top), common-mode input resistance (middle), and feedback resistance (bottom) must be considered when using op amps. Usually, R_{in} is much larger than R_s (generator resistance) and R_f (feedback resistance).

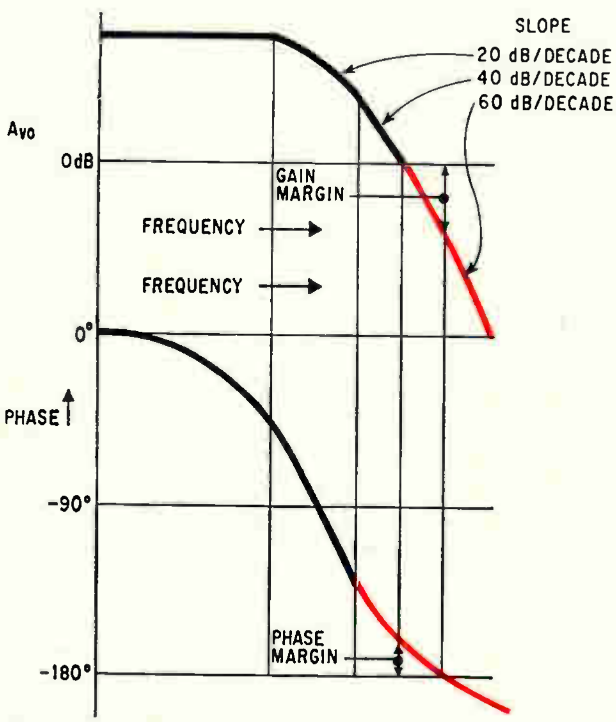
in closed-loop applications, however, because it's largely reduced by the loop gain of the circuit.

The open-loop voltage gain, A_{vo}, is the ratio of the maximum loaded output swing to the change in input voltage needed to drive the output from zero to this maximum. It's an important factor when a high level of accuracy is required, because high gain in open-loop operations causes a smaller difference voltage between the input signal and the reference. Open-loop voltage gain fixes the input range required to change the output level from saturation to cutoff, a factor called resolution in the case of comparators.

The open-loop gain of any operational amplifier



Rolloff. Oscillation can occur if the gain-vs-frequency response tapers off too slowly. The addition of external compensation networks reshapes actual response (top) into a more ideal characteristic (middle), such that the gain at the point where the phase shift (bottom) is −180° is zero db or less.



Margins. Stability is guaranteed if the gain is finite and negative where the phase is 180° (gain margin), and crosses the zero-db point where the phase is less than 180° (phase margin).

circuit also establishes the closed-loop gain. The latter is given by $A_{cl} = \beta A_{vo}/(1-\beta A_{vo})$, where β is that portion of the output fed back to the input, and A_{vo} is the open-loop gain.

Ideally, the gain from one input to the output should be equal and opposite to the gain from the other. If the same voltage were applied to both inputs, therefore, the output wouldn't change. In practice, however, equal changes in both inputs produce an output.

Common-mode rejection ratio, CMRR, is the ratio of the maximum allowable change in common input voltage, V_{cm}, to the maximum change in input offset voltage accompanying this change. Consider an amplifier with a common-mode input voltage range of ±10 volts, a 60-db (1,000 volts/volt) open-loop gain, and a CMRR of 80 db (10,000 volts/volt). The output change if the inputs are driven over the full common-mode range is the offset change, V_{cm}/CMRR, or 1 mv, multiplied by the gain of 1,000—1 volt.

Power

Another cause of output error—the biasing power supply—is unrelated to the input and therefore occasionally overlooked. Changes such as ripple will introduce both d-c and a-c output signals, but, regulator circuits, either external or on the chip, can compensate for them. If the IC has a high power-supply-rejection ratio—1 mv/V is typical—external regulator circuits may not be necessary.

Among other amplifier characteristics to consider is the limit on output drive capability. Maximum output power, P_o, usually occurs at some intermediate voltage below the rated output maximum; its value is the product of the voltage at this point and the maximum available output current.

Also, the relationship between output and input isn't completely linear, either in signal level or load, but distortions are less severe in closed-loop operation than in open because of attenuation introduced by the feedback factor.

The maximum voltage that can be applied to either input of the amplifier with respect to ground is the input voltage range, V_{cmr}, sometimes called the input common-mode voltage range. Exceeding the specified V_{cmr} limit, which is usually less than the maximum allowable output swing, can damage the amplifier.

Differential input voltage, V_{diff}—the maximum voltage that can be applied between the two input terminals—is, in turn, lower than common-mode input voltage rating. In an inverting configuration with the amplifier's noninverting input grounded, V_{diff} is the maximum voltage that can be applied to the inverting input.

Response

The gain-vs-frequency response is the key to both a-c and d-c operation, and as mentioned earlier, is the means by which oscillation is avoided. In the typical open-loop frequency response curve at the left, the 3-db bandwidth is the frequency at which the open-loop gain has decreased to 0.707 (−3 db) of its midband value. The 0-db bandwidth is the frequency at which the open-loop gain is unity.

When the feedback gain, βA_{vo}, equals −1, the closed-loop gain becomes infinite and the amplifier oscillates. To counter this, compensating networks geared to the shape of the amplifier's frequency and phase responses must be added; of particular importance here are the break points or corner frequencies.

Each corner reflects a transfer-characteristic pole capable of contributing 90° of phase shift. The most critical point coincides with a phase shift of 180°. If the gain is at least unity, the inversion introduced by the shift at that point makes the feedback positive and the circuit action regenerative. To compensate, the feedback network, acting in tandem with the external compensating network, must therefore provide a gain of less than unity where the phase response becomes 180°. Looked at another way, the 0-db point must be reached before the phase shift reaches 180°.

Gain margin is the difference between the gains at 180° and at 0-db; as long as this margin is finite, the phase shift at the 0-db point cannot have reached 180°. Similarly, phase margin is the difference between the phase at 0-db gain and at 180°. The gain-vs-frequency response on page 90 shows gain and phase margins, plus bandwidth, for a typical case.

Capacitances are present at the nodes within the amplifier and at the compensation terminals. Because of the finite amount of current available to charge capacitances, the rate of change of output voltage declines as output signal levels increase.

Slew rate, or ρ, is defined as the maximum rate of change of output waveform when the amplifier is overdriven. It's expressed as $\rho = 2\pi f V_p$, where V_p is the maximum sinewave output swing and f is the frequency at which any output swing greater than V_p will limit the rate. Slew rate is also affected by the compensation capacitors used to stabilize the amplifier at different closed-loop gains; as the gain increases, so does slew rate.

Integrated electronics II

Foggy 'specs' blur designs

Engineers using IC operational amplifiers must have a grain of salt handy when they approach manufacturers' product specifications; terms are often misleading and stated parameters ambiguous

By Everett L. Harris Jr.
Zeltex Inc., Concord, Calif.

The rating game—a contest in which integrated-circuit manufacturers use specifications to make their products appear a bit better than their rivals, —can negate the best designs of engineers. This specsmanship is widespread; the meanings of such ostensibly definitive terms as "maximum" and "minimum" can vary from maker to maker even when the same product is involved. Among linear IC's, the practice is particularly common in data sheets on operational amplifiers.

Two "709" operational amplifiers supplied by different manufacturers may have very different characteristics. Identical input signals, loads, and biasing supplies may damage one and hardly trouble the other. Until standards become universal, therefore, the engineer will have to consider each IC and each manufacturer's data sheet individually to determine what the specifications mean, and to adjust his system design accordingly.

The situation isn't hopeless, though. Parameter designations, at least, are pretty well standardized; the engineer's problem is to pin down the conditions under which the given values apply, and then to translate this information into values that would hold under the conditions applied to his system.

The first thing to note is precisely how the specifications are stated. Ratings are sometimes presented as maximum or minimum extremes, at other times as typical values. Also, the term "maximum" can mean the greatest amount the amplifier can tolerate, or the greatest amount under which it can operate properly. Common-mode input voltage is one specification liable to this confusion.

For another thing, parameters are usually given for a specific set of power-supply voltages and a particular ambient temperature (usually 25°C) that the amplifier itself isn't going to be used at. This is important when one remembers that it's not uncommon for the output current capability of some IC's to decrease by as much as 40% when the temperature drops from +25°C to −25°C.

D-c gain—the ratio of the d-c amplifier output voltage to its d-c input voltage—varies with load. The specification is usually given at no load, but the gain will drop as full load is approached.

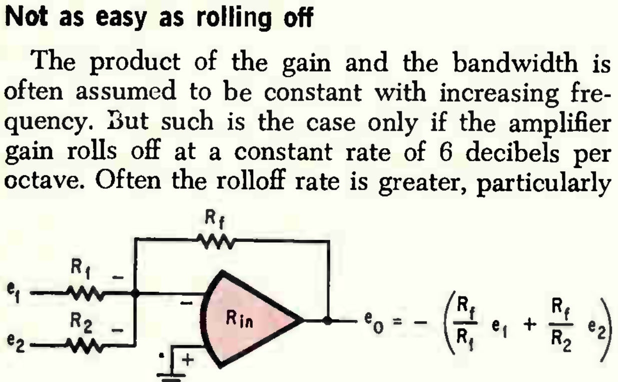
Rated output voltage and current are rarely achieved simultaneously in any circuit. In fact, maximum power output can conceivably occur when neither the voltage or current are at their respective maximums. Before installing an IC operational amplifier in a system, its actual maximum available outputs must be measured.

If the IC is driving a device with lower voltage ratings than its own, some form of overvoltage protection may be needed. Unless a voltage limiter is employed, the IC output voltage, particularly under small and no-load conditions, can sometimes swing to within a volt of the power supply. Also, if a pair of IC terminals is temporarily short-circuited, the IC may deliver a short-term output current of many times its rated value, conceivably damaging itself and the system.

Further, unless the value of the feedback resistor, which always appears as an additional load between the output and ground, is at least 10 times higher than the nominal load, it cannot be ignored in determining output levels.

Not as easy as rolling off

The product of the gain and the bandwidth is often assumed to be constant with increasing frequency. But such is the case only if the amplifier gain rolls off at a constant rate of 6 decibels per octave. Often the rolloff rate is greater, particularly



Triangle. If input impedance isn't greater than feedback and source resistances in the amplifier, gain and bandwidth are reduced. In this adder inverter circuit, R_f, R_1, and R_2 should all be at least an order of magnitude smaller than R_{in} for the output to be an exclusive function only of external resistor ratios, and for high gain-bandwidth and minimum distortion.

at high frequencies, and the unity open-loop gain therefore doesn't necessarily coincide with the frequency of the gain-bandwidth product.

The thing to look for here is whether the gain-bandwidth product is put at the frequency where the open-loop gain is unity, or if it's specified at a much lower frequency.

For negative feedback, the nominal phase shift from output to input is 180°. If the shift equals or exceeds 360° at the frequency where loop gain equals unity, the amplifier will oscillate. Even if the shift is slightly less than 360°, the amplifier, though nominally stable, will be subject to overshoots and ringing for step inputs.

Phase shift is a function of the rate of gain-vs-frequency rolloff. A rolloff of 6 db per octave gives 270° of shift and a stable closed-loop characteristic. A continued rolloff of 12 db per octave, however, will ultimately approach 360° of phase shift.

The gain-frequency curves on the data sheet give some idea of whether the amplifier will be stable at all values of closed-loop gain. They also specify what compensation networks are needed for specific gain conditions. But they don't show what capacitances from junction to ground and from output to ground—or combinations of these capacitances—can be tolerated. Nor do they indicate the values of input and feed back impedances that yield stability. These must be determined experimentally.

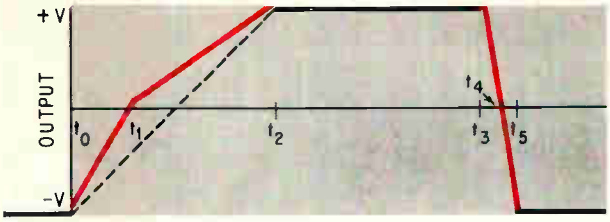
The phase margin often specified represents the limiting condition for oscillation-free operation only if it's the margin at unity open-loop gain. Otherwise, external compensation may be required. Also, phase margin decreases with capacitive loading (both on the summing junction and at the output), and further compensation may be needed—usually phaseshift networks built on an ad hoc basis.

Generally, an amplifier with a very high gain-bandwidth product needs such compensation for frequency stability at some (usually low) values of closed-loop gain. The resulting achieveable closed-loop bandwidth is considerably less than one might estimate from the manufacturer's stated gain-bandwidth product, and the IC will probably be unsuitable for certain wide-bandwidth or fast-response applications.

Full-power output frequency is the maximum frequency at which the amplifier can produce its rated output voltage and current; gain-bandwidth product only applies for small signals. Thus an amplifier with a specified 10-Mhz gain-bandwidth product and a rated output voltage of ±10 volts will probably be unable to produce a ±10-volt output at 10 Mhz, or even at 1 Mhz.

Sometimes the specification is given merely as "full output frequency," usually meaning the highest frequency at which rated output voltage can be obtained with no load on the amplifier. If the amplifier drives its rated load, the undistorted full-power output frequency will be less than the specified full output frequency.

With differential amplifiers, the full output fre-



Going rate. Segmented slope of the amplifier response curve gives rise to a nonconstant slew rate. The IC's output response to a square-wave input, shown here, has four distinct slopes, as measured against the five time intervals (t_0-t_5). Some makers specify the fastest of these (between t_0 and t_1 in the positive direction); a more realistic rating would be the average rate (between t_1 and t_2).

quency is usually given only when the amplifier is driven as an inverter. For a positive-follower configuration, this frequency level—different than in the inverter case because a new value of feedback prevails—has to be experimentally determined.

Even the basic definition of full output frequency isn't precise. It's usually taken as the frequency at which distortion is just observable in a sinewave output, but occasionally it's the frequency for which a sinewave input is completely transformed into a triangular-wave output just within the rated peak-to-peak output voltage swing.

Slew rate

The response for a step input will often have a rise time much longer than that indicated by the gain-bandwidth product. This rise time is limited by the amplifier's slew rate—the maximum rate at which the amplifier output voltage will move when the input is driven by a square wave or step signal.

In a typical amplifier output resulting from a square-wave input, shown above, the rate of output voltage change isn't constant between —V and +V, and negative-going response is faster than either of the two sections with a positive-going response.

One can thus calculate the slew rate at least four different ways: fastest for the positive direction, $V/(t_1-t_0)$; slowest for the positive direction, $V/(t_2-t_1)$; average for the positive direction, $2V/(t_2-t_0)$; and optimum for the negative direction, $V/(t_4-t_3) = V/(t_5-t_4)$.

As the results of these calculations can differ by as much as 100%, it's important to know which one the manufacturer has specified, and to account for any external compensation empirically. These networks reduce the slew rate, which is usually stated for inverter configurations with no external compensation and no load. The rate will slow as the load is increased, and may be different for the IC in a follower configuration.

Slew rate and full output frequency are related; a true-value slew rate, $\rho = 2\pi fV$, where V represents the zero-to-peak output voltage. The quantity $2\pi fV$ is the maximum rate of change of a sine wave of zero-to-peak voltage V, and frequency, f.

Spurious responses are caused by the amplifier's nonlinear condition when it slews. Various capacitances in the amplifier become charged through overdriven transistors, causing peculiar overshoots and long recovery times—critical phenomena if the application requires minimum settling time. The settling time for linear operation can be predicted from the closed-loop bandwidth, but if the amplifier is allowed to operate in the slew-limited mode, an experimental determination is again called for.

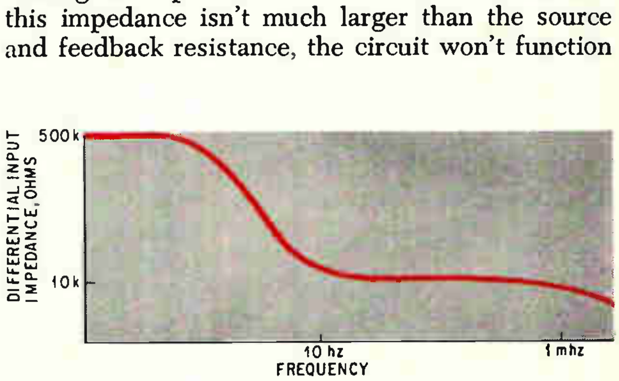
Imperfect common-mode rejection is a major cause of error in amplifiers driven as positive followers. Common-mode error isn't usually linear with input voltage, and some manufacturers specify the common-mode rejection ratio (CMRR) at some low value of common-mode voltage. CMRR is a function of frequency and amplifier load, diminishing with increases in both frequency and load. Since a worst-case (maximum frequency, full load, and rated voltage) CMRR is rarely given, the working value must be established by the designer in the actual circuit.

Input impedances

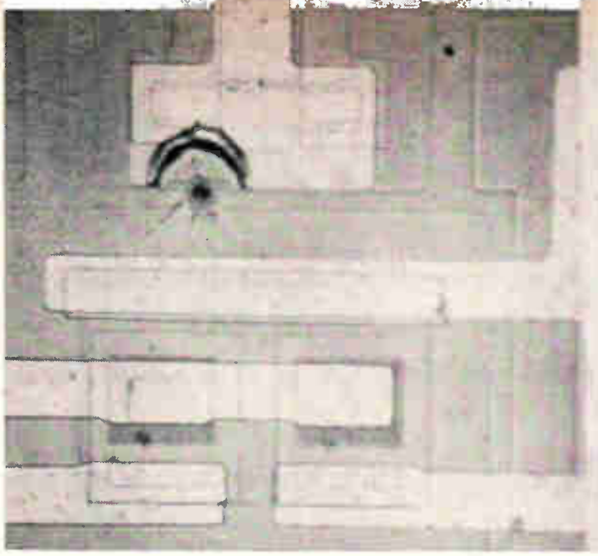
There are two types of input impedance associated with a differential operational amplifier—differential and common-mode. Differential input impedance is the frequency-dependent impedance seen between the two input terminals when the amplifier is operated without external feedback; common-mode impedance is seen between both input terminals tied together and the input ground.

For operation in the inverting mode, only the differential type is important. If this impedance is in the same range as, or smaller than, the input summing impedance ($R_1R_2/[R_1+R_2]$ in the circuit on page 92), loop gain and closed-loop bandwidth are reduced, and voltage drift and noise increase.

Differential input impedance will drop with increasing frequency. In addition, most amplifiers have at least a few picofarads of capacitance across the input, and a few more from the external connections. The sum may be as much as 10 pf, representing an impedance of 16 kilohms at 1 Mhz. If this impedance isn't much larger than the source and feedback resistance, the circuit won't function



Plot. Differential input impedance isn't constant with operating frequency in IC amplifiers; input capacitance lowers it as frequency increases. Makers usually specify only the maximum input impedance value, a practice that can mask inadequate gain at high operating frequencies.



Gap. Damage to IC's elements caused by overvoltage is evident. Excessive transients on power supply line causes arcing across transistors with consequent erosion of isolation between collectors, bases, and emitters. Manufacturer's data sheet was ambiguous about maximum voltage ratings of IC, and user neglected to protect against transients.

as a true operational amplifier.

The currents flowing in the inputs of the amplifier carry various designations. Some manufacturers refer to offset current as the average of the two quiescent input currents, a practice than can mislead the user, particularly if the input current is adjusted externally. The adjustment makes possible currents of the opposite polarity at each input, producing an average current near zero.

In most monolithic amplifiers with double-ended input, input bias current is treated as the average of the two input currents, and offset current as the difference of the two currents.

Drift

Offset voltage is that input voltage needed to bring the output to zero. The drift of this voltage and offset current with temperature is the major source of closed-loop d-c drift with temperature, and it should be noted that drift specifications may apply to the entire operating temperature range of the amplifier or only to a limited range.

A common misconception relates to the units in which voltage and current drifts are measured—μV/°C and nA/°C, respectively. These imply that the offset voltage and current vary linearly with temperature, and that the drift for any arbitrary temperature change can be calculated by multiplying the temperature variation by the drift/°C. From this, the user might infer that voltage and current drifts can be reduced to arbitrarily small values merely by restricting the ambient temperature range over which the amplifier operates.

However, not only are the voltage and current drifts usually nonlinear functions of temperature, but they may not even move in the same direction over the entire temperature range. Further, there is a lower limit to the achievable drift, often called constant environment stability. In other words, even if it were possible to keep the ambient temperature, power-supply voltages, and other environmental factors completely constant, there would still be a small amount of residual drift.

Power-supply rejection

Another potential cause of error relates to the external biases. Too few of the operational amplifier's performance characteristics are specified as functions of the power-supply voltages, despite the fact that biasing is just as important a factor as input, load, and compensation. The most commonly specified parameter is the sensitivity of offset voltage to changes in supply voltage. This specification may apply when both biases are varied together in a tracking manner; in other cases, it may apply when each power supply is varied individually. The frequency range of power-supply variations is covered by the power-supply rejection specification, a rating [see p. 90] expressing the immunity of the IC to variables in the power supply, such as ripple. Most amplifiers don't reject high frequencies appearing on the power-supply leads as well as they reject low frequencies.

Frequently missing from data sheets is an indication of the degree of accuracy and regulation required of power supplies. Most manufacturers characterize their amplifiers at particular values of supply voltages, without tolerance figures. Few indicate just how accurately these voltages must be maintained to achieve the performance claimed, and few state how high the voltage transients can become before the amplifier is permanently damaged.

A great deal of specsmanship is applied to the subject of noise. Noise valve can be specified as a zero-to-peak, peak-to-peak, or rms quantity. Peak and peak-to-peak wideband noise are difficult to measure quantitatively, and the measurement of rms wideband noise requires a true rms-reading meter. Unfortunately, there is no direct mathematical term for the conversion of a peak-to-peak wideband noise reading to an rms value. As a rough guide, one can divide the 99% peak-to-peak noise by five to estimate the rms noise.

Bandwidth is another area where noise specsmanship comes into play. The most commonly used bandwidth here is 10 khz, but this should be checked if it's not explicitly stated. If the noise is truly white noise (usually a good approximation in this frequency region) the noise voltage will vary directly with the square root of the bandwidth. Doubling the bandwidth will increase the noise voltage by the square root of two, for instance.

The author

Everett L. Harris, Jr., with Zeltex since 1965, is a senior project engineer specializing in operational amplifier design and application. A registered professional engineer and holder of an MSEE from the U. of Cal. at Berkeley, Mr. Harris was previously the chief engineer with Alpha Scientific Labs. His current responsibilities also include developmental work on hybrid analog-to-digital subsystems.

Circuit design

Designer's casebook

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

Single diode reduces ripple in d-c power supply

By Takao Kawabata
Mitsubishi Electric Corp., Amagasaki, Japan

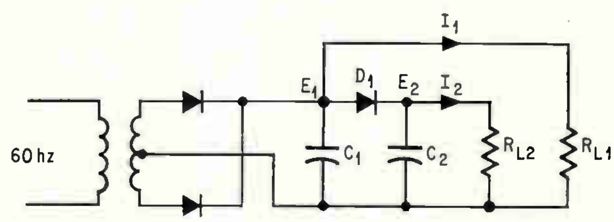
One diode added between two filter capacitors reduces the ripple in a d-c power supply.

Diode D_1 replaces the resistor in an RC filter, blocks the charge on capacitor C_2 and prevents it from flowing back to C_1 when voltage E_1 drops with the ripple frequency. Thus voltage E_2 does not follow E_1, and the ripple of E_2 is reduced without a d-c voltage drop common in conventional RC filters.

This circuit arrangement is especially effective when current I_1 is much greater than I_2, and when the load requires a large pulse current.

In the first case, the time constant formed by $R_{L2}C_2$ is made considerably longer than that for $R_{L1}C_1$. This prevents E_2 from dropping even when E_1 falls with the ripple frequency. In the second case, a large pulse voltage drop ΔE_1 occurs, but D_1 prevents E_2 from following the voltage drop of E_1, and a low ripple results.

An advantage of the circuit is that E_2 can be used as a low-ripple power source for low-power level controls.



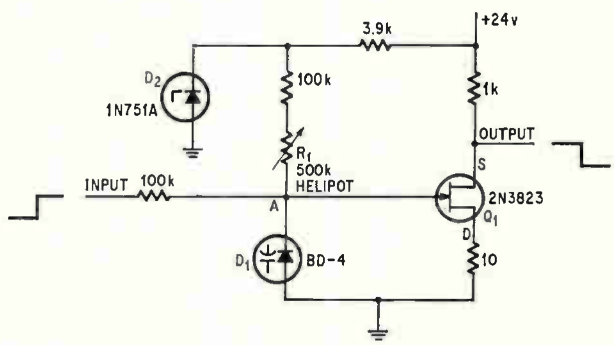
Charge blocker. Charge on capacitor C_2 cannot flow back to capacitor C_1 because diode D_1 blocks it whenever E_1 falls with ripple frequency.

Backward diode plus FET detects low currents

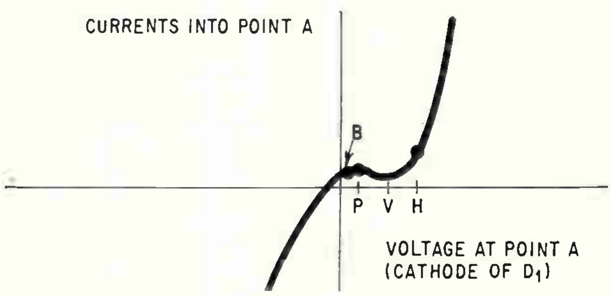
By Emanuel Elad
Lawrence Radiation Laboratory, Berkeley, Calif.

A discriminator that detects 1-microampere currents with an accuracy of 1% is possible by driving a field effect transistor with the output from a backward diode. When the input signal exceeds a preset threshold, the sum of the currents through the backward diode switch the diode to its high voltage state, generating a pulse; the pulse is then amplified by the FET output stage.

In tests of the circuit, the detection threshold was varied from 1 to 30 μa by adjusting helipot R_1; variability is limited only by a peak current of the backward diode, which is 40 μa for D_1. Temperature stability of the variable threshold is better than 1% in the —10° to +60°C range; D_1 has a negative resistance region that is thermally stable at low current, and zener diode D_2, which determines the stability of the threshold current,



Low current detector. Input current pulses combine at point A and switch D_1 into its high voltage state.



Backward diode characteristic. When an input pulse exceeds the present threshold, D_1 switches from bias point B to point H in its high voltage region.

is stable over a wide temperature range.

Threshold jitter is negligible because the current drawn by the gate of FET Q_1 is less than 0.1 nanoampere. Since Q_1 is normally on the circuit has a fast response, typically 0.1 μsec, for pulses.

When a pulse of input current exceeds the threshold, determined by the R_1 setting, D_1 switches to its high voltage state. As D_1 switches, it generates a positive pulse at point A; this pulse corresponds to a shift on the backward diode characteristic from the bias point B to a point H in the high voltage region. The pulse generated at the gate of Q_1 produces a corresponding negative pulse at its drain.

Digital IC's shrink reversible counter

By Louis J. Brocato*

Surface Division, Westinghouse Electric Corp., Baltimore

A reversible counter built entirely with digital integrated circuits (primarily NAND gates), takes up less than 1/7th the space of its discrete-component counterpart and switches in 150-nanoseconds.

Although the counter displays the difference between an error signal and its correction, it has other computer circuit applications. For example, the counter may be used as a serial adder, subtractor, or comparator. It also produces a pulse when its count reaches a predetermined level. Only four stages of the counter are shown, but the design represents a general solution.

The unit combines two identical serial counters that share a single set of flip-flops but reset in opposite directions. Thus, input pulses applied to the top half of the circuit (the count up input) are gated through the counter so that each pulse is added to the previously counted pulses; the pulse count is represented by the condition (0 to 1) of the four flip-flops as sensed by the output lines (FF1 out, FF2 out, FF3 out, and FF4 out) on the count up side of the circuit. Pulses are added by changing the states of these flip-flops.

Pulses applied to the count down input affect the circuit in the same manner. They add by resetting the flip-flops in a direction opposite to that sensed by the output lines on the count up side; thus, the pulses subtract or count down.

Electrically, pulses are added by switching a flip-flop from its 0 to its 1 state if it was previously in its 0 state. If, however, the flip-flop was formerly in its 1 state, the pulse is added by passing an overflow pulse (or carry bit) up to the next stage and then resetting the flip-flop to 0.

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To count up, an incoming pulse is inverted by amplifier A_1 and applied to terminal 2 and NAND 1, which again inverts the pulse and sends it to both terminal 1 of NOR 1 and terminal 2 of line-drive amplifier LD. The pulse from NAND 1 triggers LD, which puts out a positive pulse and enables NAND 2, NAND 3, and NAND 4. The positive pulse placed on terminal 12 of these three gates prepares them to fire off a carry bit.

The NAND 1 pulse is also sent to NOR 1 where it is inverted and applied to flip-flop 1 and terminal 1 of NAND 2. If flip-flop 1 was previously in the 0 condition it is set to 1 and the sequence ends.

If flip-flop 1 was previously in the 1 state, however, this condition will have been sensed from terminals 1 and 2 of flip-flop 1 and a positive a enabling signal will have been placed on terminal 2 of NAND 2. With terminals 2 and 12 of NAND 2 both enabled, the incoming pulse from terminal 5 of NOR 1 fires NAND 2, sending the carry bit up.

While NAND 2 is firing, the pulse from NOR 1 is still entering flip-flop 1, which is constructed to fire only when the signal is decreasing. Here it is reset to 0 by the trailing edge of the positive pulse from NOR 1. Thus the firing of flip-flop 1 is delayed by a length of time equal to the pulse width, giving NAND 2 a chance to fire off the carry bit before flip-flop 1 changes state and eliminates the positive enabling signal on terminal 2 of NAND 2. With the carry bit sent up to the next stage and flip-flop 1 reset to 0, the addition sequence ends.

The sequence is the same at the next three stages. Count down pulses applied to terminal 1 of amplifier A_2 are handled in the same manner by the lower half of the circuit.

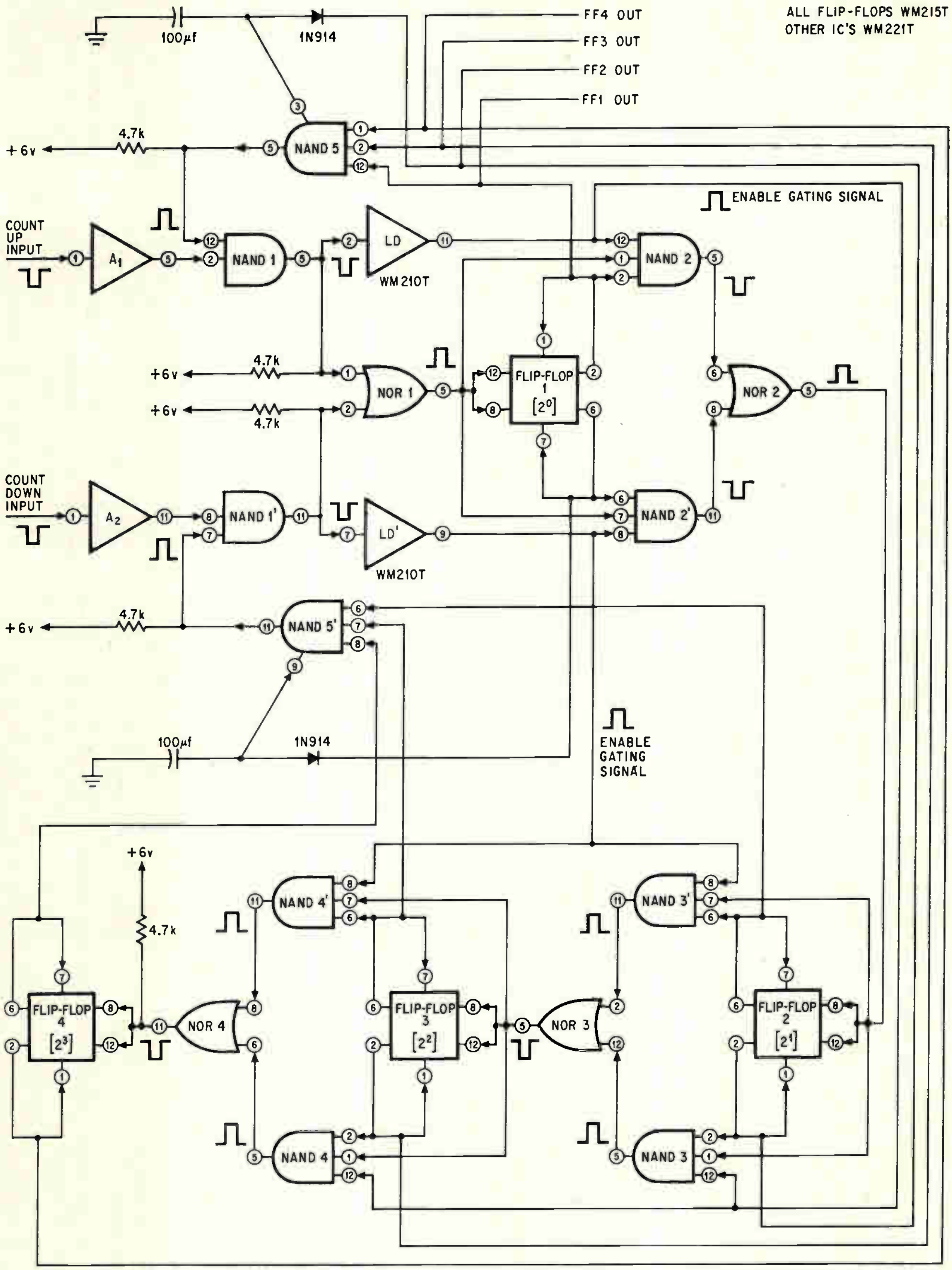
When all flip-flops are in the one state, the signals at terminals 12, 2, 1, and 3 of NAND 5 are all positive; NAND 5 then fires a negative pulse which disenables terminal 12 of NAND 1, inhibiting the entrance of additional up pulses until a down pulse resets one of the flip-flops to 0. In the same manner NAND 5′ closes the circuit to down pulses coming into NAND 1′ when all the flip-flops are at 0. The inputs to NAND 5 and 5′ may be wired to set the upper and lower limits at any points within the counter's range.

Terminal 3 of NAND 5 (and terminal 9 of NAND 5′) are add on lugs for connecting additional lines to the gate. Since some internal circuitry is bypassed, the diode-capacitor networks are required.

A numerical example illustrates the counter's operation. When the flip-flops are set at digital 7:

FF_1 or (2^0)	FF_2 or (2^1)	FF_3 or (2^2)	FF_4 or (2^3)	(1)
1	1	1	0	

an incoming up pulse generates a carry bit which



Count up. Pulses are inverted in amplifier A_1, reinverted in NAND 1 and applied to line driver LD and NOR 1. Line driver LD then enables NAND 2, NAND 3 and NAND 4. NOR 1 inverts the pulse from NAND 1 and applies it to NAND 2 and flip-flop 1.

travels through to the flip-flop 4 and sets it to 1, resetting the other three flip-flops to 0 in the process. The result is a digital 8:

FF_1 or (2^0)	FF_2 or (2^1)	FF_3 or (2^2)	FF_4 or (2^3)	
0	0	0	1	(2)

Now, if a down pulse enters with the counter showing digital 8 as in line (2), the down pulse encounters 0's in the first three flip-flops; hence the down pulse generates a carry bit which passes through to flip-flop 4 and resets it to 0, setting the first three flip-flops to 1 in the process. The counter then shows a digital 7 (line (1)).

FET boosts impedance of d-c feedback amplifier

By N.C. Voulgaris
Columbia University, New York

Stability and simplicity are achieved with a field effect transistor in a d-c amplifier that operates over a wide temperature and supply voltage range. The FET gives the circuit a high open-loop input impedance, making it attractive as an operational amplifier; the differential pair Q_2 and Q_3 deliver high gain while remaining thermally stable. Thus the circuit is a convenient building-block amplifier with a voltage gain equal to the ratio of $-R'/R$, and a maximum output swing of about ± 10 volts.

Field effect transistor Q_1, connected as a common-source drives differential amplifier stage Q_2 and Q_3. Drain-to-source and collector-to-emitter bias voltages are set by zener diode D_1 and the negative feedback. The differential amplifier, Q_2 and Q_3, compensates for voltage drift with temperature, and capacitor C_1 suppresses high-frequency oscillations. Emitter-follower Q_4 is a buffer stage between Q_3 and the load, R_L, and allows Q_3 to attain a high voltage gain.

The value of the feedback resistor R' does not influence the bias voltages; at quiescent conditions FET's gate is grounded and the output voltage is also zero. Hence, there is no voltage drop across R'.

At low frequencies, the amplifier's small-signal open-loop voltage gain, A_o, is given by:

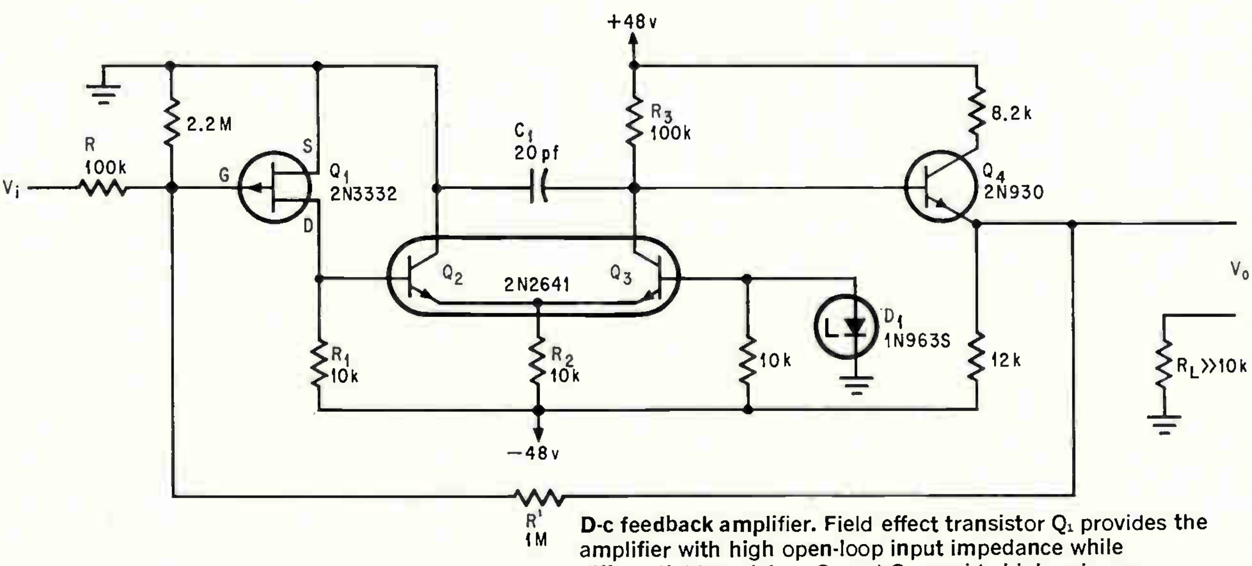
$$A_o = g_m(1 + h_{fe_2})h_{fb_3}\left[\frac{R_1 R_3}{R_1 + h_{ie_2} + h_{ib_3}(1 + h_{fe_2})}\right]$$

where g_m is the transconductance of FET, Q_1; r_d is Q_1's drain resistance; and h_{fe}, h_{fb}, h_{ie}, and h_{ib} are hybrid parameters for the transistors. The equation assumes a unity voltage gain for Q_4 and that $r_d >> R_1$, $R_2 >> h_{ib3}$, $(1/h_{oe2}) >> h_{ib3}$, and $(1/h_{ob3}) >> R_3$.

A large value for the open-loop voltage gain may be attained by maximizing g_m for Q_1 as well as $h_{fe\,2}$ and R_3.

For instance, if Q_1 is biased at $V_{GS} = 0$ and $V_{DS} >> V_P$ (where V_P is the pinch-off voltage of Q_1), then $g_m = g_{mo}$. By choosing a small resistor for R_2, transistor Q_2 can be operated at high emitter current so that h_{fe_2} is large and h_{ie_2} is small. Finally, if Q_3 has high current gain h_{fb_3}, at small values of the currents, R_3 can be large.

With the resistance values shown and with $g_m = 2{,}500$ μmhos, $h_{fe_2} = 280$, $h_{ie2} = 3.7$ kilohms, $h_{oe2} = 7.5$ μmhos, $h_{ib3} = 55$ ohms, $h_{ob3} = 0.02$ μhmo, $h_{fb3} = -0.996$, $A_o = -24{,}000$; the actual value measured at 1 khz was $-22{,}700$. When R is 100 kilohms and R' is 1 megohm, the closed loop gain is -10.



D-c feedback amplifier. Field effect transistor Q_1 provides the amplifier with high open-loop input impedance while differential transistors Q_2 and Q_3 provide high gain over a wide temperature range.

Combined feedback builds gain and input impedance

By George P. Klein*

Reeves Instrument Division, Garden City, N.Y.

Positive and negative feedback combined in a bootstrap amplifier supply high input impedance and high voltage gain. In conventional transistor amplifiers negative feedback furnishes high input impedance, but does not yield high voltage gain.

Negative feedback is provided by R_5 and R_2 in a conventional amplifier. Placing R_5 in the emitter leg of Q_1 increases the input impedance, but also reduces the voltage gain. Expressions for the voltage gain and input impedance are given by equations 1 and 2 respectively.

$$A_V = \frac{R_1R_2R_3h_{fe}}{R_s[R_1R_2+R_5(h_{fe}+1)(R_1+R_2)] + R_1R_2R_5(h_{fe}+1)} = 1.62 \quad (1)$$

$$Z_{IN} = \frac{R_1R_2R_5(h_{fe}+1)}{R_1R_2 + R_5(h_{fe}+1)(R_1+R_2)} = 3.16\text{ k} \quad (2)$$

The input impedance is dependent on the feedback resistor R_5, the current gain h_{fe} of transistor Q_1, and the values of the biasing resistors R_1 and R_2. Bootstrapping is accomplished by interchanging resistor R_5 and R_4.

Since C_1 passes all frequencies, positive feedback passes from the top of R_5 to the base of Q_1 via R_2. Because the bottom of feedback resistor R_5 is common to both input and output, negative feedback is still present.

The voltage gain expression of the modified stage is:

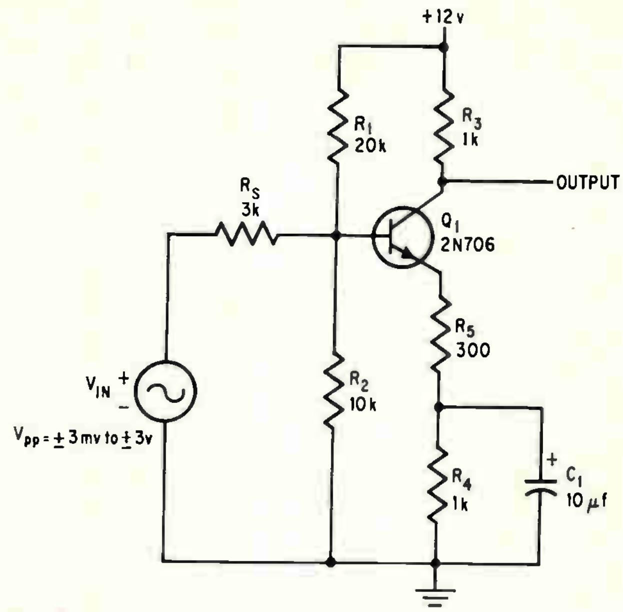
$$A_{V_{FB}} = \frac{R_2R_3\,h_{fe}}{R_2(h_{ie}+R_s)+R_5(h_{fe}+1)(R_2+R_s}\left[1+\frac{R_2R_s}{R_2(R_1+R_s)+R_1R_s}\right] = 2.29 \quad (3)$$

The new voltage gain is higher than in the conventional case because of the positive feedback. The equation for input impedance is also changed:

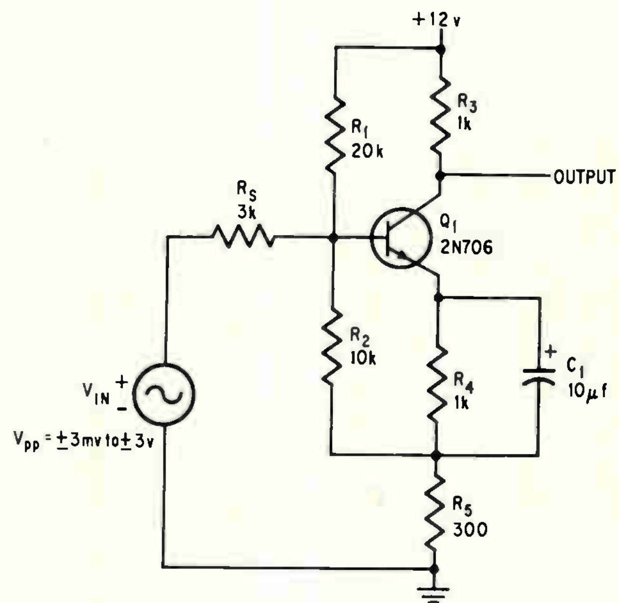
$$Z_{IN_{FB}} = \frac{R_2R_5(h_{fe}+1)}{R_2+R_5(h_{fe}+1)} = 3.75\text{ k} \quad (4)$$

Dividing equation 3 by 1 yields an expression for comparing the gain of the modified stage with the gain of the conventional configuration.

$$\frac{A_{V_{FB}}}{A_V} = 1 + \frac{R_1R_s}{R_2(R_1+R_s)+R_1R_s} = 1.414 \quad (5)$$



Conventional amplifier. Negative feedback furnished by R_5 increases the stage's input impedance but reduces its voltage gain.



Modified circuit. Positive feedback supplied by bootstrapping resistor R_2 increases both the input impedance and the voltage gain.

Equation 5 indicates a 41.4% improvement. However, the improvement diminishes as the source impedance approaches zero.

The improvement ratio for input impedance is:

$$\frac{Z_{IN_{FB}}}{Z_{IN}} = 1 + \frac{R_2R_5(h_{fe}+1)}{R_1R_2+R_1R_5(h_{fe}+1)} = 1.187 \quad (6)$$

Equation 6 shows an 18.7% improvement. Input impedance is independent of the source and depends on the value of R_5 and the current gain of Q_1.

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Quick amplifier design with scattering parameters

Smith chart and s parameters are combined in a fast, reliable method of designing stable transistor amplifiers that operate above 100 megahertz

By William H. Froehner

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Bandwidth, gain, and stability are the most important parameters in any amplifier design. Designing for one without considering the other two can mean a mediocre amplifier instead of one with high performance. A reliable technique for predicting bandwidth, determining gain, and assuring stability uses scattering or s parameters.

Scattering parameters make it easy to characterize the high-frequency performance of transistors. As with h, y, or z parameter methods, no equivalent circuit is needed to represent the transistor device. A transistor is represented as a two-port network whose terminal behavior is defined by four s parameters, s_{11}, s_{12}, s_{21}, and s_{22}.

For designs that operate under 100 megahertz the problem of accurately representing the transistor is not acute, because transistor manufacturers provide relatively complete data in a form other than s parameters. However, at frequencies above 100 Mhz the performance data is frequently incomplete or in an inconvenient form. In addition, h, y, or z parameters, ordinarily used in circuit design at lower frequencies, cannot be measured accurately. But s parameters may be measured directly up to a frequency of 12.4 gigahertz. Once the four s parameters are obtained, it is possible to convert them to h, y, or z terms with conventional tables.

Looking back

This is the second major article on scattering parameters to appear in Electronics. In the first, "Scattering parameters speed design of high-frequency transistor circuits," [Sept. 5, 1966, p. 78], F.K. Weinert described how to use the technique in a special case where the input impedance is matched to the load. This condition always results in an unconditionally stable amplifier. In practice, this ideal condition is not always possible.

In this article, author W. H. Froehner describes how to use the technique more generally—when the input impedance is not matched to the load and the scattering parameter s_{12} does not equal zero.

Defining the terms

Because scattering parameters are based on reflection characteristics derived from power ratios they provide a convenient method for measuring circuit losses. Representing a network in terms of power instead of the conventional voltage-current description can help solve microwave-transmission problems where circuits can no longer be characterized using lumped R, L, and C elements.

When a network is described with power parameters, the power into the network is called incident, the power reflected back from the load is called reflected. A description of a typical two-port network based on the incident and reflected power is given by the scattering matrix. To understand the relationships, consider the typical two-port network, bottom of page 101, which is terminated at both ports by a pure resistance of value Z_o, called the reference impedance. Incident and reflected waves for the two-port network are expressed by two sets of parameters (a_1,b_1) and (a_2,b_2) at terminals 1-1′ and 2-2′ respectively. They are

$$a_1 = \frac{1}{2}\left[\frac{V_1}{\sqrt{Z_o}} + \sqrt{Z_o}I_1\right] = \text{input power to the load applied at port 1} \quad (1a)$$

$$b_1 = \frac{1}{2}\left[\frac{V_1}{\sqrt{Z_o}} - \sqrt{Z_o}I_1\right] = \text{reflected power from the load as seen from port 1} \quad (1b)$$

$$a_2 = \frac{1}{2}\left[\frac{V_2}{\sqrt{Z_o}} + \sqrt{Z_o} I_2\right] = \text{input power to the load applied at port 2} \quad (1c)$$

$$b_2 = \frac{1}{2}\left[\frac{V_2}{\sqrt{Z_o}} - \sqrt{Z_o} I_2\right] = \text{reflected power from the load as seen from port 2} \quad (1d)$$

Hence, the scattering parameters for the two-port network are given by

$$b_1 = s_{11}a_1 + s_{12}a_2$$
$$b_2 = s_{21}a_1 + s_{22}a_2 \quad (2)$$

Expressed as a matrix, equation 2 becomes

$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} s_{11} & s_{12} \\ s_{21} & s_{22} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} \quad (3)$$

where the scattering matrix is

$$[s] = \begin{bmatrix} s_{11} & s_{12} \\ s_{21} & s_{22} \end{bmatrix} \quad (4)$$

Thus, the scattering parameters for the two-port network can be expressed as ratios of incident and reflected power waves.

$$s_{11} = \left.\frac{b_1}{a_1}\right|_{a_2=0} \qquad s_{12} = \left.\frac{b_1}{a_2}\right|_{a_1=0}$$
$$s_{21} = \left.\frac{b_2}{a_1}\right|_{a_2=0} \qquad s_{22} = \left.\frac{b_2}{a_2}\right|_{a_1=0} \quad (5)$$

The parameter s_{11} is called the input reflection coefficient; s_{21} is the forward transmission coefficient; s_{12} is the reverse transmission coefficient; and s_{22} is the output reflection coefficient.

By setting $a_2 = 0$, expressions for s_{11} and s_{21} can be found. To do this the load impedance Z_0 is set equal to the reference impedance R_{ML}. This conclusion is proven with the help of the terminating section of the two-port network shown above with the a_2 and b_2 parameters. The load resistor Z_0 is considered as a one-port network with a scattering parameter

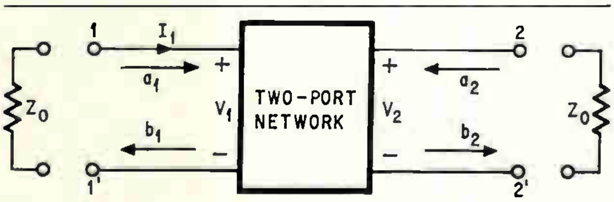
$$s_2 = \frac{Z_o - R_{ML}}{Z_o + R_{ML}} \quad (6)$$

Hence a_2 and b_2 are related by

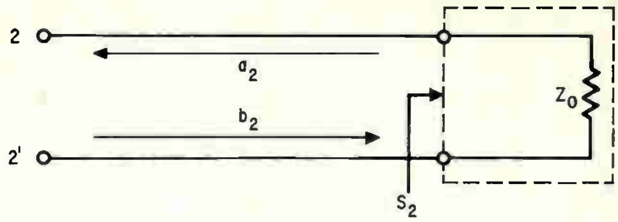
$$a_2 = s_2 b_2 \quad (7)$$

When the reference impedance R_{ML} is set equal to the load impedance Z_0, then s_2 becomes

$$s_2 = \frac{Z_o - Z_o}{Z_o + Z_o} = 0 \quad (8)$$



Defining the s parameters. Ratios of incident waves a_1, a_2 and reflected power waves b_1, b_2 for ports 1 and 2 define the four scattering parameters.



Impedance matching. By setting a_2 equal to zero the engineer can determine the s_{11} value. The condition $a_2 = 0$ implies that the reference impedance R_{MS} is set equal to the load impedance Z_0.

so that $a_2 = 0$ under this condition. Likewise, when $a_1 = 0$, the reference impedance of port 1 is equal to the terminating impedance; $R_{MS} = Z_0$.

By defining the driving-point impedances at ports 1 and 2 as

$$Z_1 = \frac{V_1}{I_1}; \qquad Z_2 = \frac{V_2}{I_2} \quad (9)$$

s_{11} and s_{22} can be written in terms of equation 9.

$$s_{11} = \left.\frac{b_1}{a_1}\right|_{a_2=0}$$
$$= \frac{\frac{1}{2}[(V_1/\sqrt{Z_o}) - \sqrt{Z_o}\, I_1]}{\frac{1}{2}[(V_1/\sqrt{Z_o}) + \sqrt{Z_o}\, I_1]} = \frac{Z_1 - Z_o}{Z_1 + Z_o} \quad (10)$$

$$s_{22} = \frac{Z_2 - Z_o}{Z_2 + Z_o} \quad (11)$$

In the expression

$$s_{21} = \left.\frac{b_2}{a_1}\right|_{a_2=0}$$

The condition $a_2 = 0$ implies that the reference impedance R_{ML} is set equal to the load Z_0. If a voltage source $2E_1$ is connected with a source impedance $R_{MS} = Z_0$, as seen on page 102, a_1 can be expressed as

$$a_1 = \frac{E_1}{\sqrt{Z_o}} \quad (12)$$

Since $a_2 = 0$, then $a_2 = 0 = \frac{1}{2}\left[\frac{V_2}{\sqrt{Z_o}} + \sqrt{Z_o}\, I_2\right]$

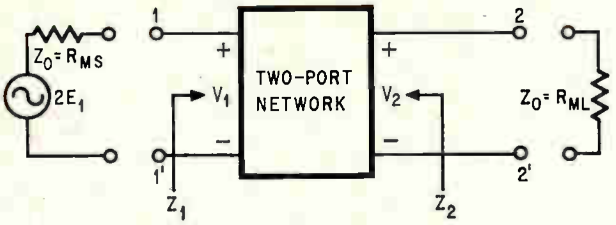
from which $\frac{V_2}{\sqrt{Z_o}} = -\sqrt{Z_o}\, I_2$

Consequently,

$$b_2 = \frac{1}{2}\left[\frac{V_2}{\sqrt{Z_o}} - \sqrt{Z_o}\, I_2\right] = \frac{V_2}{\sqrt{Z_o}}$$

Hence,

$$s_{21} = \frac{V_2}{E_1} \quad (13)$$



Finding s_{21}. By connecting a voltage source, $2E_1$, with the source impedance, Z_0, parameter s_{21} can be evaluated.

Similarly when port 1 is terminated in $R_{MS} = Z_0$ and a voltage source equal to $2E_2$ having an impedance of Z_0 is connected to port 2

$$s_{12} = \frac{V_1}{E_2} \tag{14}$$

Both s_{12} and s_{21} are voltage-ratios and therefore have no dimensions. For a passive network, $s_{21} = s_{12}$. Parameters s_{11} and s_{22} are reflection coefficients and are also dimensionless.

Stabilizing an amplifier

Since the s parameters are based on reflection coefficients, they can be plotted directly on a Smith chart and easily manipulated to establish optimum gain with matching networks. To design an amplifier the engineer first plots the s-parameter values for the transistor on a Smith chart and then, using the plot, synthesizes matching impedances between a source and load impedance.

Stability or resistance to oscillation is most important in amplifier design and is determined from the s parameters and the synthesized source and load impedances. The oscillations are only possible if either the input or the output port, or both, have negative resistance. This occurs if s_{11} or s_{22} are greater than unity. However, even with negative resistances the amplifier might still be stable.

For a device to be unconditionally stable s_{11} and s_{22} must be smaller than unity and the transistor's inherent stability factor, K, must be greater than unity and positive. K is computed from

$$K = \frac{1 + |\Delta|^2 - |s_{11}|^2 - |s_{22}|^2}{2|s_{21}s_{12}|} \tag{15}$$

Plotting circles

Stability circles can be plotted directly on a Smith chart. These separate the output or input planes into stable and potentially unstable regions. A stability circle plotted on the output plane indicates the values of all loads that provide negative real input impedance, thereby causing the circuit to oscillate. A similar circle can be plotted on the input plane which indicates the values of all loads that provide negative real output impedance and again cause oscillation. A negative real impedance is defined as a reflection coefficient which has a magnitude that is greater than unity.

The regions of instability occur within the circles whose centers and radii are expressed by

center on the input plane $= r_{s1}$

$$= \frac{C_1^*}{|s_{11}|^2 - |\Delta|^2} \tag{16}$$

radius on the input plane $= R_{s1}$

$$= \frac{|s_{12}s_{21}|}{|s_{11}|^2 - |\Delta|^2} \tag{17}$$

center on the output plane $= r_{s2}$

$$= \frac{C_2^*}{|s_{22}|^2 - |\Delta|^2} \tag{18}$$

radius on the output plane $= R_{s2}$

$$= \frac{|s_{12}s_{21}|}{|s_{22}|^2 - |\Delta|^2} \tag{19}$$

where

$$C_1 = s_{11} - \Delta s_{22}^* \tag{20}$$

$$C_2 = s_{22} - \Delta s_{11}^* \tag{21}$$

$$\Delta = s_{11}s_{22} - s_{12}s_{21} \tag{22}$$

In these equations the asterisk represents the complex conjugate value. Six examples of stable and potentially unstable regions plotted on the output plane are on the opposite page. In all cases the gray areas indicate the loads that make the circuit stable.

The first two drawings, A, and B, show the possible locations for stability, when the value of K is less than unity; C and D are for K greater than unity. When the stability circle does not enclose the origin of the Smith chart, its area provides negative real input impedance. But when the stability circle does enclose the origin, then the area bounded by the stability circle provides positive real input impedance.

Drawings E and F indicate the possible locations for stability when the value of K is greater than unity and positive. If the stability circle falls completely outside the unity circle, the area bounded by this circle provides negative real input impedance. But if the stability circle completely surrounds the unity circle then the area of the stability circle provides positive real input impedance.

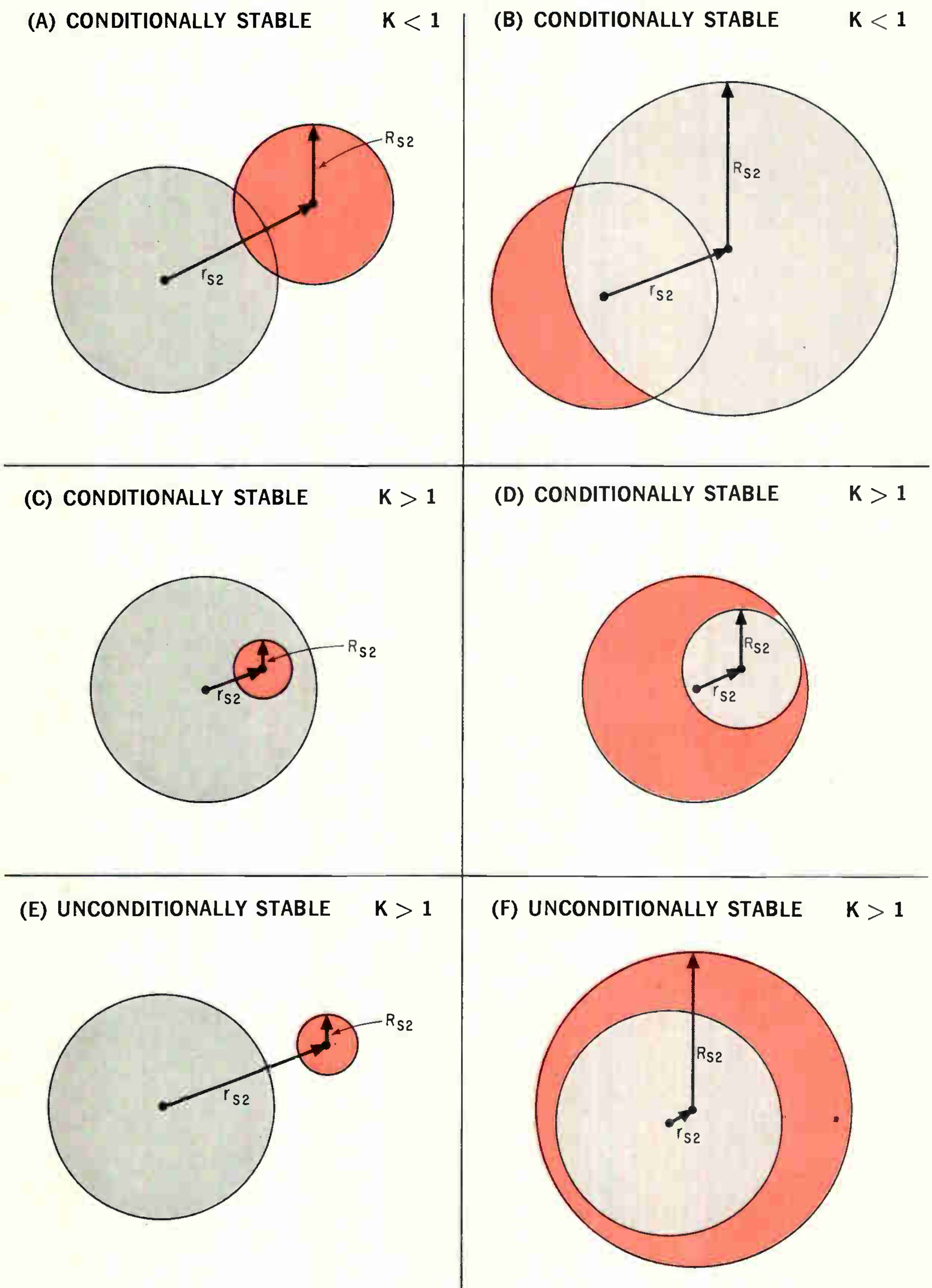
When K is positive

The design of an amplifier where K is positive and greater than unity is relatively simple since these conditions indicate that the device is unconditionally stable under any load conditions. All the designer need do is compute the values of R_{MS} and R_{ML} that will simultaneously match both the input and output ports and give the maximum power gain of the device.

Reflection coefficient of the generator impedance required to conjugately match the input of the transistor $= R_{MS}$

$$= C_1^* \left[\frac{B_1 \pm \sqrt{B_1^2 - 4|C_1|^2}}{2|C_1|^2} \right] \tag{23}$$

Stability examples



Controlling oscillation. Stability circles are superimposed on the output plane. Load impedances chosen from gray areas will not cause oscillation. Colored areas represent unstable loads.

where

$$B_1 = 1 + |s_{11}|^2 - |s_{22}|^2 - |\Delta|^2 \quad (24)$$

and

Reflection coefficient of that load impedance required to conjugately match the output of the transistor = R_{ML}

$$= C_2^* \left[\frac{B_2 \pm \sqrt{B_2^2 - 4|C_2|^2}}{2|C_2|^2} \right] \quad (25)$$

where

$$B_2 = 1 + |s_{22}|^2 - |s_{11}|^2 - |\Delta|^2 \quad (26)$$

and C_1 and C_2 are as previously defined.

If the computed value of B_1 is negative, then the plus sign should be used in front of the radical in equation 23. Conversely, if B_1 is positive, then the negative sign should be used. This also applies in equation 25 for B_2. By using the appropriate sign only one answer will be possible in either equation and a value of less than unity will be computed.

The maximum power gain possible is found from the relationship

$$G_{MAX} = \frac{|s_{21}|}{|s_{12}|} |K \pm \sqrt{K^2 - 1}| \quad (27)$$

Once again the plus sign is used if B_1 is negative and the minus sign if B_1 is positive. This maximum power gain is obtained only if the device is loaded with R_{MS} and R_{ML} expressed as reflection coefficients. These values are plotted directly on a Smith chart that has been normalized to the reference impedance, ($Z_0 = 50$ ohms, in this case). The actual values of R_{MS} and R_{ML} are read from the Smith chart coordinates and multiplied by Z_0. A lossless transforming network can then be placed between the transistor and the source and load terminations to obtain the maximum gain.

If a power gain other than G_{MAX} is desired, constant gain circles must be constructed. The solution for contours of constant gain is given by the equation of a circle whose center and radius are

The center of the constant gain circle on the output plane $= r_{02} = \left[\frac{G}{1 + D_2 G} \right] C_2^* \quad (28)$

The radius of the constant gain circle on the output plane $= R_{02}$

$$= \frac{(1 - 2K|s_{12}s_{21}|G + |s_{12}s_{21}|^2 G^2)^{1/2}}{1 + D_2 G} \quad (29)$$

where

$$D_2 = |s_{22}|^2 - |\Delta|^2 \quad (30)$$

$$G = \frac{G_p}{G_o} \quad (31)$$

$$G_o = |s_{21}|^2 \quad (32)$$

and G_p = desired total amplifier gain (numeric)

After a load that falls on the desired constant gain circle has been selected, a generator impedance is selected to achieve the desired gain. The value for the generator impedance that simultaneously matches the input load is given by

$$r_1 = \left[\frac{s_{11} - r_2 \Delta}{1 - r_2 s_{22}} \right]^* \quad (33)$$

where

r_2 = the reflection coefficient of the load picked.

To prove stability

With the following example it can be demonstrated that when a positive K is greater than unity, the amplifier will always be stable.

Objective: Design an amplifier to operate at 750 Mhz with a maximum gain using a 2N3570 transistor. The bias conditions are $V_{CE} = 10$ volts and $I_C = 4$ milliamperes. Scattering parameters for this transistor were measured and found to be

$$s_{11} = 0.277 \angle -59.0^\circ$$
$$s_{12} = 0.078 \angle 93.0^\circ$$
$$s_{21} = 1.920 \angle 64.0^\circ$$
$$s_{22} = 0.848 \angle -31.0^\circ$$

Solution: Compute the values for the maximum gain, and the load impedances R_{MS} and R_{ML}.

$$\Delta = s_{11}s_{22} - s_{12}s_{21} = 0.324 \angle -64.8^\circ$$
$$C_1 = s_{11} - \Delta s_{22}^* = 0.120 \angle -135.4^\circ$$
$$B_1 = 1 + |s_{11}|^2 - |s_{22}|^2 - |\Delta|^2 = 0.253$$
$$C_2 = s_{22} - \Delta s_{11}^* = 0.768 \angle -33.8^\circ$$
$$B_2 = 1 + |s_{22}|^2 - |s_{11}|^2 - |\Delta|^2 = 1.537$$

$$K = \frac{1 + |\Delta|^2 - |s_{11}|^2 - |s_{22}|^2}{2|s_{12}s_{21}|} = 1.033$$

$$D_2 = |s_{22}|^2 - |\Delta|^2 = 0.614$$

Since B_1 and B_2 are both positive, the negative sign is used in the following:

$$G_{MAX} = |s_{21}|K - \sqrt{K^2 - 1}|$$
$$= 19.087 = 12.807 \text{ db}$$

$$R_{MS} = C_1^* \left[\frac{B_1 - \sqrt{B_1^2 - 4|C_1|^2}}{2|C_1|^2} \right]$$
$$= 0.730 \angle 135.4^\circ$$

$$R_{ML} = C_2^* \left[\frac{B_2 - \sqrt{B_2^2 - 4|C_2|^2}}{2|C_2|^2} \right]$$
$$= 0.951 \angle 33.8^\circ$$

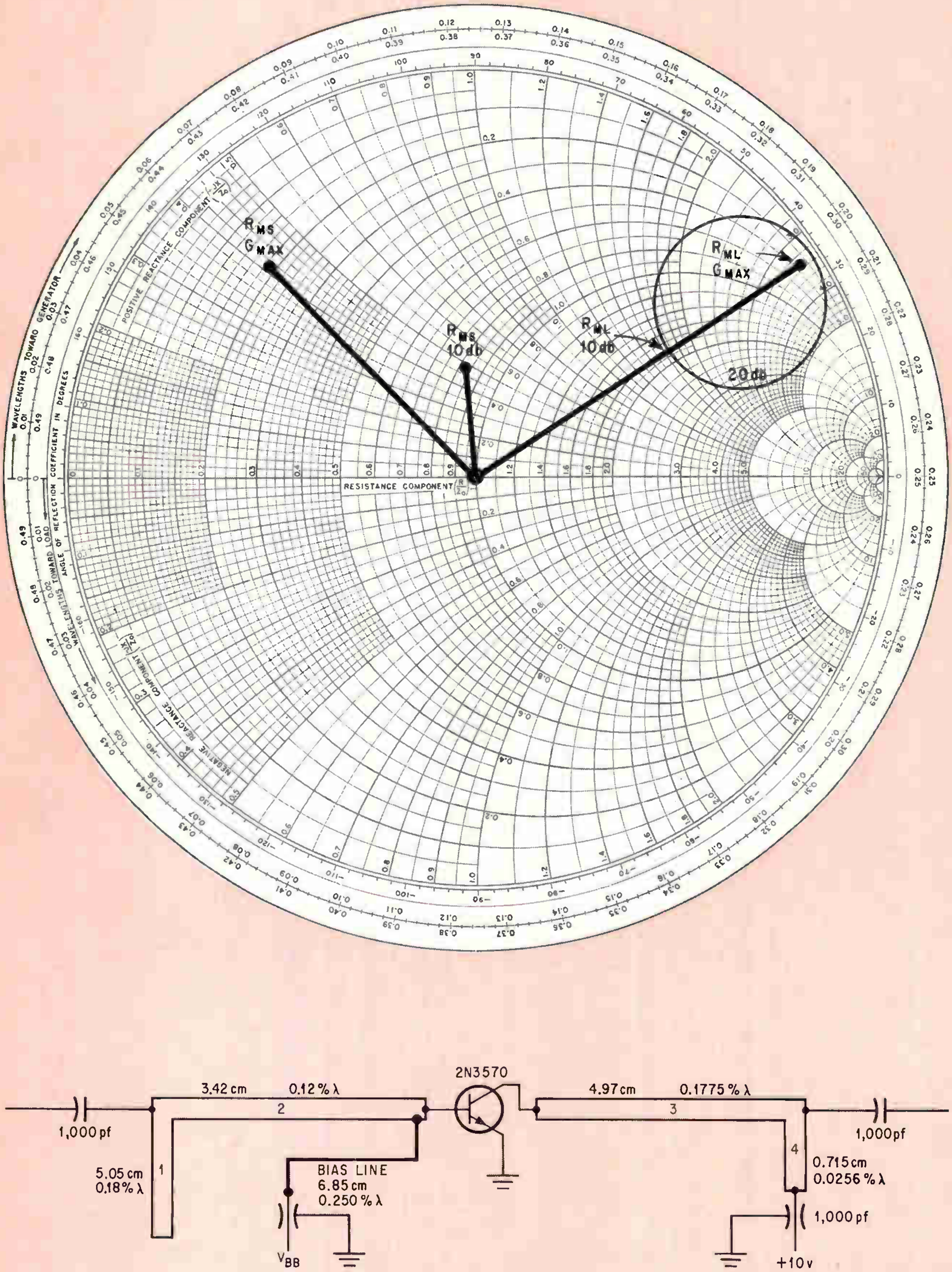
R_{MS} and R_{ML} are plotted on the Smith chart on the opposite page. The actual values of R_{MS} and R_{ML} can now be read from the Smith chart coordinates as Z_s and Z_L.

$$R_{MS} = Z_s = 9.083 + j\,19.903 \text{ ohms}$$
$$R_{ML} = Z_L = 14.686 + j\,163.096 \text{ ohms}$$

These results were obtained with a computer and do not represent the actual reading of the coordinates on the Smith chart.

A lossless matching network can now be inserted between a 50-ohm generator and the transistor to provide a conjugate match for the input of the transistor. To conjugately match the output of the transistor a lossless matching network can be inserted between the transistor and a 50-ohm load. With the transistor's input and output conjugately

Strip-line design



Design example. Graphical plot of a 750-Mhz amplifier design using a 2N3570 transistor. Completed circuit uses strip lines to match the input and output to the transistor.

matched, a maximum power gain is achieved.

In this example Teflon transmission lines, using $\frac{1}{16}''$ Teflon Fiberglas p-c board, were chosen for matching the input and output. The values for the lines are determined as follows:

Output circuit

Step 1. Transform R_{ML} to 50± jz ohms or 20± jb mmhos using the relationship

$$jb = \pm\left[\frac{|R_{ML}|^2 (Y_o + G_L)^2 - (Y_o - G_L)^2}{1 - |R_{ML}|^2}\right]^{1/2}$$

where

jb = reactance of the parallel stub
Y_o = characteristic admittance of the transmission line
G_L = real part of load admittance

In this case Y_0 and G_L = 20 mmhos. Hence,

$$jb = \pm\left[\frac{(0.951)^2(20 + 20)^2 - (20 - 20)^2}{1 - (0.951)^2}\right]^{1/2}$$

$$= \pm 123.5 \text{ mmhos}$$

The negative sign was chosen for a shorted inductive stub to keep the over-all length below $\lambda/4$.

Step 2. Find the lengths for elements 3 and 4.

$$\tan \beta L = \frac{-Y_o}{jb} = \frac{20}{123.5} = 0.162$$

therefore,

$$\beta L = 9.2°$$

but

$$\beta = \frac{2\pi}{\lambda}$$

and

$$\lambda = \frac{\text{velocity of light}}{\text{frequency}} = \frac{300 \times 10^6 \text{ meters/sec}}{750 \times 10^6 \text{ hz/sec}}$$

$$= 40 \text{ cm/hz}$$

Hence,

$$L = \frac{9.2°}{360°} \times 40 \text{ cm} = 1.02 \text{ cm}$$

For element 4

$$L_4 = (1.02)(0.7) = 0.715 \text{ cm}$$

where λ on Teflon Fiberglas $\frac{1}{16}'' = (0.7)\ (\lambda_{\text{free air}})$

For element 3

$$\Gamma = \left[\frac{Y_o - Y_L}{Y_o + Y_L}\right]$$

$$= \left[\frac{20 - (20 - j\,123.5)}{20 + (20 - j\,123.5)}\right] = 0.953\ \angle 162°$$

$$L_3 = \left[\frac{\theta_\Gamma - \theta_{R_{ML}}}{720°}\right]\lambda(0.7)$$

$$= \left[\frac{162° - 33.8°}{720°}\right](40)(0.7) = 4.97 \text{ cm}$$

Input circuit

Step 1. Transform R_{MS} to 50 ± jz ohms or 20 ± jb mmhos using the relationship

$$jb = \pm\left[\frac{|R_{MS}|^2(Y_o + G_s)^2 - (Y_o - G_s)^2}{1 - |R_{MS}|^2}\right]^{1/2}$$

where

G_S = real part of the source admittance which in this case is 20 mmhos. Hence,

$$jb = \pm\left[\frac{(0.730)^2(20 + 20)^2 - (20 - 20)^2}{1 - (0.730)^2}\right]^{1/2}$$

$$= \pm 42.8 \text{ mmhos}$$

The positive sign was chosen for an open capacitive stub to keep its length below $\lambda/4$.

Step 2. Find the lengths of elements 1 and 2.

$$\cot \beta L = \frac{Y_o}{jb}$$

$$= \frac{20}{42.8} = 0.467$$

therefore,

$$\beta L = 65°$$

and the length of element 1 is

$$L_1 = \left[\frac{65°}{360°}\right](40)(0.7)$$

$$= 5.05 \text{ cm}$$

$$\Gamma = \left[\frac{Y_o - Y_s}{Y_o + Y_s}\right]$$

$$= \left[\frac{20 - (20 + j\,42.8)}{20 + (20 + j\,42.8)}\right]$$

$$= 0.730\ \angle -137°$$

Thus the length of element 2 is

$$L = \left[\frac{\theta_\Gamma - \theta_{R_{MS}}}{720°}\right]\lambda$$

$$= \left[\frac{-137° - 135.4°}{720°}\right](40)$$

$$= -\frac{272.4}{720°} \times 40$$

Since a positive angle is required, add 360°, then

$$L_2 = \frac{87.6°}{720°}\ (40)(0.7) = 3.42 \text{ cm}$$

The completed circuit is on page 105.

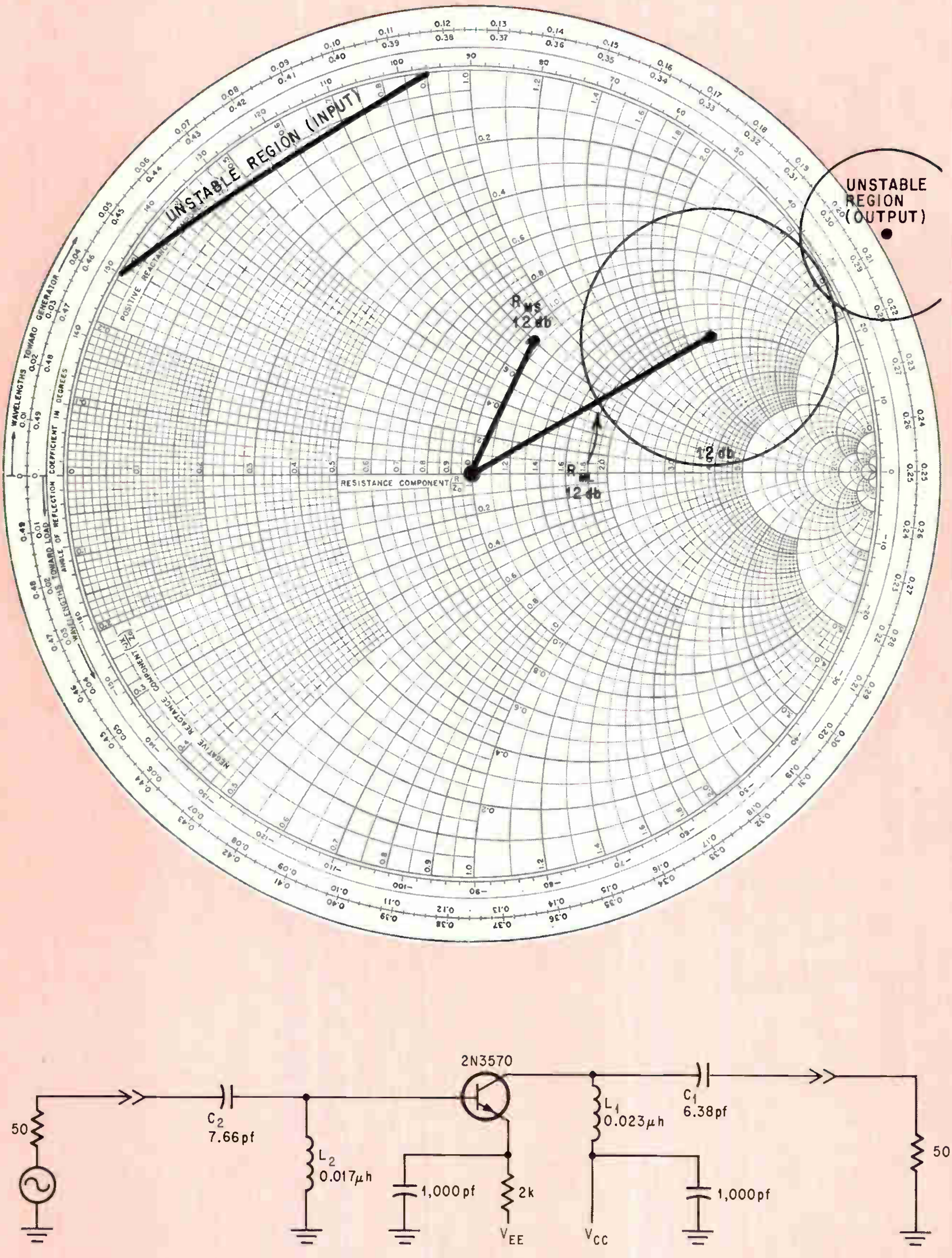
If a gain other than G_{MAX} had been desired, a constant gain circle would be required. For example, suppose a power gain of 10 db is desired. Thus,

$$G_p = 10 \text{ db}$$

and

$$G_o = |s_{21}|^2 = 3.686 = 5.666 \text{ db}$$

Discrete-component design



Design example. Graphical plot of a 500-Mhz amplifier design using a 2N3570 transistor. Matching is achieved with discrete components whose values are determined from the Smith chart plot.

then

$$G = \frac{G_p}{G_o} = 2.713 = 4.334 \text{ db}$$

Now by computing the center

$$r_{02} = \left[\frac{G}{1 + D_2G}\right] C_2^* = 0.781 \angle 33.851°$$

and radius

$$R_{02} = \frac{(1 - 2K|s_{12}s_{21}|G + |s_{12}s_{21}|^2G^2)^{1/2}}{1 + D_2G} = 0.136$$

where

$$D_2 = |s_{22}|^2 - |\Delta|^2 = 0.614$$

a constant gain circle, which shows all loads for the output that yield a power gain of 10 db, can be constructed directly on the Smith chart on page 107. The R_{ML} picked in this example was 0.567 $\angle$33.851°, and read off the Smith chart coordinates as 89.344 + j 83.177 ohms. The source reflection coefficient required with this load is

$$R_{MS} = \left[\frac{s_{11} - R_{ML}\Delta}{1 - R_{ML}s_{22}}\right]^* = 0.276 \angle 93.329°$$

Hence,

$$Z_s = 41.682 + j\,24.859 \text{ ohms.}$$

Since K is greater than unity and B_1 is positive, unconditional stability is assured for all loads.

Alternate design

When the value of K is less than unity, a load must be chosen to assure stable operation of the amplifier. To accomplish this a stability circle is plotted on the Smith chart and examined to determine those loads that may cause oscillation. As long as a load is picked that does not fall in the area of the stability circle, stable operation is assured.

When K is less than unity, the gain of a potentially unstable device approaches infinity by definition. Therefore, equations 23, 25, and 27 cannot be used. Instead, a G_p must first be chosen and then the same procedure as used for $K > 1$ is followed.

The amplifier must be protected from oscillating by careful selection of the load impedance as demonstrated in this example.

Objective: Design an amplifier using a 2N3570 transistor that has a power gain of 12 db at 500 Mhz. The bias conditions are $V_{CE} = 10$ volts and $I_C = 4$ milliamperes. The s parameters are

$$s_{11} = 0.385 \angle -55.0°$$
$$s_{12} = 0.045 \angle 90.0°$$
$$s_{21} = 2.700 \angle 78.0°$$
$$s_{22} = 0.890 \angle -26.5°$$

Solution: Compute the values of G, R_{MS}, and R_{ML}.

$$\Delta = s_{11}s_{22} - s_{12}s_{21} = 0.402 \angle -65.040°$$
$$C_1 = s_{11} - \Delta s_{22}^* = 0.110 \angle -122.395°$$
$$B_1 = 1 + |s_{11}|^2 - |s_{22}|^2 - |\Delta|^2 = 0.195$$
$$C_2 = s_{22} - \Delta s_{11}^* = 0.743 \angle -29.881°$$
$$B_2 = 1 + |s_{22}|^2 - |s_{11}|^2 - |\Delta|^2 = 1.483$$
$$D_2 = |s_{22}|^2 - |\Delta|^2 = 0.631$$

$$K = \frac{1 + |\Delta|^2 - |s_{11}|^2 - |s_{22}|^2}{2|s_{12}s_{21}|} = 0.909$$

$$G = \frac{G_o}{G_p} = 2.174 \quad \text{or} \quad 3.373 \text{ db}$$

Since K is less than unity it is necessary to pick a load that does not cause oscillation. To accomplish this, first consider a stability circle on the output plane. This circle has a center at

$$r_{s2} = \frac{C_2^*}{|s_{22}|^2 - |\Delta|^2} = 1.178 \angle 29.881°$$

and a radius of

$$R_{s2} = \frac{|s_{12}s_{21}|}{|s_{22}|^2 - |\Delta|^2} = 0.193$$

and is represented as the unstable region on the Smith chart on the previous page. As long as an output load is not picked that lies in the unstable region, stable operation is assured.

The constant gain circle that yields 12.0 db of power gain now has a center at

$$r_{02} = \left[\frac{G}{1 + D_2G}\right] C_2^* = 0.681 \angle 29.881°$$

and a radius of

$$R_{02} = \frac{(1 + 2K|s_{12}s_{21}|G + |s_{12}s_{21}|^2G^2)^{1/2}}{1 + D_2G} = 0.324$$

By constructing this constant gain circle, an output load is again chosen. The R_{ML} chosen on the circle had a reflection coefficient of 0.357 $\angle$29.881°, and was read off the Smith chart coordinates as 85.866 + j 35.063 ohms. The source reflection coefficient required for this load is

$$R_{MS} = \left[\frac{s_{11} - R_{ML}\Delta}{1 - R_{ML}s_{22}}\right]^* = 0.373 \angle 64.457°$$

Thus,

$$Z_s = 52.654 + j\,41.172 \text{ ohms}$$

Now a look at the stability circle plotted on the input plane is required to see if the value of R_{MS} assures stable operation. The circle on the input plane has a center at

$$r_{s1} = \frac{C_1^*}{|s_{11}|^2 - |\Delta|^2} = 8.372 \angle -57.605°$$

and a radius of

$$R_{s1} = \frac{|s_{12}s_{21}|}{|s_{11}|^2 - |\Delta|^2} = 9.271$$

Only a portion of the input stability circle is shown due to its size. The shaded area is unstable.

Since R_{MS} does not fall inside this circle and R_{ML} does not fall inside the output circle stable operation is assured.

The complete circuit, bottom of page 107, was constructed from this data. Values for the matching components were obtained using the following procedure.

Output circuit

Step 1. Transform R_{ML} to $50 \pm jz$ ohms or $20 \pm jb$ mmhos. Since individual components are used for matching it is necessary to convert R_{ML} to its parallel equivalent circuit by adding $-180°$ to a positive angle, or $+180°$ to a negative angle.

Therefore,

$$R_{ML_1} = 0.357 \angle -150.119°$$

Using the formula

$$Y_L = \left[\frac{1 + R_{ML_1}}{1 - R_{ML_1}}\right] Y_o$$

where $Y_o = 20$ mmhos

$$Y_L = 10 - j\,4.08 \text{ mmhos}$$

Converting the Y_L admittance to an impedance yields $Z_L = 100 - j\,245$ ohms.

Step 2. Compute the value for the capacitor from the relationship

$$X_c = \sqrt{(R_p - R_s)R_s}$$

where

R_p = real part of Z_L = 100
R_s = load impedance = 50

therefore,

$$X_c = \sqrt{2500} = 50$$

and

$$C_1 = \frac{1}{2\pi f X_c} = 6.38 \text{ pf}$$

Step 3. Compute I_1 from

$$X_{L_1} = \frac{R_s^2 + X_c^2}{X_c} = \frac{(50)^2 + (50)^2}{50} = 100$$

The total X_L is

$$X_{LT} = \frac{(X_{L_1})(X_L)}{(X_{L_1} + X_L)} = 71$$

where

X_L = 245 ohms = imaginary part of Z_L

hence,

$$L_2 = \frac{X_{LT}}{2\pi f} = 0.023\ \mu h$$

Input circuit

Step 1. Transform R_{MS} to $50 \pm jz$ ohms or $20 \pm jb$ mmhos. To do so convert R_{MS} to its parallel equivalent circuit by adding $-180°$ to a positive angle, or $+180°$ to a negative angle.

Therefore,

$$R_{MS_1} = 0.373 \angle -115.543°$$

Using the formula

$$Y_s = \left[\frac{(1 + R_{MS})}{(1 - R_{MS})}\right] Y_o$$

where $Y_0 = 20$ mmhos

Compute Y_S. Thus,

$$Y_s = 11.8 - j\,9.4 \text{ mmhos}$$

or

$$Z_s = 84.7 - j\,106.4 \text{ ohms}$$

Step 2. Compute C_2

$$X_{C_2} = \sqrt{(R_p - R_s)R_s}$$

where

R_p = real part of Z_s = 84.7 ohms
R_s = source impedance = 50 ohms

Thus,

$$X_{C_2} = 41.6 \text{ ohms}$$

and

$$C_2 = \frac{1}{2\pi f X_c} = 7.66 \text{ pf}$$

Step 3. Compute L_2

$$X_{L2} = \frac{R_s^2 + Y_C^2}{X_C} = \frac{(50)^2 + (41.6)^2}{41.6}$$

$$= 102 \text{ ohms}$$

$$X_{LT} = \frac{(X_{L_1})(X_L)}{(X_{L_1})(X_L)} = 52.2 \text{ ohms}$$

where

X_L = imaginary part of Z_s = 106.4 ohms

hence

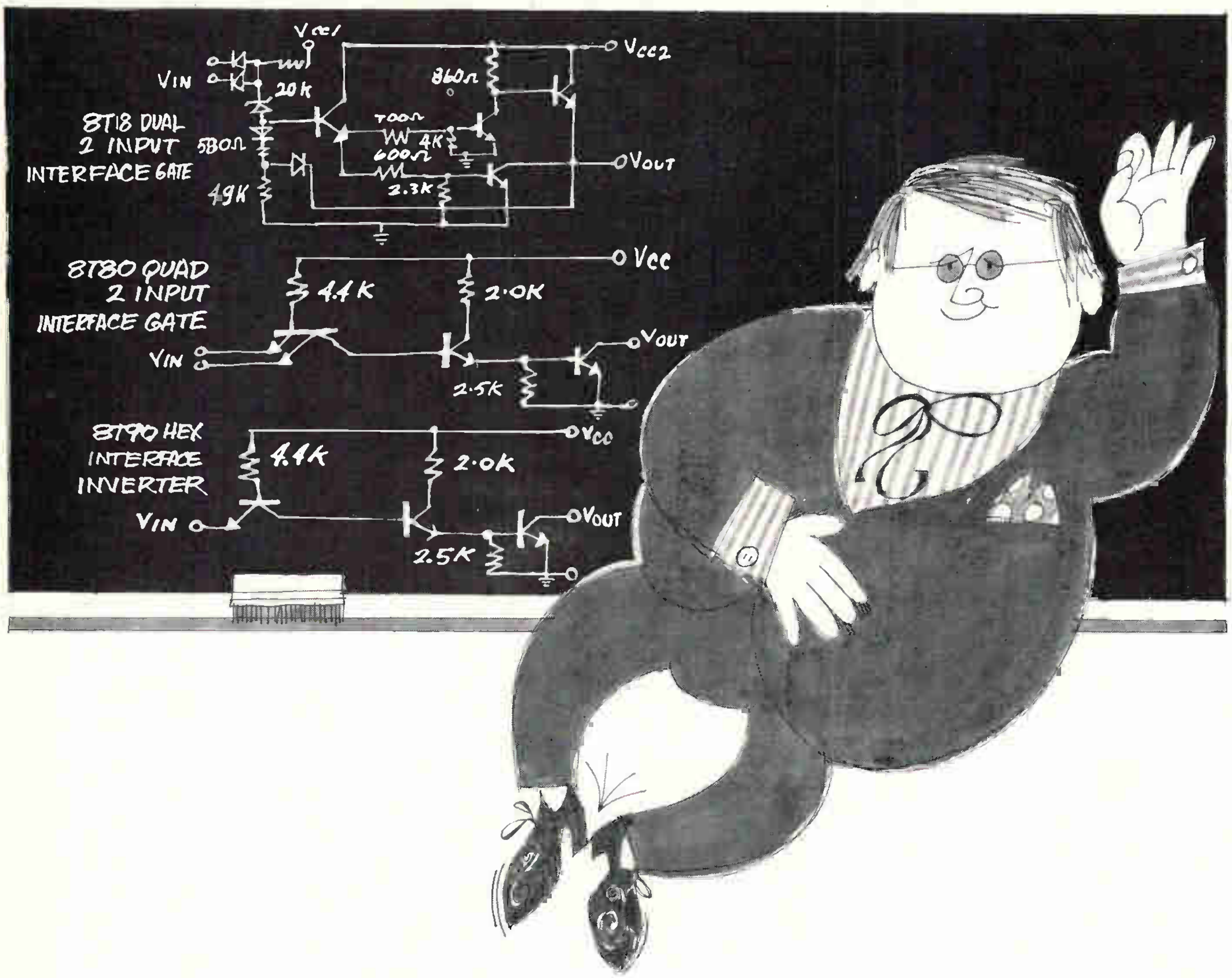
$$L_2 = \frac{X_{LT}}{2\pi f} = 0.017\ \mu h$$

Bandwidth, the third important design factor, is dependent on the Q of the circuit. There are no magic formulas for accurately predicting bandwidth in all cases. Many LC combinations provide the same complex impedance at the center frequency but yield different Q's and bandwidths.

If the inherent bandwidth, Q, of a transistor loaded with a particular LC combination yields a bandwidth that is greater than desired, adding LC elements narrows the bandwidth and keeps the gain constant. But if the inherent bandwidth is narrower than desired, a gain reduction or different LC combination changes the bandwidth.

The author

William H. Froehner, who started working at TI in 1964, designs high frequency measurement and test equipment. In the last 18 months he has been applying the scattering parameter technique to design high frequency amplifiers.



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Air traffic cop eyes 'bandits,' too

First solid state 3-D radar uses digital signal processing to zero in on a plane's range, bearing and altitude; Air Force is planning to install the new system at its forward bases

"Bandit at 33,000 . . . bearing, three-two-zero . . . range, 150 miles and closing fast!"

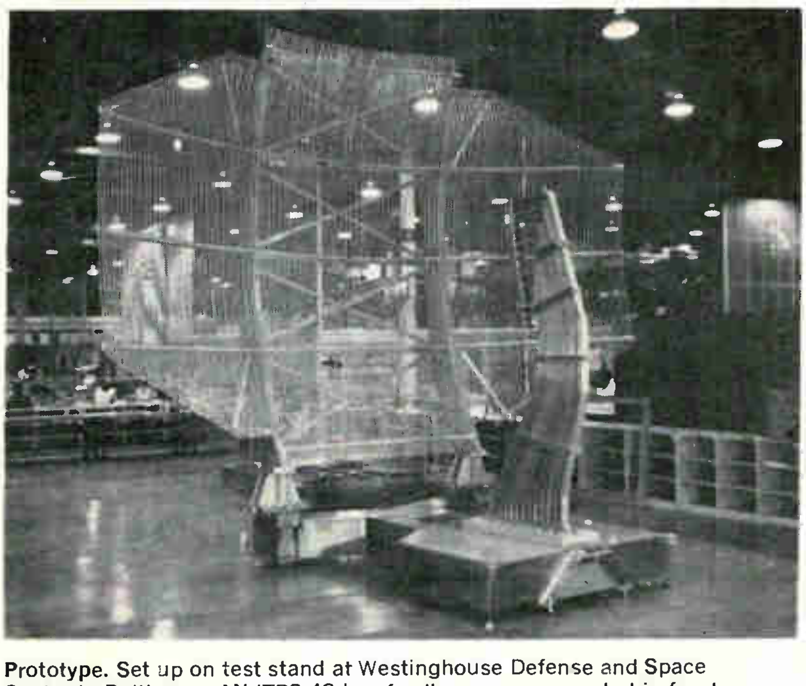
Sound like a line from an old John Wayne war movie? Perhaps. But it could also be what an operator of a tactical three-dimensional radar says. For, in effect, it sums up the many military roles of 3-D radar: detecting enemy aircraft and missiles, guiding interceptor aircraft and missiles, and controlling air traffic. The radar does all this by computing and displaying a target aircraft's altitude as well as its bearing and range.

The Air Force's newest 3-D radar is the AN/TPS-43, which has several design features that set it apart from others in its class. Among these is the unusually shaped array of feedhorns shown below, part of a computer-designed beam-sharing system that is expected to make the radar exceptionally accurate.

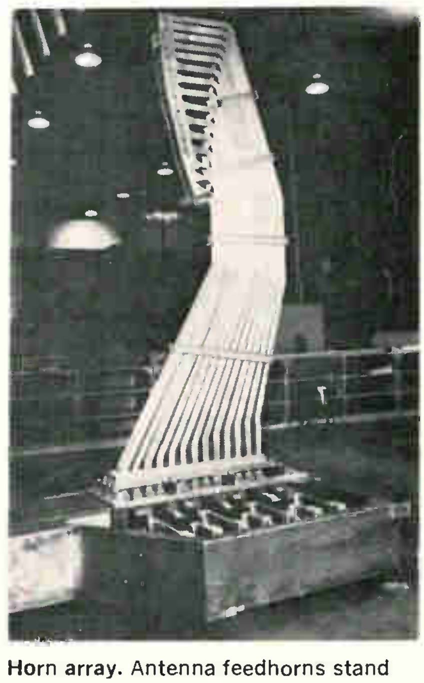
Built by the Westinghouse Electric Corp. as part of the Air Force's 407L tactical air control system, the radar was designed so that all the transmitting and receiving circuitry fit into a housing that is easily transportable by helicopter. In so doing, the company came up with the first solid state, 3-D tactical radar. About 70% of the search- and altitude-processing circuits are monolithic and hybrid integrated circuits—about 3,000 IC's in all. Its moving target-indicator subsystem is also the first to operate digitally, the company claims.

The Air Force plans to deploy the 3-megawatt radar at forward air bases, primarily to control the traffic of friendly aircraft and to detect intrusions by unfriendly planes.

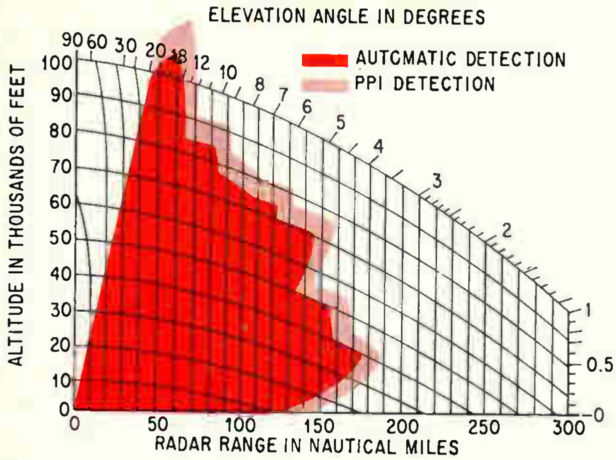
A new coding technique and a narrower signal bandwidth—2.9 to 3.1 megahertz—makes the TPS-



Prototype. Set up on test stand at Westinghouse Defense and Space Center in Baltimore, AN/TPS-43 has feedhorn array mounted in front of 20-by-14-foot reflector. A second S-band antenna, for sidelobe signals, which would be mounted behind the feedhorn assembly, isn't shown.



Horn array. Antenna feedhorns stand on base containing transmission waveguide and a stripline matrix that feeds six receivers.



Three-dimensional. Search coverage of antenna-beam pattern. Azimuth is determined by pedestal rotation.

43 less susceptible to countermeasures than previous 3-D radars and contributes to the accuracy.

Air Force specifications require the radar to be capable of detecting aircraft at ranges up to 150 miles and altitudes up to 75,000 feet, and to compute the height to within ±3,000 feet. Westinghouse's engineers claim the system will surpass these specifications.

Moreover, because of the high percentage of IC's, they expect a mean time between failure of 200 hours— about 10 times the reliability, they say, of previous systems of this type. The only tubes in the set are the modulator-driver thyratron, transmitter power amplifier and driver, traveling-wave tubes in the receiver, and the cathode-ray tube of the plan position indicator (PPI).

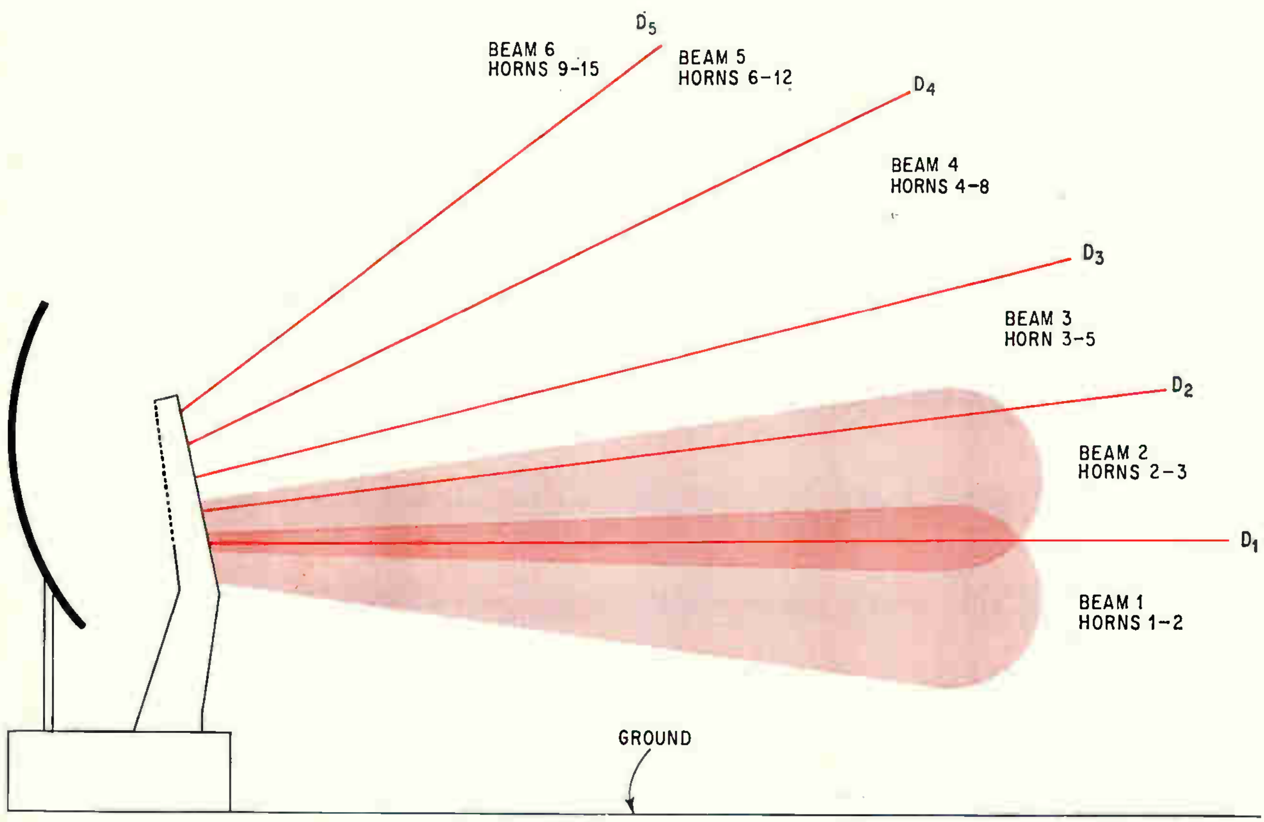
Under an $18.5-million contract with the Air Force System Command's Electronic Systems Division, Westinghouse's Surface division is providing two prototypes and 17 production models of the system.

Shared apertures

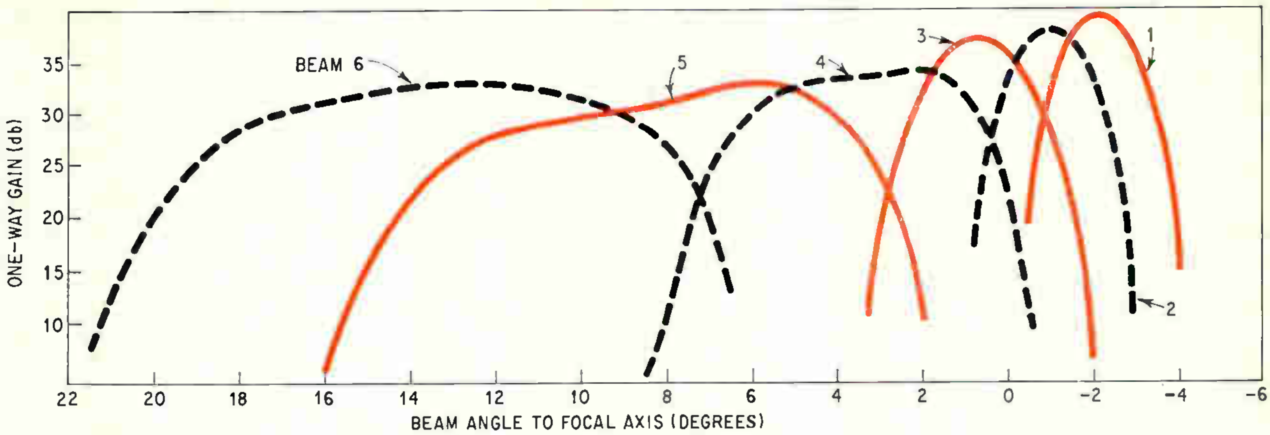
There are 15 feedhorns in the array. When the radar is transmitting a pulse, the horns radiate in concert and a unified beam fans out from the parabolic reflector to cover a narrow slice of sky. As indicated by the range-elevation plot at the left, the elevation coverage is from 0.5 to 20° above the horizon. The horizontal beam pattern is narrow—about 1.1°—for accurate bearing or azimuth discrimination.

In the receive mode, the radar's return signals are viewed as being in six overlapping beams, shown below. Two or more feedhorns jointly receive each beam, and each beam shares one or more horns with adjacent beams. There are six receivers in the system. The basic beam-stacking technique was devised several years ago by the company and used in earlier three-dimensional radars.

For the TPS-43, however, the designers came up with the new microwave subsystem shown on



Overlapping beams. Five pairs of receive beams are formed by the overlapping of adjacent beams. Difference curves D_1 through D_5 must be approximately straight lines for accurate height interpolation. Tinted area is the lowest beam pair.



Beam shapes. Beams 4, 5, and 6 were deliberately distorted to make the difference curves between beams as straight as possible.

this page, which separates transmission and receiving functions. Waveguide is now needed only to handle the transmitter's high-power output. Large pieces of waveguide are no longer required in the receiver's beam-forming matrix. To combine the energy received by each group of horns and feed the radar's receivers, a matrix made of stripline is used.

Beam alignment

The separation of transmitting and receiving functions enabled Westinghouse's engineers to optimize the antenna design for both the transmission and reception of radar signals.

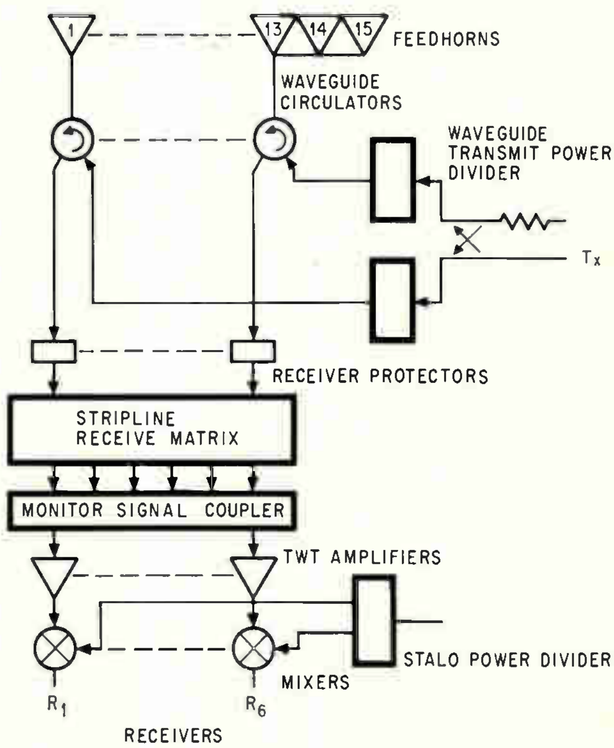
As a transmitter, the TPS-43 operates much like a conventional two-dimensional radar. The feedhorns aim energy at the paraboloid antenna to form a cosecant-squared beam pattern.

In the receive mode, beam 1—the beam closest to the horizon—uses horns 1 and 2. Beam 2 shares horn 2 with beam 1 and horn 3 with beam 3. Beam 3 uses horns 3 through 5, beam 4 uses horns 4 through 8, beam 5 uses horns 6 through 12, and beam 6 uses horns 9 through 15. Antenna gain ranges from 39.2 decibels for beam 1 to 32.6 db for beam 6.

To prove the aperture-sharing concepts and design the antenna, the engineers employed a digital computer. With it, they evaluated the beam-diffraction patterns for a given set of reflector and feedhorn parameters. After beam patterns for an initial set of conditions were computed, the parameters were modified to resolve the differences between the computed and desired patterns.

The biggest design problem was shaping the beams for proper coverage and overlap within the 0.5-20° elevation pattern. To make the difference curve between any two adjacent beams approximate a straight line—necessary for high accuracy in elevation—the vertical shapes of the beams were adjusted. In stacked-beam radars, the difference curves are straightened by making each beam's aperture overlap and physically interfere with its neighbor. Since each beam in the TPS-43 shares several apertures, the horn grouping for each beam was first designed as though the others weren't present. Then, as the array was built up, the apertures overlapped.

Another consideration in designing a multihorn array is that a beam's elevation angle is determined by the angle between the focal axis of the antenna and a line drawn from the feed point to the center of the antenna. Only one feedhorn can be placed at the focal point of a parabolic reflector; the others in the array must be displaced. Although displacement of the horns is necessary in achieving high elevation angles, it has a drawback: the farther the horns are from the axis, the smaller the reflector area they can



Microwave subsystem. Waveguide-power divider feeds transmitted power to feedhorns. Return signals are routed through circulators and stripline to receivers. The use of stripline cuts antenna weight.

How frequency scanning stacks up

The advent of integrated circuits in 3-D tactical radar has done little, apparently, to end the design contest between stacked-beam and electronically scanned systems.

Although Westinghouse Electric Corp. has scored a point for stacked beams with the Air Force's AN/TPS-43, ITT Gilfillan Inc. has scored for electronic scanning with the Marine Corps' AN/TPS-32. The Gilfillan system, like Westinghouse's, contains thousands of digital integrated circuits.

The first of these height-finding, air-defense radars is now undergoing acceptance tests at the West Coast plant of the International Telephone & Telegraph Corp. subsidiary. Eventually, it will be tried out as the primary sensor in the Marines' tactical-data system.

The TPS-32 is a follow-on to the Navy's AN/SPS-48, which has been in service in Vietnam for more than a year. But the new radar is more than a microminiature, younger brother of the SPS-48, says Neil T. Keyes, manager of Gilfillan's tactical-radar operation.

Keyes says the TPS-32 is the first frequency-scanning system conceived from the start as a fully automatic sensor. It processes both radar and IFF (identification friend or foe) data automatically. "The output," he explains, "is a correlated message for each target, providing data on position and IFF without human intervention."

Frequency scanning. Digital techniques have been used before in frequency-scanned radars, members of the electronic-scanning family [Electronics, June 27, 1966, p. 80]. Frequency shifts, which result in phase shifts that change direction of the transmitted beam, are often computer controlled.

In the TPS-32, a digital programer manages power transmission. It controls—as a function of elevation—peak power, interpulse period, and the number of hits on a target. A target is seen by multiple beams. Its altitude is measured by finding what Gilfillan calls the "center of gravity" of the region where the target is seen.

Irving Hammer, manager of the firm's advanced systems operations, says this method is less prone to error than the stacked-beam method of finding altitude by comparing amplitudes of signals in adjacent beams. Direct comparisons can't be made, because the TPS-32's range, height-measuring accuracy, frequency band, and scan sensitivity are classified.

There is, he points out, a receiver for each beam in a stack, so angular accuracy is related to receiver stability and how well the receivers' gains match. The match must be maintained regardless of signal strength, he continues, so a stacked-beam system is more susceptible to jamming. "You can't depend on getting instantaneous amplitude comparison, and you lose one of your three dimensions —target altitude."

Hammer and Keyes also contend that the shape of the lowest beam in a stack continually varies because of radiation reflected from the ground. "If you can't predict the shape of the lowest beam, you can't accurately measure the amplitude of the signal from the two adjacent beams," Keyes says.

Keyes claims further that a frequency-scanned radar's planar-antenna array can provide optimum illumination throughout the area of coverage. He contrasts this with the stacked-beam problem of being able to put only one horn at the reflector's focal point.

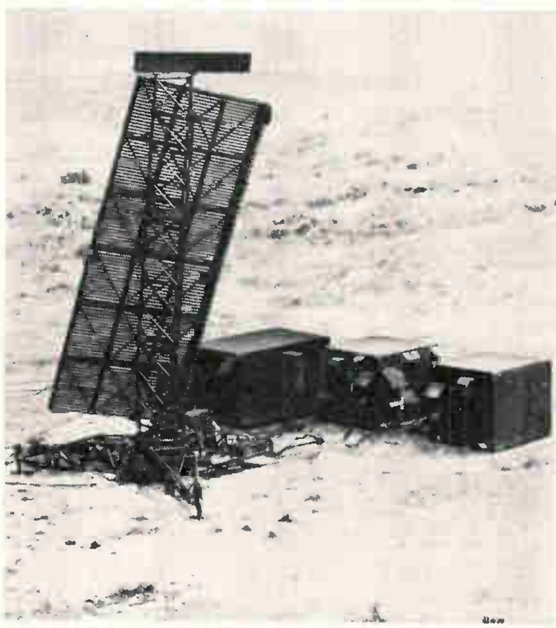
"Typically, in a stacked-beam system, the horn at the optimum position provides the lowest beam," he adds. "As you go up in elevation, side lobes become very poor and the system doesn't operate effectively in an electronic countermeasures environment."

Clutter. Designers of stacked-beam systems concede that the use of multiple receivers is a drawback, but contend that it is offset by a number of advantages, including lower losses, more target returns, greater freedom in changing frequencies to avoid jamming, and better indication of moving targets. And, they claim cross-polarization reduces weather clutter.

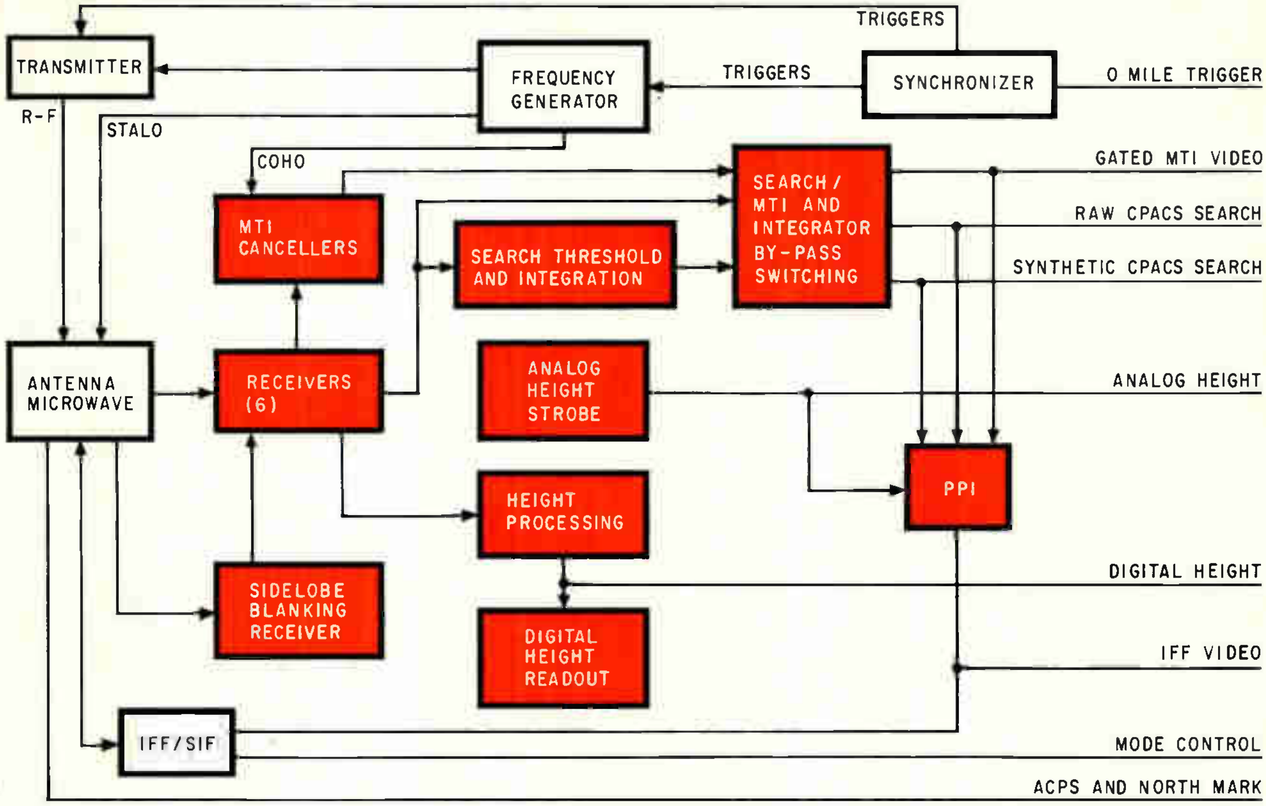
Keyes says special emphasis was given to clutter reduction in the TPS-32 design, and that the system now being tested "successfully eliminates clutter by combining a sophisticated moving-target indicator and three-dimensional blanking of the residue."

Integrated circuits. Most of the digital IC's in the TPS-32 are diode-transistor logic (DTL) circuits, with some transistor-transistor logic (TTL) in driver and timing circuits. DTL costs less, Keyes explains.

In the digital portions of the radar, the IC's are packaged in throwaway modules of six IC's each, to simplify maintenance. Seven types of these modules are used and inexperienced maintenance men can easily replace them. Field troops could handle 90% of the troubles that could occur in the system, Keyes says.



Bigger system. Frequency-scanning AN/TPS-32 is much larger than the stacked-beam AN/TPS-43. Its antenna is 30 feet high and circuitry is packaged in three helihuts, one measuring 12 by 7 by 7 feet and the other two 8 by 7 by 7 feet.



Radar system. Except for traveling-wave tubes and the PPI cathode-ray tube, receiver circuits (in color) are solid state and computing is done digitally.

use and the broader the reflected beam.

Westinghouse's engineers overcame the difficulty by placing the horns above and below the focal axis as shown by the curves on page 113, thus limiting the beam size, and then tilting the antenna to aim the low beams near the horizon.

Signal processing

As a receiver, the TPS-43 starts out as a collection of six radar receivers whose outputs are merged through an intricate processing and computing sequence (above, and p. 116). After amplification in the radio-frequency and intermediate-frequency stages, the signals are pulse-compressed. Each signal is then divided between a search channel, which examines the video for moving targets, and a channel that determines target height. In both channels, the signal processing is digital. A digital shaft encoder on the antenna pedestal indicates target bearing.

To detect and display moving targets, the analog signals are digitized and stored in a ferrite-core memory. A digital two-pulse canceller compares the phases of two successive returns. If the phase has not shifted between pulse periods, it means the target is stationary and it is cancelled.

Lane Letsch, a Westinghouse project engineer, says the digital technique eliminates the frequency-drift problems of analog moving-target-indicator circuits. These generally use quartz delay lines to hold a pulse for phase comparison with the following pulse. Frequency variations could be read as phase shifts, falsely identifying a stationary or slow-moving object as a moving aircraft—a real target.

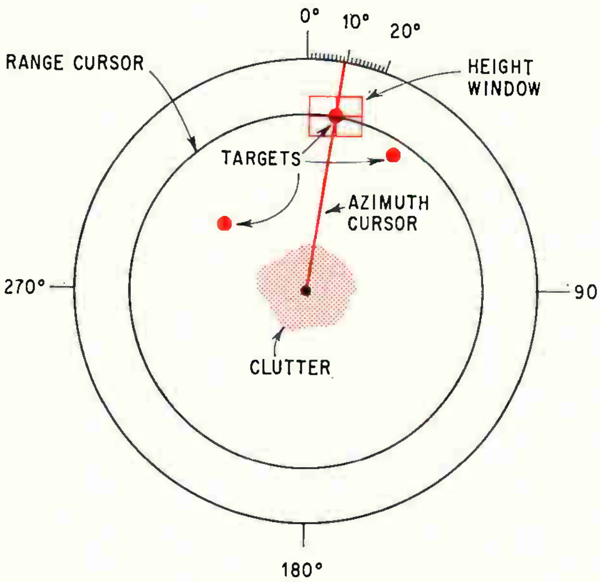
Pulse compression and phase coding are done by a classified technique, which Westinghouse calls Cpacs (coded-pulse anticlutter system). It shortens the length of received pulses—as do other pulse-compression techniques—to improve ranging accuracy. Altitude accuracy is also improved, since range is a factor used to compute target height. In addition, Cpacs helps prevent false target identification and reduces the effects of meteorological and other natural disturbances.

Sidelobe cutout

Reference signals for sidelobe blanking are obtained from a second S-band antenna. This is a dipole array forming a 12-by-51-inch rectangle that is mounted on the back of the feedhorn assembly. The beam pattern overlaps the main antenna's azimuth sidelobes.

Signals picked up by the sidelobe antenna are processed like the signals in the main receiver channels, except that the sidelobe receiver's gain is about 1 db higher. A difference amplifier compares the return-signal energy in the sidelobe channel with the signal energy in the main channel. If the sidelobe-signal level is greater, the supposed target is in the sidelobes and the logic circuitry blanks it from the radar's display.

Beam splitting or amplitude monopulsing—a common radar technique—is the basis for the



Height window. Radar operator uses range and height cursors to set height window over a selected target on the plan position indicator. The target altitude is then displayed.

height computation. Westinghouse splits each of the receiver's six input channels in two so that the sum and difference of the radar return energy in adjacent beams can be computed.

From among the five beam-pairs, a peak selector chooses the pair that contains the greatest signal energy. The selector's output is used to establish the target base-height angle, θ_B. The difference in the radar energy in each of the selected beams yields the target interpolation angle, θ_i, as shown on facing page.

The base-height angle is formed by the centerline of the beam pair that contains the return signals and a line drawn from the radar to the horizon. The interpolation height is the distance the target aircraft is above or below the beam centerline. Therefore the aircraft's height, H, is

$$H = R \sin (\theta_B + \theta_i)$$

where R is the slant range to the target. This equation can be extended to show that

$$H = R \sin \theta_B \cos \theta_i \pm R \sin \theta_i \cos \theta_B$$

but since θ_i is small, it is safe to assume $\cos \theta_i = 1$, and $\sin \theta_i = \theta_i$. The aircraft's height would then be equal to the base height plus the interpolation height, or

$$H = R \sin \theta_B \pm K_i \theta_i R \cos \theta_B$$

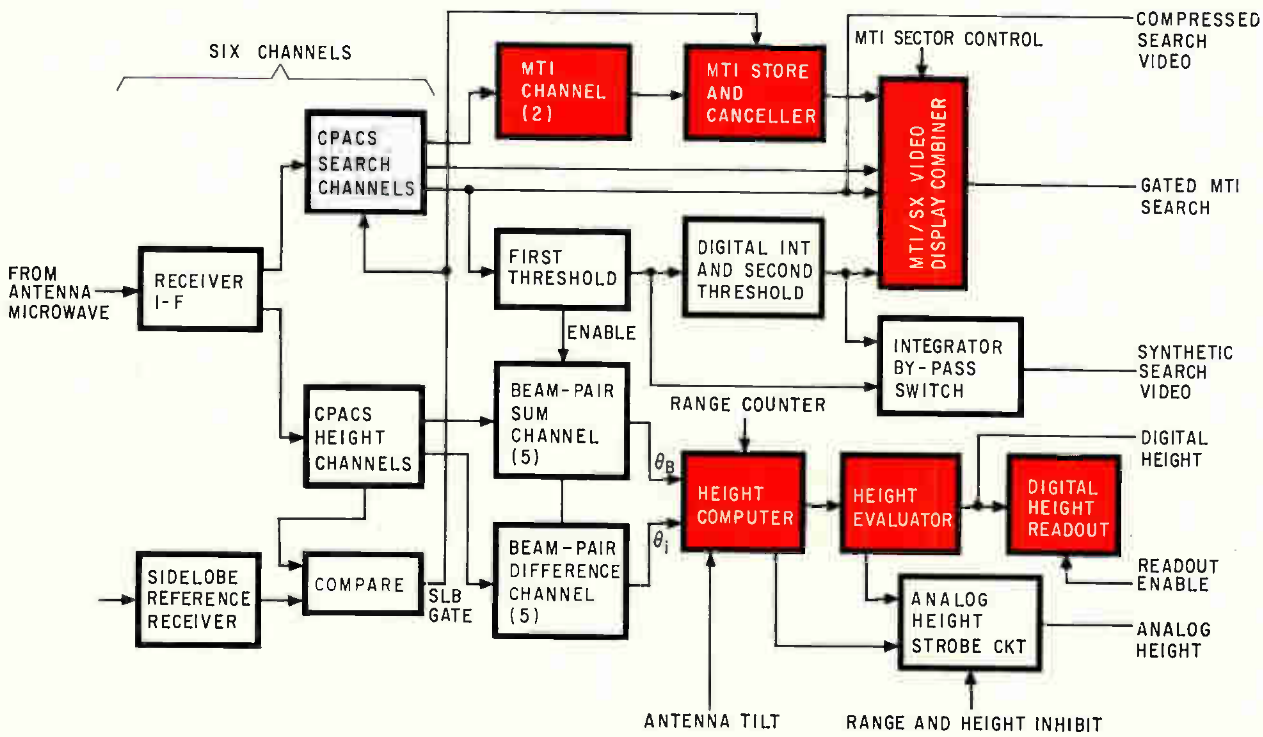
where K_i is a scale factor of θ_i.

However, in addition to the base and interpolation angles and the range signal from the radar's search channel, the computer receives a tilt-angle signal, θ_T, from a sensor on the antenna pedestal. Corrections for the earth's curvature, K_e, and atmospheric bending of the radar beam are precalculated and stored on pin boards in the computer's memory-circuit banks.

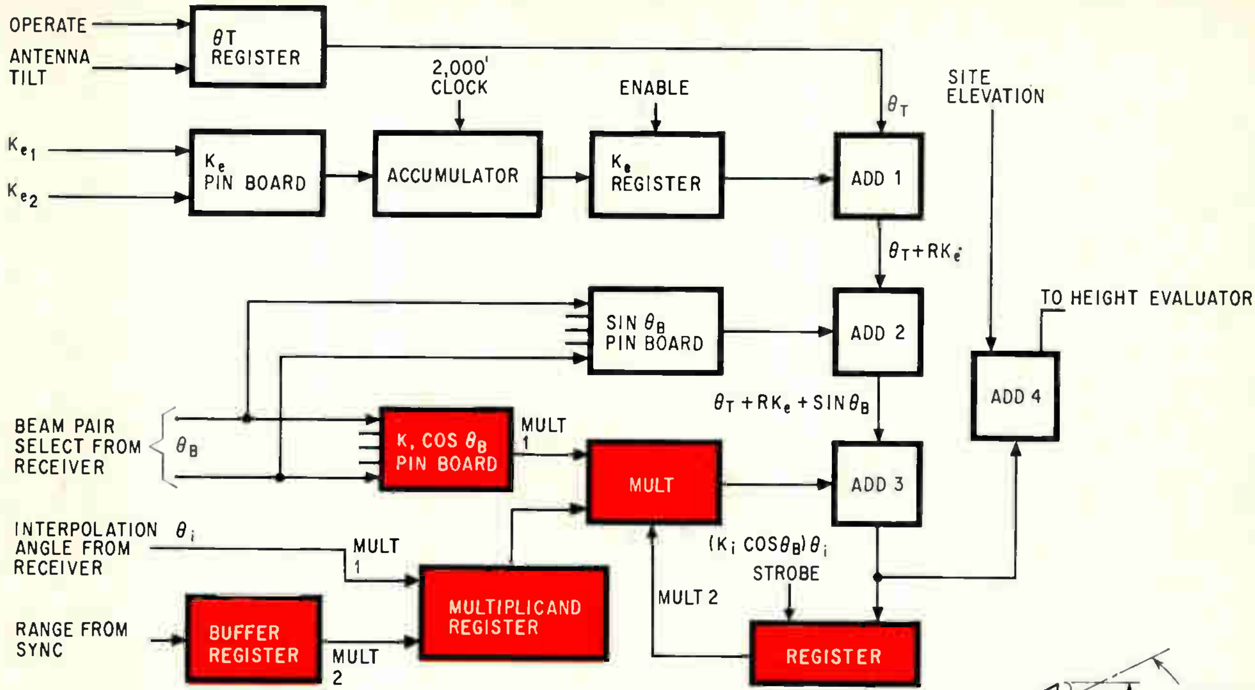
Actual aircraft altitude is the sum of all these variables, or

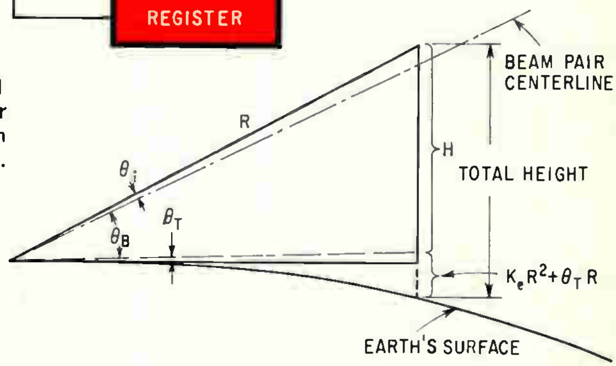
$$H_T = [\theta_T + RK_e + \sin \theta_B + (K_i \cos \theta_B)\, \theta_i]\, R$$

plus site elevation.



Receiver. Each of the six input channels is split so target altitude and radar video can be processed separately. Moving targets are detected and height computed with the digital subsystem shown in color.





Height computer. Constants and variables processed by the computer are defined at right. The computer selects the correct set of beam constants, then sums them and multiplies by range in the tinted blocks.

Each time the radar beam strikes a target the computer calculates the target's height. A logic circuit at the output of the height computer selects the average of the three most consistent altitude calculations for display.

Three videos

At a control station remote from the radar unit, Air Force traffic controllers will be able to display any of three video outputs: raw undigitized, synthetic, or gated moving-target-indicator video. The raw-video display, the most sensitive of the three, is used for ordinary radar search purposes. For automatic tracking, the operator usually employs the synthetic-video output because the radar signal is integrated over a finite time period to lower the false-alarm rate. In high-clutter areas, however, he may choose to display a gated output. In this instance, he selects the sector in which he wants to detect moving targets in clutter; raw video is displayed in all other areas.

To determine an aircraft's altitude, the operator merely flips a toggle switch on the control panel and turns on a window—whose width in azimuth is 10 nautical miles and length in range is 4 miles —like that shown on the preceding page.

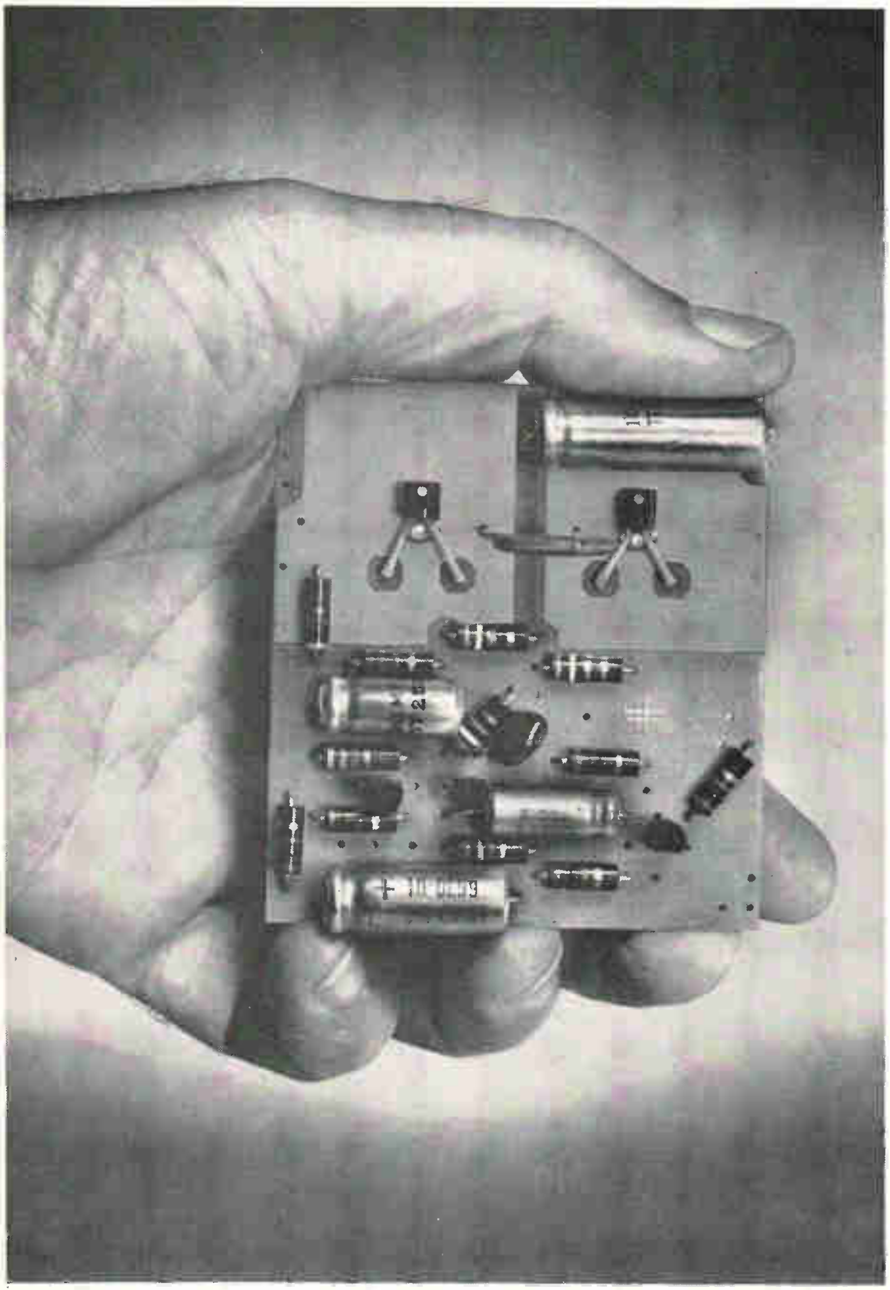
By manipulating the range and azimuth cursors, the operator places the window over the target. This sets up the range and azimuth gates in the digital height-evaluation circuit. He then presses a button that causes the data in these gates to be sent into a register. After the register is decoded, the height is displayed numerically.

To obtain the relative altitude between two targets, the height window is positioned over the second target. By depressing a relative-height switch, the altitude data on this target is inserted into a second register. Then the data in the two registers are subtracted one from the other and the difference displayed. The radar operator can also use a wedge-shaped height window, 5° wide and 4 nautical miles long. It is useful in determining the relative altitude of close-in targets.

To keep the radar's downtime low, the TPS-43 has a built-in manual test system that checks the radar even while it's operating. A low-level signal from the frequency generator is coupled into the low-noise traveling-wave tube at the input of each receiver channel. The radar processes the signal as if it was an actual return. By using the test signal, technicians can set amplifier gains and adjust threshold levels. If the signal is not being processed correctly, a fault is indicated.

The radar's electronics (transmitter, receiver, processors, and so forth) are contained in a 7-by-7-by-9-foot hut, and the antenna and microwave assembly are mounted on a separate pallet. Total weight of each is about 3,500 pounds. Multiconductor cables and flexible waveguide interconnect the hut, antenna, and control station.

Reduce circuit costs with 16 new plastic-package transistors from TI



Texas Instruments announces 16 new transistors to improve performance, simplify circuitry and reduce your product costs. Included are silicon amplifiers, oscillators and switches. An economy version of the 2N4416 FET is available, too.

All the new transistors are offered in TI's exclusive SILECT™ economy plastic package. Lead configurations include: in-line, TO-18, and high-frequency. The new HF arrangement provides improved isolation and lower feedback capacitance for VHF and UHF devices.

TI's SILECT package, backed by 30,000,000 hours of testing, is fully capable of meeting military specifications. Reliability has been found to be equivalent to metal-can devices tested under the same conditions.

High-dissipation SILECT package eliminates heat sinks

Here are the first economy small-signal transistors to feature power dissipation of 1.6 watts at 25°C case temperature – nearly twice that of devices with comparable packages. Specially processed, high-thermal conductivity leads achieve this added dissipation. Designated as NPN types TIS90 and TIS92, and PNP types TIS91 and TIS93, these complementary devices are also available in matched pairs (TIS90M/TIS91M and TIS92M/TIS93M).

The new, high-dissipation packaging allows plastic transistors to be used in applications formerly restricted to metal-case, medium power devices or to the use of elaborate and expensive heat sinks.

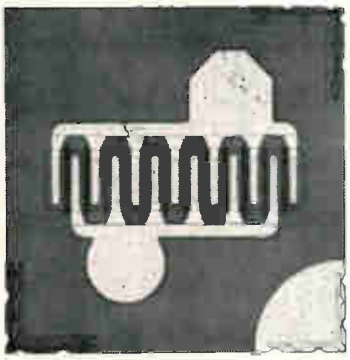
An effective heat sink can be obtained *at no extra cost* by leaving an area of copper on the face of the etched circuit board and connecting the high-conductivity collector lead to it (as shown at left).

The complementary pairs are designed for low-cost audio driver and output circuits up to two watts for phonograph applications.

Electrical characteristics are similar to the 2N2222 NPN and 2N2907 PNP families.

Circle 325 for data sheet.

New high-frequency FET doubles previous frequency capability



The new TIS88 silicon FET—plastic-encapsulated equivalent of the 2N4416 also offered by TI—features a frequency capability twice that of similar devices previously available in low-cost plastic packages. The high-performance FET operates up to 400 MHz with 10 dB minimum power gain. High transconductance and low feedback capacitance make this new device especially useful for consumer, industrial and military applications, including FM RF amplifiers, cascode-connected VHF amplifiers and sonobouy input amplifiers. Performance characteristics include a low noise figure (4 dB maximum at 400 MHz) and low leakage (I_{GSS} = 1nA maximum).

Circle 326 for data sheet.

New low-cost NPN devices for TV and audio applications

TIS83. Designed for use in UHF tuners, the new TIS83 transistor features a high injection current (I_{osc} = 2.5 mA minimum at 930 MHz). Transconductance is high (Y_{fs} = 70 mmhos at 200 MHz), permitting use with Schottky-barrier or AFC diodes.

Circle 328 for data sheet.

TIS84-85. New TIS84-85 transistors are designed for RF amplifiers and first and second video IF applications. They feature low noise figures (3.3 dB max @ 200 MHz for the TIS84), low feedback capacitance (0.4 pF maximum) and excellent forward AGC characteristics. The AGC control-voltage range is narrow, making only one device necessary for both IF sockets. The 100-mil B-E-C high frequency pin configuration isolates input and output circuitry.

Circle 329 for data sheet, which includes 10 performance curves and two application circuits.

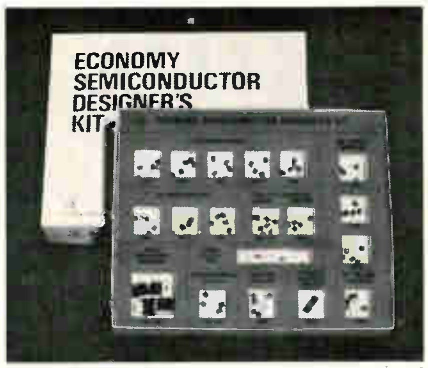
TIS86-87. New TIS86-87 high-frequency silicon transistors are designed for such TV applications as mixers, reverse-AGC IF, and third IF. Feedback capacitance is low at 0.45 pF maximum, permitting unneutralized IF-stage design. Real and imaginary parts of y-parameters at 45 and 200 MHz simplify circuit design. Pin configurations are 100-mil, B-E-C.

Circle 330 for data sheet.

TIS94-99. This is a complete family of low-noise, low-to-medium current SILECT transistors for use in hi-fi audio amplifiers and general purpose low-frequency applications. They feature excellent Beta linearity to 100 mA, high current gain, low noise figures and high breakdown voltage (65 V min $V_{(BR)\,CEO}$ for the TIS96 and TIS99).

Circle 331 for data sheet.

New economy semiconductor designer's kit



TI's new designer's kit enables you to evaluate a wide variety of 94 economy semiconductors for only $24.50*—less than one-fourth their usual low cost. Order your kit TODAY from your authorized TI distributor.

*suggested manufacturer's retail price

TEXAS INSTRUMENTS
INCORPORATED

Computers

Do-it-yourself display brightens the outlook for low-cost CAD

Simple interface unit turns conventional laboratory oscilloscope into an effective display for a computer—and costs only $1,500

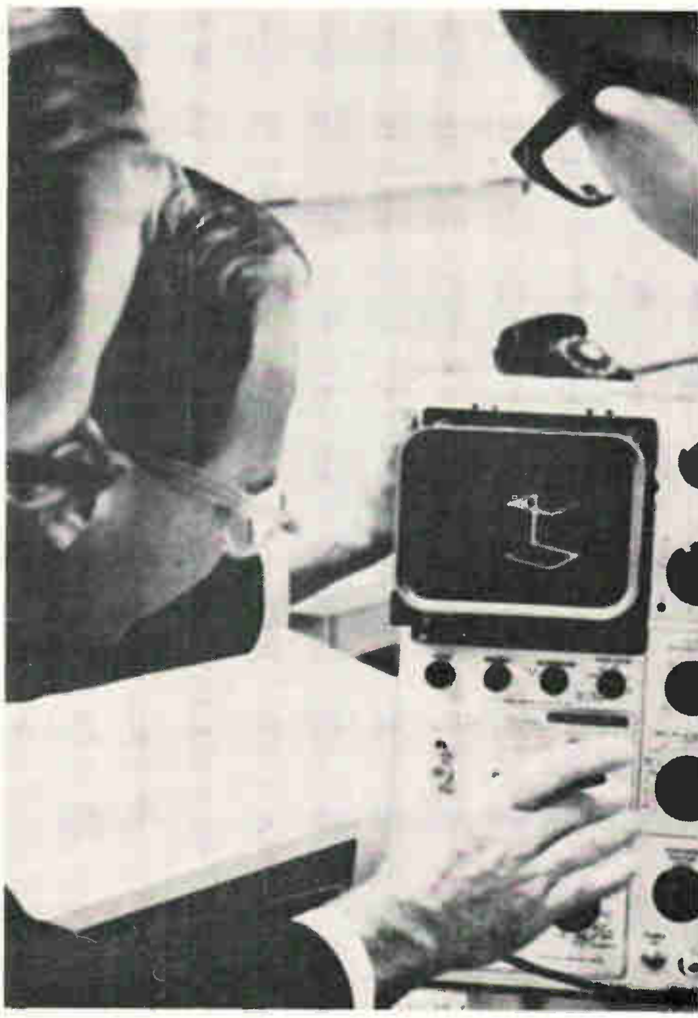
By Jerry Shumway
Friden Inc., San Leandro, Calif.

Advocates of computer-aided design are drawing a steadily growing following. But even more engineers would be attracted if the cost of ready-made CAD systems, which normally is $10,000 or more, wasn't prohibitive to some companies.

Engineers at Friden Inc., a subsidiary of the Singer Co., wanted to take advantage of CAD as a design tool, and they also wanted to gain experience in the design of displays as a component in electronic calculators. So they designed a flexible home-made display system that could be built inexpensively and connected to a computer easily. Friden engineers put about $1,500 worth of components into an assembly to which they connected a conventional laboratory oscilloscope and an old computer. The resulting system is capable of displaying engineering drawings, design curves, and similar graphics.

To simplify both designing and programing, Friden used an elementary form of digital-to-analog conversion—a network of resistances scaled in powers of 2. With incremental conversion, the picture is built up on the oscilloscope screen by a series of small, overlapping spots of light.

The display is used in designing a calculator having a cathode-ray tube display as its output. Friden's engineers simulate the design in an International Business Machines Corp. 1620 computer. The operator uses an external keyboard as he would an electronic calculator's keyboard; the computer makes the calculations and displays the results on the oscilloscope screen as they would appear on the calculator's crt. With simulation, the designer can alter the calculator's specifications merely by changing the computer's program. For example, the display can have five rows of 15 digits each instead of four rows of 10,



Rotating display. Outline of a cube appears on an ordinary laboratory oscilloscope, controlled by a computer and a special interface unit.

or an exponential function can be added corresponding to one of the keys on the keyboard.

Unlike some commercially available display systems, the Friden system lacks the capability of instructing the computer directly through the display. However, this can be added by means of a light pen and some more circuitry. Provision has been made for adding a buffer memory and special conversion functions to the basic display.

Spots of light

Each word or digit transmitted from the computer causes the cathode ray to move a slight distance in any one of eight directions, or to turn on or off. To draw a line, the beam is on while it is moved through successive points; to end a line, the beam is turned off when it is moved to the next point or points and on again to start a new line.

The typical spot size on the display is about 0.02 inch. The screen area used for the display is about 3 inches square, divided into 1,024 horizontal and vertical increments. A single incremental movement of a spot is therefore about one-seventh its own diameter.

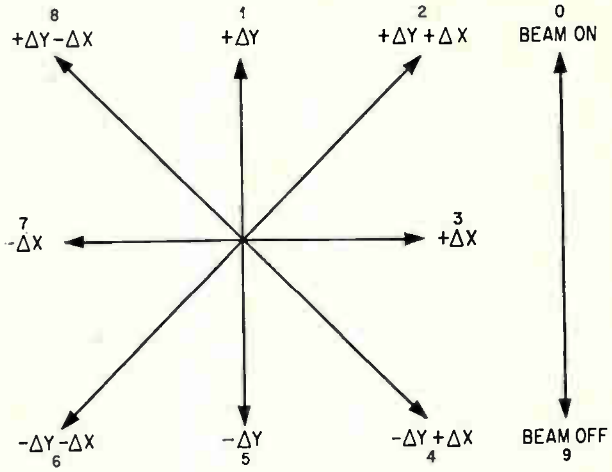
In some display systems, each new word from the computer is the absolute address of a specific point on the crt screen. Although these systems are faster than Friden's and can display more information without flicker, the full coordinate addresses require longer data words or multiple words and more complex interface logic.

With the oscilloscope's centering and deflection-gain controls, the operator can select any part of the display for expansion and closer examination—a feature lacking in most commercially available systems except through program modification. A standard oscilloscope camera is used to make hard copies of the displayed images.

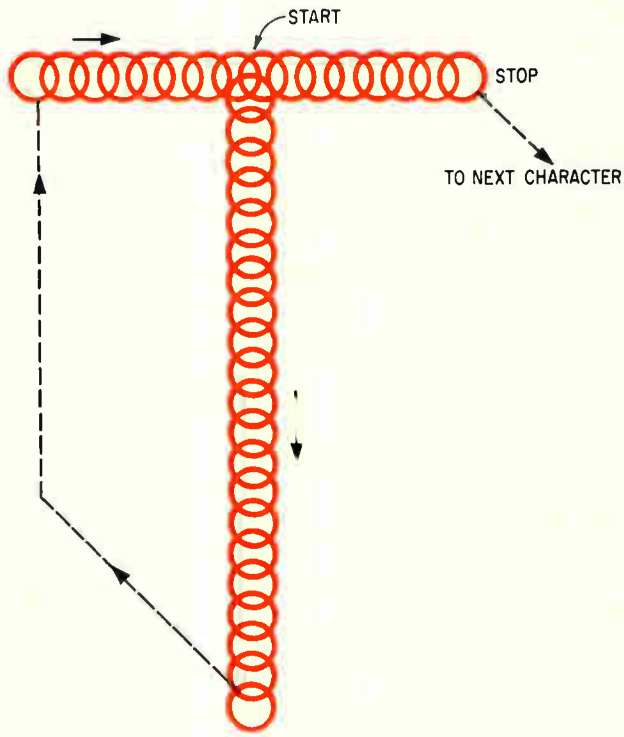
The simplicity of the system can be attributed, at least in part, to the incremental mode itself. This mode enables the display to be programed the same way as the system's digital plotter. In fact, it was because of the plotter that the company designed the interface with the incremental mode. But despite offering this advantage, the mode has one major drawback: in the absence of an external buffer memory, it heavily loads the computer.

This disadvantage crops up when the oscilloscope display is viewed directly. Like most crt displays, the Friden system requires continuous refreshing—retransmitting data from the computer. Unless refreshing occurs at least 30 times per second, the oscilloscope display tends to flicker noticeably. Flickering is the fading of that part of the display that is traced first, before the tracing of the later parts has been completed. The price paid for refreshing is the slowing of the computer's concurrent operations by making the machine take time out from them for retransmission.

Because of the flickering and refreshing problems, the designers considered using a storage oscilloscope for the display. With this instrument, the picture can be traced just once and a storage grid just behind the screen retains the pattern indefinitely by secondary emission of electrons. The pattern is erased by a signal from a pushbutton or other source that removes the power from the storage grid. This approach was rejected because the display is difficult to change quickly—erasing takes a large fraction of a second.



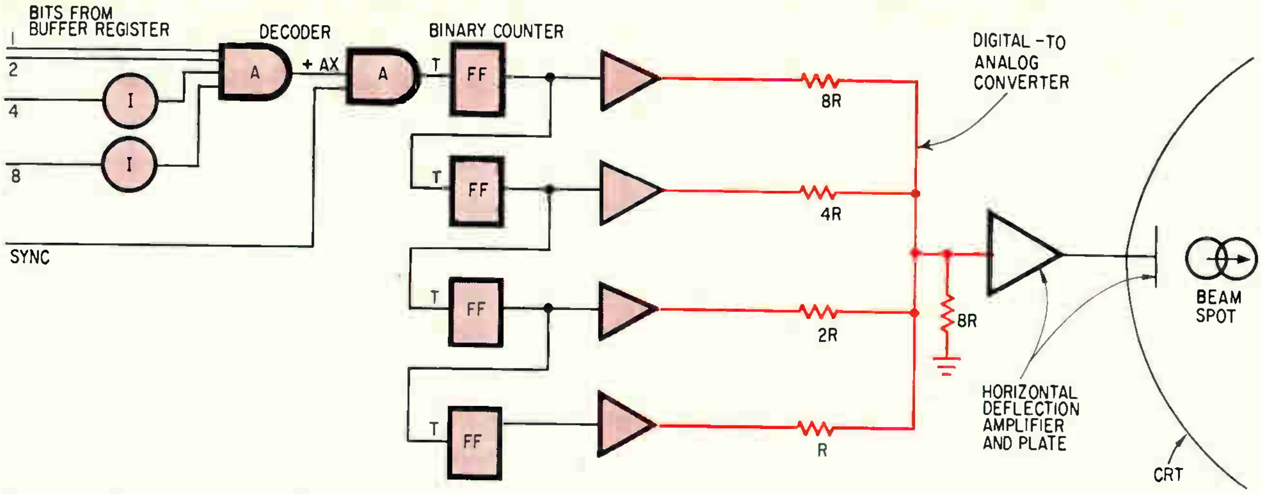
Direction. A single digit transmitted from the computer directs oscilloscope's electron beam to move in one of eight directions, or to turn on or off.



Step by step. A series of overlapping spots can be put together to display any character, here a T, or graphic outline.

By the numbers

The IBM 1620 memory is organized in four-bit binary-coded decimal digits. If the data transmitted from a particular memory location to the display interface is one of the digits 1 through 8,



Incremental conversion. A digit received from the computer is decoded into a signal that steps a counter up or down. A digital-to-analog converter alters the deflection voltage in the oscilloscope tube to match the counter contents.

the oscilloscope's electron beam moves in one of eight directions. The digits 0 and 9 turn the beam on and off, respectively.

To display the letter T, for example, the computer must transmit a series of digits to the screen. Starting at a particular point, a series of 5's—each causing an incremental movement downward—traces the vertical bar. Then a single 9 turns off the beam. A series of 8's and 1's then locates one end of the crossbar, and 0 turns the beam on again. With the beam on, the computer transmits 3's to trace the top of the T, a 9 to blank the beam, and in this example a series of 4's to direct the beam to the beginning of the next line to be traced.

Counting up and down

To convert the digit 3 into horizontal incremental movement to the right, four bits—1, 2, not-4, and not-8, the binary-coded decimal representation of 3—are decoded in the incremental converter shown above to generate a signal called $+\Delta X$. A synchronizing signal gates the output of the decoder to add +1 to a binary counter. The counter drives a digital-to-analog converter, which is simply a series of resistors with a common connection and with values related by powers of 2. The resulting voltage is the input to the horizontal deflection amplifier, which deflects the beam to the right on the oscilloscope screen.

In the same way, the digit 7 is decoded, but this adds −1 to the binary counter. When the counter counts down, the output of the digital-to-analog converter decreases and the electron beam is deflected to the left, by a corresponding increment $-\Delta X$.

The decoder, up-down counter, and digital-to-analog converter are duplicated for the vertical axis. The digit 1 is decoded for an upward increment; a downward motion results from a digit 5 transmitted from the computer.

For diagonal motions, the digits 2, 4, 6, or 8 are decoded and both counters are stepped in the appropriate direction. The beam moves farther in a diagonal direction than in the orthogonal directions by a factor of $\sqrt{2}$, but the same amount of time is allotted for it.

To turn on the crt's electron beam, the digit 0 is decoded to set a beam control flip-flop. The decoded digit 9 resets the flip-flop and turns the beam off.

In the complete interface unit on the facing page, the buffer register temporarily stores the data from the computer during the decoding process. Although included in the design in anticipation of possible expansion of the system, this register isn't necessary in a simple incremental system.

The timing control is a clock and decoder that generate pulses to set and reset the buffer register, step the x and y binary counters up or down, and trigger a monostable multivibrator that momentarily turns off the electron beam while transients from the digital-to-analog converter decay. This blanking action lasts for about 3 microseconds—long enough to prevent the transients from degrading the display but short enough to prevent the blank time from decreasing the display's intensity.

In the Friden unit, new digits can be transmitted from the computer no oftener than once every 10 μsec, which is the duration of the 1620 computer's storage cycle. Other factors that limit the rate are the particular circuits in the interface unit and the bandwidth of the oscilloscope's deflecting amplifiers.

A synchronizing signal from the computer rises on the data-sync line to start the timing control. This signal rises after a digit has been placed on the data lines, allowing time for transients on those lines to decay at the input to the buffer register. The timing control sets the flip-flops in the register, then sends a transfer response signal back to the computer. This tells the computer that the data has been accepted and that it can therefore turn off the data-sync and digit signals. Thus the data transfer is asynchronous —the interface unit timing is independent of the computer timing.

Pause that refreshes

Although the display must be continually refreshed because of flickering, retransmission takes place from a reserved area of the computer memory. As a result, the screen can be temporarily blanked during high-priority computations without necessarily altering the data to be displayed. New data for display can be moved into the reserved area at any time regardless of whether a display is in progress.

If refreshing is to occur often enough to prevent noticeable flicker when the display is to be viewed directly, the number of points in the display is limited. The minimum refreshing rate depends on many parameters, including intensity, type of phosphor on the screen, size of screen, and ambient light level. A refreshing rate slow enough to allow some flickering may be permissible as long as the display remains legible. In most systems, the minimum is between 25 and 50 per second.

Since the 1620 can produce a new increment every 10 μsec, its maximum increment rate is 100 kilohertz. Thus, 100,000 increments must generate a complete display enough times per second to prevent flicker. If the refreshing rate is 25, the maximum number of increments permissible in a single display is 100,000/25 = 4,000.

To generate any reasonably complex graphic or alphanumeric display, the electron beam must zigzag across the screen a great deal, and the 4,000 or so increments are used up rather quickly. Therefore the full 1,024-position resolution of the display is not always useful. When that happens, the effective resolution can be decreased and the picture enlarged by manipulating the centering and deflection-gain controls. This increases the total length of the displayed line without introducing flicker. But it also decreases the resolution, makes the lines grainy, reduces spot overlapping, and can lose details of small figures.

Often, the beam can be returned quickly from the right side of the screen to the left side, or from the bottom to the top, by stepping it forward until the counter overflows. The beam then returns to the opposite side of the screen in one increment.

Figuring the flicker

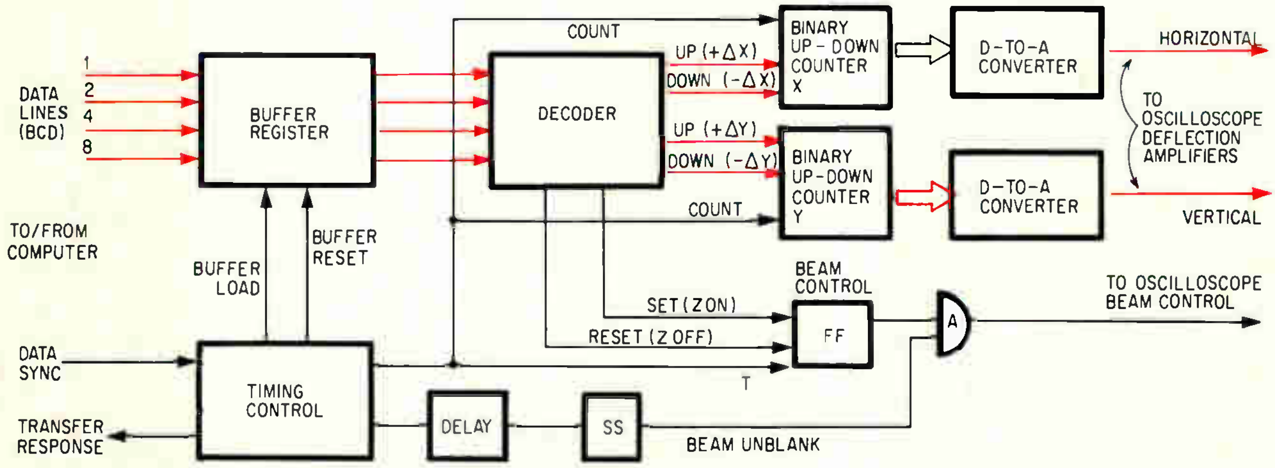
The tendency of a proposed display to flicker can be estimated in advance by determining the number of lines, N, that can be generated across the face of the display with the formula:

$$N = \frac{R}{2^{M}F}$$

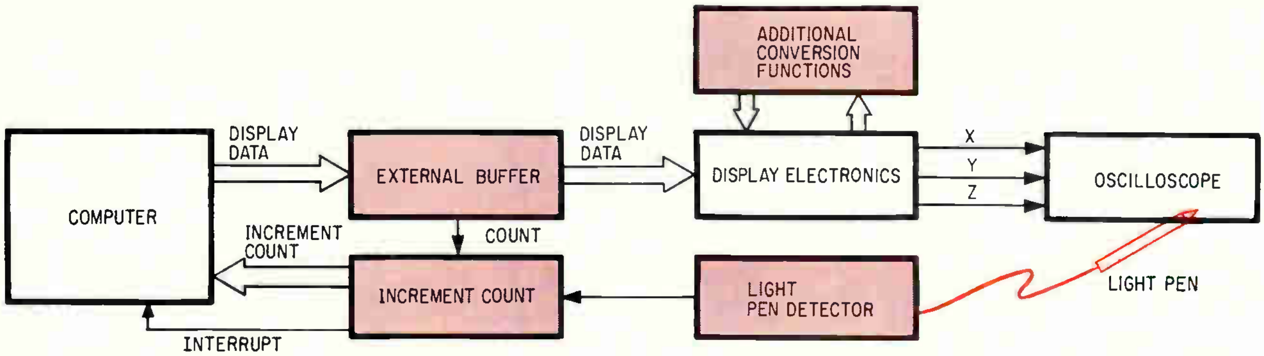
where R = increment rate, F = frame rate, and M = number of changing bits in the counter as the lines are generated. For example, if R = 100,000, F = 25, and M = 9, then 7.8 lines across the display can be generated. If the unchanging bit is the most significant or high-order bit in the counter, then the lines will occupy only one half of the unenlarged display. If the lines are centered by changing the program that generates the display, the high-order bit will change once during the tracing of each line, but the net effect is the same. The easiest way to center the display is with the oscilloscope controls.

The formula is intended to predict the amount of flicker at a particular refreshing rate, rather than to describe any specific display. In general, the 7.8 lines would consist of four lines drawn in the normal or forward direction and three lines plus in reverse, as with a retrace. The formula makes no allowance for spacing between horizontal lines or for vertical movement of the beam in any particular display.

In alphanumeric displays, the number of characters that can be presented without flicker de-



Interface. Data from the computer moves through the converter to the oscilloscope over the paths in color. The decoder converts each digit into a pulse that steps one or both counters up or down. The count is converted into a deflection voltage for the oscilloscope crt. Control signals are routed over the other paths.



Expandable display. The basic system comprises the display electronics connected directly to a computer and an oscilloscope. Other functional units (color) can be added to improve the system's performance.

pends on the maximum number of increments, rather than the available area on the screen. If the average character requires 30 increments for tracing, then with the previously assumed increment and refreshing rates, the maximum number of characters that can be displayed is 4,000/30 = 133.

Time exposure

When hard copy is desired, the operator can mount a standard oscilloscope camera and form the picture once. As long as the camera shutter remains open, the length of time required to form the picture is unimportant, and any number of points can be included in the display.

With a camera, the screen area becomes the factor that limits the number of characters. For a 3-inch square display area and a 0.02-inch spot, the number of resolvable elements (tangent non-overlapping spots) is $(3/0.02)^2 = 22{,}500$. If a single character, including the space between it and adjacent characters, occupies an 11-by-11-element square, the maximum number of characters that can be displayed is 22,500/121 = 186. (A 3-inch square on a page of Electronics contains about 1,000 characters.)

Improving the capabilities

The basic incremental display built at Friden could be, and quite possibly will be, expanded by adding such features as an external buffer memory, a light pen, and special conversion functions. These all add to the cost of the system but also improve its capability.

An external buffer memory enables the computer to transfer display data once and then continue on with other computations. Thus, refreshing of a single display is possible from the buffer memory and the computer need not be overloaded. The most flexible form of such a buffer would be a random-access core memory, which would allow the greatest number and most sophisticated display functions. A magnetostrictive delay line or other serial memory is considerably cheaper, but its applications are limited.

With a light pen added to the system, the operator can flag any part of the displayed data. The flag can interrupt the computer program, which takes any appropriate action depending on the part of the display indicated and on any other signals received concurrently. The light pen merely generates a pulse when the spot traverses that part of the screen directly under it. In an incremental system, this is most useful to the computer when combined with the increment count or the contents of the two 10-bit counters. And a light pen is more likely to be feasible if the display system has a buffer memory, and perhaps also has enough logic ability to execute a few simple functions without involving the computer.

Special conversion functions can be added to the basic interface unit to move the beam more than one step at a time. These can reduce the time to move the beam when it is off, therefore displaying more data per frame. Sixteen different combinations of signals are available on the four BCD lines. Ten of these are already committed for the eight directions on the screen and the beam on-off signal, leaving six to implement the special conversion functions. Additional control signals would require the addition of more lines to the computer.

Bibliography

D.R. Haring, "The beam pen: a novel high-speed, input-output device for cathode-ray tube display systems," Proceedings, Fall Joint Computer Conference; American Federation of Information Processing Societies, volume 27, 1965, p. 847.

R.E. Turnage Jr., "The perception of flicker in cathode-ray tube displays," Information Display, May/June 1966, p. 38.

Carl Machover, "Family of computer-controlled crt graphic displays," Information Display, July/August 1966, p. 43.

N.A. Ball, H.Q. Foster, W.H. Long, I.E. Sutherland, R.L. Wigington, "A shared-memory computer-display system," IEEE Transactions on Electronic Computers, October 1966, p. 751.

The author

Jerry L. Shumway directs the design of special computer peripheral equipment at Friden Inc.'s research center.

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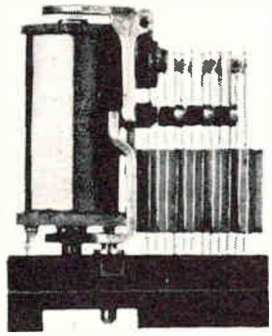

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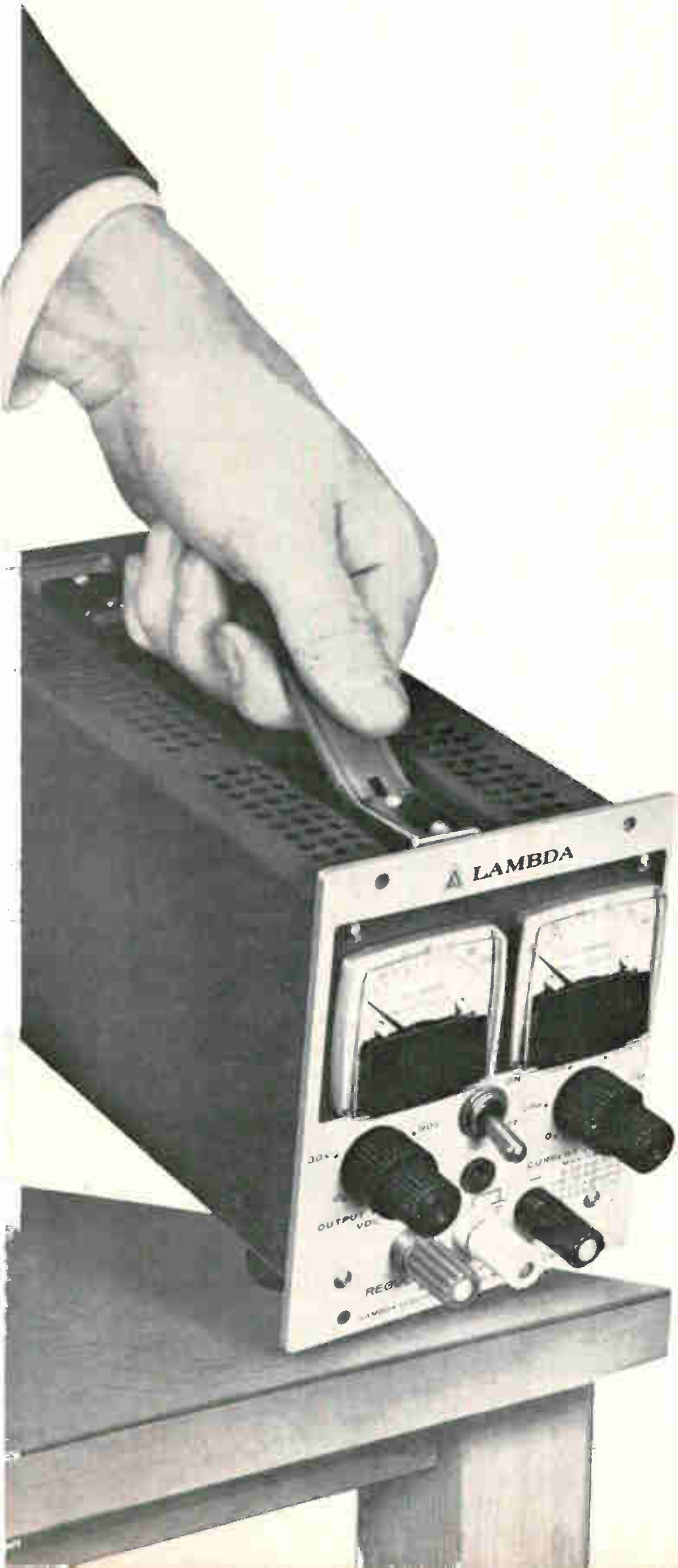

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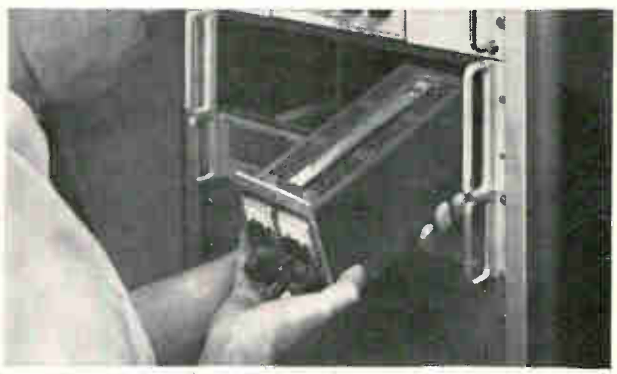

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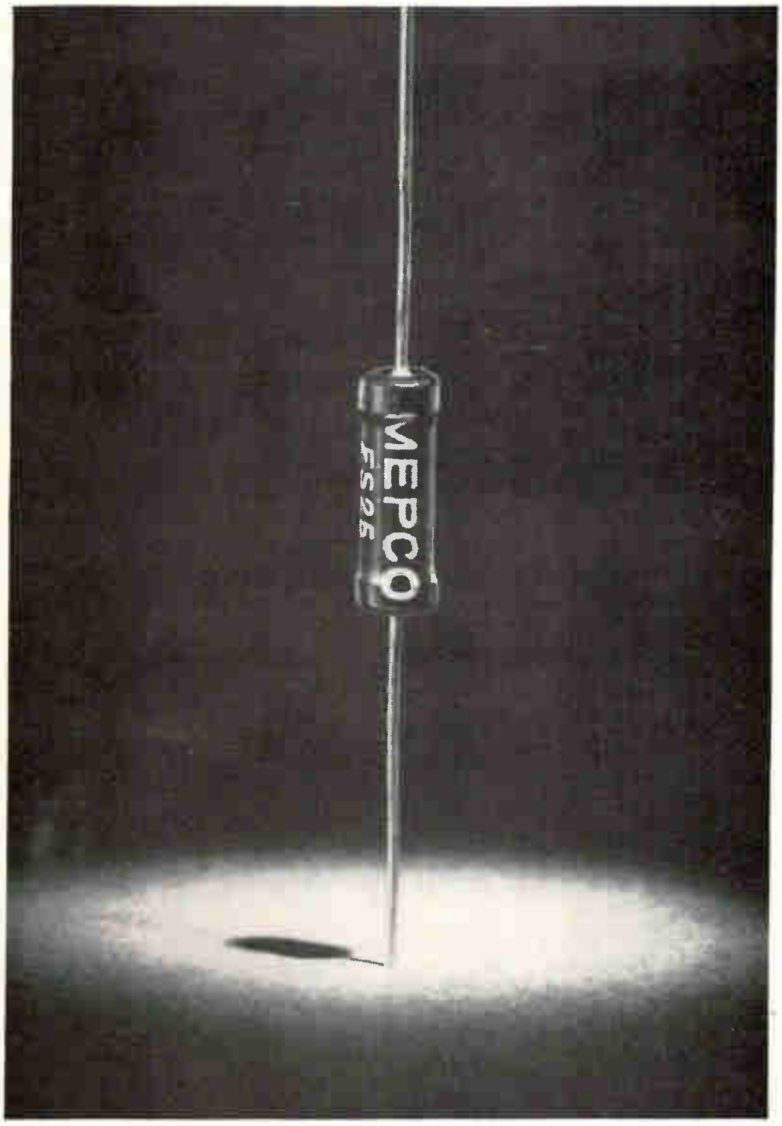

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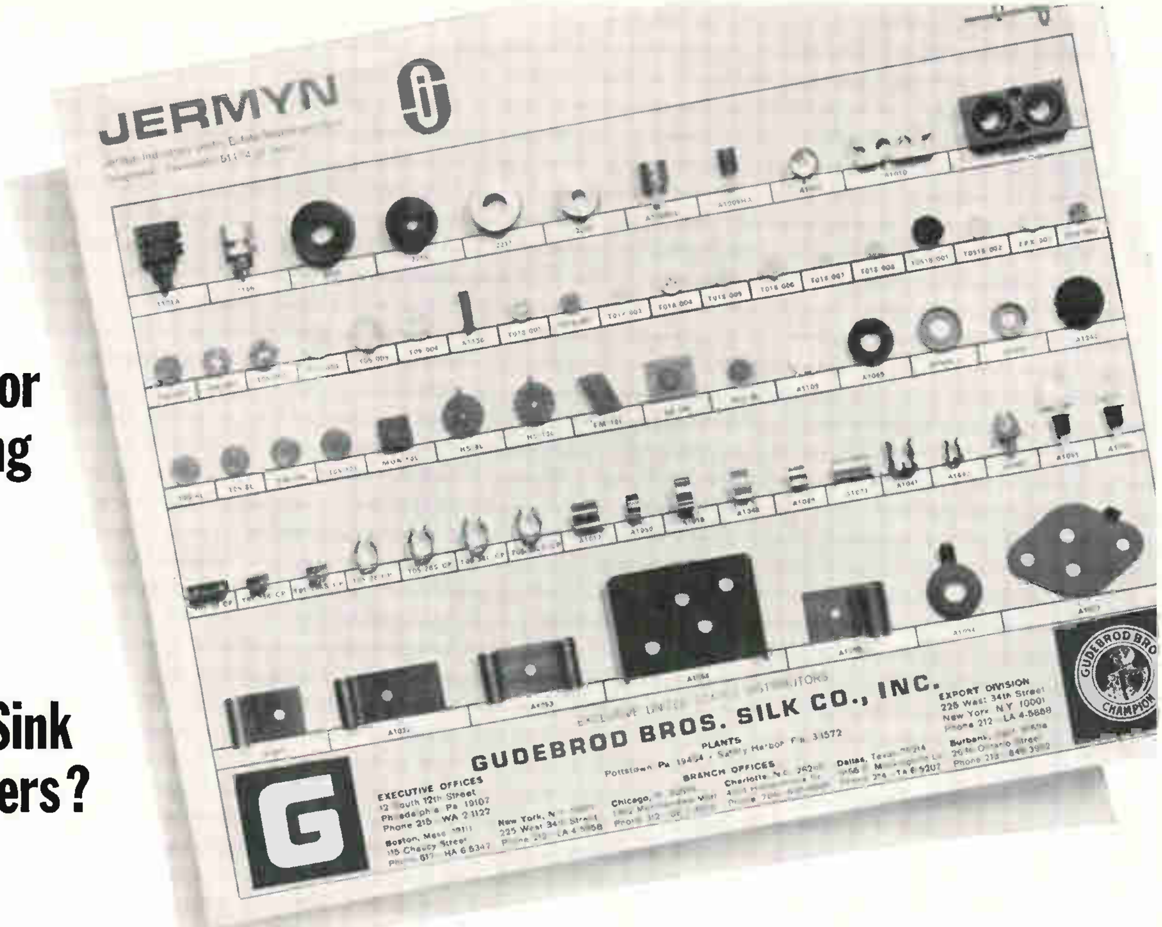

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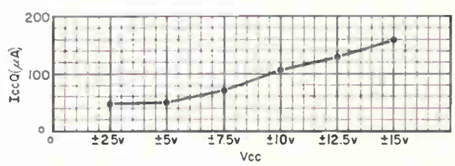

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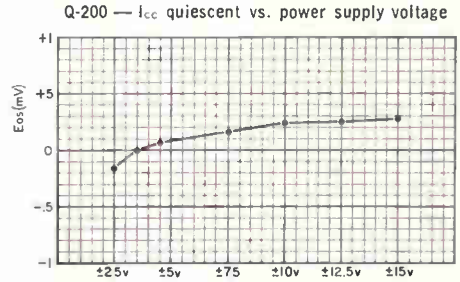

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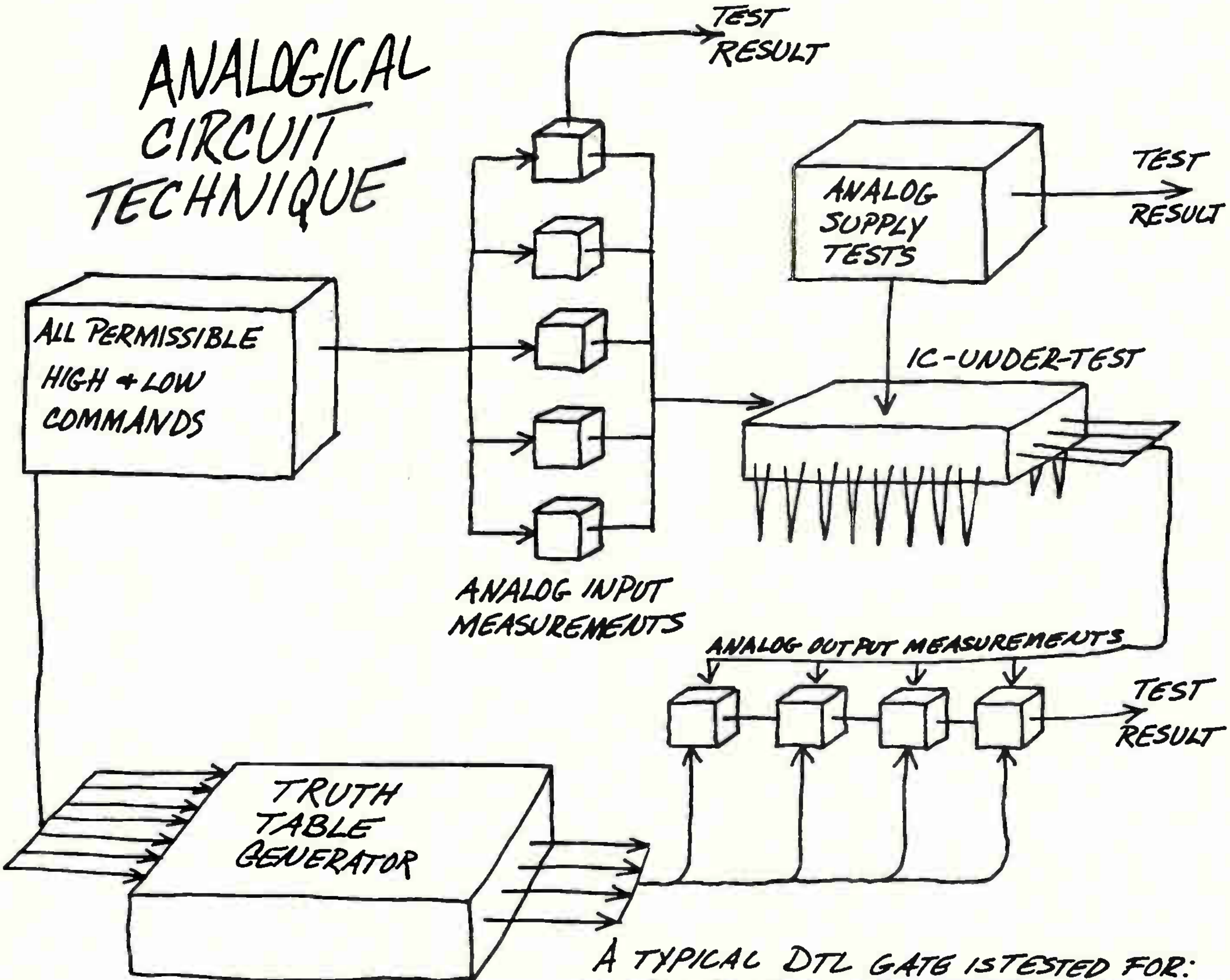

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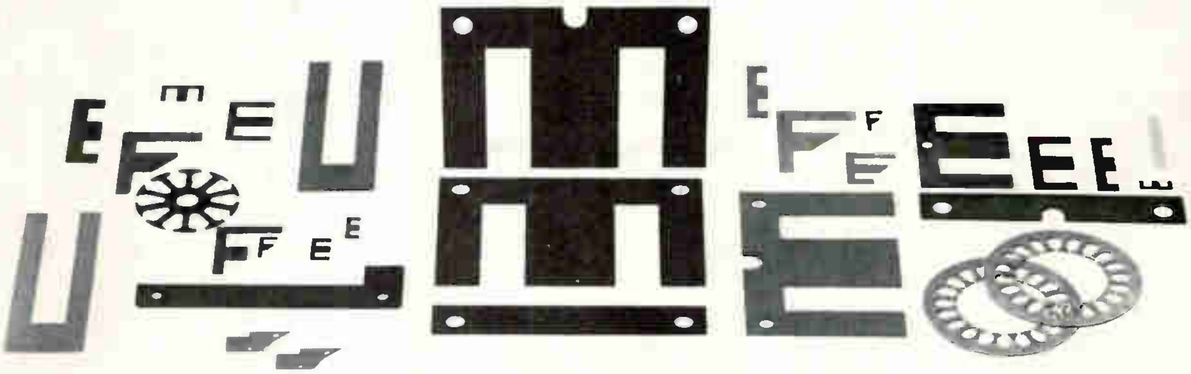

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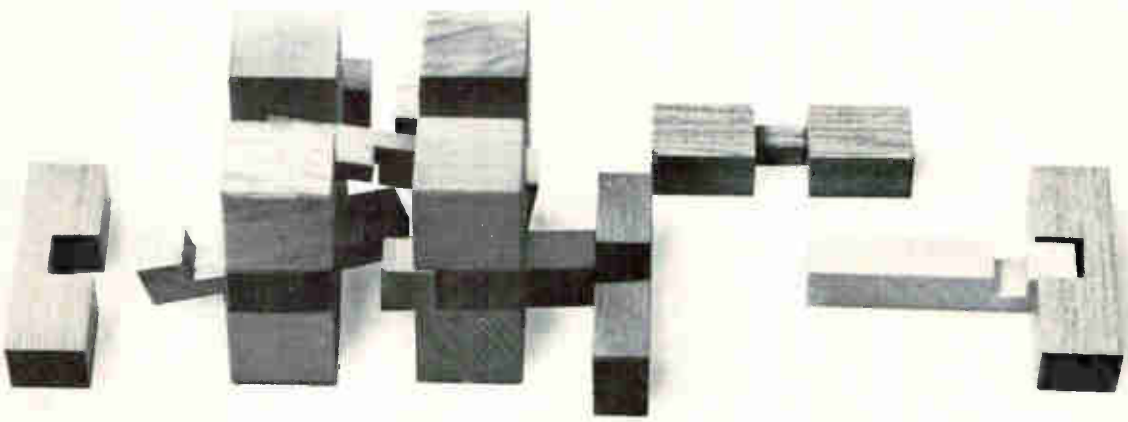

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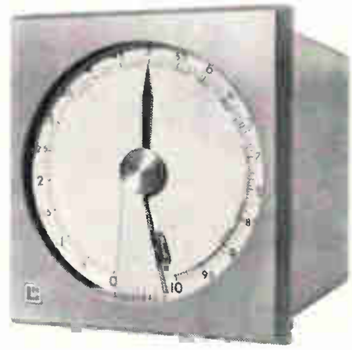

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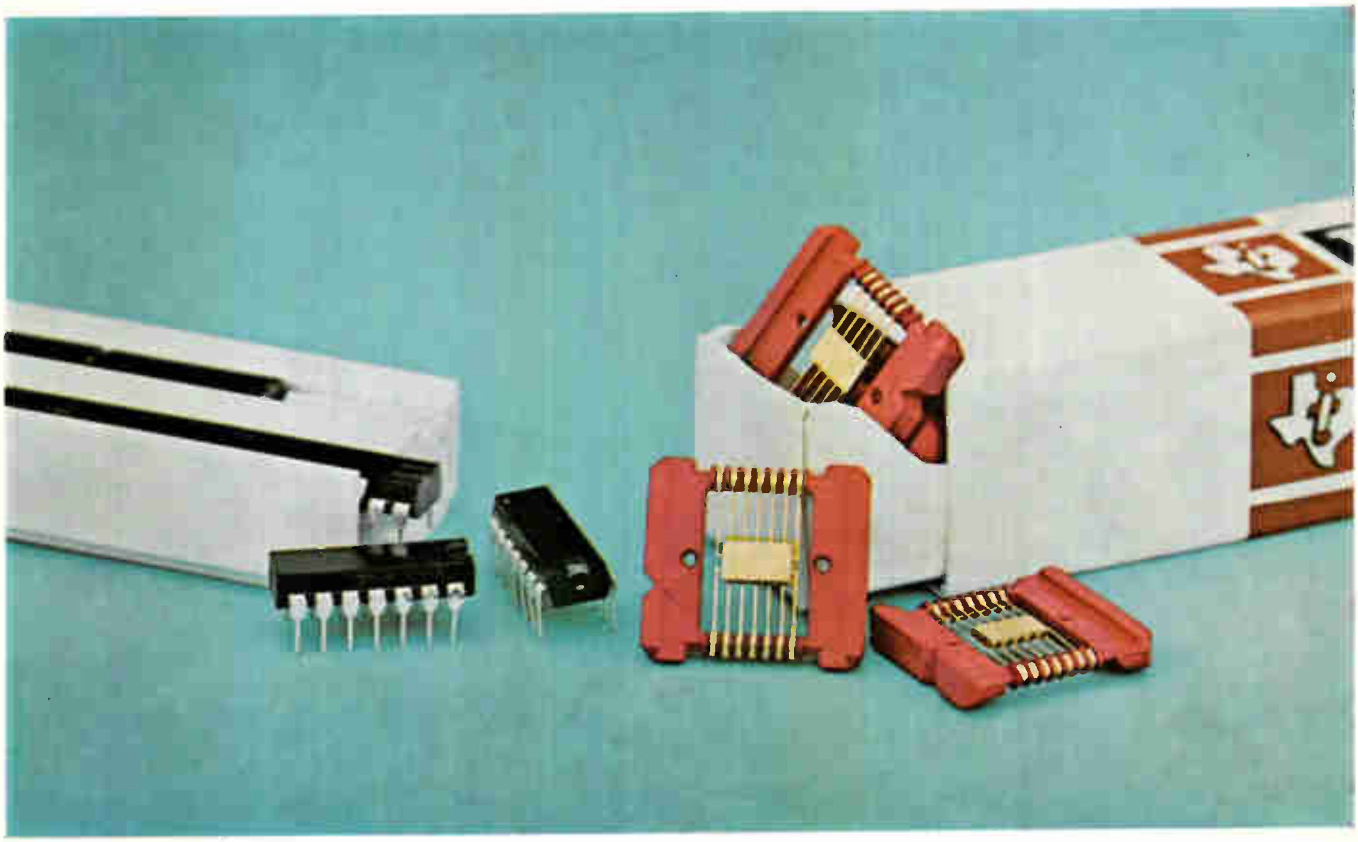

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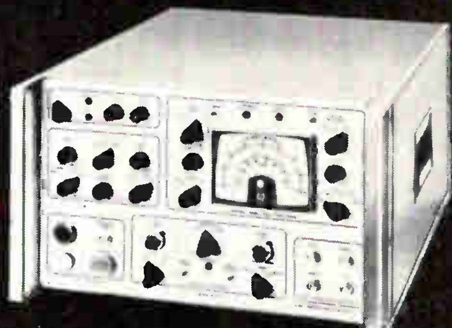

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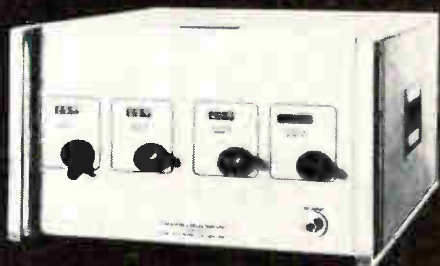

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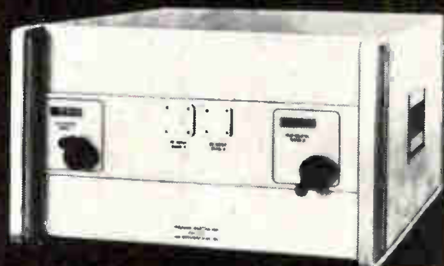

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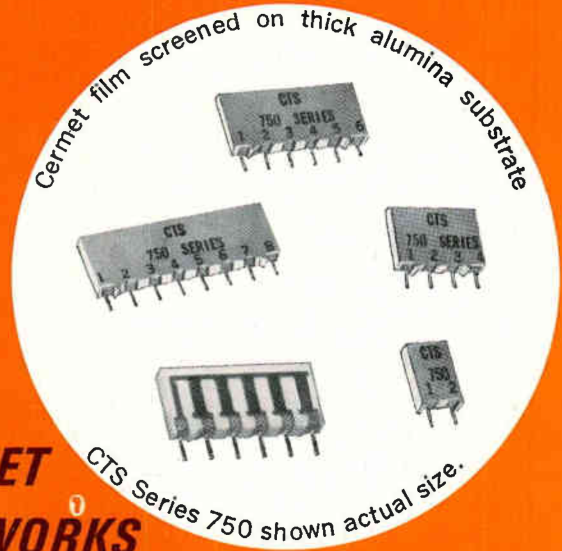

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Probing the News

Space electronics

Apollo 4's time of trial

Upcoming shot is crucial in the U.S. effort to put men on the moon before 1970; program's electronic design, largely unchanged by the capsule fire, still has problems

When the giant Saturn 5 rocket blasts off from Cape Kennedy for the first time—hopefully next month —NASA will be looking to regain momentum for its fire-stalled program to land men on the moon and bring them back by 1970. Increasingly, however, top space agency officials are doubtful about meeting the deadline.

Saturn 5 will carry an unmanned Apollo spacecraft; the first manned flight, originally slated for last February, is not expected to get off the ground before mid-1968 at the earliest. The fire that killed three astronauts last January has not affected the electronic design of the lunar craft, but it has impaired confidence in the over-all program. Even though the electronics design is five years old, this portion of the project continues to be plagued by a succession of petty problems.

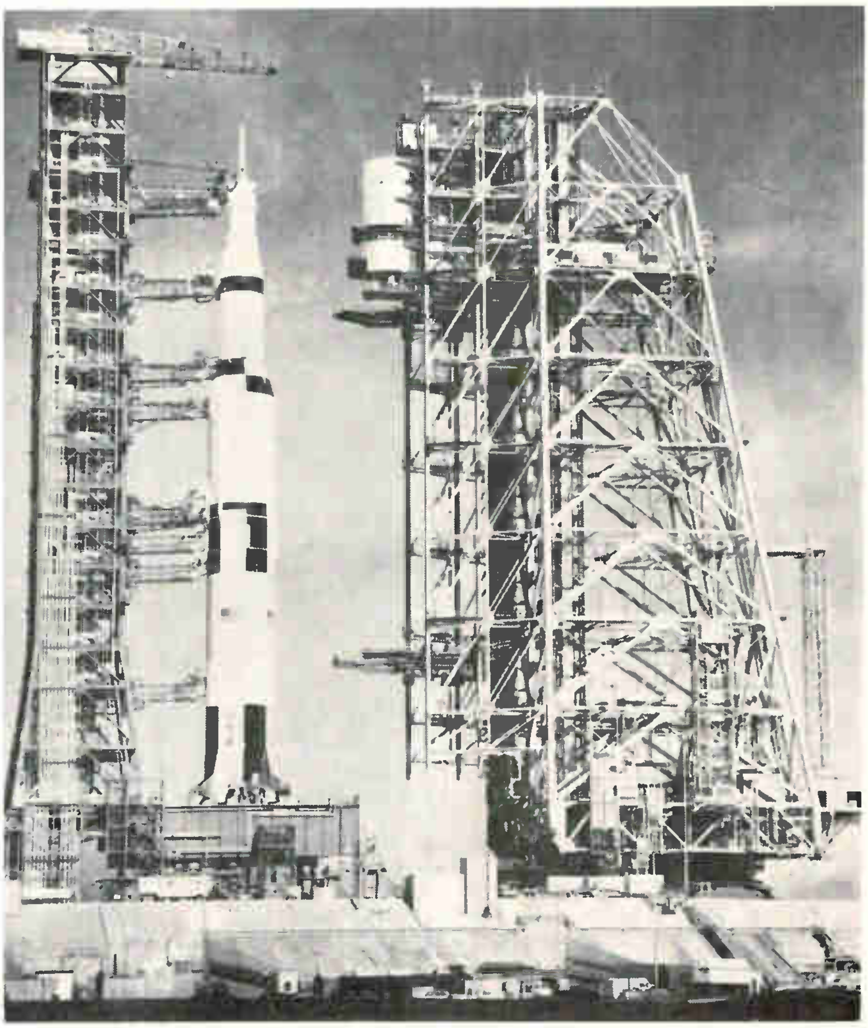
There are also a number of big problems: late last month, North American Rockwell Corp., the prime contractor for Apollo spacecraft, announced it had replaced its assistant program manager for the first manned spacecraft and its assistant director of Apollo test and operations. The company says such personnel changes are not unusual for an organization of its size.

Trio. In the upcoming flight, designated Apollo 4, the three-stage Saturn 5 launch vehicle will carry command and service modules for earth-orbit missions as well as a dummy of the lunar module.

Principal mission of the Apollo 4 is to see whether the 364-foot-high Saturn 5—the only U.S. system capable of putting men on the moon—will work in flight. The National Aeronautics and Space Administration hopes to separate the vehicle's three stages not only to demonstrate that the systems can operate under space-flight conditions but also to check out ground-support facilities.

I. Keeping in touch

High on the list of Apollo 4 priorities are comprehensive space tests of the new unified S-band communications system. The manned space flight network will transmit both S-band tracking and telemetry commands. In addition, the omnidirectional antenna, flush-mounted on the command module that will be used on the flight to the moon, is due to be checked. Apollo 4 will not carry the S-band high-gain antenna, mounted on the service



Towering achievement. The 364-foot-high Saturn 5 is set to boost unmanned Apollo 4 into an earth orbit next month; objective is a lunar landing by 1970.

. . . two communications blackouts are anticipated during reentry . . .

module set for manned flights, because it is not needed for earth-orbit missions.

Earth calling. Voice signals will be transmitted from ground stations via the S-band system and recorded in the spacecraft. Analog signals, simulating biomedical data from a manned spacecraft, will also be sent during the mission.

A C-band command and tracking system, used in earlier Apollo and Gemini space flights, will also be aboard the Block 1 earth-orbiting Apollo 4. However, this system will be phased out of Block 2 lunar mission manned capsules which will rely on S-band gear.

Communications subsystems aboard the command and service modules will be tested, using very-high-frequency omnidirectional antennas. Voice commands will be simulated by transmitting a 400-hertz signal that will be recorded on the spacecraft for subsequent evaluation. The modules will also carry 27 ultrahigh-frequency telemetry links for relaying commands and updating the computer.

Itinerary. Saturn 5's first stage will push Apollo 4 to an altitude of about 46 miles. After separation, the second-stage rocket will fire, propelling the bird 115 miles above the earth. The third stage will accelerate Apollo 4 into an elliptical orbit with a 10,350-mile apogee.

The rocket in the service module will simulate an attempt to reach the moon by pushing the craft from its earth orbit to a distance of 11,400 miles from earth. At this point, Apollo 4 will head back, propelled by a second burn of the service-module engine, reentering the atmosphere at close to 25,000 miles an hour—about equal to the reentry velocity of a manned craft returning from the moon. Elapsed time of the mission will be approximately nine hours.

Quiet time. Engineers expect two communications blackouts during Apollo's reentry. While a great deal of work has been done in this area, NASA officials have now concluded they can live with the problem. "At this point, the astronaut is on his own," says one. "We can afford to wait a few minutes to learn if he's alive or dead." The first communications cutoff will occur when the spacecraft enters the atmosphere at about 400,000 feet. S-band communications will be lost; a few

Sister ship. Tracking vessel, Redstone, is similar to the Vanguard which will be part of the space flight network for the Apollo 4 shot.

The numbers game

The numbering system for NASA's missions, launch vehicles, and spacecraft is confusingly complicated. Although the upcoming shot is designated Apollo 4, there was no 1, 2, or 3. The first three shots of the Apollo program, completed during 1966, were AS 201, AS 203, and AS 202, in that order. The AS designation referred to Apollo-Saturn I while the numbers called out the Apollo vehicles in the order they were built. The launch vehicle was the two-stage, uprated Saturn I. The spacecraft destroyed by fire in January was the AS 204. In an attempt at clarity, NASA has switched to a numbering system similar to that used for the Gemini flights.

seconds later, C band will follow. The blackout should last about two and one-half minutes as the spacecraft hurtles down to below 300,000 feet. Communications should then be restored for about three minutes, when the spacecraft lifts up in its skip reentry and cools a little.

The second blackout, occurring from about 220,000 feet down to 100,000 feet, will last about a minute and a half. The plan, tried on one of the Gemini flights, to overcome the blackout by squirting water into the plasma stream in front of the spacecraft, has been abandoned for Apollo missions. The water added too much weight.

II. Check points

Of the 14 stations in the worldwide manned space flight network, 12 will be used for the Apollo 4 mission. New unified S-band installations with 30-foot diameter tracking antennas are on Merritt Island near the launch complex at Cape Kennedy. Similar facilities are on Antigua, Grand Bahama and Ascension Islands in the Caribbean, as well as on Guam in the Pacific. New 85-foot diameter dishes for deep space use are at Goldstone, Calif.; Madrid, Spain; and Canberra, Australia. There are also upgraded stations used during the Gemini shots in Bermuda; the Canary Islands; Canarvon, Australia; Guaymas, Mexico; Kawaii, Hawaii; and Corpus Christi, Tex.

After launch, Merritt Island will track Apollo for about five minutes,

Uncertain schedule

After Apollo 4 there will be at least two more unmanned Apollo flights. Apollo 5 will test the lunar module to verify the ascent and descent control systems. It will be placed in earth orbit by an uprated Saturn I, in December at the earliest.

Apollo 6 will be the second flight test of the Saturn 5, putting an instrumented lunar module dummy and an unmanned command and service module in earth orbit. The mission will test the new command module escape hatch. If all goes well, the manned flights will begin with Apollo 7, which will be lifted into orbit by an uprated Saturn 1. The 10-day mission will evaluate crew and craft performance during a long flight. This was the job assigned to the ill-fated spacecraft that burned on the ground last January. Problems will probably hold this flight back until at least mid-1968.

Apollo 8 will be the first manned flight carrying the lunar module. It will be launched by Saturn 5 only if the unmanned Saturn 5 flights are letter-perfect. If either malfunctions, Apollo 8 will be unmanned.

If all goes well, Apollo 9 might head for the moon.

or halfway to Bermuda. The Bermuda station will keep track for about three more minutes. The tracking ship Vanguard, positioned between Bermuda and the Canary Islands, will follow the craft into orbit. The Vanguard will be the only one of five new instrumentation ships for the space flight network ready for Apollo 4.

For drill. Two of the eight new Apollo Range Instrumented Aircraft—electronics-laden C-135's—will also be ready for Apollo 4. The planes fly out of Marcus Island in the Pacific and will patrol the reentry track. Their mission will be strictly a performance evaulation to locate the Apollo with nose-mounted radar and to store data transmitted from the spacecraft. The tapes will be sent to the Manned Spacecraft Center in Houston, Tex., for evaluation. Two or more of the planes will be ready when the next unmanned space shot, Apollo 5, goes up later this year; all eight are supposed to be on hand for the first manned Apollo when they'll retransmit data and voice via uhf to ground stations.

III. Jots and tittles

The Apollo fire left no fundamental problems for electronics manufacturers. "I can't think of anything in electronics or in electronic design that is a problem now," says Lee B. James, deputy director of the Apollo program for NASA. "Instead, we're stuck with some pretty mundane problems like soldering and welding."

The soldering headache was most apparent in the attitude and translation control assembly on the lunar module. This assembly, built by the Radio Corp. of America's Aerospace Systems division, Burlington, Mass., developed hairline cracks in certain solder joints when subjected to the thermal cycling needed for applying and curing the urethane protective coating.

No electrical failure was involved, says an RCA spokesman. The cracks were discovered during visual inspection following quality testing. Stresses causing the cracks occurred in a connection between some of the cordwood modules and their motherboard, the RCA spokesman says. The cracks were eliminated by modifying the soldering procedures and using a more ductile solder with a higher ratio of lead to tin. Solder cracks were also reported in the flight control computer on the instrument unit for one of the Saturn 5 boosters.

Bulk effect. But James says he is having problems with production items that are not as good as the prototypes. And some of the systems are overweight, particularly the rendezvous radar for the lunar module, says another space agency official.

"The problem is that we went from breadboard to hardware without prototypes on the radar," he says. "And we have lost something in controlling the weight. I imagine we'll have to end up slacking off on some of the specifications in order to get the weight down."

James feels that electronics has contributed to weight problems because new packaging techniques have not been developed. For example, potting compounds and electric connectors have not been reduced in weight. He also says that electrical connectors have been failing in tests. Typically, failures are due to bent or recessed pins, bad potting, and poor welds [Electronics, Oct. 3, p. 64]. Teflon, used to cover electrical wires as a safety precaution after the fire, is also causing a problem. According to James, this material scars and breaks easily. The space agency is now trying to give Teflon better handling characteristics.

James is also concerned with the potential problems of communicating and tracking at lunar distances. However, these are difficulties which will emerge and be worked out only in actual flight.

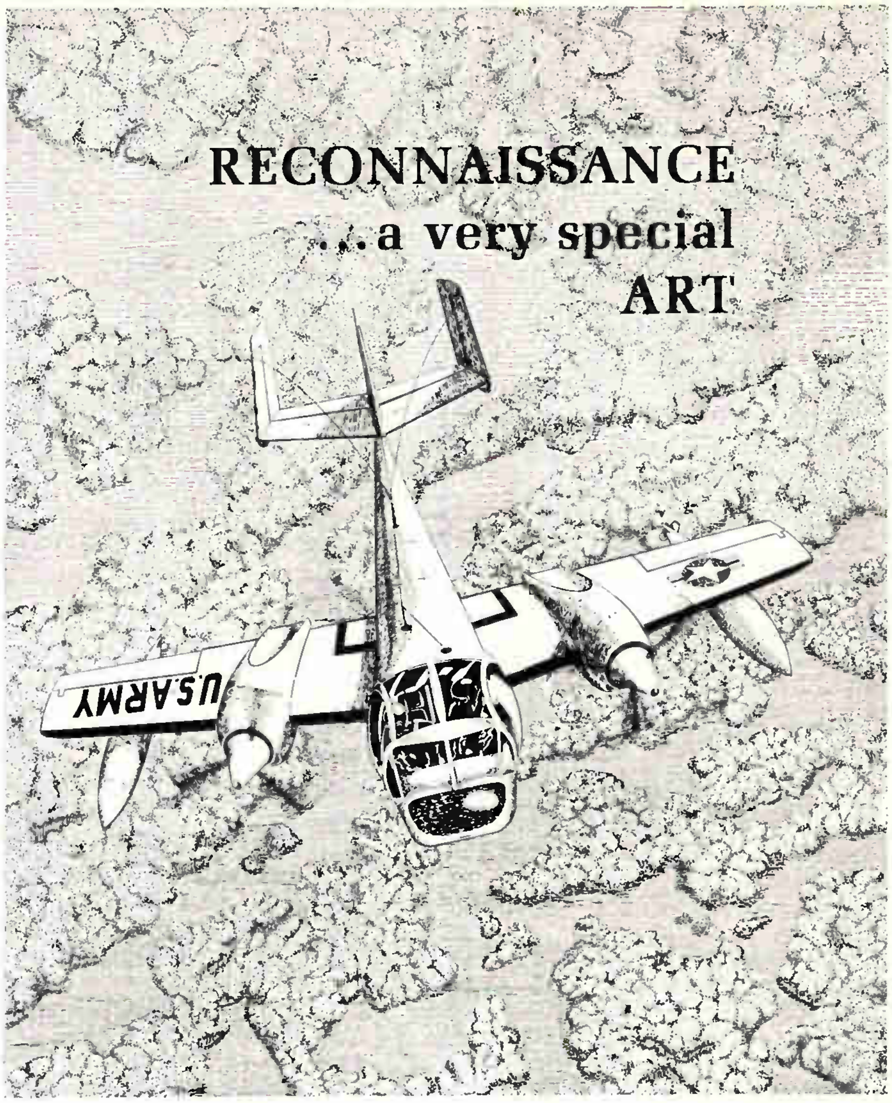
IV. Marking time

Meanwhile, half a world away the Russians are encountering problems of their own. Since the dawn of the space age, every anniversary of the 1917 revolution brings speculation that the Soviets are planning a commemorative space spectacular. Foreign diplomats in Moscow feel there will be some sort of splash again this fall because Nov. 7 marks the 50th year of Communist rule.

However, informed U. S. sources tend to doubt the Soviets have any manned flights scheduled for 1967. They are still making changes in the design of the Soyuz spacecraft, the one in which Soviet cosmonaut Komarov was killed, according to Edward S. Welsh, executive secretary of the President's National Space Council. Welsh feels the Soviets are not planning any manned missions until next year.

The tip-off to a manned flight, says Welsh, will be a Soyuz flight which will be either unmanned or will use an animal. He feels the Soviets would not send up an improved craft without testing it first. He predicts: "Next year the U. S. and the USSR will have manned flights, and both will be earth-orbit missions."

Contributions to this report were made by: Lawrence Curran, June Ranill, and Darrell Maddox in Los Angeles; Sue Butler at Cape Kennedy; Robert E. Lee in Houston; William Arnold in San Francisco; Paul Dickson in Washington; Howard Rausch in Moscow; and Alfred Rosenblatt in New York.



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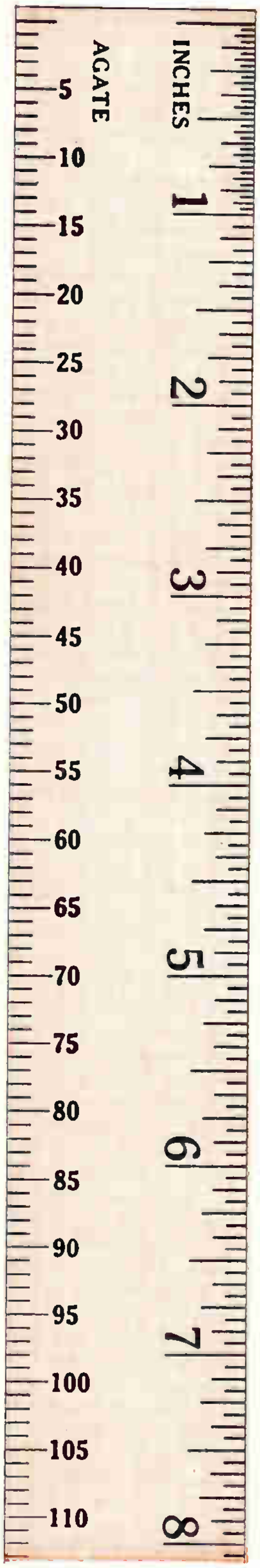

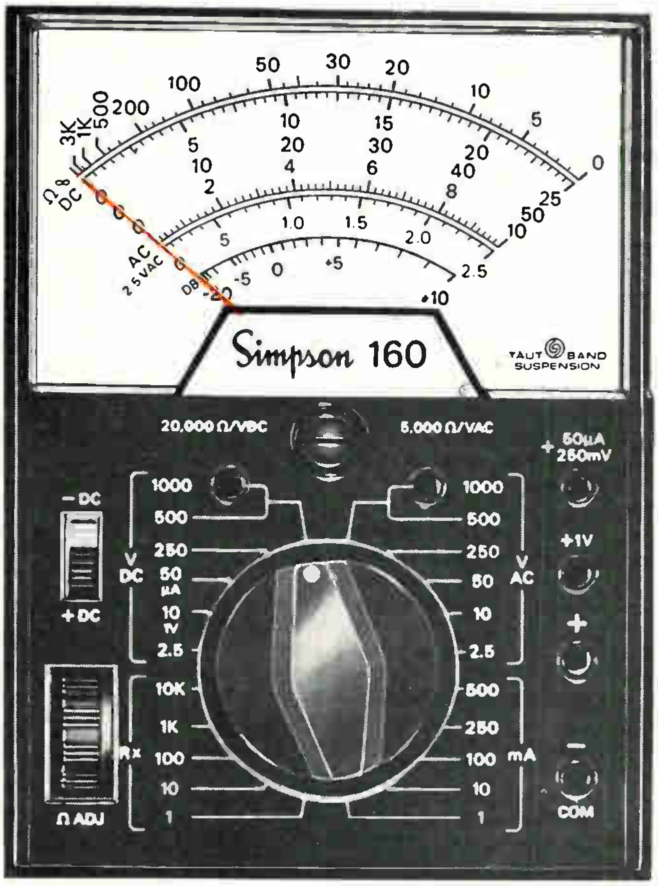

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WORLD'S LARGEST MANUFACTURER OF ELECTRONIC TEST EQUIPMENT

Long-term R&D goes on short rations

Emphasis on immediately practical hardware for Vietnam is slowing the flow of Pentagon funds to advanced military and civilian projects

By Paul A. Dickson
Washington regional editor

An increasing number of advanced research projects with a high electronics content are being deferred or stretched out as a result of the Vietnam war. The stepped-up involvement of the U.S. in Southeast Asia has put a severe strain on the Federal budget, and funds are being channeled away from long-range programs—both civilian and military—and into conventional weaponry and support gear.

At the moment, the Pentagon's line is that the siphoning off of long-term R&D funds presents no particularly pressing problems for the present or the future. Suspicion is growing, however, that lasting dislocations, particularly in the electronics sphere, may result if some sort of balance is not restored.

Defense officials can point out that there's plenty of research money around for advanced hardware, but the fact is that these funds are going for equipment that is almost immediately useful in limited warfare. For example, contractors promising production designs within two years for electronic countermeasure and night-fighting equipment can just about write their own tickets with Armed Forces procurement people, but their industry fellows working in such related fields as light-sensitive materials are getting short shrift.

I. Treadmill to oblivion

Defense officials as well as interested observers are in general agreement on three major points:

- While long-range R&D projects are not, for the most part, losing ground, neither are they gaining any. Most are simply not expanding at the rates the services intended or industry expected. The word "defer" is in vogue to describe what's happening to fiscal 1968 spending as well as what will happen in the fiscal 1969 requests now being framed. "From a dollars-and-cents standpoint, most programs are not being cut back," says a Pentagon official. "But quite a few that many people expected to expand won't grow for a while."
- Among the programs feeling the deferral pinch are long-range air-defense systems, long-distance communications projects, and tactical data-processing equipment.
- The R&D projects which are 18 to 24 months from fruition are getting immediate and generous support from the military. However, "stated requirement"—Pentagonese for "can we use it right away in Vietnam?" is the operative consideration in such cases.

II. Arrested development

In 1964, the Defense Department provided funds to develop a three-dimensional radar system that could be used by all the services. For the past three years, however, this project has languished in the status of advanced development objectives (ADO)—a phase in which engineers develop the required technology and test it against the military's specifications. For lack of available funds to move it out of the ADO category, the tri-service

Smaller slice of bigger pie

Government agencies, industrial firms, and universities—which do about 33%, 57%, and 10%, respectively, of the nation's research and development work—have all felt the effects of the slowdown in the funding of long-range programs. During the calendar 1958-1965 period, Federal and private expenditures for R&D in the U.S. grew at an average annual rate of 9.5%. Last year, however, when outlays hit $22.4 billion, according to the National Science Foundation, marked the beginning of a deceleration in the rate of yearly gain. The foundation estimates R&D spending this year at $24 billion, and puts the 1968 total at $25 billion—a less than 7% average annual growth rate over the three-year span. As a rule of thumb, the Government picks up about two-thirds of the national tab for research, so it isn't overly difficult to detect where the slowdown originates.

Furthermore, the proportion of R&D funds allocated for defense purposes—defined as those supported by the Pentagon and certain programs of the Atomic Energy Commission—averaged about 50% of total annual R&D expenditures during the 1953-1961 period. Subsequently, however, defense outlays plummeted rapidly, accounting for just slightly more than 30% of the total during the past three years.

Part of the Pentagon's declining importance in the R&D scheme of things is attributable to the vast sums now appropriated for space and medical programs. Then, too, there is a larger pie to slice. But the fact remains that in absolute terms, spending has made little headway in recent years—indeed in the last decade.

Last year, Federal spending for R&D totaled $17.1 billion, with an estimated $7.5 billion coming from the Defense Department. These levels are expected to be about unchanged during 1967: $16.6 billion and $7.4 billion, respectively. The comparable figures for 1955—two years after the Korean truce and two years before the advent of the space age—were $15.7 billion and $6.8 billion.

3-D radar remains on dead center.

Similarly, a new shipboard radar development project has been consigned to limbo because the Pentagon lacks R&D money to keep the program going. And the Navy's long-heralded ASMS, an advanced surface-to-air missile system, is still stuck in precontract definition work —ostensibly awaiting determination of its commonality with the Army's SAM-D antiaircraft missile.

Delay lines. A West Coast source believes that the development of new reentry vehicles for the Pershing missile system may be delayed because of financial exigencies. Likewise, the long-planned Advanced Defense Communications Satellite Program (ADCSP) is being delayed as a result of war expenditures. Chances are, say some observers, that the Initial Defense Communications Satellite Program, now providing long-haul service between the U.S. and Southeast Asia, may be upgraded to fully operational status. But these observers are increasingly concerned about the time it's taking to decide whether or not to fund ADCSP.

A probable dropout is Program 120A, a scheme for an advanced intercontinental ballistic missile. A go or no-go decision on this project is expected within six months. Observers stress that the program's fate will depend to a large extent on the course of the war.

Military men are taking a harder look at some of technology's more futuristic recommendations. As a result, funds are in short supply for long-term programs to harness lasers and millimeter waves.

Civilian casualties. Targets aren't limited to the military. The National Institutes of Health, the National Aeronautics and Space Administration, and the National Science Foundation are all experiencing difficulty in securing as much money as they would like.

An economy-minded but defense-conscious Congress has been whacking away at NASA's new programs. Among the victims of the pruning are Voyager, the Apollo Applications Program, and Mariner. Similarly, the NSF, on its own, pared a $130-million package of six proposed radio and radar astronomy programs to a pair of projects costing $18 million.

Sense of balance. Most Pentagon

officials are inclined to pooh-pooh the contention that the piper must eventually be paid as a result of R&D fund diversions. "We'll probably come out about even. Some areas of technology are being pushed ahead rapidly, while others are falling behind," says Ernest C. Wood, assistant to the assistant director for communications and electronics in the Office of the Director of Defense Research and Engineering.

Others are not so sanguine about the long-term efficacy of this approach. "The impact is being absorbed by the smaller projects funded for less than $1 million," says an executive of an East Coast military supplier. "The state of the art is being affected by current decisions." This source cites Fort Monmouth's recent award of a contract to ITT Gilfillan Inc., a division of the International Telephone & Telegraph Corp., to develop a conventional mechanical-scan radar for a countermortar system; the Emerson Electric Co.'s proposal of a phased-array unit was bypassed. "This is a prime example of a case where current needs made it impossible for the military to take a chance on state-of-the-art advancements," he says.

"Because of the DDR&E's insistence that projects have a stated requirement, there is an adverse impact on the long-range work being done at such places as the Army's Rome Air Development Center and the Air Force's Hanscom Field and Wright-Patterson base," says a knowledgeable industrial observer. "The 3-D radar will never be ready by the 1973 target date and will probably have to be thoroughly restudied before it can be built because of the current lag. And the Navy's ASMS has been taking a three-year shellacking."

III. Overhaul

Clearly, it's difficult, if not impossible, to secure funds for long-range projects not tied to existing systems. But equipment shortcomings revealed by combat have stimulated interim development work. For example, the success of North Vietnamese surface-to-air missile batteries against U.S. aircraft has shown that present electronic counter-measures gear isn't as effective as it was supposed to be. As a result, large sums are being expended to develop better systems and even improve such components as broad-band power tubes and microwave tubes. Night-vision apparatus is another area in which contractors have access to funds—always provided they can promise deliveries within two years. Deficiencies in avionics, some a decade or more old, have been underscored in combat engagements; massive doses of R&D funds are being applied in the search for correctives.

"A lot of new programs aren't going to start," says DDR&E's Wood. "Exploratory efforts have been slowed down in many areas so we can support near-term needs."

Army way. "In terms of dollars, not much is being affected, but the impact of not expanding R&D is quite evident," says Howard P. Gates Jr., assistant for electronics to the Assistant Secretary of the Army for research and development. Gates notes that funds for long-range tactical air defense systems are in short supply; the AN/TSQ-73, for one, is feeling the pinch.

Long-range tactical communications programs like Mallard [Electronics, May 15, p. 153] and RADA, for random access discrete address, are being stretched out. "The Army is fighting to maintain these systems, but they will undoubtedly suffer from less funding," says Gates. "The cutbacks won't hurt them ultimately, but it'll be a fight to get operational by 1975 as originally planned."

Stepping on the tail. Also affected by the emphasis on economy are the three elements of ADSAF, (automatic data system within the army in the field)—a tactical artillery fire control system, a tactical intelligence operations system, and a combat service support system for administrative and logistical operations. Gates says the Army is battling harder to prevent a slowdown in this area than it is in other projects. He is resigned, however, to some slippage since all three projects are long-range.

IV. Priorities

New instrumentation that would test missile developments at the

White Sands Missile Range is also a deferred item, as are long-distance night-vision projects. Photo interpretation and processing will feel the current pinch for a long time; existing equipment and techniques will have to serve for at least another five years and perhaps 10. But night-vision work related to jungle warfare and base defense against infiltration is going full blast with plenty of R&D money being stoked in.

Vice Adm. H.C. Mason, vice commander of the Navy's Electronics Systems Command, feels his service has suffered less from staitened finances than others. However, he concedes that a tri-service radar, some communications programs, and ASMS have been deferred. Polaris submarine communications programs haven't been hampered, though, he says.

Another tack. A spokesman at the Air Force's Office of the Director of Development says: "Deferrals and the fact that we're not getting the funds we want cannot be blamed totally on the war." In some cases it is a matter of technology he explains, citing the case of the 3-D tri-service radar. This program, managed by the Air Force, is "difficult to administer since the services are having a hard time getting together on specifications," he says.

Awacs, for airborne warning and control system, is another Air Force program that was moving cautiously because of both technical and budgetary considerations. However, the decision to deploy a "thin" Nike-X system has restored it to fiscal favor [Electronics, Oct. 2, p. 63]. But certain air-defense projects are being postponed for lack of funds, as is work on voice-to-digital data communications systems.

Donald M. MacArthur, deputy director in charge of research and technology at DDR&E, administers projects that are seven to 20 years from fruition. "The war has underscored deficiencies in certain fields, and we're recognizing long-range areas that we must pursue," he says. However, MacArthur notes "less effort is [being expended] on research and technology now because the amounts of money we're getting are remaining constant. Due to such factors as inflation, this amounts to a slippage for us."

Post Office cancels old ways

Officials seek aid of electronics industry in speeding mail handling and delivery; a substantial market is shaping up

By Robert Skole
Manager, Washington Bureau

Aircraft and trucks have replaced the Pony Express, but the U.S. mail is otherwise handled today pretty much as it was a hundred years ago. Ben Franklin, the father of the postal system, would feel at home in most of America's post offices. However, it's obvious to the public, the Congress, and the Post Office Department itself that with mail volume at 80 billion pieces a year and increasing at the rate of 3 billion pieces annually, fundamental changes are needed.

The new postal officials trying to give meaning to brave new words about bringing the postal system up to date are just beginning to breach the agency's bureaucratic barrier, and their efforts are opening a giant and relatively untouched market for electronics.

How large this market can become is anybody's guess, but systems-oriented firms will get some idea on Nov. 3 in Washington when Post Office research and engineering brass outline what they're up to now and what future needs will be. The word "systems" is the key: that the Post Office is one large system is apparent, but a systems approach to solving postal problems has never been applied.

I. Forwarding the mail

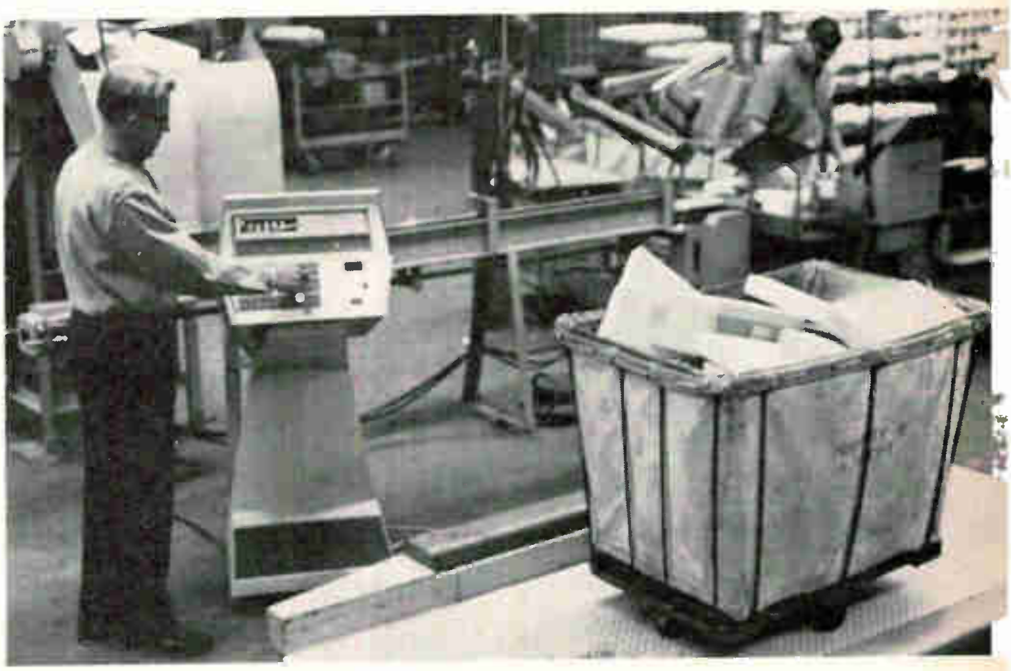
To get industry thinking of the Post Office as a systems customer is the job of Leo S. Packer, assistant postmaster general in charge of the agency's new Bureau of Research and Engineering. Packer, a former engineering manager at the Xerox Corp., himself is evidence that a fresh attitude toward modernization is sweeping the department. Hired about a year ago, he was told that one of his major projects was to interest industry in doing business with the Post Office. And to give him some cards to play, the budget makers set aside $23 million for research and engineering in fiscal 1968, compared with $16 million last year and $9 million the year before.

Initiation. During his first year, Packer learned quickly why industry has generally shunned the Post Office for many years. For one thing, the ponderous workings of bureaucracy created maddening delays in the simplest procurements. For another, it was almost impossible for outside engineers and developers to get technically competent officials to listen to—and act on—proposals for new hardware or systems.

The upcoming conference with industry was originally scheduled for last spring, but Packer realized he wouldn't be able to gather a high-level staff of engineering experts in time. "I didn't want to mislead people and disappoint them," he says. "There would have been disillusionment if we got people excited about making proposals and they found out there was nobody in the Post Office they could talk to."

After that false start, Packer established an Office of Industry Liaison within his bureau and named Kenneth M. Baker to head it. Baker, a former director of marketing at the Pennsalt Chemical Co.'s Equipment division, says his main task now is "to improve the image of the Post Office as a marketplace for sophisticated equipment and systems."

Down to earth. Another recent addition is Walter C. Scott, who was director of programs and resources in NASA's Office of Advanced Research and Technology.



Weigh-in. Electronic scale is part of a $33-million data system that will link 75 main post offices and 1,230 branch facilities.

. . . engineers couldn't find competent officials to act on proposals . . .

Scott admits that he wasn't much interested when Packer offered him a Post Office job as assistant director of general research in the R&D section. But the prospects of applying aerospace-type management techniques to the problems of getting the mail through intrigued him. "I'm still not sure the job can be done," he says. "But we've made progress by establishing a research and development philosophy modeled after aerospace techniques. Our job isn't to develop hardware but technology."

Handle with care. As if Packer and his associates didn't have enough trouble with entrenched bureaucracy and reluctant companies, they also found that they can run afoul of the law if they carry modernization too far—Federal statutes direct that certain postal jobs be done by hand. Furthermore, every postmaster in the country is a political appointee who oversees the work of Civil Service employees.

Baker says: "We think of long-range solutions while the men in the post offices are worrying that Christmas is coming. It's pretty tough to phase out a system and replace it with a new one when you're just keeping ahead of demand now."

Help wanted. But the Post Office has plenty of technical problems for engineers to wrestle with. For example, the department envisions the day when it will not only be aided by alphanumeric zip-code and address readers, but by complete address registers in computers programed to sort mail according to letter carriers' frequently changing routes.

Despite the tempting challenges, however, the Post Office has had trouble attracting talented engineers to maintain its 1 to 5 ratio of in-house to outside research. Young engineer grads find more glamor in industry and aerospace programs than in the projects at the Post Office's temporary R&D facilities in Bethesda, Md.

II. Speed reading

The most sophisticated electronics projects undertaken so far—in-house or out—have been aimed at developing alphanumeric readers. Working on a $9 million contract, the Philco-Ford Corp.'s Communications & Electronics division is installing four reader-sorters at post offices in Detroit, Houston, Boston, and San Francisco. The Detroit and Houston units are already plugged in and are sorting 2,000 to 2,500 pieces of mail an hour. Philco-Ford says its electronic address reader, which employs a flying-spot, cathode-ray-tube scanner, can sort at least 75% of the daily intake of properly addressed mail. In addition, the company is scheduled to deliver within the next six weeks a script-numeric reader developed under a $293,000 contract and containing a flying-spot crt scanner and a proprietary recognition system.

But the Post Office, concerned that Philco-Ford might take over the field of reader-sorters, has continued to seek industry bids on zip-code readers. Prototype zip-code readers have been submitted by the National Cash Register Co.; the Burroughs Corp.; and Rabinow Electronics Inc., a subsidiary of the Control Data Corp.; all have been rejected because they couldn't meet a requirement that the error rate be 2% or less. The postal R&D office soon will award a new contract to one of the companies for an improved version of its prototype, however.

Machine age. Another electronics market in the making at the Post

Matchmaker. Leo S. Packer heads effort to modernize the Post Office.

Office is data processing. Two years ago, the Post Office had 20 people managing its data processing program; it now has 150—mainly programers and analysts. The data processing office is headed by Keith D. Carter, who spent 17 years at the Defense Department; he concedes that "up to now, it's been a seat-of-the-pants operation." But so far, his office has used computers to figure out the fastest route for an air mail letter, a process under which the machine might order a sack of mail to be moved on and off as many as four flights between, say, New York City and Birmingham, Ala.

This is just the start. The office is programing the routing of surface mail, and eventually would like to see computers handle the entire routing task—including the printing of destination tags for mail sacks and a precoded tag for each piece of mail so that it could be sorted automatically according to the carrier route at the point of destination.

Every letter bit. Now the Post Office is installing what it touts as the world's largest computer-controlled data collection system. When fully installed in 1968 by the Control Data Corp. at a cost of $33 million, the on-line system will link 75 major post offices and 1,230 branches, and have about 8,000 terminals. Each post office will have electronic "badge readers" to record employees' work time, attendance, and types of jobs performed; also slated are alphanumeric input and output units, plus electronic scales. The scales, made for Control Data by the Hardy Scale Co. of Ogden, Utah, use strain gages and give weights to 1/100ths of a pound and can handle trays, hand trucks, or conveyors.

All data from the branches will be accumulated and transmitted to one of four teleconcentrator sites in New York, Washington, Chicago, and San Francisco, each equipped with a CDC 1700 computer. Information will then be transferred to CDC 3300 computers at centers in Paramus, N. J., and St. Louis in 2,400-bit-per-second lines. About 25 post offices and 300 branches in New York State and New England already are equipped; it's expected that after the first 75 post offices are on line, 150 to 200 more will be cranked in at a cost of $30 million.

III. In the wings

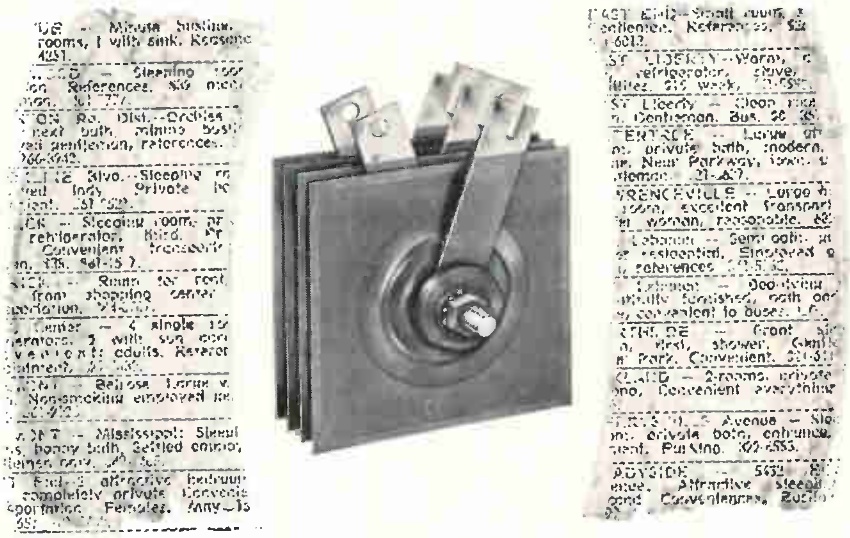
A fully computerized post office could be operating in 10 years, says Fred Hartman, a vice president of Rabinow. The firm, now vying for the contract for zip-code readers, developed the first mail-sorting machine in 1958. To handle that electromechanical unit, the operator had to memorize 276 code numbers for postal locations. However, the Post Office is testing a Rabinow unit that replaces human memory with a 2-million-bit electronic memory.

The firm also has proposed a study of a "video remoting" system that could sort mail by optical scanning without first having someone weed out the letters that can't be read by scanner. Those that defy the scanner would have their image projected on a screen by a strobe vidicon, and a clerk would direct the letter to its destination.

Down the chute. Another project in the works aims at developing speech recognition equipment. The Radio Corp. of America's Electronics Products division has a $250,000 Post Office contract [Electronics, June 26, p. 52] calling for delivery next year of a unit that "hears" zip-code numbers on packages. If the device passes a two-month evaluation, RCA will build an engineering model.

Abraham Tersoff, chief of advance development for the Office of Research and Development, notes that current postal optical readers employ techniques developed years ago. He expects research contracts to be let next year for readers incorporating laser and holography technology. And Post Office engineers are also keeping their eye on developments in infrared technology.

Touchy subject. Another area of interest is facsimile, once a dirty word in postal circles. In 1959-60, the operation of an experimental fax link between Battle Creek, Mich., and Washington, using Western Union lines touched off a furor in Congress over alleged Post Office invasion of a sector served by private industry. However, says one engineer, "facsimile is just a half-dirty word today."



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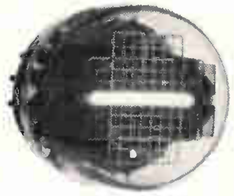
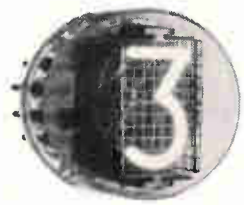


CK1901—Interchangeable with B5016 and NL5016; CK1902—Interchangeable with B5032, NL5032, B50911 and NL50911.



8421—Interchangeable with B5092 and NL8421; 8037—Interchangeable with B5031 and NL8037. Also available: 6844A.

CK1900 (used with CK8650, CK1905, CK1906); CK1907 (used with 8754)—Interchangeable with NL843.

8754—Also available with right- and/or left-hand decimal points; Interchangeable with NL840/8754. Decimal-point types interchangeable with NL841, 842, 848.

CK1905; CK1906 (right-hand decimal point).

CK8650

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RAYTHEON

If it's so great, how come it's so cheap?

It's only $5,000 because you said that's what it ought to cost. Our market research boys told us there was a tremendous need for an IC tester specifically designed for QC, QA, reliability testing, and everyday engineering evaluation. They also told us we could sell four times as many at $5,000 as we could at $7,500.

So we gave our design department a list of functions, a $5,000 pricetag, and locked the door. Here's what came out: A $5,000 IC tester that:

- Performs both pulse and dc parameter tests as well as functional tests without external equipment.
- Has a measurement accuracy of 1% (0.1% with an optional digital readout DMM.)
- Can be operated by a bright girl with half-a-day's training.
- Programs with thumbwheels in less than 60 seconds for most IC's.
- Has power supply accuracy of 0.1% ±1mv. (All supplies have adjustable current or voltage limiting and will both source or sink current.)
- Has Kelvin connections to the device under test.
- Has self powered, line-isolated modules.
- Has a complete line of device adaptors available.

How were we able to deliver so much machine per dollar? It was a snap. All we did was make every damn penny do a dime's work. We did it by committing to an annual agreement wherever there was a price advantage.

We did it by cutting out the fat. If a function was non-essential, it went. (This is one ungilded lily.)

We did it with painstaking project engineering. For example, the loads module: We could have made 1% capacitive loads. But it would have cost three times as much, and no one knows what to do with capacitive accuracy of better than 5% anyhow. Another example: the thumb-wheel switches. We found a great one, but discovered the price included $2 each for a pair of stainless-steel screws. We bought them knocked-down, assembled them ourselves and used 6¢ screws instead.

Or the pulse generator. Ours is equivalent to two single-channel output units like the ones that Datapulse sells for $775. They're great, but by sacrificing separate control and adjustment (which isn't necessary in our tester anyway) and the fancy case cut the price in half.

We found a terrific $15 digital switch. But we didn't use it. We built one without superfluous extras for a buck and a half apiece.

We're handling the AC-switching with 32 controlled planar devices. This saves 192 reed relays, that is to say, greenbacks.

One thing we did was hardest of all. We cut the profit margin. We're honest-to-gosh taking only ¾ the typical profit.

One more thing. The 990 turns out to cost $4,950 instead of $5,000. Use the extra $50 to take the little woman out to a show and dinner.

Write for complete technical data, or if you're in a hurry, call us collect.

Redcor's 990 IC tester

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With the introduction of a new, low cost 25 Amp PNP Germanium Power Transistor, Solitron provides the industry a device with power capability of 106 Watts. This transistor also complements and expands Solitron's wide line of germanium high reliability and commercial transistors. Identified as the SDT3080 Series, the device is available in a TO-3 or TO-41 case. It is a general purpose transistor for use in military and industrial inverters, converters, switches, regulators, control circuitry and audio amplifier applications.

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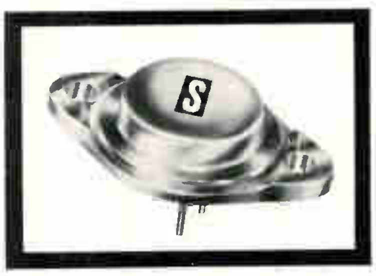

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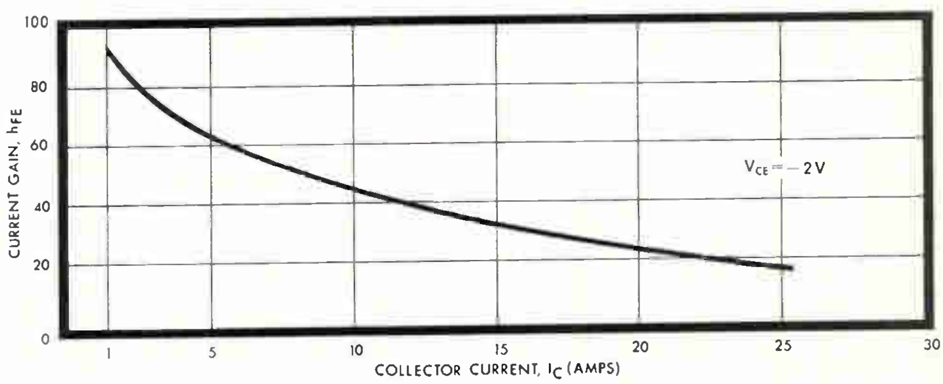

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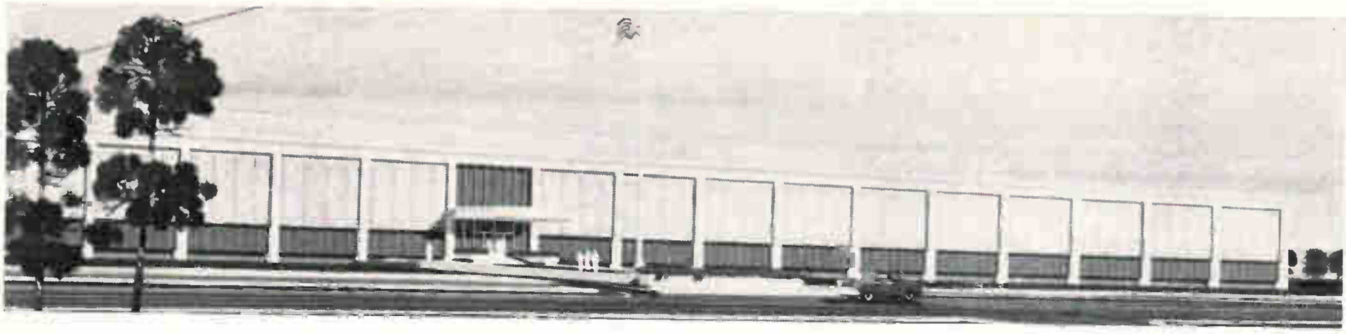
Circle 159 on reader service card



THE PLANT IN PERSPECTIVE

The Fort Worth Division of General Dynamics plant, located in the northwest quadrant of the Greater Fort Worth area, is one of the largest and best equipped facilities in the country. The 600 acre site contains well over 100 buildings. More than 100 acres of floor area are enclosed; 75 acres are under the roof of the main building. Of primary interest in the Fort Worth Division's current $37 million facility expansion program is the new $8 million Engineering and Office Building, encompassing 581,400 square feet and covering 12 acres.

Numerous laboratories are provided for performing tests and experiments in a wide range of disciplines. In addition to the well equipped Engineering Test Laboratories, there are several other major laboratories:

- Advanced Mechanics Lab
- Analog Computer Lab
- Antenna Range
- Biological Lab
- Cryogenic Lab
- Design Aids Lab
- Digital Computer Lab with an IBM 360 System (Model 65/40 ASP) assigned to Engineering
- Extensive Electronics Labs
- Infrared Visual Ultraviolet Lab
- Instrumentation Lab
- Nuclear Science Labs
- Radar Scattering Range

Production facilities are continually being updated in order to capitalize on new techniques, materials, manufacturing processes, and services. The emphasis on staying abreast of the state of the art provides an ever increasing capability for the manufacture of high performance aerospace vehicles.

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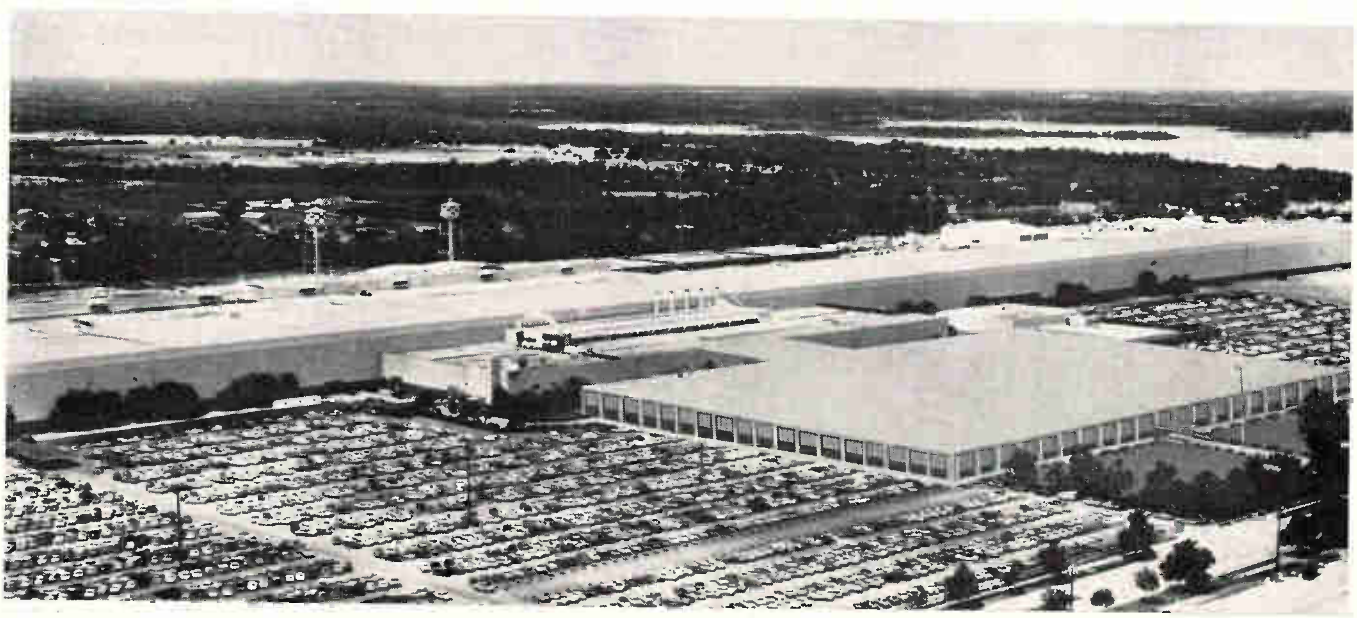
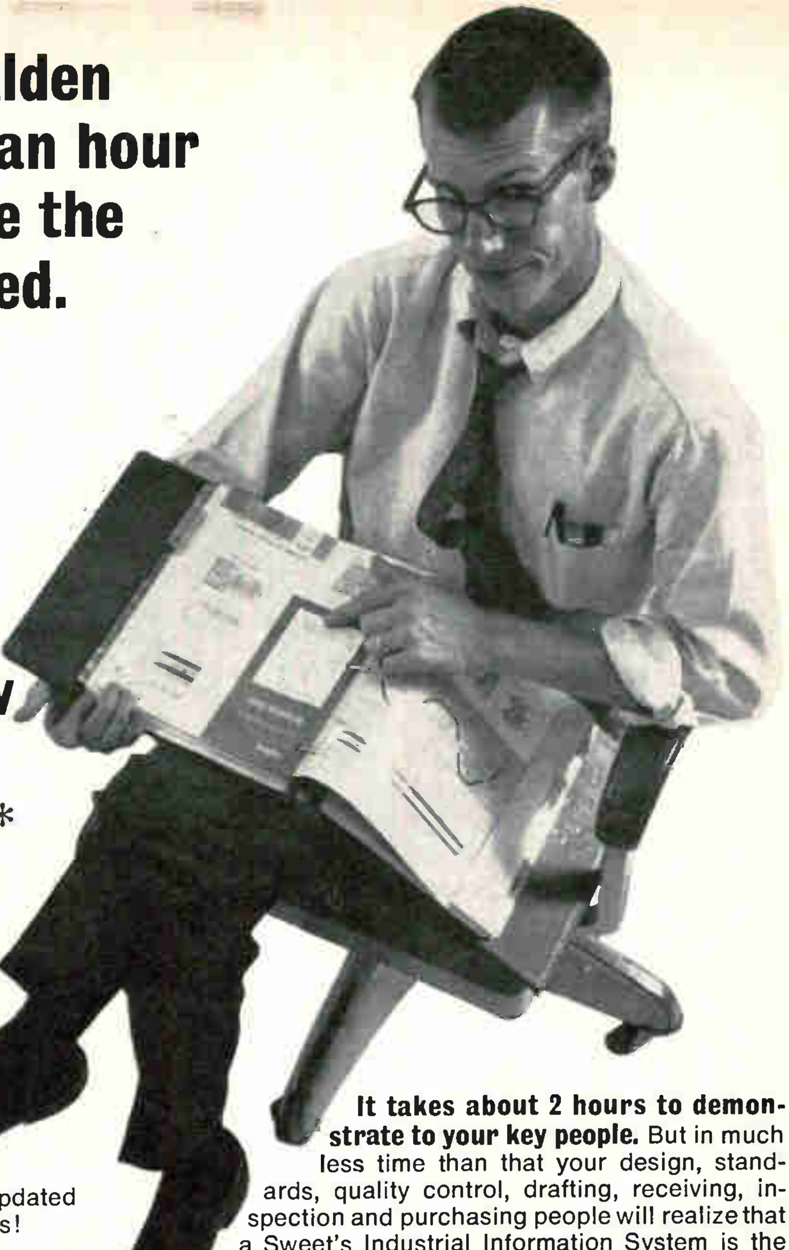
GENERAL DYNAMICS

Fort Worth Division



Design engineer Bob Alden searched for nearly an hour to find he didn't have the information he needed.



Chances are 10 to 1 he'd have found it in less than 5 minutes in the new Sweet's Industrial Information System*

Sweet's Industrial Information System is a vendor catalog file on microfilm. Because we make no charge to vendors, and microfilm everything they have in print, Sweet's has more than 600,000 pages of vendor data including application notes, reliability tests, price lists and names of distributors and reps. What's more, the Sweet's vendor catalog file on microfilm is updated every 60 days!

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You can install a Sweet's vendor catalog file on an annual subscription for less than the cost of a file clerk. Sweet's vendor catalog files are in use in plants with as few as fifty employees. The "user-orientated" idea not only provides current knowledge of the component state-of-the-art, but also expedites the purchasing function. Because of its complete coverage, more than 60% of our recent installations have replaced other microfilmed vendor catalog systems.

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read a little

Pay a Little. The price is as small as the product. It's a miniature rear projection readout, and it costs as little as $14.00. The new IEE Series 345 Readout requires very little space, but it offers the readability and versatility available only with rear projection readouts. And the price is comparable to other types of readouts with limited messages and cluttered displays.

The Series 345 operates on the rear projection principle. A lamp in the rear of the unit illuminates one of the 11 film messages, and projects it to the front viewing screen. A single plane display on the non-glare screen, so you get no distortion or confusion. It is very versatile, since anything that can be put on film can be displayed on the screen. You can display a variety of messages or colors.

The Series 345 has a front plug-in feature. It can be quickly inserted into the housing. It can be just as easily removed to insert a new readout with a different display, or to replace a lamp.

Series 345 Readout: ½" wide x ¾" high. Six digits will fit in a 3" wide panel space. Depth, 2½". Character height, ⅜". Weight, ¾ oz. Six available colors, including white, amber, yellow, blue, red or green. Straight decimal input. Vertical and horizontal viewing angle 175° with V-1 viewing screen, or 160° with standard screen.

IEE "I double-E," the world's largest manufacturer of rear projection readouts.
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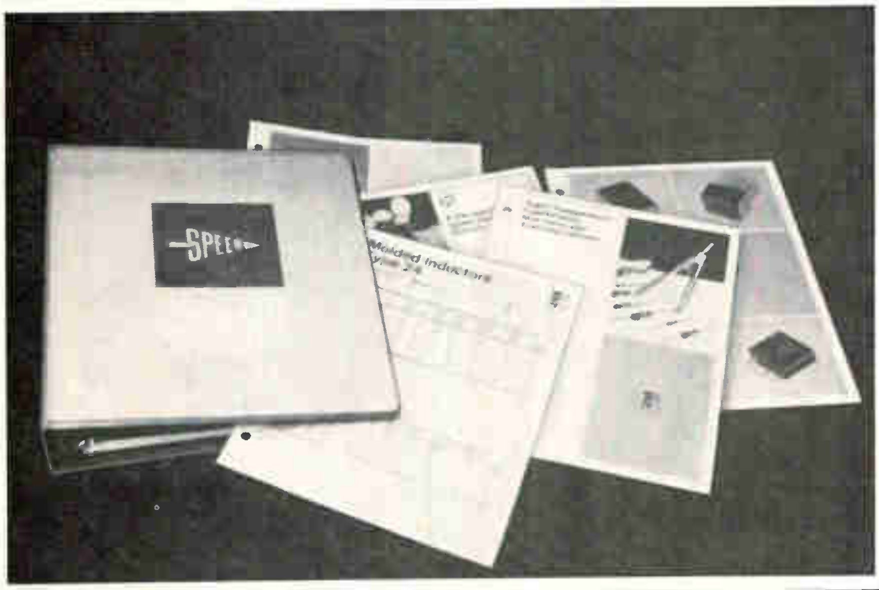
SPEER COMPONENT



Over 2 pounds of electronics lore that you may not already have

Does your company have a copy of the new 94-page Speer Electronic Components Handbook? It's 2 pounds and 5 ounces of useful electronics information plus up-to-date data on our inductors, capacitors, carbon composition resistors and JXP precision resistors. (Actually, much of the Handbook's total weight consists merely of a heavy loose-leaf binder. But look at it this way. The binder contributes both permanence and — paradoxically — flexibility. As data becomes obsolete, you'll receive revised pages which you'll be able to substitute immediately.)

Here, in one handy Handbook, is everything—from how our composition resistors are made to how our MIL Conformance Program for inductors operates.

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How to correct for Typical Error #5 when you're testing inductors

From time to time, we've been highlighting the various test errors that are commonly made when measuring inductance and Q in accordance with MIL-C-15305. There are eight errors in all.

Error #5? Failing to apply the Correction Factor when it's applicable.

Inductance values of 10 μh and lower must be corrected. Use of the TFA Test Fixture (also standardized by MIL-C-15305) should give a -0.06 μh factor.

For still more errors—and their "correction factors"— stay with us.

How the curious economics of precision resistor technology can benefit your commercial products

As you may already know, TCs of ± 2 PPM/°C and tolerances of $\pm 0.02\%$ are available upon request with our JXP precision resistors.

But did you also know that you don't have to pay more to start enjoying this greater precision?

Curiously enough, you'll pay less—particularly if the precision resistors you're now using are of the "wire-wound" type.

JXP metal film resistors reflect important Speer advances in evaporated metal film technology. As a result, they can be produced to tighter tolerances than wire-wounds at significantly less cost for most resistance ranges. And they automatically incorporate faster response and settling times at no additional cost—making them especially ideal for high frequency and high-speed computer applications.

JXPs can benefit your commercial products in other surprising ways as well. (Also your military products, needless to say.) Mail the coupon for complete information.

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☐ Rush the name and address of the Speer representative who has my company's free copy of your weighty Electronic Components Handbook.

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Circle 163 on reader service card

New Products

New computer peripherals

Picture looks brighter for computer displays

Storage crt's that provide long-lasting images make displays handy tools in applications ranging from airline reservation systems to seismic-plot analysis

Next week at the National Electronics Conference in Chicago, Tektronix Inc. the nation's biggest manufacturer of oscilloscopes, will announce a major diversification into peripheral equipment for computers. As its first offering along this line, the company will introduce two models of a cathode-ray-tube display capable of holding alphanumeric or vector information for several hours. These displays, which use the storage tube Tektronix developed for special versions of oscilloscopes, have been priced at $2,500 and $1,050—without character generators. They are intended for applications that require many readout stations, applications such as time-sharing systems or automated teaching by computer.

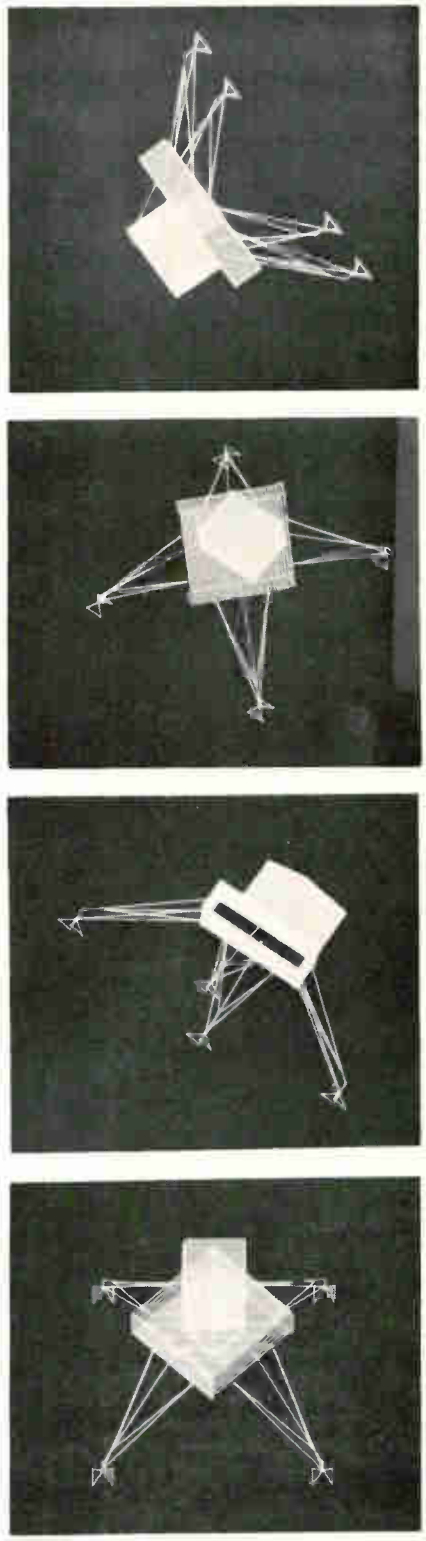
With the timing of its announcement, Tektronix barely edged out two other companies who have eyed the same segment of the graphic-display market. In Los Angeles, the Conrac division of the Conrac Corp. is about to announce graphic-display equipment for computers with a price tag of $7,000—but this gear includes a character generator and keyboard. And in New Hampshire, Sanders Associates has started producing still another piece of equipment that will do the same job as the Tektronix or Conrac devices.

Behind this sudden upsurge of activity is a realization that more users of computers want the kind of computer readout that only a cathode-ray tube can provide. Tektronix, for example, decided to enter the market after many customers tried to buy its 564 oscilloscope for computer-display purposes, or the cathode-ray storage tube alone. Albert L. Landsperger, director of marketing at Conrac, predicts that 120,000 crt-display units will be in service, driven by computers, by 1971. That would amount to nearly $800 million worth of displays.

I. Plane seats to optics

Almost everywhere computers are being used these days there is a demand for the crt display. Even before product introduction, Conrac has an order for 2,000 devices—with an option for 2,700 more—from Trans World Airlines, which will use them with its computer-reservation system being built by the Burroughs Corp. United Air-lines has ordered 2,200 Conrac units for a new reservation system.

A computer-graphics system at Beckman Instruments Inc. aids engineers in designing monochromators, optical devices that separate a broad energy spectrum into narrow bands. Studying traces on a crt, which is connected to a



Looking up. In sophisticated computer-graphic terminals, images can be rotated, even made to fly. Adage system presents views of lunar model for study of flight conditions.

Tektronix stores graphics in the tube

Four years ago, when the Tektronix Type 564 storage oscilloscope was introduced, researchers working with time-shared computers quickly saw its potential as an operator-oriented computer graphics display.

Two years ago, the company's newly appointed director of research and production, C. Norman Winningstad, took aim at the computer-peripheral market. Tektronix worked with the Massachusetts Institute of Technology's Project MAC (Multi-access Computer), and lent an early version of its storage cathode-ray tube to MIT researchers for evaluation.

This crt retains the image of an electrical event after the event. As in conventional crt's a gun scribes the input signal on the tube's fluorescent screen with an electron beam. A second gun sprays the screen with slow-moving electrons, holding the written areas bright and the unwritten areas dark. This characteristic—bright trace on dark background—is called bistability.

Erasing. The screen is erased by writing the whole screen bright with a positive pulse, then dark with a negative pulse.

Tektronix modified its earlier storage crt, added circuits, and packaged two storage-display units. It shipped a production model of its new Type 611 storage-display unit to Project MAC, and lent another to the University of California at Santa Barbara, where time-shared computer work is also under way. Evaluation quantities are available, says Tektronix, for delivery in 90 days.

No memory. The Type 611, has an $8\frac{5}{32}$-by-$6\frac{1}{16}$-inch display area. The bistable crt in the unit eliminates the memory usually needed to refresh the image, a modification that probably will reduce the 611's cost as well as the fees for use of data-transmission lines from remote computers to the display terminal.

The MIT engineers are still hoping for an 11-by-11-inch storage crt, but will build a prototype terminal around the Tektronix unit [Electronics, June 27, 1966, p. 48]. The full terminal is scheduled for initial tests in December. MIT will build about 10 and then try to interest some company in manufacturing them under a license.

Unlike crt's that must be refreshed frequently to prevent flicker, the bistable tube's image is constant and retains the selected operating mode. It requires 0.5 second to erase a stored image.

The 611 flat-faced tube is electromagnetically deflected to preserve small spot size, a method that usually gives rise to such problems as nonlinearity, and pincushion and barrel distortion. Although they won't say how, Tektronix claims it found the right answers.

A write-through feature enables the operator to position the writing beam to any point on the crt screen without storing the new trace or erasing any previously stored traces.

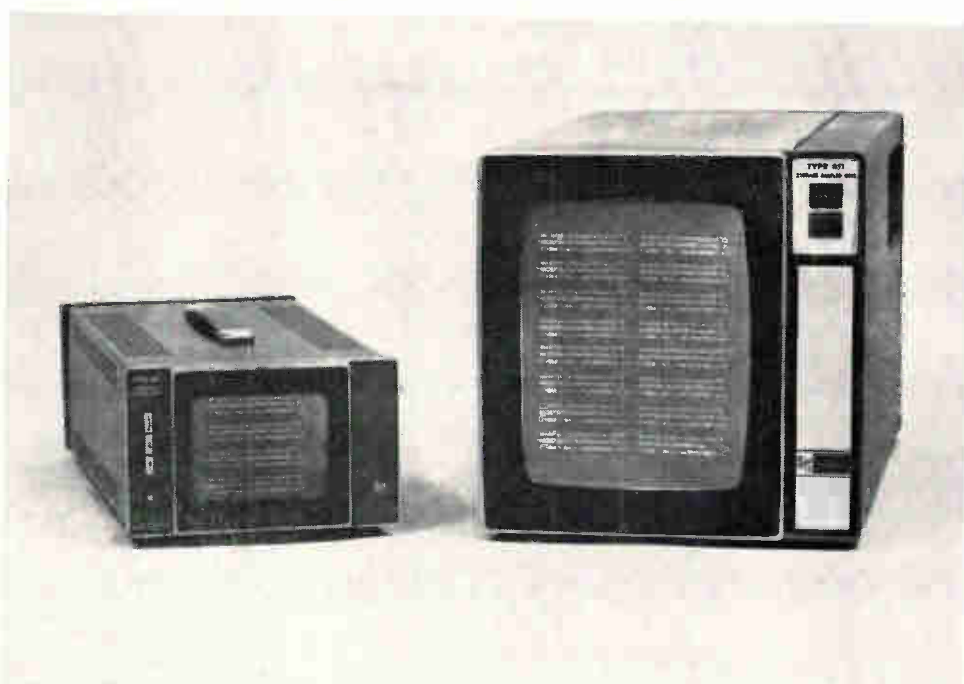
Resolution of the 611 is 500 stored line pairs vertical, 400 stored line pairs horizontal. Dot writing time is 20 microseconds.

The erase, nonstore, write-through, and view modes are remotely programable through contacts on the rear panel. Switches on the front panel provide manual control of erase and view functions.

The long view. Maximum recommended viewing time is 15 minutes, but images can be held under conditions of reduced brightness for about an hour. If held longer than that, some traces will remain.

The 611 sells for $2,500, its smaller companion, the 601, for $1,050. But neither stands alone as a display terminal. A workable graphic system would require at least a character generator, a keyboard, and a communications-line interface, so that a system using the 611 would cost about $7,000 with hardware.

Textronix Inc., P. O. Box 500, Beaverton, Ore. 97005. **[338]**



Displaymates. Tektronix Type 601 storage display unit, left, retains nonfading alphanumeric and graphic information on 3.2-by-4 inch screen. Type 611 has a 6.5-by-8 inch screen, offers write-through traces than can be viewed without being stored and without disturbing previous graphics.

digital computer that stores data and makes calculations, the engineer gets a visual pattern of both the monochromator's image plane and the rays striking the plane. With this system, he rapidly arrives at the best design for the required optics. The model of the design is in the computer, and the engineer interacts—based on what he sees on the crt—with the model.

Searching the file. Other, simpler kinds of crt displays are in use on a more widespread basis. They are primarily used to give the viewer, at his request, access to computer-stored information. Such inquiry stations, for example, display pages of inventory information. But, normally, the viewer cannot use his display to interact with the computer to change the inventory situation.

The interacting system and the inquiry station demonstrate the breadth of computer-graphic-system capabilities. Two years ago, a survey showed 35 types of computer-graphic systems available, but few were sold in quantity. According to one group, greater interest in these systems would result if costs were lower for such hardware as crt displays, character generators, digital computers, and communications links. And, this group argues, there must be a greater availability of low-cost computer programs. Another group contends that proof of an extensive market is needed to stimulate product and systems makers to develop what's needed.

II. Big systems emerge

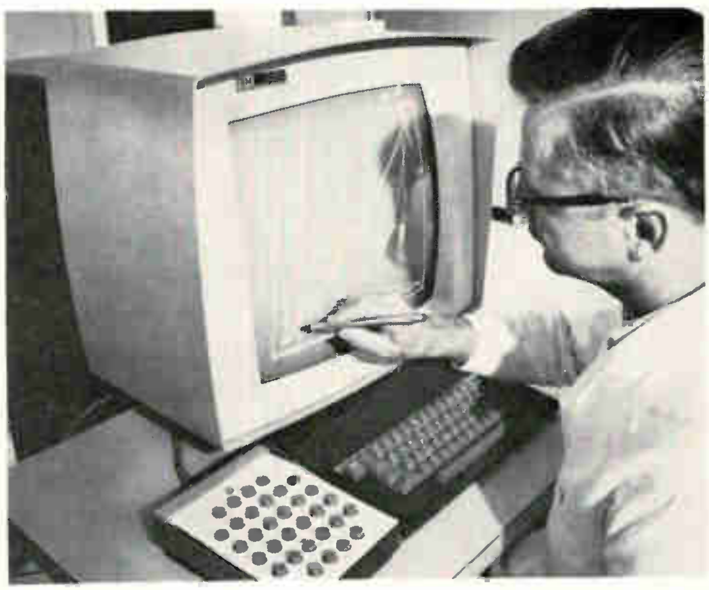
Now market studies have been made, and new products and systems are being offered. These include large-scale computer-graphic equipment for analyzing complex data and for modeling dynamic systems.

From such studies has come the conclusion that three kinds of graphic display equipment are needed:

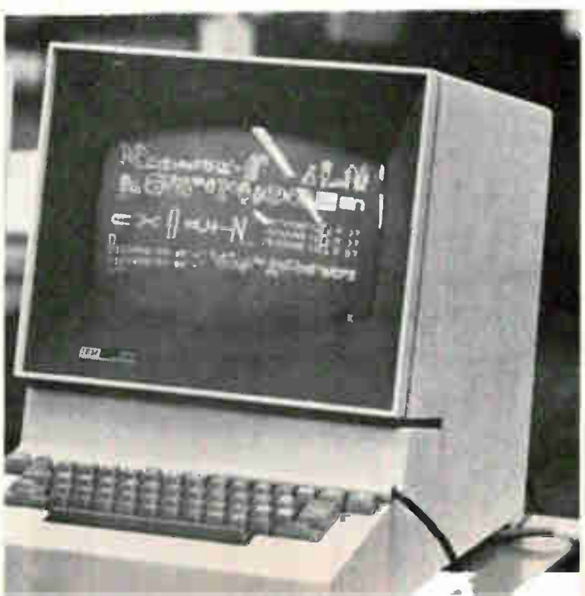
- sophisticated equipment that will do anything the user wants from rotating the angle of viewing of an automobile design to plotting several variables simultaneously.
- simple, low-cost equipment that will display limited amounts of information such as a customer's balance to a bank teller or an addi-

Computer graphics reinforce man's skills

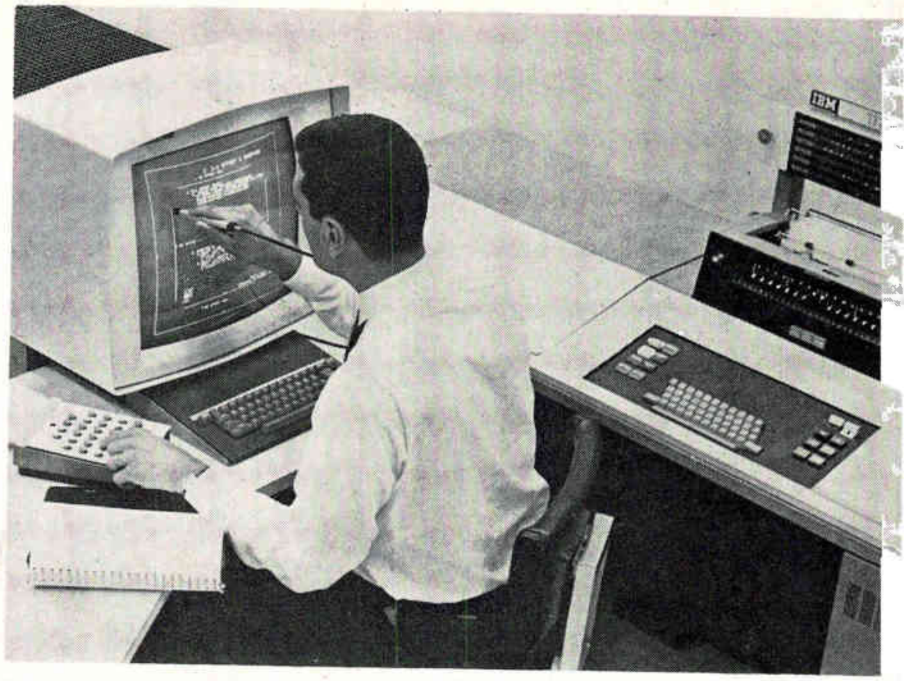
Textile designer uses computer-stored weaves, concentrates on designing novel patterns with light-pen input.



Drug researcher determines where drug goes after it enters body, then makes mathematical tests on computer model.



Student station teaches California school children. Education applications of graphic displays are expected to expand as prices come down.



Expanding the line. Even small computers can provide graphics readout. For its 1130 computer system, IBM adds new functions to its 2250 display, now called 2250 Model 4.

tion or subtraction to a student.

▪ systems that fit in between these two extremes in cost and performance.

Just how much users are willing to pay for a low-cost system is still one of the big unknowns of graphic displays. Last year, at MIT's Project Mac, the time-sharing study group, John Ward estimated that $5,000 would be the highest price that group would be willing to pay for a graphic display that included crt, character and vector generator, and link to telephone lines. Now Ward believes the minimum price will have to be upped to at least $10,000 to get equipment that will

Conrac refreshes display with delay line

Conrac's terminal contains a cathode-ray tube, delay-line local memory for image refreshing, desk-type keyboard, electronic character generator, and buffer to interface the unit with a communications link like a telephone company data set—at 1,200 or 2,400 bits per second.

The crt face is 12 inches measured across the diagonal, and displays characters 0.200-in. high. Repetition rate is 60 hertz, synchronized to line frequency to minimize flicker.

Priced at just under $7,500, the Conrac equipment is aimed at computer-graphic-systems makers. But the company anticipates the unit price will be considerably less in production quantities.

The Conrac display includes two types of alphanumeric-pattern generators to suit customer preference. One plug-in card produces dot-matrix characters, each matrix made up of 5 by 7 dots. In this format, the crt can display 24 rows of 37 characters per row, for a total of 888 characters. Another card offers stroke-written, starburst characters in 16 rows of 37 characters per row, for a total of 592 characters.

Related to the character generator are internal decoding and control logic. Control logic, for example, positions the cursor—which shifts the start position of an alphanumeric sequence on the crt screen. The integrated circuit logic is based on diode-transistor logic and transistor-transistor logic configurations.

The keyboard has 64 positions, for alphanumeric characters, punctuation, and editing functions like carriage-return mode.

Conrac Corp., Conrac Div. Covina, Calif. 91722 [339] satisfy the requirements of a time-shared computer.

Researchers who have studied the educational market believe that school boards could not possibly afford that much money for each display since every student ought to have one. For such applications, the price probably will have to be under $1,000 and maybe even under $500.

Thus at Tektronix, marketers believe the first buyers of graphic displays for automated teaching will be in the colleges which have more money available for such expenditures and which can restrict their use to a few special courses.

Engineers and scientists are starting to use the sophisticated computer graphic systems in applications that lets them use their unique creative abilities, with the computer and display interacting with them—cutting elapsed time from problem to visual answer.

Adage Inc.'s vice president, Irving R. Schwartz, predicts sales of these systems reaching $50 million in 1968, at an average cost of about $200,000 a system. To meet the demand, the company has unveiled its Adage Graphic Terminal that uses the company's Ambilog 200 computer with both analog and digital capabilities.

Oil hunt tool. Adage recently sold two such terminals to a major oil company. They will be used as remote graphic stations, linked to the user's large digital computer, for analyzing seismic-data plots. The system will be operating shortly after the first of the year.

The International Business Machine Corp., which pioneered the computer-graphics market, now is adding more functional capabilities to its 2250 display terminal, calling it the IBM 2250 Model 4. The new display offers upper and lower case alphanumerics, subscripting and superscripting, and hardware-assisted programable-character generation. It sells for $115,000, and leases for $2,400 a month.

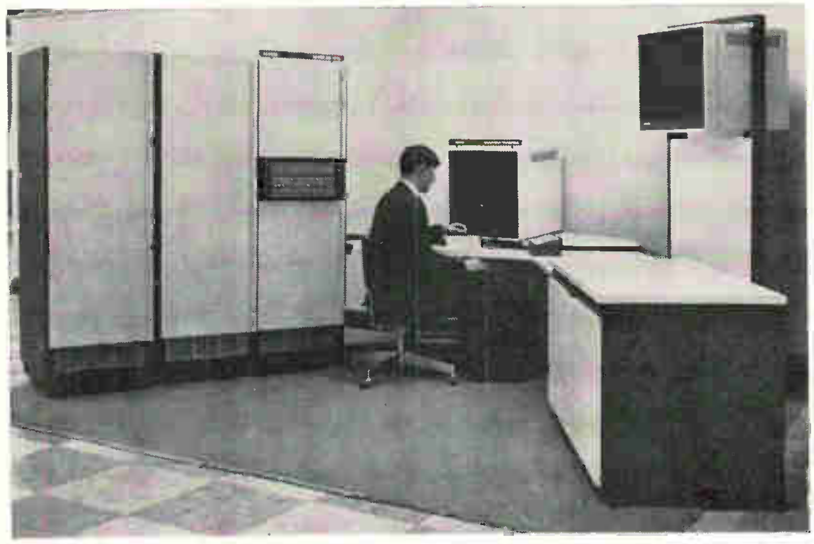
Alone or attached. Computer programs are the lifeblood of a graphics system. How much this software is needed depends on the kinds of jobs the terminal will do and the equipment configuration.

In one configuration of the IBM 2250/1130, the system operates on a stand-alone basis. Located phys-

Software expands job range . . .

ically close to each other, the computer and the display unit operate from data stored in the computer's disk and core memories. For this stand-alone configuration, two programs are used: the Disk Monitor Systems 2 (DSM) is the control, which assists the programer in establishing flow and timing in getting information into the computer and out to the display console, and the Graphic Subroutine Package (GSP) for the 1130 computer, which lets the user enter his specific jobs in Fortran.

In the attached configuration, the 2250/1130 can be connected to an IBM 360 computer, model 40 and



Dynamic interaction. Adage Graphics Terminal lets user examine, modify, and experiment with images representing designs and problems. Rapid access allows engineers and scientists to interact with computer-stored information.

Adage terminal adds motion to image

A general-purpose system, the Adage Graphics Terminal can produce dynamic images of three-dimensional objects that move continuously. Basic elements are a high-resolution (1,000 lines) crt display, a hybrid computing array, a digital processor, a transmit/receiver interface, and systems programs for graphics operations and communications.

Complex pictures are created by processing multiple-image definitions for display on the crt. Each image—represented in core memory as a structured-data list—is under the control of the user, who interacts with the terminal through a command language. Manipulations of images include repositioning, scaling, rotating, transforming, and dissecting.

Using subprograms, which are executed each time an image is displayed, the operator adds motion to the image, such as a picture of the lunar module flying through space.

Spare the computer. Adage offers three models of its terminal, ranging in price from $75,000 to $250,000. In all three, image refreshing and manipulation are accomplished at the terminal. Loading of a central computer's memory and multiplexing facilities, as well as transfer of bits between computer and terminal, are kept to a minimum. Thus a low-cost communications link like a data-phone line is adequate.

The top-of-the-line Model 50 terminal includes a crt console, 16,000-bit core memory, data-phone interface, and a disk memory for storage of image and program libraries. The console has operator's controls for image translation, rotation, and scaling.

Terminal options include hard-copy display recorder and analog-input tablet. Software packages include a monitor, a graphics interpreter, image subprograms, basic communications, and remote interface modules.

Adage Inc., 1079 Commonwealth Ave., Boston, Mass. 02215 **[340]** up, through a communications adapter, thus making the power of a large, remote computer available for advanced display problems.

In this configuration, the computer-graphics terminal is just one of many input/output terminals sharing the central computer. Thus the computer must execute a variety of programs either within a specified time in the computing cycle or when a given event (an interrupt) occurs. Over-all programing thus becomes much more complex, to the point that software often isn't available by the time a computer is ready for installation. IBM now has available its OS/360 software for multiprograming applications like the remote computer-graphic system. To ensure continuous display, the OS/360 program gives the graphics terminal highest-priority access to the computer.

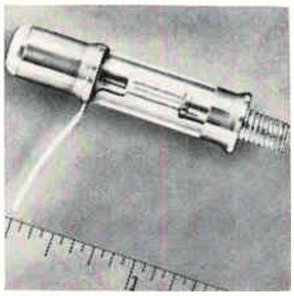
III. Refresh without pause

In conventional crt tubes, the image disappears unless refreshed—usually 40 times per second for flicker-free display. If, for example, the tube face can display a maximum of 800 characters and each character requires 10 bits, all of this must be refreshed 40 times a second. The over-all bit rate is so high that transmission directly from a computer's memory would require excessive capacity and an extremely wide communication band. Instead a local memory such as a delay line is used to refresh an image. Thus, only new data is called for from the computer. This cuts down cost, which is affected by length and bandwidth of communication links. Most systems can now operate satisfactorily at a rate of 2,000 bits per second, the bandwidth of data-phone service.

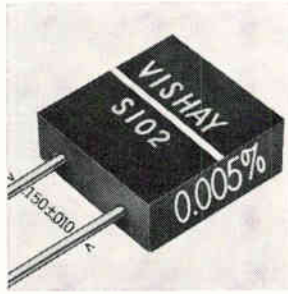
In the wings. As exotic as some of the computer-graphics terminals are right now, new developments will continue. Methods of providing graphic inputs are limited. Adage's Schwartz says his company is developing a graphic input to scan 100 lines per inch. Due some time next year, this additional equipment is expected to be priced under $2,000 with its associated software package. With such a unit, scanning and analyzing seismic-activity plots will be easier and faster.

New Components Review

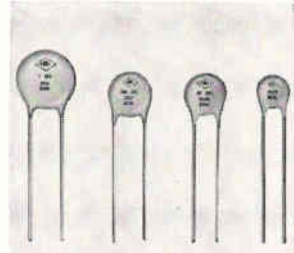
Miniature tube sockets (7- and 9-pin) are offered with TFE bodies and brass hardware. Contacts are silver-plated beryllium copper (also available with cadmium or nickel plate) and tabs are solder-dipped. Sockets are available in shield- or saddle-base types and in bottom-mounting type. Specifications meet MIL-S-12883A. Chemelec Products Inc., 8 Fellowship Rd., Cherry Hill, N.J. [341]



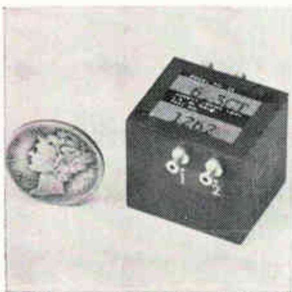
Piston trimmer capacitor 1616D works over a frequency range of 1 to 30 Mhz. R-f voltage level is 3,100 v peak at +25° C derated to 2,500 v peak at +200° C. Capacitance is variable from 0.5 to 5 pf, and temperature range is from −55 to +200° C. Turning torque is 1-10 in. oz. Insulation resistance is 10^6 megohms. JFD Electronics Co., 1462-62d St., Brooklyn, N.Y. [342]



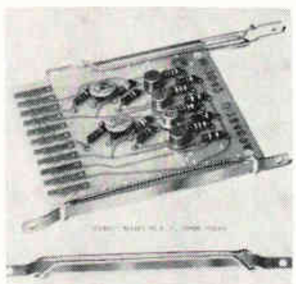
Standard absolute resistance tolerance of 0.005% is offered in a line of precision resistors. Temperature coefficient is 0±1 ppm (0° to 60° C). Shelf-life stability is 25 ppm/year; load-life stability 0.030% at 125° C, 2,000 hours. Standard resistance range is from 30 to 30,000 ohms. Price is $4.56 each in 100-lot quantities. Vishay Resistor Products, 63 Lincoln Highway, Malvern, Pa. [343]



Ultra-Kap disk capacitors rated at 16 v and 25 v are offered with values of 0.01, 0.022, 0.033, 0.05, 0.068, and 0.1 μf. Leakage resistance is 10 megohms. Max. dissipation factor is 5% at 1 khz. Disk diameters vary from 0.290 in. to 0.760 in., and all units have a max. thickness of 0.156 in. Centralab Electronics Division, Globe-Union Inc. 5757 N. Green Bay Ave., Milwaukee. [344]

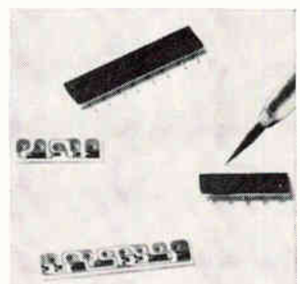


Miniature 400-hz power transformer model 2E, encased in diallylphthalate, develops voltages of 5 to 150 v a-c with a power rating of 2 w. Suited for aerospace and industrial use, the unit measures 0.87 x 0.74 x 0.78 in. It meets MIL-T-27A specs, and operates at a max. of 105° C. Price is $14.40. Abott Transistor Laboratories Inc., 5200 W. Jefferson Blvd., Los Angeles. [345]



All-steel p-c board guides, series 90, provide a positive grip for vertical or horizontal mounting. They come in a wide variety of sizes in increments of 1 in. Guides are available with 1, 2, or 3 wires and with an extra mounting hole in the center. Effective grip is 2 in. per wire. Finish is cadmium plate per QQP-416, Type I. Taurus Corp., Academy Hill, Lambertville, N.J. [346]

Image intensifier WX-30677 has a brightness gain of 200 min. The single-stage device is electrostatically focused and has a 40-mm fiber optic input and a 25-mm fiber optic output. The tube is used in low light level television where it is coupled to the camera. Prices range from $5,000 to $6,000 each for 5 to 10 units. Westinghouse Electronic Tube Division, Elmira, N.Y. 14902. [347]



Eight tin-oxide film resistor networks, series 1000, range in overall length from 1.230 to 0.355 in. Resistors on a single network range from 2 to 9. Resistance values range from a minimum of 20 ohms to a maximum of 250 kilohms depending on tolerance (1, 2, or 5%). Temperature coefficient of 150 ppm is typical from −55° to + 165° C. Corning Glass Works, Raleigh, N.C. [348]

New components

Hybrid servoamp drives aerospace motors

Integrated circuit device takes up only a quarter-inch; $200 price could limit applications of functional block

A licensing agreement with the Canadian Marconi Co. gives the Bulova Watch Co.'s Electronics division what is said to be the first commercially available hybrid microelectronic servoamplifier. The device incorporates a hybrid integrated circuit developed by the Canadian firm for in-house use.

The servoamplifier will drive motors ranging from sizes 5 to 11 in the 3½-to-4-watt category. It is less than ¼ cubic inch in volume, has an output impedance of only 1 ohm, and has an efficiency of 90% to 95%.

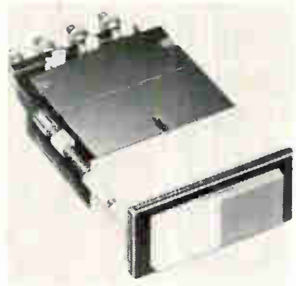
The major factor limiting its application is cost—about $200 each in quantities of less than 25, compared with about $75 for standard servoamplifiers in Bulova's inventory.

"We still have to determine what part of the market this leaves for it," says Nick Sakellarios, Bulova's sales manager for servo products. "If small size and realiability are the chief needs, the price won't be an obstacle."

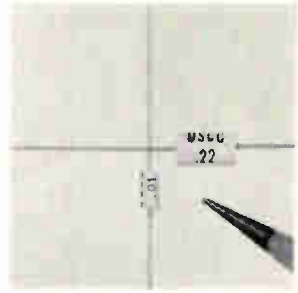
For aerospace systems. The device is a functional electronic block developed for Marconi systems. Bulova acquired U.S. market rights because it felt that the unit could

General-purpose, 400-cycle motor model 210 measures 1⅛ x 1⅜ in. and produces a 3 oz-in. torque. It is offered in 3 versions: a 2-phase, 6-pole, servomotor; a single-phase, 6-pole, capacitor-type induction motor; and a 3-phase, 4-pole induction motor. A double-disk clutch that isolates rotor inertia is available. Magnedyne Inc., 5580 El Camino Real, Carlsbad, Calif. [349]

Tiny metalized Mylar capacitors types 315 (tubular) and 315F (oval) have a 75 v d-c rating, in addition to the standard 50 v d-c. They operate within a temperature range of −55° to +85° C at rated voltage, and up to 125° C with 50% derating. Insulation resistance equals or exceeds 15,000 megohms-μf at 25° C. Texas Capacitor Co., 7830 Westglen Dr., Houston. [350]

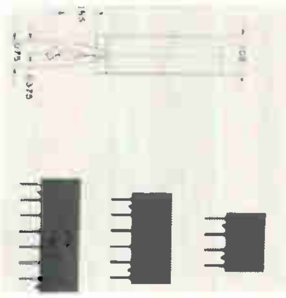


Split-action switch series 03 uses T-2 lamps with lens caps available in six colors and is rated at 10^6 cycles. Silver contacts are rated at 12 amps, 120-v a-c or ½ amp, 120-v d-c. Switching combinations are spdt with momentary or maintained contacts and positive push-button action. It can be panel-mounted in a ⅞ x 1⅝ in. hole. Truco Inc., Box 95, Simsbury, Conn. [351]

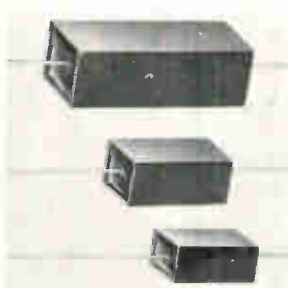


Ceramic capacitors in the C20 series range from 220,000 pf in a 0.140 x 0.250 in. package down to 10 pf in a 0.080 x 0.150 in. size. Capacitance change with temperature is nominally less than ±15% from −55° to 125° C. The 50 v d-c units are for packaging in filtering, bypass, and blocking applications. U.S. Capacitor Corp., 2151 N. Lincoln St., Burbank, Calif. [352]

Dust cap 50-001-9028 seals 50-ohm, screw-on jacks of the MIL-C-22557 ConheX series. It is supplied with three 0.025-in. diameter lockwire holes in the corners of the hex. The cap is engineered to stay put under severe vibration and prevents unwanted contaminants from entering the jack to which it is attached. Sealectro Corp., 225 Hoyt St., Mamaroneck, N.Y. 10543. [353]



A longer formed lead on the series 750 cermet resistor networks snaps into place instantly and holds the module in a rigid upright position during wave soldering into p-c boards. The lead is for 0.058-in.-diameter holes in boards from 3/64 in. to 3/32 in. thick. Prices range from 19 cents for a 4-pin 3-resistor unit to 26 cents for an 8-pin 7-resistor unit. CTS of Berne Inc., Berne, Ind. [354]



Epoxy-encased, metalized polycarbonate capacitors series 22B are suited for use in many wave filter, discriminator, and critical timing circuits. They are available in 200, 400, and 600 v ratings in sizes from 0.17 x 0.29 x 0.42 to 0.56 x 0.72 x 1.75 in. Capacitance values range from 0.001 to 3 μf with tolerances from 20% to 1%. SEI Manufacturing, Northridge, Calif. 91324. [355]

The Trans-O-Netic time-delay relay has a time interval repeatability of ± 2% at 70°F and 115 v a-c (unaffected by line variations from 100 to 135 v a-c). Standard time range for the delay-on-make model is 1 to 60 sec; for the delay-on-break, 1 to 30 sec, Prices are $20 and $26 respectively. Heinemann Electric Co., 252 Magnetic Drive, Trenton, N.J. 08602. [356]

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serve the needs of customers making such aerospace hardware as inertial navigation systems, target-intercept computers, pitch-and-roll indicators, vector analog computers, and drift-angle indicators.

The servoamplifier uses a hybrid thin-film IC combined with several discrete components, chiefly tantalum capacitors. The discretes and the hybrid portion of the amplifier are potted into a single structure that takes up only 0.236 cubic inch.

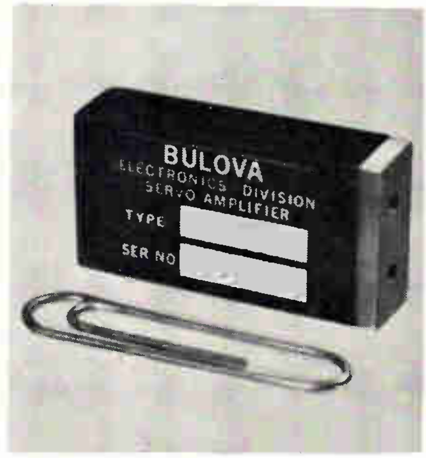
Sakellarios says a Bulova competitor has a monolithic IC servoamplifier that is "marginally smaller" than the Marconi device, but he claims it is only 50%-55% efficient, and requires large control-phase tuning capacitors outside the IC package. These tuning capacitors, typically ½-inch diameter and 1½-inches long, aren't needed in the Bulova amplifier because of its low output impedance. "Besides cutting the weight of the device, we also reduce interconnections with their inherent unreliability," says Sakellarios.

According to Dan Rosenthal, Canadian Marconi's applications engineer, an electronic ripple filter in the module will work with the most inexpensive, crude, and non-regulated power supply—an ordinary transformer, for example, with four diodes and a capacitor.

Cuts signal loss. The preamplifier is followed by an active phase shifter that provides a 90° controlled phase shift, reduces signal loss and, according to Rosenthal, requires less space than a passive phase shifter would.

The power amplifier employs a quasi-complementary-pair bridge circuit that increases efficiency when the device is in cutoff. "This type of circuit nominally gives less than ¼-watt internal power dissipation," says Rosenthal. "The kind of efficiency it provides is inherent in this type of output stage, and doesn't require the use of a center-

. . . 90% efficiency claimed for unit . . .



Power block. Canadian-made servo amplifier will drive motors with ratings up to 4 watts.

type motor. The output swings symmetrically about one-half the power supply voltage, so we can keep very tight control over the performance parameters."

The waveshape of the output is basically sinusoidal up to saturation, according to Sakellarios, then it essentially becomes a square wave. He adds, "Because of the tight control we have over input-output characteristics, this amplifier could form the basis for very high power servoamplifiers—possibly 30 to 40 watts."

Because of high efficiency and "careful thermal design," only 10% of the input power is lost as heat, says Sakellarios.

The servoamplifier is being manufactured, and qualification testing has begun. Bulova expects to have production quantities available in three to four months.

Specifications

Operating frequency	400 hz, ±20 hz
Input impedance	10,000 ohms min.
Input signal	26 v max. at max. gain
Voltage gain	2,500, ±1 db V/V_{max}., adjustable down
Gain stability	±2 db
Phase shift (linear region)	90° ±10°
Phase shift (through saturation)	90° ±20°
Voltage output	26 v rms at 28 d-c input, ±5%
Power output	4 watts
Input power	(28 v d-c, ±10%) 4.2 watts at rated output 250 mw at zero signal
Temperature range	—55 to 125°C

Bulova Watch Co., Electronics Division, 61-20 Woodside Ave., Woodside, N.Y. 11377. **[357]**

New components

Power modules replace hot tubes

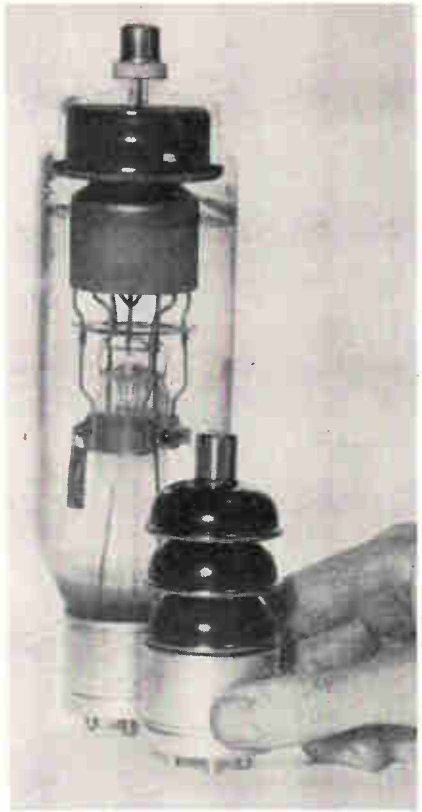
High-voltage solid state diodes proved in radar; industry is next

In replacing tubes with solid state devices to minimize overheating and other problems, one of the major roadblocks that still remain is the high-voltage, high-current rectifier tube. Companies have tried to produce a solid state diode—or series of diodes—to perform this function in radar and communications equipment, but the devices failed. The latest attempt, by the Unitrode Corp. has succeeded in military systems. Industrial and commercial targets are next.

Unitrode's diode modules, which look like a series of doorbell-shaped units combined with a tube-type base and an anode cap, were successfully tested for 10,000 hours at the FPS-26A height-finder radar installations in Canada. Satisfied with the results, the Air Force installed doorbells in both the FPS-6 and FPS-20 long-range air defense radars. Initially, the doorbells cost more than tubes. Since they last almost indefinitely, preventive maintenance costs are eliminated. The Air Force has found that the break-even point is about six months. And the tubes run cooler so equipment cabinets are 30 to 50°C cooler.

Continental Electronics, Dallas, will use the modules to replace mercury-vapor rectifier tubes in its high-power transmitters, and the Aluminum Co. of America is preparing to install them in electrostatic dust precipitators.

Self supporting. Unitrode's approach was to design a series of modules that could be stacked together and combined with a tube-type base and an anode cap. These bases and caps allow a stack of modules to be combined at the equipment site into a complete, self-supporting assembly that fits into the same socket as the tube. Shunting resistors, capacitors, and



Solid and cool. Stack of doorbell shaped diodes eliminates tube maintenance woes.

additional hardware aren't needed. Usually, there is no change in circuit wiring. The supplier has to stock only a few types of modules to handle a broad range of tube types.

Five different peak-inverse-voltage ratings, from 2.5 to 15 kilovolts per module, and continuous-current ratings up to 6.6 amps in air are available. These ratings enable the engineer to fill a wide range of power-supply and pulse-handling requirements.

Back and forth. The modules can handle high forward and reverse transients without failure or damage. Transients, that can cause tube-destroying arc-over or shorten the life of a rectifier tube, have no permanent effect on the doorbells. The module's monolithic, void-free diodes can carry as much energy in reverse-transient avalanche as in the forward direction, and the controlled avalanche ensures equal voltage division across the module's series diodes during avalanche.

The modules range in price from \$15.85 to \$53.60 each for single pieces; tube-type bases are \$4.50 each; and anode caps are \$1 each. Unitrode Corp., 580 Pleasant St., Watertown, Mass. **[358]**

Metal Glaze resistors offer .02% reliability and low cost

IRC Metal Glaze resistors now offer you a combination of proved reliability and economy that just can't be matched. You can upgrade your circuit designs and still keep the lid on costs.

- **RELIABILITY PROVEN DESIGN.** A design so conservatively rated that even at *twice rated load*, performance still far exceeds applicable MIL requirements.
- **RELIABILITY PROVEN BY TESTS.** After more than 4 million unit hours of testing, estimated maximum failure rate is .02%/1000 hours, full load @ 70°C, at 60% confidence. Failure is defined as Δ R > ± 4%.
- **RELIABILITY PROVEN IN USE.** Millions used in a wide range of applications. No in-circuit failure—*catastrophic or otherwise*—has ever been reported.

Metal Glaze resistors offer other benefits, too: indestructible thick-film resistance element, plated-on copper end cap, high-temperature soldered termination and a smooth, tough molded body that resists solvents, corrosion, and mechanical abuse.

For top resistor performance without any cost penalty, specify IRC Type RG. Write for data, prices, and sample. IRC, Inc., 401 N. Broad St., Phila., Pa. 19108.

CAPSULE SPECIFICATION

WATTAGE:	¼ W @ 70°C	½ W @ 70°C
RESISTANCE:	51Ω thru 150K	10Ω thru 470K
TOLERANCES:	± 2%, ± 5%	± 2%, ± 5%
TEMP. COEF.	± 200ppm/°C	± 200ppm/°C
IRC TYPE:	RG07	RG20

IRC

Circle 177 on reader service card

New components

Construction makes the big difference

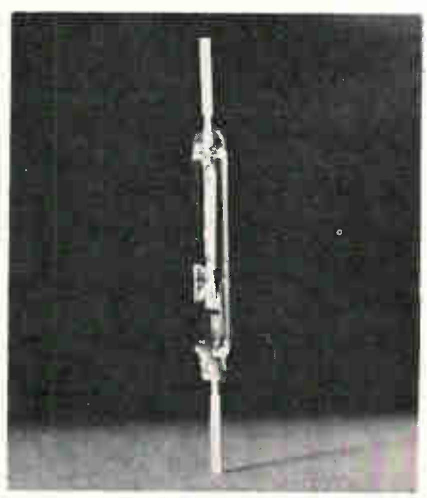
Reed switch handles 15-amp inductive loads without contact bounce or arcing

Until now, reed switches were capable of handling nominal break ratings of only 15 volt-ampere at 250 volts with 1-ampere currents. To carry higher industrial loads, they needed elaborate protection circuitry. But Cutler-Hammer engineers have developed a new reed switch that handles much higher currents yet uses the same size glass envelope.

Called Powereed, the new reed switch will make an inductive inrush current of 15 amps or 1,875 volt-amperes, and break current loads of 3 amps or 375 volt-amperes when operated at 125 volts a-c. At 250 volts a-c, the switch will make 10 amps and break 2 amps.

To achieve this capacity, Cutler-Hammer engineers departed from the conventional design of a solid armature reed and a solid stator reed. The new switch has separate members for current carrying and magnetic path. The Powereed also has a fixed air gap between terminals and armature that assures fast dropout by reducing the effects of residual magnetism.

Cutler-Hammer Inc., Milwaukee **[359]**

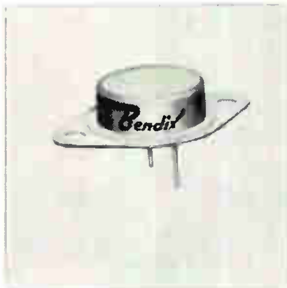


Heavy load. Reed switch has hinged, instead of solid, armature.

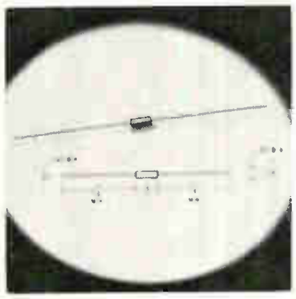
Circle 179 on reader service card

New Semiconductor Review

Ultrafast recovery rectifiers operate at full power to 100 khz square wave and are available in both 3- and 4-amp ratings with piv's to 200 v. The devices have recovery time of less than 100 nsec. They withstand surges to 80 amps for 8.3 msec and have leakages under 5 μa. Price is $4.05 (100 quantity). Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172. [436]



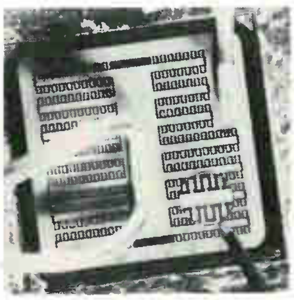
Five d-c voltage regulator modules in series BN-4100 have output voltages of 5, 6, 12, 18, and 25 v. A full 1 amp output is obtained between −30° and +125° C. Temperature coefficient is 0.1%/°C. Load regulation is ±2%. Maximum power dissipation is 15 w at 25°C case. Price: $6.60 each for quantities of 100 to 499. Semiconductor Division, Bendix Corp., Holmdel, N.J. [437]



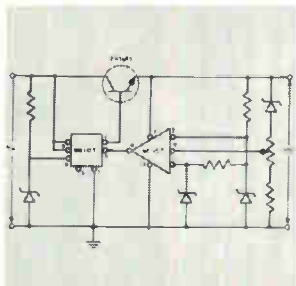
Silicon rectifiers RMC160A-RMC-300A and RMC160B-RMC300B offer piv's between 1,600 and 3,000 v and a forward current rating of 350 ma. They are for use with square-wave inputs of 5,000 to 40,000 hz and sine-wave inputs to 300 khz. The RMC300A series has a recovery time of 200 nsec; the RMC300B, 300 nsec. Electronic Devices Inc., 21 Gray Oaks Ave., Yonkers, N.Y. [438]

Microminiature, convertible pellet diodes are silicon devices suited for thin or thick film use and p-c board insertion. Units are whiskerless, and occupy approximately 1/50th of the volume of standard subminiature DO-7 packages. Typical specifications are 4 pf and 4 nsec. Prices start at 79 cents each in 100 lots. Micro Semiconductor Corp., 11250 Playa Court, Culver City, Calif. [439]

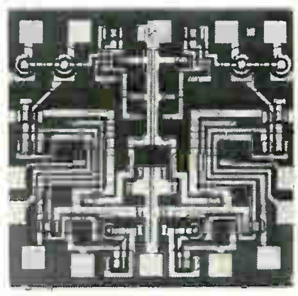
Small-signal, pnp epitaxial base amplifier and chopper transistors offer low offset voltages and low dynamic impedance. Gain is 60 at 1 ma; leakage, less than 1 na. Amplifier series are 2N327A-9A, 2N935-7, 2N1025-6, 2N938-40, and 2N1469; choppers, 2N1917-18, 2N941-2, 2N1921, 2N945, 2N2944-6, and 2N3217-9. Solitron Devices Inc., Blue Heron Blvd., Riviera Beach, Fla. [440]



Power transistor 2N5000 combines a series of discrete emitters with an integrated feedback resistor system. The series is in 4 package configurations (either npn's or pnp's) with a capability of 60 to 80 v. The 6-to 30-w device operates to 60 Mhz with beta guaranteed at 3 points (50 ma, 1 amp, and 2 amps). Fairchild Camera & Instrument Corp., Mountain View, Calif. [441]



IC voltage regulator WM110T combines, in a TO-3 package, a reference diode and sensing amplifier, followed by Darlington connected series regulator power transistors on a single silicon chip. The unit's low diode resistance is 14 ohms at 5 ma. Regulation is within 2% for an 8-to 48-v output. Molecular Electronics Division, Westinghouse Electric Corp., Elkridge, Md. [442]



Multifunction packaging is brought to linear IC's by dual operational amplifier MC1535. Open-loop voltage gain of the 2 amplifiers in the monolithic device is within ±1 db. Input offset voltage at 25°C is 1 mv. Common-mode rejection ratio is 90 db. Price for the metal can is $8.50; the ceramic flat-pack, $15. Motorola Semiconductor Products Inc., Box 13408, Phoenix, Ariz. [443]

New semiconductors

Triacs threaten SCR market

The cost of full-wave solid state control is now approaching that of half-wave control

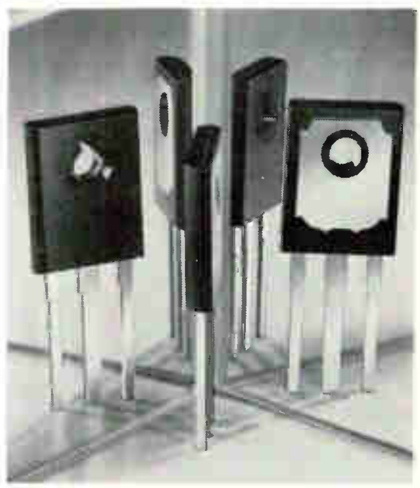


Plate. Metal plate acts as a heat sink for 8-amp triacs.

When it comes to power control devices for consumer applications, semiconductor makers are expending a lot of brain power trying to guess in what direction to turn. One company, Motorola Inc.'s Semiconductor Products division, has decided on at least one course it will take. The company is turning to a plastic-packaged triac (triode a-c switch) and associated trigger, which it believes will replace the transistor and silicon controlled rectifier in many applications and dominate full-wave a-c consumer-power control.

"The triac-type thyristor has been around for about three years in commercial applications," says Jack C. Haenichen, Motorola's operations manager for thyristors and microwave devices, "but it hasn't taken off yet in consumer applications because of its high price."

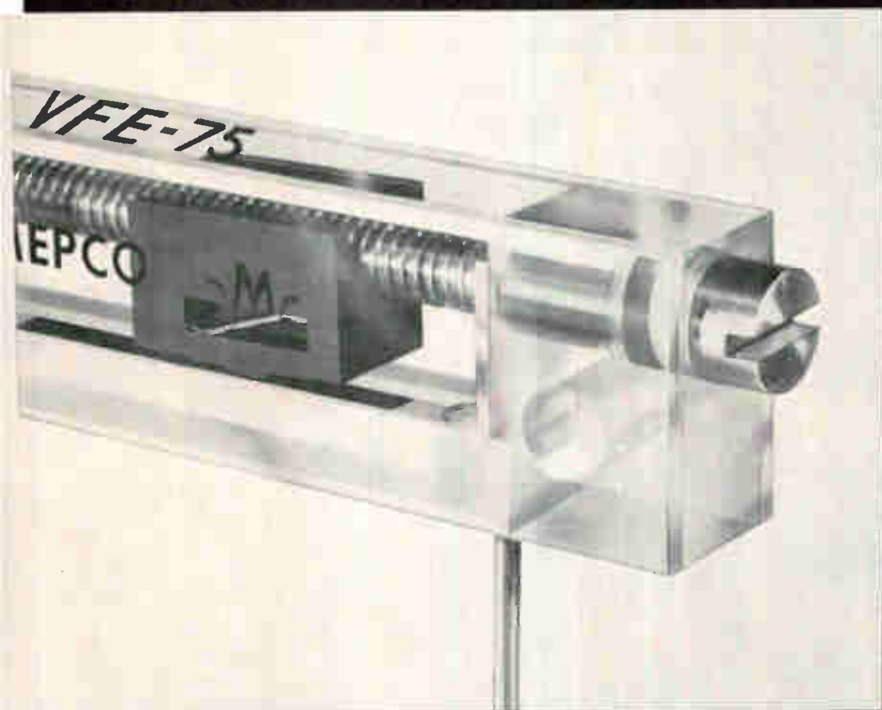
Under a dollar. The Motorola device is an outgrowth of the firm's metal-packaged triacs, which have been selling for about $1.25 in production quantities. Putting the silicon chip into a plastic package will lower the price to less than a dollar. "We haven't made enough of them yet to say how much under a dollar the price will be," Haenichen says. But he's convinced the price of the plastic-packaged version, called the Mac 11, will open the door to a broad range of appliances in the 8-ampere category. Heretofore, Haenichen says, thyristor prices have restricted the applications to appliance makers' top-of-the-line models.

The Mac 11 will be introduced before the end of the year. Hermetically sealed metal triacs now represent an annual market of five million units.

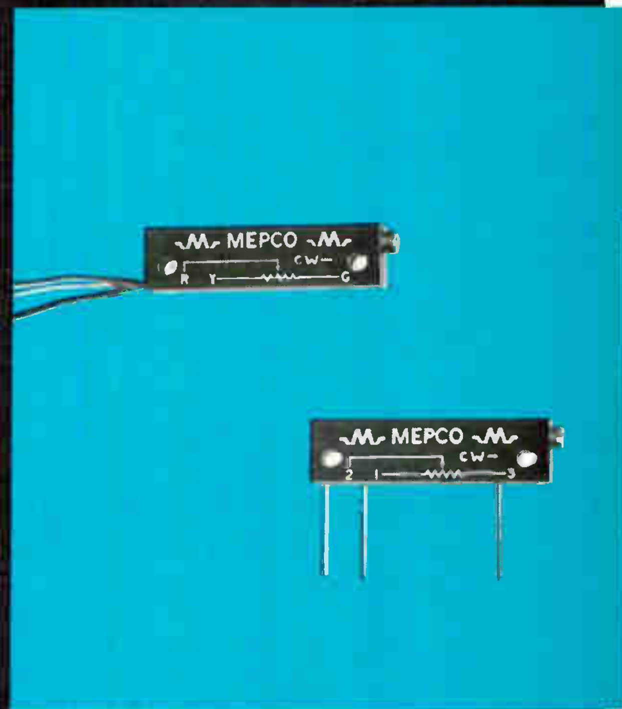
In line with chips. The 32-year-old Haenichen explains that Motorola's reason for putting the triac in a plastic package is to bring package cost more in line with chip cost. "Packaging costs have been dominant in semiconductor power devices up until now. Although the chip is big in a power device, it hasn't represented 50% of the device cost—it's been more like 20%, with the package accounting for the balance. With plastic packaging, the chip cost is about half the device cost, and some customers may want to buy chips only and save the packaging cost." However, he believes packaged devices will be in greater demand for consumer products. "You have to get into the semiconductor assembly business to use chips only," he says.

The new devices have a peak blocking voltage of 50 to 400 volts, and a maximum rms conduction current of 8 amperes. Peak surge current is 100 amperes; peak gate power, 10 watts; and average gate power, 0.5 watt. Chip size of the Mac 11 is 120 mils square.

Motorola Semiconductor Products, Box 955, Phoenix, Ariz. 85001 [444]



VFE-75



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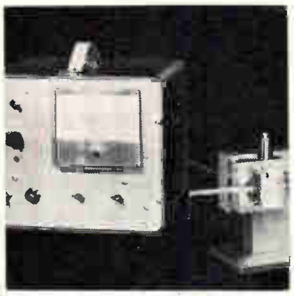
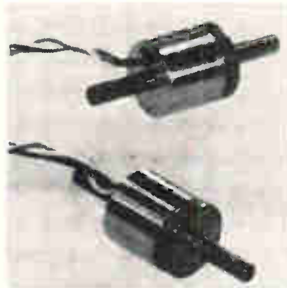


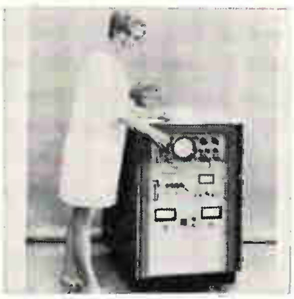
Self-calibrating, the 3403 tests bond strength in fine wires used in connecting terminals to IC and transistor chips. Its full-scale range can be adjusted over a wide value but usually a 0-to 10-gram range is adequate. Wires whose bond strength is no more than a fraction of a gram can be tested. Price is about $2,000. Transmetrics Inc., Box 2055, Newport Beach, Calif. [361]

Digital timing control 490 assures readings of 0.1-sec resolution with no potentiometer settings. Time delay accuracy is better than 0.5%; repeatability better than 0.1%. Designed for panel mounting or in original equipment, the unit is suitable for photographic, welding, and lab uses. Prices start at $134. Artisan Electronics Corp., 5 Eastmans Rd., Parsippany, N.J. [362]

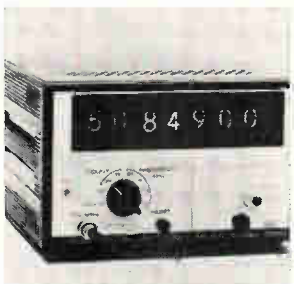


Differential pressure transducer SA-SD M-6HP has the same volume pressure cavity on each side of the diaphragm. Transducer body is 0.290 x 0.270 in. Pressure stems are 0.063 in. o-d and extend 0.188 in. The unit uses bonded strain gages in a 4-arm bridge and provides sensitivity up to 20 mv/v. Scientific Advances Inc., 1400 Holly Ave., Columbus, Ohio. [363]

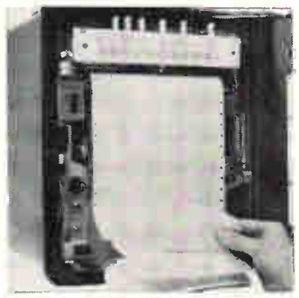
Photoelectronic pyrometer EP-1 measures temperatures of remote targets at 700° to 3,000°C. Sensitivity is better than 1°C at all temperatures and reaches 0.1° at 1,000°C. Temperature readout is in 2 expanded scales: 700° to 1,500°C, and 1,400° to 3,000°C. Response time is 5 msec. Price is $4,950; delivery, 60 days. Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn. [364]



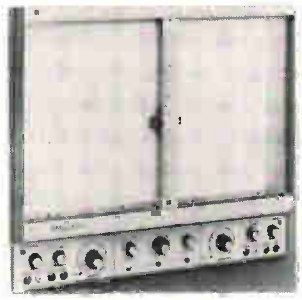
Laboratory mass spectrometer QUAD 160, with quadrupole design, offers linear mass resolution from 1 to 250 atomic mass units (amu). It sweeps the mass range from 10 to 250 amu in 100 msec to 10 minutes. Resolution is better than unity, using the 10% valley definition. Price is $13,850. Electronic Associates Inc., 4151 Middlefield Road, Palo Alto, Calif. 94303. [365]



Digital frequency meter 8220, with measurement to 500 Mhz and 7-digit resolution, is a compact unit for communications applications and industrial and lab uses. No tuning adjustments are needed for direct reading across the 10-hz to 500-Mhz range. Price is $1,695. Fairchild Instrumentation Division, Fairchild Camera & Instrument Corp., Mountain View, Calif [366]



Modular construction of the solid state ERB series strip-chart recorders offers manufacturers of original equipment flexibility of application and easy servicing and replacement of parts. The series receives measurements from d-c mv and ma sources. Single pen and multipoint models are available. Scan-fold strip charts are 7⅛ in. wide. Foxboro Co., Mechanic St., Foxboro, Mass. [367]



X-Y graphic recorder 550 is a general-purpose lab tool that measures low-level d-c or l-f analog data to determine functional or time-varying relationships. Sensitivity from 100 μv/in. eliminates the need for preamplification. True differential input permits measurements of grounded or ungrounded sources. Honeywell Inc., 4800 E. Dry Creek Rd., Denver, Colo. [368]

New instruments

Controller backs computers

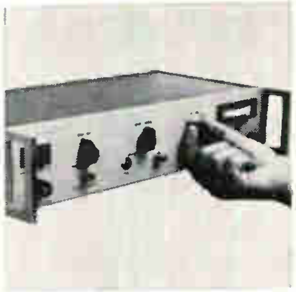
Pressed by DDC, analog units find new uses in interface and emergency roles

Even the most enthusiastic industrial backers of direct digital process control find it prudent to hedge their bets.

Thus, when the Humble Oil & Refining Co., the chief domestic subsidiary of the Standard Oil Co. (New Jersey), awarded contracts last month for control equipment to outfit a modernized and expanded refinery in Bayway, N.J., the package included a $1 million order for analog instrumentation. Motorola Inc. won the analog order, the largest single item of which is the company's new Universal Computer Control Station (UCCS), while the General Electric Co. will furnish three GE/PAC 4020 digital computers.

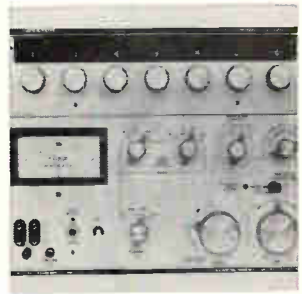
The project, which will involve more than 500 direct digital control loops, is the latest example of a trend among oil concerns. For an expanded refinery at Coryton, England, the Mobil Oil Co. awarded Motorola a $200,000 contract for analog control stations and transmitters to interface with a Ferranti-Argus direct digital control (DDC) computer system. And the American Oil Co. is using analog control stations to backstop an IBM 1800 digital system at its

Instrumentation for measuring envelope delay functions instantly upon turn-on, yielding stable, reproducible results, even where data transmission circuits being tested may be hundreds of miles long. Model LD2 was developed for the 200-hz to 600-khz range. Sensitivity is 1 μsec at all frequencies. Tel-Com Instruments Inc., 6 Great Meadow Lane, Hanover, N.J. [369]



Spectrum generator BSSG-1 permits precise measurement of signal-to-noise ratio, frequency calibration, and relative gain. The instrument generates discrete spectral lines of equal amplitude (±2 db) with 50- or 100-khz spacing, and provides output of 1,000/100/10/1 μv absolute into 50 ohms. Squires-Sanders Inc., Martinsville Rd., Liberty Corner, Millington, N.J. 07946. [370]

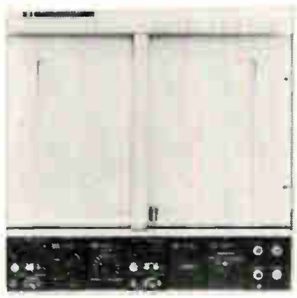
A semiconductor strain gage with a theoretical detection limit of 100 picostrain is for industrial and commercial use. One picostrain is equal to 10^{-12} in./in. strain. Mean time between failures is 100,000 hours. At 500 microstrain, the unit withstands over 50 million operations without degradation. Electro-Optical Systems Inc., 300 N. Halstead St., Pasadena, Calif. [371]



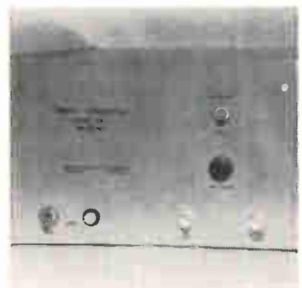
Instrument calibrator 166 uses a fractional scale-divider for swift calibration over a meter range without resetting full-scale values or amplitude controls. A-c and d-c voltages to 1,100 v, currents to 11 amps, and resistance to 11 megohms are possible with 6-digit resolution. Accuracy is 0.1% of reading for d-c voltages. Weston Instruments Inc., 17 Hartwell Ave., Lexington, Mass. [372]

Thermocouple gage controls TG-7 and TG-27 use solid state design and construction and modular ¼-rack size that is adaptable to bench use with 4 rubber feet. Pressure range for the TG-7 is 1 to 1,000 millitorr; for the TG-27, 0 to 20 torr. Dimensions of both are 5 3/16 x 4 5/32 x 11 in.; weight is 6¾ lbs. Veeco Instruments Inc., Terminal Drive, Plainview, N.Y. 11803. [373]

Impulse distribution analyzer model 318 measures the amplitude and width of random or repetitive pulses and stores the number of times that pulses of certian preselected widths or amplitudes occur in a given time. It is intended to measure interference on data transmission channels caused by cross-modulation. Quan-Tech Laboratories Inc., 43 S. Jefferson Rd., Whippany, N.J. 07981. [374]



X-Y recorder 7004A, plots one variable as a function of another on 11- x 17-in. paper, and accelerates along either axis more than 1,000 in./sec². Slewing speed is greater than 30 in./sec. Plug-ins now available are a d-c coupler, d-c preamp, filter, d-c offset, null detector, and time base. Others will be available soon. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. [375]

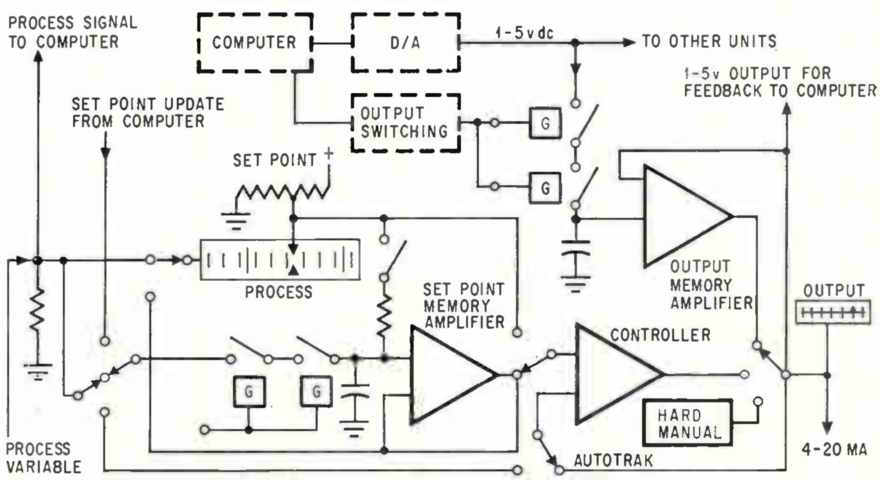


Tv/i-f sweep generator model 64-1 is completely solid state to assure reliability. A built-in electronic attenuator allows greater than 15-db control of the r-f level from its maximum of 1 v rms into 75 ohms. A linear preset sweep covers the 39-to-49-Mhz range with zero retrace line. Price is $540. Radio Research Co., 189 Mt. Pleasant Ave., Rockaway, N.J. [376]

Whiting, Ind., refinery.

Playing safe. The reason for the trend toward analog backups is clear enough. Few process control engineers—and even fewer plant managers—are willing to entrust an expensive processing operation completely to a possibly capricious digital computer. They may appreciate the advantages DDC offers in control capability, but they want standby analog equipment—automatic or manual—to take over process control if the computer conks out.

Motorola's new control station serves not only as a DDC backup, but, at the flip of a switch, as a



Options. Front-panel switches and plug-in modules suit the basic analog controller for DDC backup, supervisory-computer, and automatic or manual control.

. . . analog station stands between computer and process, smooths out rough spots in control . . .

conventional analog controller and as a set point station to interface with supervisory digital computers. The prototype was evaluated by outside control engineers—notably from Humble and American Oil—some of whose ideas were incorporated into the final design.

The UCCS has independent outputs for computer control, analog automatic control, and manual control. Its designers reasoned that a digital process-control computer takes from one to three years to become fully operational, and that the analog station can be used to get a new processing plant on stream during this breaking-in period. When the digital computer is ready to take over, the station is put into the computer-control mode—one station at a time until all loops are under computer control.

Ever ready. In this role, the analog station stands between computer output and process, and compensates for transient disturbances. Off line, the controller automatically tracks the computer output. And as an option, the set point memory amplifier can track the value of the process variable so that should the computer have to disengage, the last value stored in the memory amplifier could serve as the set point for the analog controller.

Another option provides for a "soft" changeover. Here, the desired set point leaks through an R-C time constant circuit into the set point memory amplifier, ensuring that the process will shift to a safe operating level without a bump should the computer transfer control to the analog station. Available time constants are 1,2,3,4, and 5 minutes.

Specifications

Input	1-5 v d-c, incremental or pulse amplitude
Outputs	4-20 ma d-c continuous signal
Front-panel controls	Set - point adjust and automatic/computer/manual switch
Power	24 v d-c; battery backup available
Size	Two UCCS units fit into standard Motorola 3"x9" instrument module
Price	$300-$400 per loop, depending on options

Hard manual control uses an internal current source set between 4 and 20 milliamperes. The process variable thus changes rapidly to the desired value. On hard manual, feedback to the output memory amplifier gives a continuously updated value for the condition of the process variable, making for a smooth return to automatic computer control.

Motorola Instrumentation & Control Inc., P. O. Box 5409, Phoenix, Ariz. 85010 [377]

New instruments

Poland manufactures scope for export

60 Mhz unit priced to compete with Western scopes

"Poland's best electronic instrument." That's how one Warsaw trade official describes a partially-transistorized oscilloscope being produced for export. Horizontal and vertical plug-in units boost the versatility of the instrument, designated the OSA 601.

Metronex, the official Polish trade agency, says 100 units have thus far been exported—all to Communist nations. Of the 100, 20 are in use at the highly regarded Joint Nuclear Research Institute at Dubna, near Moscow.

Made at the Experimental Plant of Nuclear Technology in Warsaw, the oscilloscope is priced in the Soviet Union at 4,200 rubles, which is about $4,666 at the official but inflated exchange rate. Soviet-bloc countries, however, generally sell equipment for about half the "ruble price" if payment is in hard currency. This would make the oscilloscope competitively priced with U.S. instruments having comparable specifications. All dials on the

SPERRY RAND

Sperry Rand Corporation has solved a unique oscillator application problem for multi-mode radars on the RF-4C and the A-7A. Texas Instruments Incorporated, prime contractor for both radar systems, needed a dual function tube — one which could serve as local oscillator in the radar, and would also work in the test and check-out circuit.

Sperry suggested the SRU-2161, and tests proved they were right. Today every AN/APQ-99 (for the RF-4C) and AN/APQ-116 (for the A-7A) system carries two of these Sperry reflex klystron oscillators.

The SRU-2161 delivers 50 mW at Ku band, while operating from a 300 V power supply. Since the oscillator has Sperry's unique adjustable reflector voltage, both tubes in the system can be driven from a single power supply. Mode shapes can be controlled to comply with the exacting tolerances of both systems.

If you need unusual performance from klystron oscillators, Sperry is the place to look. Contact your Cain & Co. representative, or write Sperry Electronic Tube Division, Sperry Rand Corporation, Gainesville, Florida 32601.

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MICROWAVE ELECTRONICS AND ELECTRONIC TUBE DIVISIONS
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Why multi-mode radars for RF-4C and A-7A depend on dual-purpose oscillators from Sperry... the first name in microwaves.

Circle 187 on reader service card

... Tunnel diodes trigger to 100 Mhz ...

instrument are labeled in English.

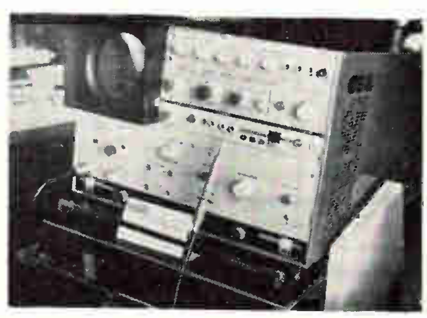
Easy to use. The scope provides a 60-megahertz bandwidth at sensitivity of 50 millivolts per centimeter. Tunnel-diode circuitry permits triggering to 100 Mhz. No stability control is necessary, and a beam-finder that automatically locates an off-screen spot is simple enough to be used by inexperienced operators.

Horizontal sensitivity, with bandwidth from d-c to 2 Mhz, is in three ranges: 0.3 volt per centimeter, 1 volt, and 10 volts. Time markers are provided for 5 and 20 nsec, accurate to +2%.

The vertical amplifier's bandwidth is reduced to 40 Mhz when the magnification is increased to 10:1. Rise time is 6 nsec at 1:1 and 9 nsec at 10:1. The signal delay of the main vertical amplifier is 150 μsec. Sensitivity is 50 millivolts per centimeter to 20 v/cm in sequence 1, 2 and 5 (1:1), or 5 mv/cm to 2 v/cm in 1, 2 and 5 sequence (10:1).

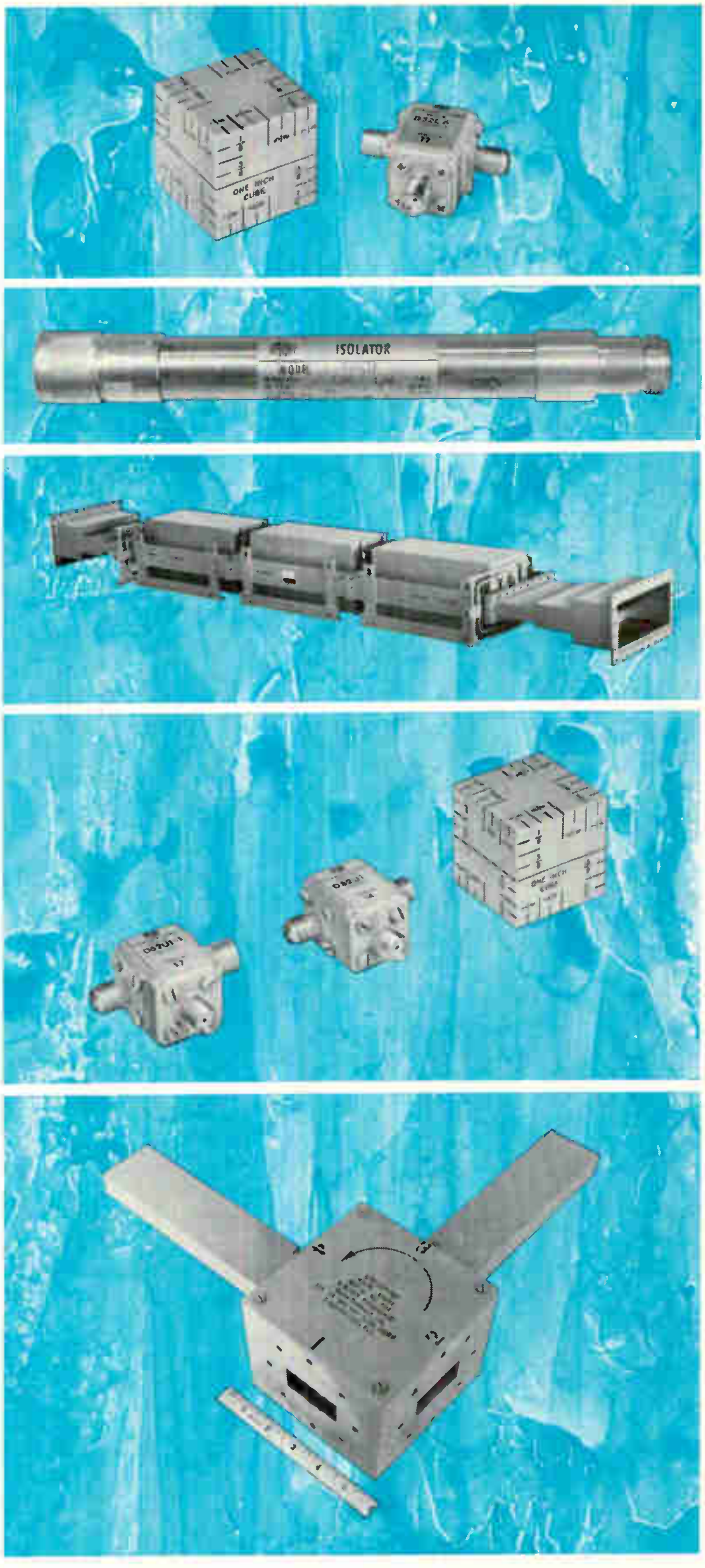
Calibration is by square wave of 1, 10 or 100 volts, with accuracy of ±2%. The oscilloscope measures 13 by 19 by 28 inches, and weighs 95 pounds without plug-ins.

At a recent exhibition of electronic and nuclear instruments at Dubna, the Polish trade agency also showed a few fully-transistorized instruments, including a stabilized power supply for general laboratory use where low-voltage, high-current-supply circuits are required. This instrument, labeled simply Type 204, operates at 3 amperes from 0 to 32 volts with remote-control capability. Output voltage is variable in steps of 0.1 volt.



Warsaw entry. All dials on Polish oscilloscope are labeled in English.

SPERRY RAND



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New Subassemblies Review

Combination timer/counter CT101 is designed for use on machine and process control panels, and eliminates the need for separate or outboard mounts. It accepts up to 30,000 counts per sec. Intervals from 10 msec to 9.99 sec, in 10-msec increments, can be timed with ±0.01-sec accuracy. Reset time is 8 msec. Eagle Signal Division, E.W. Bliss Co., 736 Federal St., Davenport, Iowa. [381]

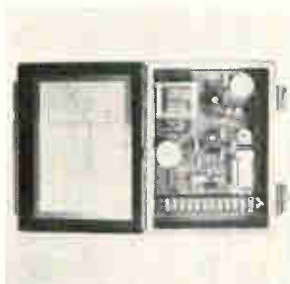
Sine-wave modulator model 152 offers proportional d-c to a-c conversion with 0.1% linearity. It accepts −7 to +7 v d-c input and provides a 0 to 1 v rms output into a 50-kilohm load. The unit drifts only 1 mv max. and has a gain stability of ±3%. Operating temperature is −55° to +85°C. Price is $120. Transmagnetics Inc., 134-25 Northern Blvd., Flushing, N. Y. [382]

Hybrid d-c voltage regulators models 802 and 804 are short-circuit proof and externally adjustable from 9 to 21 v and 20 to 32 v respectively. Output regulation is ±0.05% for line and load variations. Load current is ½ amp. Power rating is 1.8 w at +25°C. Operating temperature is −55° to +125°C. Beckman Instruments Inc., 2500 Harbor Blvd., Fullerton, Calif. [383]

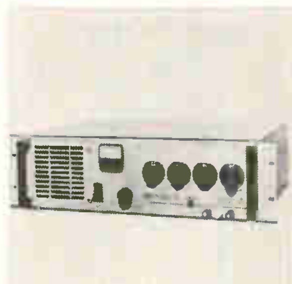
Multiplexer Mark 81, for use with general-purpose video sweep generators, allows increased usage of existing equipment in the adjustment of tv systems. It adds EIA tv sync pulses to the output of video sweeping oscillators. Output is a test signal in tv format for measuring response of video amplifiers. Price is $390. Ball Bros. Research Corp., Box 1062, Boulder, Colo. [384]

Crowbar-type overvoltage protector model OVP-1, connected across the d-c output of a power supply prevents damage to the load caused by excessive voltage. It features dual voltage ranges, 3 to 24 v and 24 to 45 v, both adjustable. Continuous rating is 12 amps with heat sink, 2 amps in free air. Response time is 3 μsec. Power Mate Corp., 163 Clay St., Hackensack, N.J. [385]

Regulated, 10-kv to 30-kv d-c power supply model 1579 furnishes low-noise and corona-free voltages for operating character generator or display crt's, photomultiplier tubes, and similar devices. Output current is 1 ma max. Regulation is 0.0025% for line or load variations. Ripple is less than 250 mv. Price is $2,250. Power Designs Inc., 1700 Shames Dr., Westbury, N.Y. [386]



Millivolt to current converter series MAS100 is a magnetic-transistor amplifier that converts input signal spans ranging from 2 to 50 mv into output current ranges of 1 to 5, 4 to 20, or 10 to 50 ma. Accuracy is 0.1%; repeatibility, 0.01% of span; linearity (d-c input/output), 0.05%; dead band, 0.1% of span. Airpax Electronics Inc., P.O. Box 8488, Fort Lauderdale, Fla. [387]

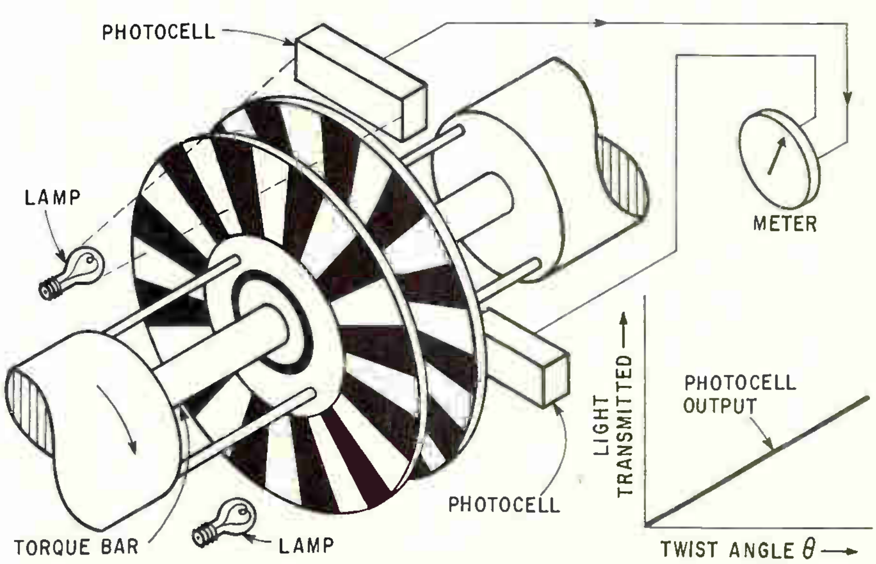


Precision a-c power source model 150 has an output of 0 to 150 v-a, 2 or 3 phase. The amplifier unit accepts any of 40 standard plug-in oscillators with fixed or variable output frequencies from 45 hz to 10 khz. Accuracies range from ±0.1% to ±0.0001%. The unit measures 5¼ x 19 x 14½ in. Weight is approximately 50 lbs. Elgar Corp., 8046 Engineer Rd., San Diego, Calif. [388]

New subassemblies

New twist on light

Torque transducer uses photocells as sensors



When the Vibrac Corp. started manufacturing magnetic parts for breaks and clutches used in small servosystems, it found that none of the available torque transducers could test its products.

Strain-gage units couldn't be used because the slip rings needed

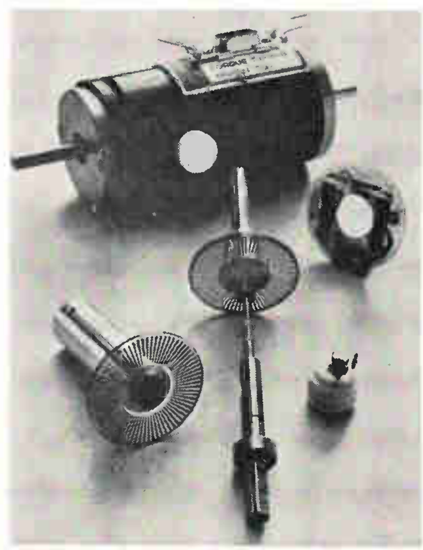
. . . twisting shaft changes light output . . .

to transmit the signal produced too much noise; magnetic transducers proved ineffective because they had a limited frequency response; and digital-optical sensors wouldn't work because they had to be used with constant-speed motors. "We were forced to design a new type transducer so we could test what we were making," says Roger Foskett, Vibrac's chief engineer.

The result is a simple optical test system that can also be used as a sensor for both on-line process control and system analysis. Designated the model TQ torque-measuring system, it senses the amount of transmitted light and records this on a meter.

Two discs, having alternating transparent and opaque sections, are mounted on a shaft. On one side of the discs there are two lamps; on the other side, two silicon photocells, which are connected to a meter.

Reading change. When no torque is applied to the shaft, half the light is transmitted to the cells. When the shaft is rotated, either more or less light is transmitted—depending on the direction of rotation. This changes the photocells' output and, thus, changes the meter reading. Since the no-torque reading corresponds to 50% transmission, the unit is operating in the linear portion of the photocells and



Slotted discs. Transducer, because of its simple construction, requires only one adjustment for calibration.

is accurate to 0.5% of full scale.

The transducer can also be used in liquid-process control by attaching a propeller to one side of the device and a motor to the other side. When the propeller is immersed in a liquid, the viscosity of the liquid can be determined. And since the output is a d-c voltage proportional to torque (or viscosity), it can be connected directly to a computer.

The complete measuring system—including transducer, display meter, power supply, and cables—is priced at $745 for torque ranges of 10, 32, and 100 ounce-inches. The transducer is also available separately for $450.

Specifications

Resonant frequency	700 hz
Stiffness	2,900 oz-in./radian
Overall moment of inertia	1.5 x 10^{-5} oz-in.-sec^2
Linearity	0.5% of full scale
Repeatability	0.25% of full scale
Speed range	0 to 8,000 rpm
Max. torque overload	100%
Output at rated torque	±100 μa
Load resistance	500 ohms max.
Shaft twist at rated torque	0.6°
Lamp life	4,000 hrs

Vibrac Corp., Alpha Industrial Park, Chelmsford, Mass. **[389]**

New subassemblies

Fuel cells go down to the sea

Air-alcohol device powers a lighthouse off Japanese coast

Engineers at one Japanese company are preoccupied these days with the production of electricity without conventional generators. First, Matsushita came out with a new solar cell [Electronics, Sept. 18, p. 196], now it has introduced a commercial fuel cell.

Remote power sources are not in great demand in Japan. The country is small enough to run commercial power lines to almost any location. And where power lines can't be used, solar cells can. But an unusual situation developed when a power source was needed

. . . conversion efficiency is about 75% . . .

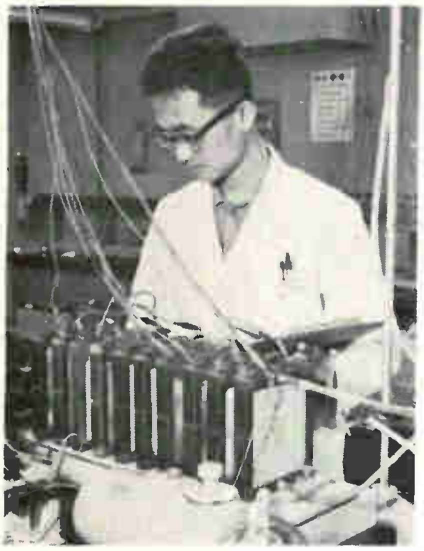
for a lighthouse in northern Japan. Power lines were not available and there wasn't enough sunlight to keep solar cells going. The fuel cell was a natural alternative.

Many types of fuel cells have been developed, but few units have been put to practical use. The most common type is the hydrogen fuel cell that has been used in the U.S. space program, but it has drawbacks. Hydrogen is expensive and there is the ever-present danger of explosion. Its principal asset is its conversion efficiency—about 85%. Matsushita's fuel cell uses a mixture of air and alcohol which is safe, inexpensive, and has an efficiency of about 75%.

Operation. Constant quantities of liquid methyl alcohol and air are fed to the fuel cell by a pump, which derives its power from the device. Ten cells are connected in series to form a block, and each cell has an output of 0.2 volt. The complete power supply consists of six blocks for a total output of 12 volts. This is fed to a chopper-type voltage regulator that keeps the output constant regardless of temperature changes. Total output power is 25 watts. The cell operates 24 hours a day charging a 48 amp-hour battery that is connected to the lighthouse beacon by a daylight switch. Initial tests indicate that the lighthouse can operate for a period of one year without refueling.

Chemistry. A single cell is composed of two chambers, one inside

On the water. Fuel cells are in the base of the lighthouse.



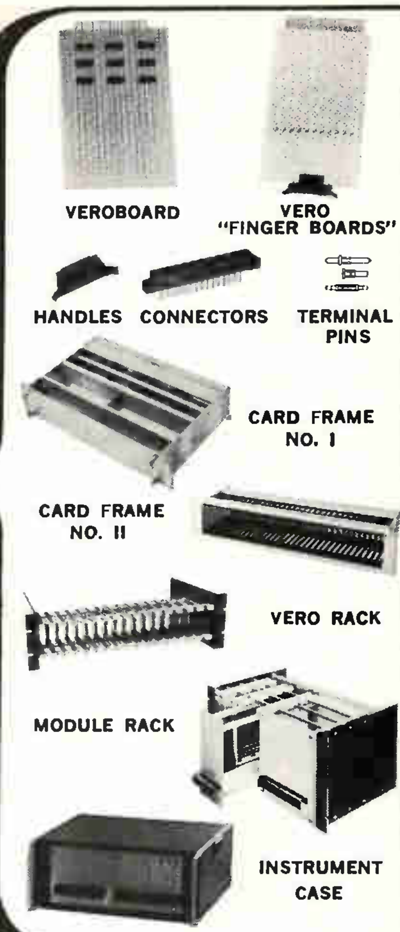
Bench model. Individual cells are series-connected providing 12 volts.

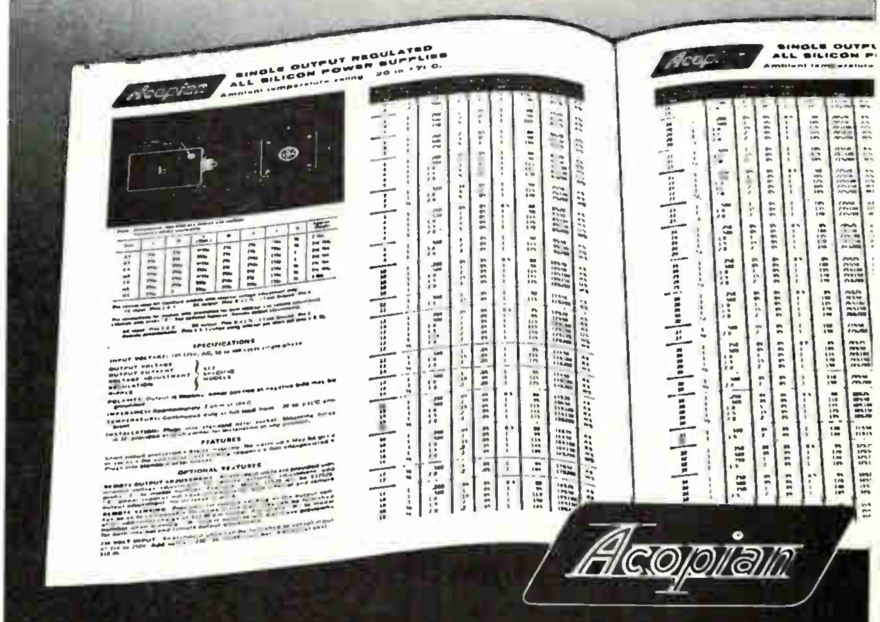
the other, separated by a layer of caustic potash. Air is pumped to the outer chamber while alcohol is fed to the inner one. A reaction takes place on the potash, and this produces water, potassium carbonate, and a flow of electrons.

The lighthouse, according to the U.S. Navy Hydrographic Office ocean charts, must be visible for eight miles in heavy fog or in clear weather. To achieve sufficient brightness from a 25-watt power supply, seems an impossible feat. Since common incandescent light sources couldn't be used because of their low efficiency, Matsushita engineers were left with the choice of either a quartz-iodide lamp or a xenon flash tube. The quartz-iodide lamp, even though it could supply the required brightness, was ruled out because it couldn't be turned off fast enough for the flashing beacon—the lamp takes too long to cool off. The xenon flash tube, because it is fired by a charged capacitor, can be triggered rapidly and runs cooler, therefore it was chosen. As a bonus—because the xenon works on a pulse principle—the battery has enough time between flashes to build up a sufficient charge to restore the capacitor.

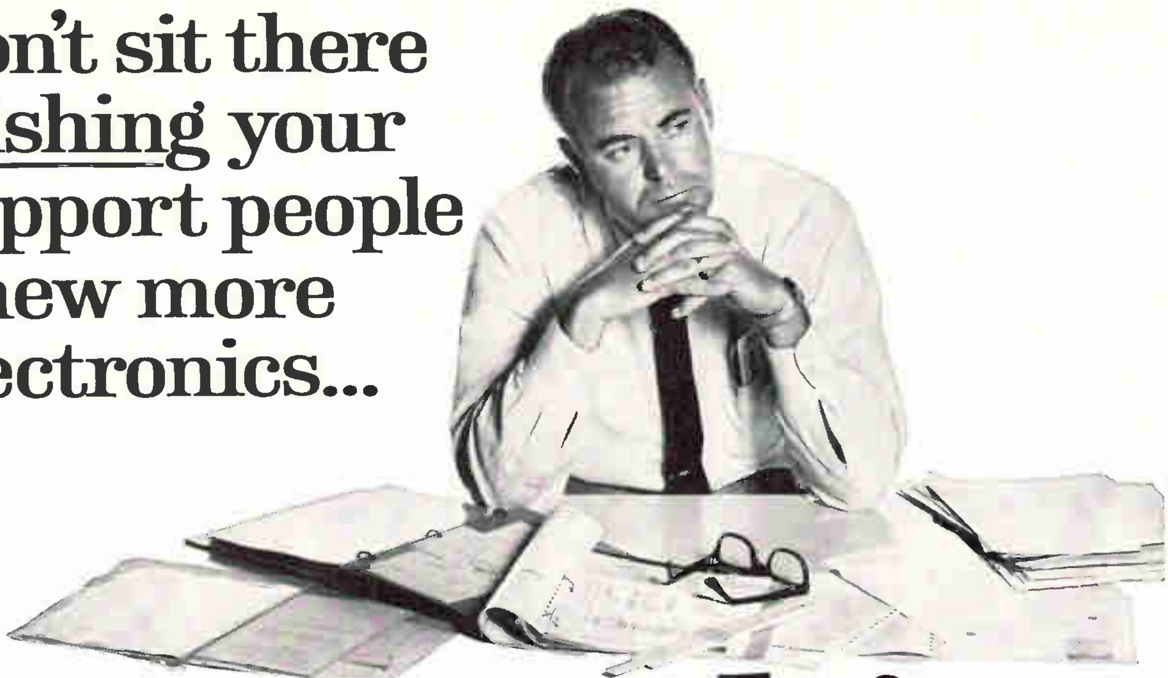
Matsushita engineers see large-scale applications for fuel cells after further development. These include operatorless satellite stations and portable communication devices.

Matsushita Electric Industrial Co., Tokyo [390]





Don't sit there <u>wishing</u> your support people knew more electronics...



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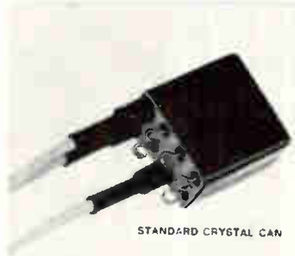
(Not enough room? Attach sheet of paper with additional names and addresses)

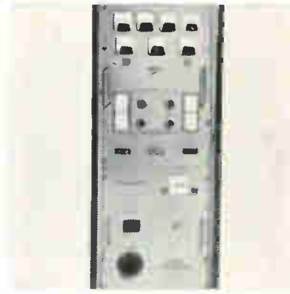
New Microwave Review

Pill terminations for stripline have built-in spring contacts that automatically compensate for variations in ground plane spacing. Units are designed for 1/8 and 1/4 in. spacings. Models rated at 1 w and 3 w are available with vswr of 1.1 max. (d-c to 4 Ghz), 1.25 max. (4 to 8 Ghz), and 1.35 max. (8 to 12 Ghz). Prices start at $4.50. EMC Technology Inc., 1133 Arch St., Philadelphia. [401]

Solenoid operated, waveguide switches type GH, covering 7 to 18 Ghz, are available in WR-62, WR-90, WR-102, and WR-112. Vswr is 1.1:1; isolation, 60 db minimum; insertion loss, 0.2 db max; operating temperature, −54° to +100°C. The GH is pressurized and has an antibounce braking device. Weight is 1.25 to 2.5 lbs. Transco Products Inc., 4241 Glencoe Ave., Venice, Calif. [402]



A miniature coaxial relay line is suitable as an antenna switch or channel selector in communications and radar equipment. The basic relay meets requirements of MIL-R-5757. Usable frequency range up to 1 Ghz. Standard units have a 50-ohm impedance with vswr of 1.15:1 max., insertion loss of 0.4 db max., and isolation of −40 db min. Hi-G Inc., Windsor Locks, Conn. [403]



Klystron 1,000-w c-w amplifier systems have applications in mobile or transportable tropospheric forward scatter communications and in radar equipment. Ten individual systems cover frequency increments from 1.7 to 18 Ghz. Vswr is 2:1 max, output load; 1.1:1 max, input circuit. Microwave Cavity Laboratories Inc., 10 North Beach Ave., LaGrange, Ill. 60525. [404]

Miniature circulator model J-8689 operates at 555 Mhz. It has no more than 0.5 db of insertion loss and provides at least 20 db of isolation over its 33-Mhz bandwidth. Max. vswr is 1.25, and the unit handles 10 w. Size, excluding connectors, is 1 1/8 x 1 5/8 in. Weight is approximately 1 3/4 oz. Melabs, 3300 Hillview Ave., Stanford Industrial Park, Palo Alto, Calif. [405]

Solid state local oscillator MA-82X15 for X-band radar systems operates in the 9.2-Ghz range with an output of 10 mw minimum, 20 mw typical. It is tunable both mechanically and electrically, with a range of ±25 Mhz and ±50 Mhz, respectively. Tuning sensitivity is 50 Mhz/v max., reduceable by adjusting input impedance. Microwave Associates Inc., Burlington, Mass. [406]

Waveguide junction circulator model CKuM7 is designed to operate at a peak power of 50 kw at a frequency of 16.6 to 17.1 Ghz. Average operating power is 50 w. The circulator achieves a min. isolation of 12 db and a max. insertion loss of 0.4 db. Max. vswr is 1.20:1. Cooling is not required. The unit weighs 5 oz. Raytheon Co., 130 Second Ave., Waltham, Mass. [407]

Microline model 6235 slotted line is designed for precise measurements of the impedance, vswr, and reflection coefficient of distributed and lumped elements at r-f frequencies from 395 Mhz to 8.5 Ghz. It has a characteristic impedance of 50 ohms, ±0.1%, and meets requirements for testing of advanced coaxial systems. Narda Microwave Corp., Plainview, N.Y. 11803. [408]

New microwave

Receiver in splendid isolation

Radar protector handles 20 kilowatts with insertion loss of only 0.3 decibels

Every time a radar transmitter sends out a pulse, some of its power is reflected back from the antenna feed and, if not stopped, may enter the receiver and burn it out. The radar engineer's solution to this problem is the limiter, or receiver protector—a device inserted in the transmission line between the antenna and the receiver.

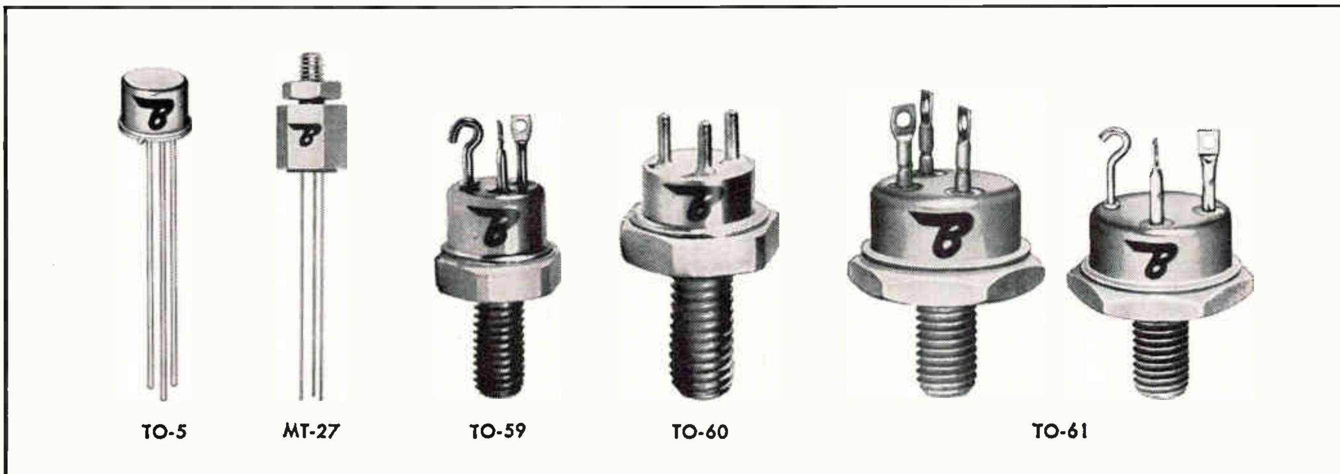
A perfect protector would stop all unwanted power during transmission, then switch to a wide-open state during the system's receive cycle, allowing as much power as possible to enter the detector. Just as high isolation is needed to protect the receiver, low insertion loss is required to keep system noise low and allow the receiver its maximum sensitivity.

Now, Microwave Associates Inc., Burlington, Mass., has produced a solid state, coaxial protector that handles 20-kilowatt, 10-microsecond pulses—isolating the receiver by some 100 decibels. Its insertion loss is only about 0.3 db across a frequency range of 400 to 1,100 megahertz—more than an octave.

The company developed the protector for the Jet Propulsion Laboratory of the California Institute of Technology, which will use it in a

Would radiation-resistant transistors, with predictable minimum changes in gain, simplify your circuit design problem?

Consider it simplified.

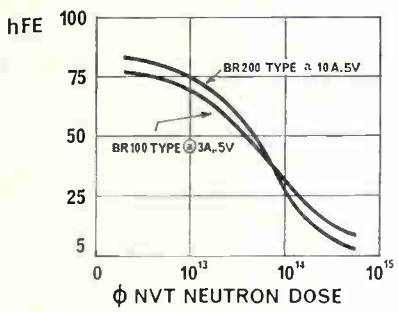


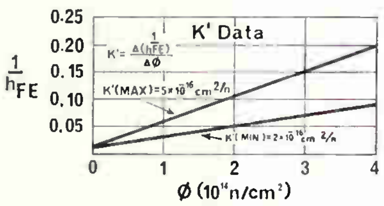
Minimum gain change *and* predictable gain change. Bendix has teamed these two unique features in the vital power transistor to bring you far easier circuit design. How? Bendix radiation-resistant, silicon power transistors boast base widths of 0.6 microns and superior process techniques with large area devices. More important, from the designer's view, the Bendix approach permits you to predict post-radiation gain of power transistors with VCEO's ranging from 40 to 100 volts and maximum current levels of 5, 10 and 25 amps. Exposure levels? You name them and we'll provide superior performance.

The prediction technique is as simple as $\Delta \frac{1}{h_{FE}} = K'\emptyset$. Here K′ equals a function of base-width transit time and device material. Ø is equal to the level of exposure. Note that K′ values for Bendix radiation-resistant types are specified at the right. Armed with this knowledge, you can design the circuit for optimum pre-radiation and post-radiation performance.

Now consider our credentials. Bendix is the leader in the field of radiation-resistant power transistors. We offer you 16 different types, six different packages, too: TO-5, MT-27, TO-59, TO-60, TO-61 collector-to-case and TO-61 isolated. Like more information? Just contact Bendix Semiconductor Division, Holmdel, New Jersey, and inquire about the BR100 and BR200 series of transistors.

Bendix Electronics





. . . unwanted power is reflected to antenna . . .

radar-equipped sounding rocket.

Never before. The designer, project engineer Paul Basken, says that the company has never before produced a solid state limiter with such a combination of bandwidth, power handling, and low loss. Solid state techniques had to be used, he says, because of the scarcity of reliable coaxial transmit-receive tubes. While most high-power limiters use these gas discharge devices, Microwave Associates' uses none, thus reducing size and weight, and adding ruggedness. Basken says that other protectors for this frequency range are from 10 to 100 times bigger than his company's 5-inch long, 5-ounce device. And even then, their power handling capabilities are limited to peaks of about 500 watts, he says.

Designated MA 8307-1L3S, the protector is a diode switch which shorts out the transmission line in response to a triggering signal from the transmitter. Unwanted power is reflected to antenna.

Limiting connectors. By dividing the switched energy among the nine high-power diodes, the limiter can handle the required power levels—in fact, power handling is limited only by the coaxial connector used. Large connectors like the HN and SC types allow utilization of the 20-kw peak power capability; with smaller connectors such as the type N, Basken recommends limiting power to about half that.

Isolation may even be better than 100 db—the company's test equipment won't permit reliable measurement beyond this point. Basken says that computer estimates show that the protector should be able to reach about 105 db.

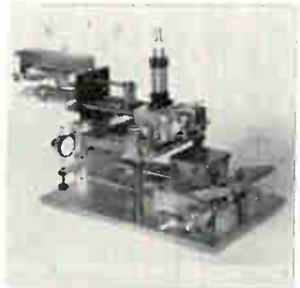
Specifications

Frequency range	400-1100Mhz
Power handling	20 kw peak, 50 w average
Isolation (typical)	about 100 db
Insertion loss in receive state	less than 0.3 db
Switching time	about 1μsec.
Vswr	less than 1.3:1
Operating temperature range	—60 to +100°C
Shock	100 G for 10 msec.
Vibration	10G, 20 hz to 2 khz
Acceleration	15 G for 15 msec.
Price	$850
Delivery	60 days

Microwave Associates Inc., South Avenue, Burlington, Mass. [409]

Dynamil 50 is a table model precision chemical etcher for lab and experimental etching, and for fabricating production quantities of thick-film masks. It etches workpieces up to 6 x 6 in. to 1 mil line/mil space tolerance with the VRP (vertical rotary planetary) spray-etching method. Weight is 40 lbs. Price is $995. Western Technology Inc., 220 W. Central Ave., Santa Ana, Calif. [421]

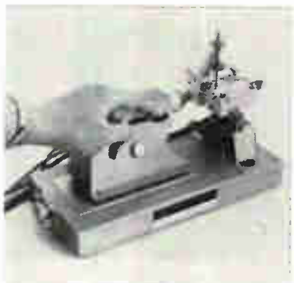
Series TT-X wave soldering system automatically processes p-c boards down to 1/32 in. thick, components, and other equipment. The solder module provides a standing fountain of solder that is 1⅛ in. deep. The length of the wave can be 14 in. or longer, while the 4-in. width helps eliminate solder icicles and bridging. Hollis Engineering Inc., Nashua, N.H. 03060. [422]



Screen printer model 100, for IC production, has a hand-operated carriage and adjustable squeegee travel time. It uses a 5 x 5 in. screen and accommodates substrates up to 3 x 3 in. Micrometer-type adjustments provide accurate x, y, z, orientation of the screen to the part. Controls can be mounted on or under the table. Precision Systems Co., Box 148, Somerville, N.J. [423]

Micro-Bonder model 95002 automatically places and bonds semiconductor flip-chip elements to substrate IC's. Elements include a numerically controlled table, control logic electronics, a bonding transducer, and an automatic vacuum pencil transfer mechanism that is fed from one of three magazines. It handles 1,000 flip-chips per hour. Bulova Watch Co., Valley Stream, N.Y. [424]

A production-research oven has an operating range to 650°F and solid state controls with ±½°F sensitivity. The horizontal-air-flow, forced convection unit was originally designed for the use of IC manufacturers. Front-mounted controls allow independent adjustment for both fresh air intake and exhaust to 30 cfm. Despatch Oven Co., 619 S.E. Eighth St., Minneapolis 55414. [425]



Bench fixture model 720, for use with the company's arc percussion welding system, has an automatic gap setting mechanism that allows up to 6 times as many welds per minute as previously possible. With a weld schedule established, materials to be joined need only to be placed in the fixture and the switch activated. Butt and other welds can be made. Sippican Corp., Mattapoisett, Mass. [426]

Resistance trimmer RU-1, for thick- and thin-film units, avoids the hazardous and cumbersome exhaust system of the abrasive dust method. It removes material by ultrasonically vibrating a diamond tip. The substrate is moved in the x or y direction automatically. Probes connect the resistor to a bridge circuit. Desired resistance is preset. Axion Corp., 6 Commerce Park, Danbury, Conn. [427]

Drilling machine PCB has 4 spindles that simultaneously produce stacks af identical p-c boards. Infinitely adjustable hydraulic feed is pressure balanced to eliminate burrs and assure true holes. Positioning and drilling are tape controlled. Model 20 is for holes up to 16 x 20 in.; model 12, for 16 x 12 in. Leland-Gifford Co., 1001 Southbridge St., Worcester, Mass. [428]

New production equipment

Tailor-made windings for precision pots

Variation in resistance winding pitch can be introduced into control system by photoelectric scan of Mylar chart

Only two machines in this country can automatically wind potentiometers whose pitch—and therefore function—is accurate to within 0.01%, says David Rathje, president of Solatron Enterprises.

One was designed and built at Litton Precision Products Inc.'s Potentiometer division to make windings for precision pots used in such applications as inertial guidance systems. The other, says Rathje, was made by his company for TIC of California, a subsidiary of the Bowmar Instrument Corp.

Solatron's machine has a photoelectric curve follower and a feedback control system that can introduce nonlinear functions during winding of custom pots. The machine has been operating sucessfully at TIC for six months, and Solatron is now offering comparable machines to other companies that want to wind their own precision pots. But they'll have to wait six months for delivery and pay upwards of $22,000.

"In this business," Rathje says in explaining the long delivery time, "you have to be sure of a customer before you start making the machine."

Feedback control. The winding

Who's crazy enough to tear down and rebuild $100,000 worth of machinery just to turn out an 18-inch spherical commutator?

Some company called Poly-Scientific.

Sometimes we get pretty strange projects in the house. But we find a way to deliver—even if it means busting up our own expensive equipment to do it. And that's just what we did for a Navy job.

An 18-inch spherical sonar device required 53 concentric circles machined on its hand polished, three-microinch finish, silver contact surface. It then had to be quartered into 212 segments. Angular tolerance of segments .00025 inches.

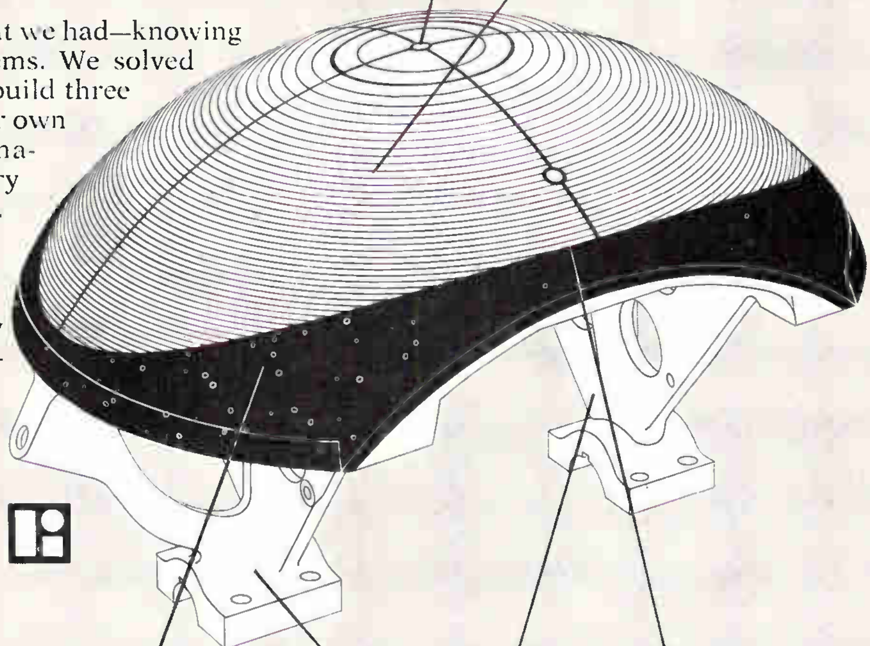
Tough enough order. But with one additional catch: the Navy wanted it in a rush—there wasn't time to test new materials or new processes.

This meant we had to do with what we had—knowing there'd be warping and stress problems. We solved them. But we had to tear down and rebuild three machine lathes, design and develop our own feeds, cutting heads and bonding materials to do it. What's more, delivery was made in less time than promised.

It's been seven years since the first unit was installed in one of our nuclear subs. And it's still there. How satisfied was the Navy? Well, today Poly-Sci is still making these devices—and other, more sophisticated ones.

Care to have a crazy company like this working for you?

POLY-SCIENTIFIC
A DIVISION OF LITTON INDUSTRIES



... simple chart plots custom windings ...

lathe's accuracy can be attributed to an improved control system that Solatron had devised several years ago for a $50,000 winder [Electronics, Nov. 8, 1963, p. 80]. Besides cutting the price in half—partly by eliminating some special equipment in the old machine—the firm doubled accuracy. The older machine achieved a resolution of 0.015% to 0.02% in a 40-inch winding with a nominal pitch of 0.003 inch, compared with the new equipment's accuracy of 0.01%.

When linear windings are being made, the function generator is a slidewire potentiometer in the bed of the machine. Its linearity is better than 0.003%. A constant voltage is applied to the master potentiometer and a constant current is applied to the winding being made. The voltages generated by each are continuously compared. Any variation in the winding resistance from the desired value is immediately corrected by a servosystem that drives the lead screw of the winding lathe to vary the pitch of the winding.

Photoelectric follower. If a nonlinear function is desired—that is, a variation in the winding pitch—a difference function is plotted in rectangular coordinates on a Mylar chart. A photoelectric line follower reads the chart. The motion of the follower is converted to an output that is summed with the voltage from the slidewire. Then, the feedback system controls the winding machine to reproduce the nonlinearity in the winding.

Custom windings are easily prepared with this technique, Rathje says. "You just put the Mylar sheet on a drafting table and plot the difference function. It's an engineering design job instead of a time-consuming machining job, like making a special cam."

For greater flexibility in potentiometer slope ratios, the machine can be fitted with multiple de-reeling devices. Cuts can then be made in the main resistance wire and welded insert wires used to raise or lower the resistivities of selected sections of the winding.

Solatron Enterprises, 4079 Glencoe Ave., Venice, Calif. 90291 [429]

New Books

Off balance

Residue Arithmetic and Its Applications to Computer Technology
Nicholas S. Szabo and Richard I. Tanaka
McGraw-Hill Book Co., 223 pp., $12.50

The authors have performed a valuable service with this book, the first in its field. They have surveyed magazines and journals and assembled an excellent list of references. However, in covering both residue-class arithmetic and its computer applications, they have tried to satisfy the divergent interests of two types of readers—mathematicians and engineers—and the task appears to have been too formidable.

The application of residue-class arithmetic to computer technology has been highly specialized. Operations such as general division, relative magnitute determination, and sign detection are still difficult to build into hardware that would be competitive with the equipment used for similar operations with ordered number systems, such as binary.

The book won't improve this situation, as it's strongly slanted toward theory at the expense of applications. The number theorist will undoubtedly say that the treatment of applications is fascinating, but the theoretical discussions are too elementary. The computer engineer, though, would probably find the applications oversimplified and the theory interesting, but with too few specific examples and too many formal mathematical proofs.

My personal preference would have been for shorter mathematical sections aimed at quickly giving the reader a working understanding of residue arithmetic. The major part of the book then could have been devoted to a description and evaluation of applications.

The best thing in the book is a description of the use of residue-class techniques for error checking. The most disturbing thing is the lack of good explanations of the many tables included.

H. Fleisher
International Business Machines Corp.
Poughkeepsie, N.Y.

Basically complex

Integrated Electronics
K.J. Dean
Chapman and Hall Ltd., 132 pp., $5.25

Too much and too little perhaps best describes K. J. Dean's "Integrated Electronics." For engineers with little knowledge of integrated circuits, the book may be too weighty. But for engineers working in this area, it may be too basic.

Although the author's knowledge of thin films, field effect transistors, digital and linear IC's is beyond question, his treatment of the material isn't. The section on linear ampifiers, for example, is too shallow to give an engineer even a start in applying such circuits. Then, too, because of its detail, the section doesn't invite casual reading.

Dean fares better in his chapter on logic circuits, which covers such schemes as diode-transistor-logic, transistor-transistor-logic, and current-mode-logic. It provides a fairly comprehensive discussion of the merits and problems of each circuit type. Although the engineer who must actually choose between these circuits will have to dig much deeper, this discussion will start him off in the right direction.

In the section on silicon diffusion, the author presents an excellent discussion of the techniques involved. Of particular interest to those working with IC's, the chapter can also benefit other engineers.

But the chapter on application of bistable elements quickly becomes so enmeshed in logic-design methods that few engineers would read it for a quick overview of the field. In fact, one wonders whether a quick overview of logic design would be of any use at all. Those working in the field need far more information than is presented, while those outside the field have little interest in it.

Recently published

Analysis and Design of Integrated Circuits, Engineering Staff of Motorola Inc., McGraw-Hill Book Co., 539 pp., $16.50

Intended as a companion piece to Motorola's earlier volume on IC's, this book deals with the steps involved in choosing a circuit configuration and completing the design. It also contains a comparison of the four basic

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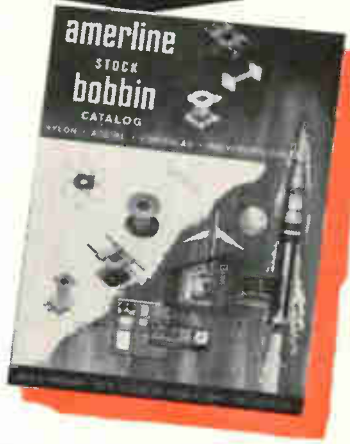

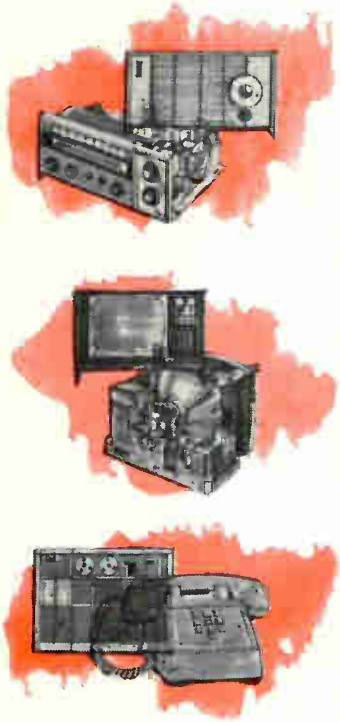

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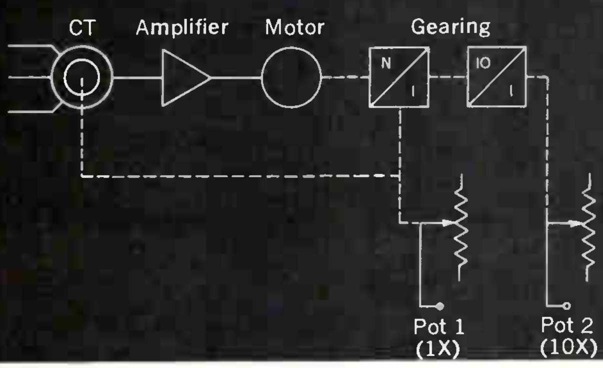

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This customer's application required a 400-cycle synchro converter that would provide DC inputs to a flight test recorder. Mechanical design was critical, since the assembly had to fit an existing aircraft system, include calibration checking facilities, and provide for a digital output to be added later. ☐ To solve the problem Transicoil designed this unit with a switch-actuated calibration referencing circuit plus provision for later addition of a size 11 digital shaft encoder. ☐ Synchro data to the CT produces an error signal which is amplified and applied to the servomotor. This signal drives the system into agreement with a remote transmitter, and positions the output potentiometers as well.

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New Books

types of logic circuits as well as design techniques for linear IC's.

Electronic Circuit Analysis, Vol. 2, Phillip Cutler, McGraw-Hill Book Co., 618 pp., $10

This volume, an undergraduate text, stresses the development and application of equivalent circuits to basic amplifiers, four-terminal networks, feedback circuits, and rectifiers. Many illustrative problems demonstrate practical applications.

VLF Radio Engineering, A.D. Watt, Pergamon Press Inc., 700 pp., $20

Offering the practicing engineer a detailed coverage of very-low-frequency radio, the book includes a compendium of basic antenna, propagation, and system information. It also deals with practical considerations, such as atmospheric noise, selection of transmitting and receiving antennas, and economic factors.

Universal Tables for Magnetic Fields of Filamentary and Distributed Circular Currents, Philip J. Hart, Elsevier Publishing Co., 489 pp., $19

This rather specialized work minimizes the time and effort required in making magnetic-field determinations. It presents a new method of calculation based on a simple arithmetic operation.

Prediction Analysis, John R. Wolberg, D. Van Nostrand Co., 291 pp., $10.95

Providing a basis on which to predict the standard deviation of the results of an experiment, the book is based on the least-squares method of data analysis. It also supplies the necessary background material in mathematics and statistics.

Thermoelectric and Thermodynamic Effects and Applications, T.C. Harman and J.M. Honig, McGraw-Hill Book Co., 370 pp., $17.50

This book is directed at the scientist and engineer involved in thermoelectric and thermomagnetic effects. It covers the theory of such effects on metals, semimetals or semiconductors subjected to electric, magnetic, and temperature fields. It also includes a detailed presentation of the energy conversion processes.

Analysis and Design of Transistor Circuits, L.G. Cowles, D. Van Nostrand Co., 309 pp., $9.75

Primarily concerned with practical design, this book includes charts, formulas, tables, and design data for transistor circuits. Special attention is given to thermal runaway and to field effect transistors.

Handbook of Numerical Methods and Applications, Louis G. Kelly, Addison-Wesley Publishing Co., 354 pp., $14.50

The volume is designed as a handbook and reference for engineers and scientists programing their own computer problems. A great deal of the material included on numerical methods could only be found previously in many different books.

Handbook of Tables for Mathematics, third edition, Robert C. Weast and Samuel M. Selby, Editors, Chemical Rubber Co., 1,050 pp., $16

This edition is about 400 pages thicker than the preceding one. Material has been added on matrixes and determinants, Laplace and Fourier transforms, Gamma functions, Boolean algebra, and ordinary and partial differential equations.

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Technical Abstracts

Light conversation

A gallium-arsenide laser diode communicator

F. Terry Harris and
Donald P. Lubin, Radio Corp of America, Burlington, Mass.
Dainis Karlsons, Radio Corp. of America, Camden, N.J.

One deterrent to the use of the injection laser in a portable voice communication system has been power requirements. Now low-power switching circuitry appears to solve the problem. With two gallium-arsenide laser diodes producing outputs at invisible wavelengths for covert communications, the transmitter has a range up to two miles. It is adaptable to radar and ranging equipment.

The transmitter uses pulse frequency modulation by varying the drive circuit instead of relying on external optical modulation of the light beam. The laser diodes are low-threshold types—13 to 15 amps—and their output wavelength—0.9 microns—is near the response peak of the silicon photodiode detector in the receiver.

The laser diode switching circuit uses two silicon controlled rectifiers. The SCR's have different turn-on times so that the first fires about 400 nanoseconds before the second, and generates a high-current pulse by discharging a capacitor into the gate of the second SCR. The second, which starts to turn on just as the current hits it, discharges a capacitor through the two laser diodes—series-connected for higher outputs. The switches thus produce the needed high-current, narrow drive pulses—30 amperes, 50 nanoseconds.

Although the prototype was designed using SCR's, avalanche transistors with low series impedance would do a better job of reducing power requirements. However, turn-on time characteristics of available avalanche transistors vary too much.

Presented at the ISA Conference, Chicago, Sept. 11-14.

Sonic boon

Strain-sensitive thin magnetic films

L.S. Onyshkevych
RCA Laboratories, Princeton, N.J.

Thin magnetic films that react to ultrasonic pulses are the basis for a new digital memory that's small and reliable, and could replace bulky tapes and discs. During readout and write-in the ultrasonic pulses momentarily strain the magnetic film and change its magnetization.

The film, a nickel-iron-cobalt alloy, is vacuum-deposited on a glass slide while a strong magnetic film is applied to initially orient the film. An ultrasonic transducer, coupled to one edge of the slide, launches a wave into the glass when it is energized. The wave travels down the slide, straining

Technical Abstracts

film memory elements and causing magnetization to shift. The changing flux induces a voltage in the sense lines deposited over the film and provides a serial nondestructive readout.

Output signals are about 0.5 millivolts, about the same as in electrically addressed magnetic thin-film memories.

For write-in, the ultrasonic pulse momentarily reduces the switching threshold of the film, allowing an impressed magnetic field to set it in a particular direction of magnetization.

Goals of the project are to produce 100-million-bit memories with 10 nanosecond bit rates, although present, small-capacity models are about four times slower. Speed depends primarily on the spacing of the magnetic elements, since the ultrasonic wave travels at a constant speed. Present spacing, about 5 mils from element to element, must be wide enough to avoid interaction of the strains from bit to bit.

Presented at 1967 International Congress on Magnetism, Boston, Sept. 11-15.

One for the road . . .

An investigation of highway automation
R.E. Fenton, Ohio State University
R.L. Cosgriff, University of Kentucky
L.M. Blackwell, West Virginia Institute of Technology

More roads isn't the answer to the highway-safety problem. Nor is a less powerful auto engine. Perhaps the best hope lies in a completely automated vehicle.

Presently undergoing tests is a computer-guided auto that is automatically controlled in two modes: longitudinal, for acceleration and braking; and lateral, for steering. The automatic modes can be interchanged with manual control.

The longitudinal control maintains stability and proper spacing of the controlled auto with respect to the position of a vehicle ahead of it. When there are no other cars near the controlled vehicle, the vehicle moves at a speed chosen by the driver. Normal acceleration or deceleration is not allowed to exceed a gravitational force (g) of

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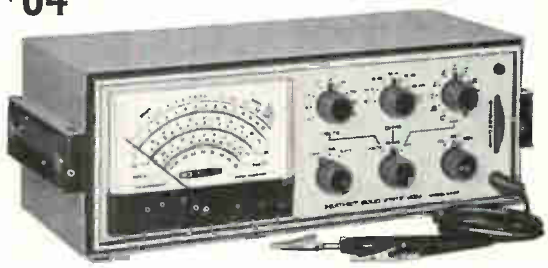

(B) Kit IM-25 $80.00
Wired IMW-25 $115.00

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Presented at the IEEE Automotive Conference, Detroit, Sept. 22-23.

. . . and one more

System for automatic vehicle control
J. Treiterer and R.M. Campbell
Ohio State University
Columbus, Ohio

Another method of automatic vehicle control that is under development uses an infrared source and a sensor to provide continuous information on the differential velocity and the distance between leading and trailing vehicles.

An infrared source, placed at the rear of a vehicle, produces a pulsed beam whose pulse frequency is a function of the vehicle speed. If the controlled vehicle is within 400 feet of the car ahead, it, by sensor, picks up the signal, locks on, and compares the leading vehicle's speed with its own. The speed difference is displayed on a meter in the controlled vehicle.

The intensity of the infrared signal from the preceding vehicle is measured to indicate the distance between the vehicles. This information also is displayed on the control panel.

No attempt was made to achieve fully automatic control of either the throttle or the brake by the infrared source-sensor system. The primary objective of the tests were to establish both the operating range and accuracy of the system.

Presented at the IEEE Automotive Conference, Detroit, Sept. 22-23.

New Literature

Barretter mount. Weinschel Engineering, Gaithersburg, Md., has published a data sheet on the model 926 barreter mount with built in noise suppressor.
Circle 446 on reader service card.

Synchros. Clifton Division of Litton Industries, Marple at Broadway, Clifton Heights, Pa. Bulletin 200 covers the size 8, five-minute Silverline synchros. **[447]**

Crimping tools. Buchanan Electrical Products Corp., 1065 Floral Ave., Union, N.J. 07083. Twenty-page catalog T-102A describes and illustrates a line of cycle-controlled crimping tools. **[448]**

IC reliability. Texas Instruments Incorporated, 13500 N. Central Expressway, Dallas. Bulletins SC-9999 and SC-10211 deal with the reliability of integrated circuits. **[449]**

Operational amplifiers. GPS Instrument Co., 188 Needham St., Newton, Mass. 02164, has issued a catalog listing specifications and prices for 12 operational amplifier types. **[450]**

Stainless alloy wire. Fort Wayne Metals Inc., 3211 MacArthur Dr., Fort Wayne, Ind. 46809, has published monograph No. 4 dealing with scientific, aerospace, and military applications for its precision stainless alloy wire. **[451]**

Silicon power modules. Electronic Research Associates Inc., 67 Sand Park Rd., Cedar Grove, N.J. 07009. Catalog 145A is a four-page technical bulletin-catalog describing a line of silicon military-specification power modules. **[452]**

Crt catalog. Thomas Electronics Inc., 100 Riverview Dr., Wayne, N.J., announces a catalog containing specifications for a broad range of cathode-ray tubes and phosphor screens. **[453]**

Wirewound potentiometers. Continental-Wirt Electronics Corp., 26 W. Queen Lane, Philadelphia 19144. Bulletin 2080-67 covers a line of ¾-in.-diameter, 3-w variable wirewound potentiometers. **[454]**

Shield tubing. Magnetic Metals Co., 2106 Hayes Ave., Camden, N.J., offers a technical bulletin on high permeability, seamless welded 80% nickel-iron alloy tubing for low-frequency electromagnetic shielding. **[455]**

Laminar flow work stations. Edcraft Industries Inc., 620 Commerce Rd., Linden, N.J. 07036, has available literature describing the CHL series console type, laminar flow work stations. **[456]**

Ferrite core press. Computer Test Corp., 3 Computer Drive, Cherry Hill, N.J. 08034. The Multipak model 1104 ferrite core press is described in an illustrated 36-page instruction manual. **[457]**

Power supplies. Kepco Inc., 131-38 Sanford Ave., Flushing, N.Y. 11352. Catalog B-678 contains descriptive data on 22 power supply design groups. Included is a five-page glossary of terms employed in the data and applications sections. **[458]**

Precision potentiometers. Digilog Electronics Corp., P.O. Box 9368, Seattle, Wash. 98109, has available data sheets on single and multiturn precision pots, with illustrations, dimensions, specifications, and graphs of resolution vs total resistance and power rating vs ambient temperature. **[459]**

Gas lasers. Spectra-Physics Inc., 1255 Terra Bella Ave., Mountain View, Calif. 94040, offers a six-page, full-color catalog covering gas lasers and accessories. **[460]**

TTL IC's. Electronic Components Group, Sylvania Electric Products Inc., Seneca Falls, N.Y. 13148. A four-color mailing piece gives specifications for the entire SUHL I and II lines of TTL IC's. **[461]**

D-c tachometer. Helipot Division, Beckman Instruments Inc., 2500 Harbor Blvd., Fullerton, Calif. 92634. Data sheet 671129 describes the low-cost, temperature-compensated model 9011-2710-0 d-c tachometer. **[462]**

Modular products. Optical Electronics Inc., Box 11140, Tucson, Ariz. 85706, has released a 10-page catalog of modular products including operational amplifiers, linear amplifiers, analog function modules, and logarithmic amplifiers. **[463]**

Memory modules. Sealectro Corp., 225 Hoyt St., Mamaroneck, N.Y. 10543. Bulletin DT-28 covers the RZ-90 series of six memory modules employing magnetostrictive delay lines in the RZ mode. **[464]**

Semiconductor test systems. Fairchild Instrumentation Division, Fairchild Camera & Instrument Corp., 475 Ellis St., Mountain View, Calif. 94040. A 12-page brochure covers a line of solid state device test systems. **[465]**

Computer measuring system. Potter Instrument Co., 151 Sunnyside Blvd., Plainview, N.Y. 11803. A newly-designed model Picomm computer-driven coordinate measuring system is described in a six-page brochure. **[466]**

High-reliability resistors. Corning Glass Works, Raleigh, N.C. 27602. An eight-page illustrated brochure details the performance characteristics of four

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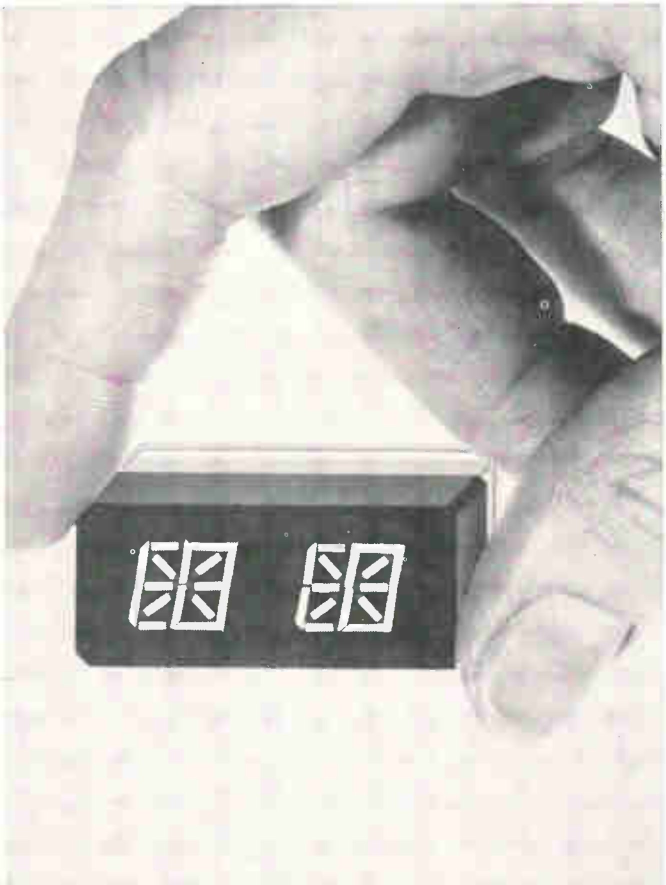
NEW, high visibility alphanumeric readout



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Electronics Buyers' Guide

A McGraw-Hill *Market Directed* Publication,
330 West 42nd Street, New York, N.Y. 10036

New Literature

styles of high reliability resistors. [467]

Bonding wire. Sigmund Cohn Corp., 121 So. Columbus Ave., Mount Vernon, N.Y. 10553. An eight-page brochure covers aluminum alloy bonding wires for the IC and semiconductor industry. [468]

Solid state supplies. Technipower Inc., Benrus Center, Ridgefield, Conn. 06877. Catalog 671 lists 4,159 standard models of solid state power modules and power supplies. [469]

Monolithic IC's. Texas Instruments Incorporated, 13500 N. Central Expressway, Dallas. A 48-page brochure describes a line of 180 TTL monolithic IC types, with 39 distinct circuit functions. [470]

Schottky-barrier diodes. Microwave Associates Inc., Burlington, Mass., has issued bulletin 4048 describing a series of X-band, Schottky-barrier junction diodes for use in broadband mixers. [471]

Commercial lasers. Scientific and Electro-Optical Equipment Dept., Westinghouse Electric Corp. P.O. Box 8606, Pittsburgh. 15221. Bulletin AD96-180 on commercial laser applications discusses welding of IC's, waveguides, and aerospace materials, as well as laser drilling of aluminum, titanium, and steel alloys. [472]

Magnet wire. Hudson Wire Co., Ossining, N.Y. Bulletin MW-1012 is a 16-page, illustrated engineering reference that describes and compares film-insulated copper magnet wire in sizes 20 through 44AWG. [473]

Log ratemeter. Hamner Electronics Co., Box 531, Princeton, N.J. 08540. Technical bulletin NR-15 describes a log ratemeter that measures integrated count rate. [474]

Modular instrumentation. McKee-Pedersen Instruments, P.O. Box 322, Danville, Calif. 94526. An eight-page brochure-catalog covers the series 1000 modular instrumentation system. [475]

Resistance welding control. General Electric Co., Schenectady, N.Y. 12305. Six-page bulletin GEA-8263 covers the CR175S solid state resistance welding control. [476]

Industrial thermal relays. G-V Controls Inc., Okner Parkway, Livingston, N.J. 07039, has issued a file folder on its line of industrial thermal relays. [477]

Hybrid IC's. WEMS Inc., 4650 W. Rosecrans Ave., Hawthorne, Calif. A 12-page brochure tells the story of a hybrid IC from the engineer's schematic to the final package. Copies may be obtained by request on company letterhead.

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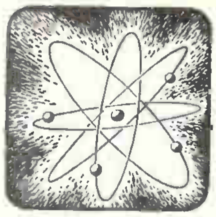

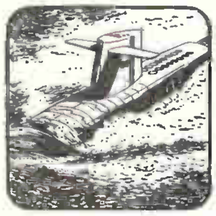


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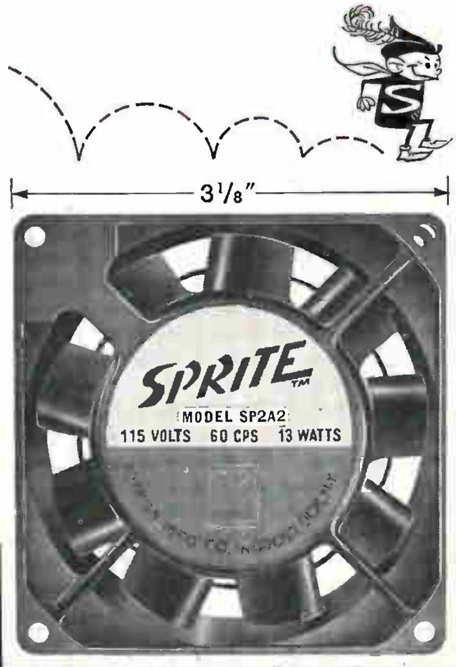

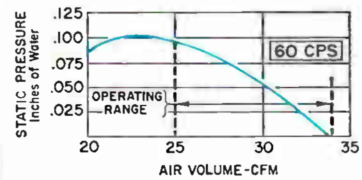

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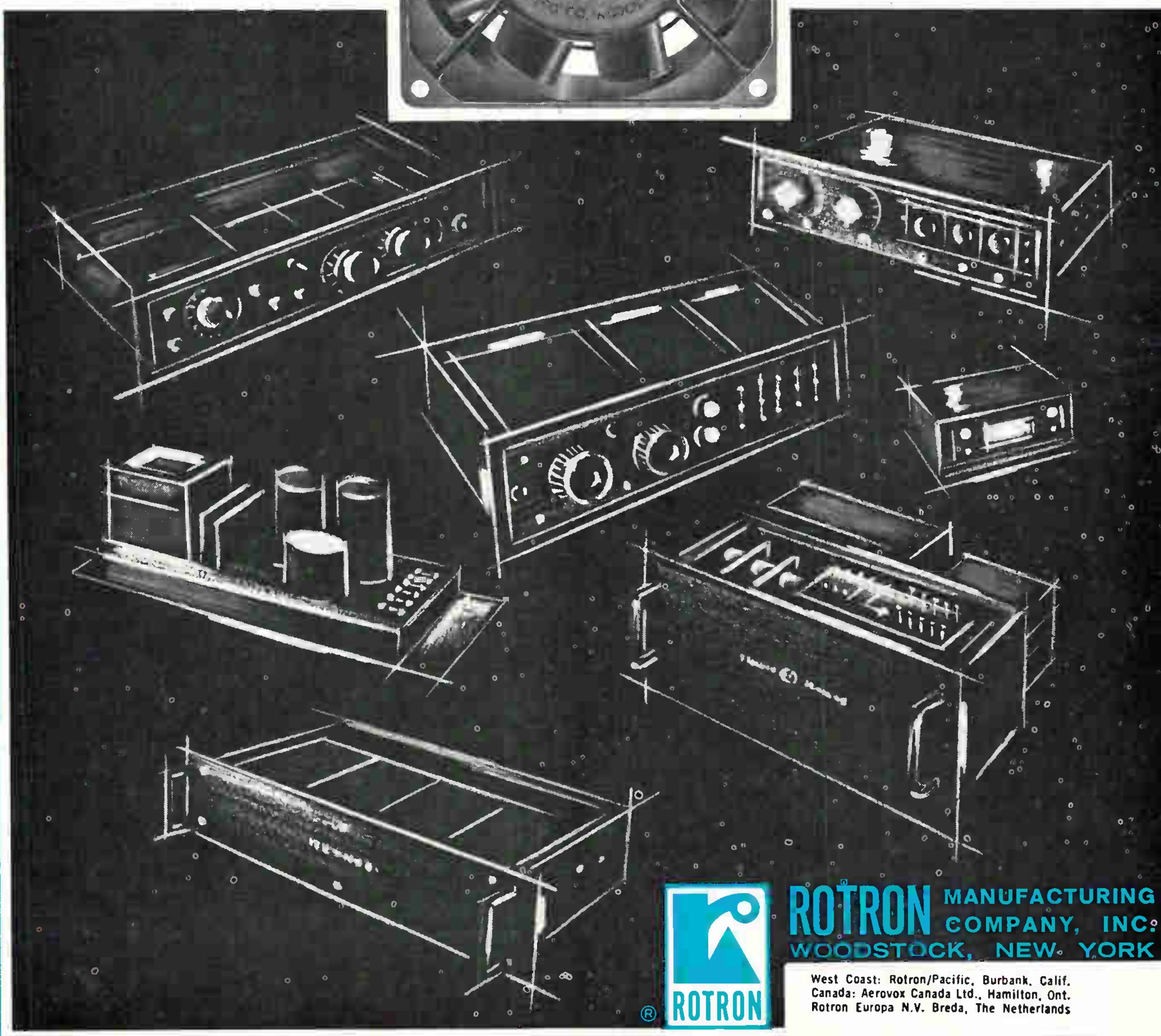

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Newsletter from Abroad

October 16, 1967

Merger moves sure to change scene in British industry

Britain's electronics industry figures to take on a new look no matter what the outcome of this month's bid by the General Electric Co. to take over Associated Electrical Industries.

If GEC prevails (GEC is not connected with General Electric in the U.S.), Britain will get a second billion-dollar electrical-electronics company. The first was formed this summer when English Electric took Elliott-Automation Ltd. into its fold [Electronics, July 10, 1967, p. 196]. **To stave off the merger with the smaller, more aggressive GEC, management of AEI most likely will promise stockholders a sweeping streamlining of its operations.** AEI has showed a low return on its $530 million assets in recent years and its profits outlook is poor.

London stock-market watchers say it's too early to tell who'll win out in what presumably will turn out to be a long merger struggle. The odds seem to favor GEC slightly. **During the past six years the company has become one of the most profitable in Britain and now is returning 15.4% on its assets of $320 million.** And the government's Industrial Reorganization Corp., set up to foster mergers, is pushing for the takeover.

However, insiders say there's about an even chance that the takeover will be blocked by an antimonopoly action. GEC and AEI both are members of Britain's "telecommunications club," which supplies most of the equipment for the country's telephone network. The two now account for 42% of the outstanding equipment contracts for the Post-Office-run system. GEC and AEI together would become the country's largest television-tube maker and threaten to dominate that segment of the electronics business. The merged pair also would hold an overwhelmingly strong position in some categories of heavy electrical equipment.

Hanoi trade team shops in France

The de Gaulle government may back its diplomatic support of North Vietnam with something more substantial. Ten North Vietnamese technicians are now touring French electronics, automotive, and chemical plants, with an eye to possible purchases.

The delegation's reception as official guests of the French government could signal an escalation in President de Gaulle's opposition to the U.S. role in Vietnam. He earlier had permitted Hanoi to set up a diplomatic mission in Paris, but until now had made no move to establish commercial relations with the North Vietnamese.

Most French electronics companies are silent about plans for hosting the group, although **the North Vietnamese are expected to window shop, at least, for defense electronics during their visit.** Several firms say they would rather not risk losing American business by trading with Hanoi.

U. S. gear may guide Anglo-French SST

Avionics insiders now think that production versions of the French-British Concorde supersonic transport most likely will carry American inertial guidance systems.

Originally, the plane's builders wanted to keep all the hardware on the SST either French or British. **But U.S. airlines that have ordered the planes, particularly, are pressuring for American navigation equipment.** The inertial guidance system for the first two Concorde prototypes was developed jointly by France's Sagem and Britain's Ferranti Ltd. How-

Newsletter from Abroad

ever, it turned out considerably more bulky than available U.S. equipment.

Avionics contracts for two pre-production versions of the Concorde will be awarded next month. **Litton Industries and the AC Electronics division of General Motors apparently have the inside track for the inertial guidance system.** If Litton gets the nod, Sagem and Ferranti will produce much of the hardware in collaboration with Litton. Bendix had the same sort of deal with France's Sfena and Elliott-Automation for autopilots for the first two Concorde prototypes.

Tough U.S. stand on missile deal stuns Japanese

Japan's defense agency has been taken aback by the hard line adopted by the Pentagon in negotiations for Japanese production of Nike and Hawk missiles. Some government officials in Tokyo even say that a U.S. demand for $10 million in missile-development costs led to the suicide last week of Mikio Morita, head of the agency's procurement division.

In the past, Japan's major purchases of American arms have been subsidized under the U.S. military sales assistance program. **A Pentagon policy change was anticipated this time around, but the Japanese expected to be asked to pay only the full production cost of hardware. The additional development charge the U.S. wants came as a shock.** The Japanese defense agency's draft budget for the upcoming fiscal year takes into consideration only the cost of hardware. Morita apparently couldn't face up to trying to sell the finance ministry on an additional major expense he hadn't counted on.

Japan's present plans call for an outlay of about $247 million to ready two Nike-Hercules battalions and two Hawk battalions by 1971. Sources close to the defense agency say it wants to arrange for complete domestic production of the Hawk. Only the airframe and engine of the Nike-Hercules would be produced in Japan.

Lufthansa and BEA cool on airbus

Avionics makers in Europe have begun to fret over the future of the European airbus, a project they'd hoped would mean considerable business for them starting in the early 1970's.

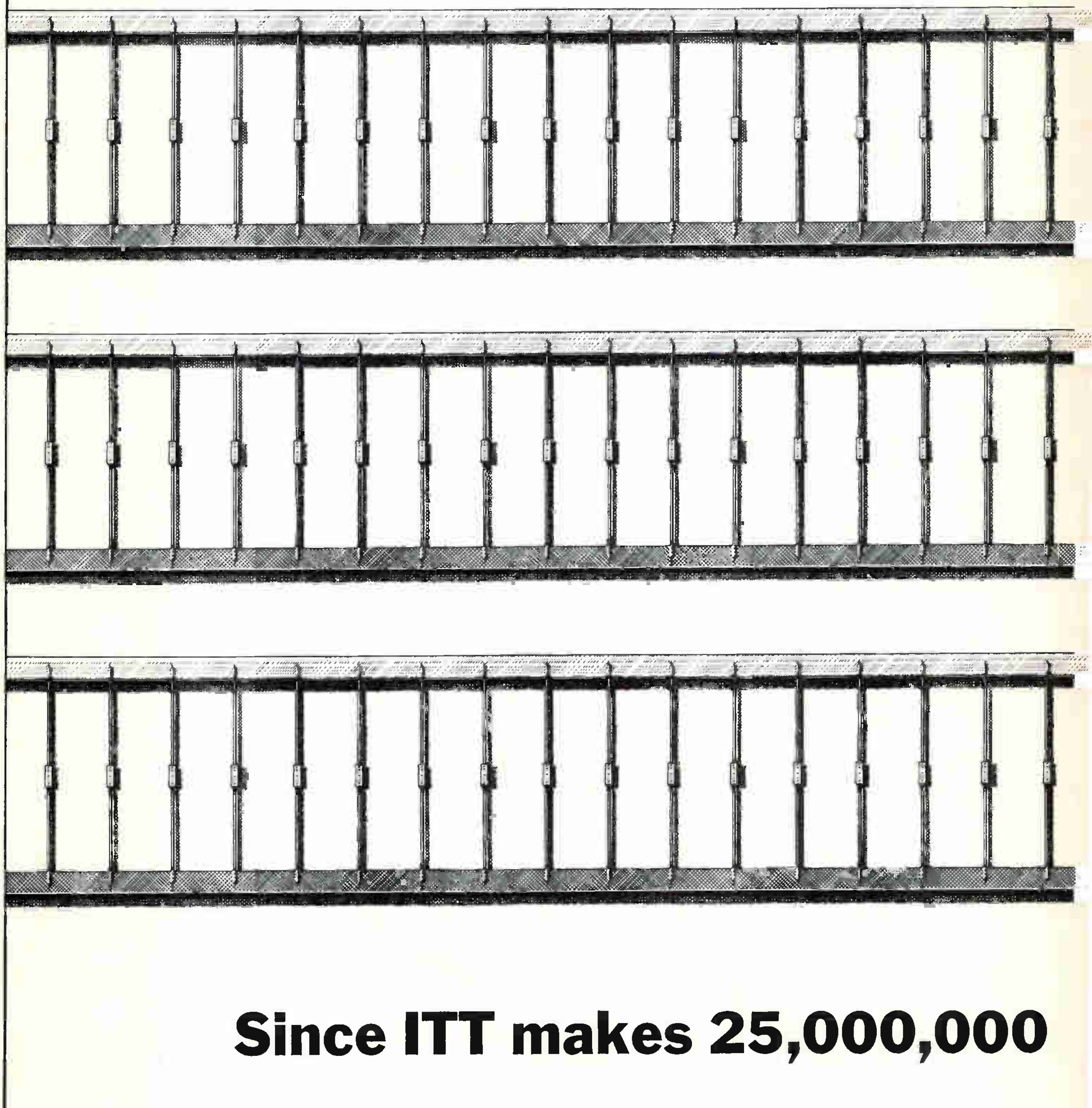
The French, British, and West German governments agreed this fall to go through with the first phase of the project. **But the 300-passenger short-haul jet may never get off the ground.** The reason: both Lufthansa and British European Airways are showing little enthusiasm for the project. Airbus project planners figured that Lufthansa, BEA and Air France would among them buy about 100 airbuses at $10 million a copy during the 10 years starting in 1973. The export market—much less certain—was also estimated at 100 planes.

Air France is plumping strongly for the airbus, but there's little chance the plane will get into production unless Lufthansa and BEA are pressured into adopting the plane by their governments.

Bonn to banish electronic bugs

West German components makers will lose a small—but fast growing—market next year. The country's legislature has passed a law that forbids electronic eavesdropping.

The government decided to crack down on bugging after a rash of complaints, many from businessmen. It's estimated that some 10,000 eavesdropping devices, most made in two- or three-man shops, have been sold in the country.



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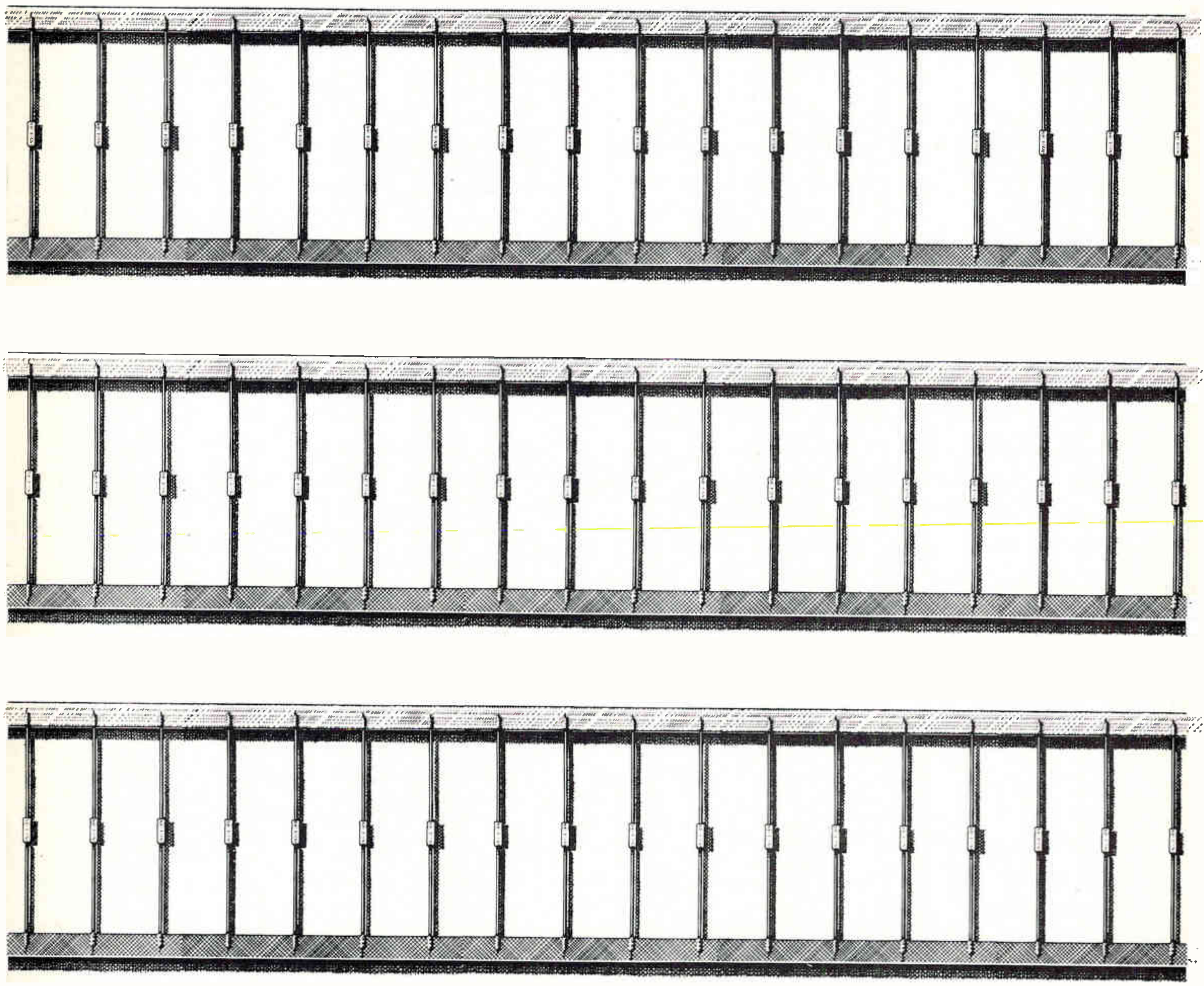

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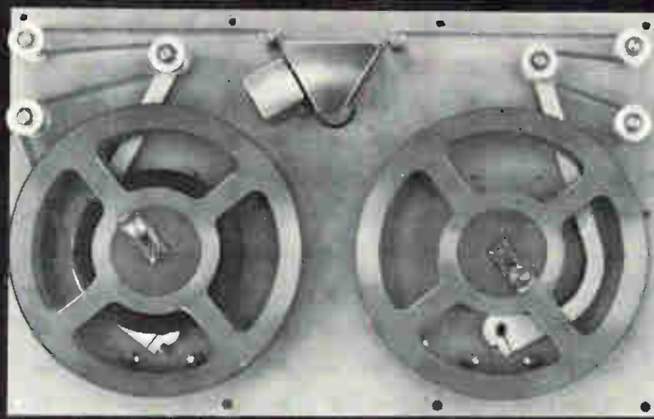

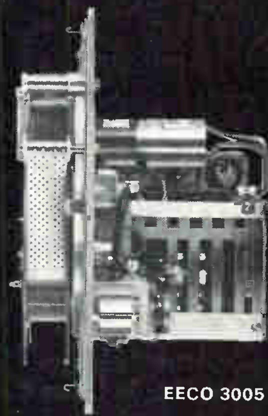

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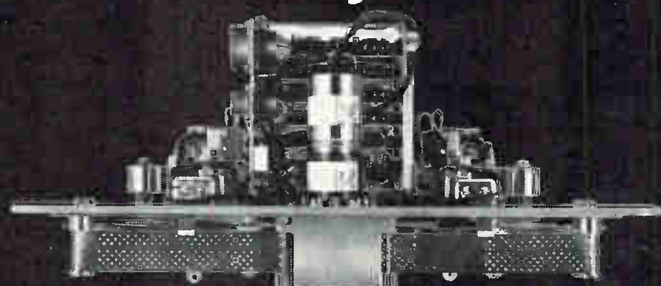

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October 16, 1967

Electronics Abroad

Volume 40
Number 21

Great Britain

One for the road

As far as integrated circuits go, Joseph Lucas Ltd. is right up there with General Motors.

With its voltage regulator for the 1968 Pontiac, GM became the first U.S. automaker to put an IC under the hood [Electronics, Oct. 2, p. 137]. Lucas is now marketing a 28-amp automotive alternator with an IC voltage regulator tucked inside. Under the bonnets of British-built cars, Lucas generating equipment turns up more than half the time.

Like GM's Delco-Remy division, which developed the Pontiac unit, Lucas took a do-it-yourself tack to make sure the IC regulator would stand up to the rigors of under-hood conditions. The thick-film hybrid IC Lucas uses is produced by the company's semiconductor division.

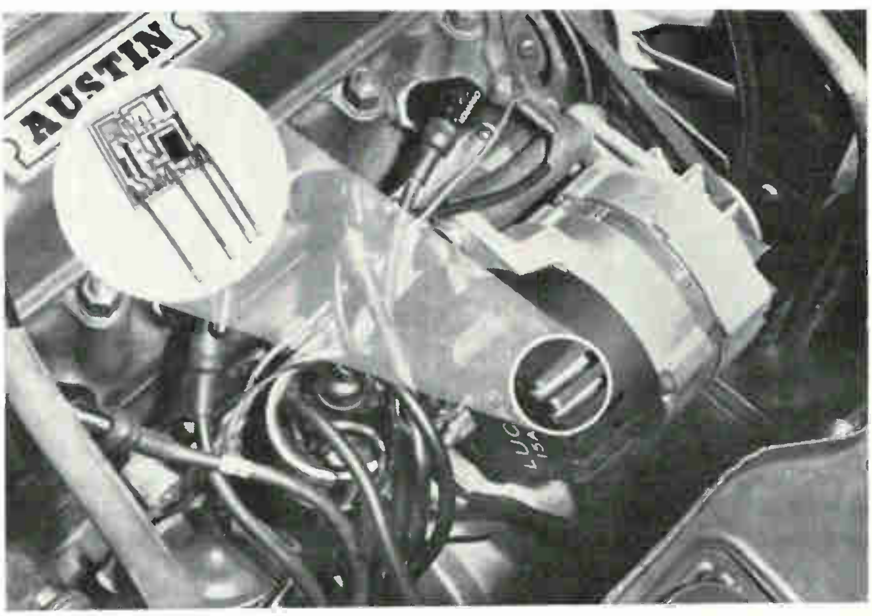
Staying power. Lucas says the alternator-regulator package should see an automobile through at least 100,000 miles, a much longer life than can be expected for a conventional direct-current dynamo with a separate electromechanical regulator. Initial cost for an alternator, Lucas admits, is higher than for a d-c generator. Lucas won't say what price it will charge automakers for the alternator-IC regulator package; but the company hints the package will be more competitive than the alternators with separate transistor regulators it has had on the market for about a year.

Much the same. Fundamentally, the British and American IC regulators are very similar. Both, for example, use a zener diode as the voltage-sensing element that controls the rate at which the alternator charges the battery. And both use three transistors in the circuit that varies the field current supplied to the alternator.

Delco-Remy, however, put three more diodes into its IC than Lucas did. These diodes, which provide self-excitation for the field at normal engine running speeds, are included in the rectifier pack in the Lucas alternator. Lucas kept these diodes off the IC largely because it had developed the pack for use with its transistorized regulator. And because the diodes were separate, Lucas could put the output transistor on the hybrid circuit rather than in a separate can as did Delco-Remy.

Hot and cold. Another major difference is that Lucas' circuit has no thermistor for temperature compensation. Instead of a Darlington pair for the output stage, the British regulator has two transistors. Thermal characteristics of the transistors, Lucas maintains, provide adequate compensation.

Substrate for the IC is a slab of alumina about 1-inch square and the whole regulator—potted in silicone rubber—is about $\frac{1}{16}$-inch thick. The unit is mounted in an aluminum heat sink on one face of the alternator.



Hit the road. Integrated-circuit regulator tucks into Lucas automobile alternator. Four leads interface regulator and alternator.

Well wired

The Plessey Co. has joined the ranks of memory makers who are convinced that plated wires will supplant the ferrite core as the workhorse element in computer stores.

Pilot production of plated-wire memory modules, already underway, is expected to step up to full production in a year or so. This would make Plessey—unless a competitor springs a surprise—the first European company to go for plated-wire memories in a big way.

In the U.S., the Univac division of Sperry Rand has opted for plated wire in its Univac 9000 series computers [Electronics, May 15, p. 101]. Honeywell Inc. also is looking into the technique and the National Cash Register Co. has something very similar in the rod memory used in its NCR 315 machine. All maintain that plated-wire memories are inherently faster and cheaper than core stores.

Forerunner. Plessey Co.'s initial plated-wire unit is a module of

102,400 bits grouped to form 1,024 words of 100 bits. The basic module will be used to build off-the-shelf stores in any size up to 16,000 words of 50 bits.

These first stores will have destructive readout with a cycle time of about 250 nanoseconds. Plessey plans to extend the line to much larger stores—up to 10 million bits—with nondestructive readout and cycle times of 1 microsecond or so. For smaller stores with nondestructive readout, the goal is a cycle time of 100 nanoseconds.

Thick and thin. A key difference between the destructive and nondestructive versions is the wall thickness of the magnetic film plated onto a substrate of 0.0065-inch diameter beryllium copper wire. For destructive readout, the wall thickness runs about 1 micron, about twice that for nondestructive operation. The thicker walls are easier to control on the plating line, hence Plessey's decision to start with destructive readout modules.

To be sure, the savings on the plating are offset by the fact that twice as many bit drive circuits are required in the memory to rewrite after destructive readout. But Plessey says the advantages outweigh this penalty with the smaller stores.

The lineup. In the destructive readout modules, two plated wires per bit are connected in a bridge circuit so that sense pulses add and cross-point noise cancels. In the normal 100-bit format, each word line makes two turns around the 100 pairs of plated wires.

To form the word lines, Plessey uses a printed-circuit technique to lay down 128 pairs of copper strips on an epoxy glass sheet. The sheet is later folded over to get the turn. Before folding, though, half the sheet is covered with epoxy resin into which 200 grooves are molded. The plated wires are slipped into the grooves. Eight of the folded sheets are mounted together to make up the 1,024-word module.

Thinning down. Plessey will use a different packaging technique for the nondestructive readout modules but still hasn't decided what it will be. However, some of the kingpin parameters for the follow-on units are all but set. The wall thickness of the plated magnetic material will very likely be 0.39 micron and the word current about 350 milliamps (compared to 500 ma in the first modules). In tests, this combination gave steady 10-millivolt sense pulses regardless of the number of readouts. Pulse lengths ran between 60 and 80 nanoseconds, which would give a cycle time of about 100 nanoseconds.

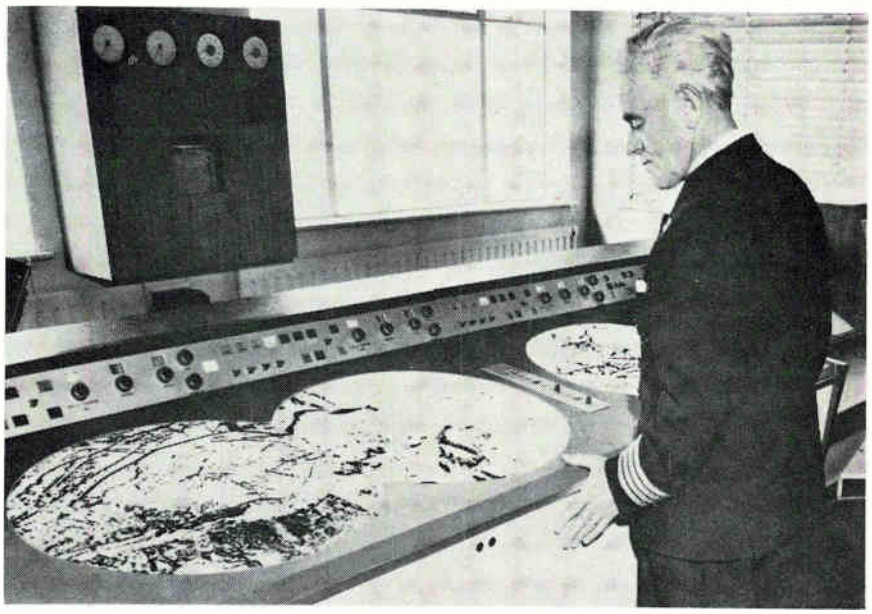
The big picture

No matter how foul the weather, the harbormaster of the Tees estuary in northeast England has a clear picture of what's going on in the tanker-busy channel and the anchorage area offshore. To size up the situation when ordinary binoculars are no help, he simply turns to a large binocular-shaped display. It shows ships' position information from two radars projected onto a chart of the estuary.

Radar watches for harbors aren't new, but the builder of the Tees system, the Kevin Hughes division of Smith Industries Ltd., says it's the first to combine displays from overlapping radars into one big picture. At Tees, two radar scanners about three miles apart feed position data to the control-tower display. One scanner is mounted hard by the control tower. Data from the remote scanner comes in over a microwave link.

Ship-position information from each radar is displayed initially on a separate 3-inch cathode-ray tube. Its image then is combined optically with a transparency of the chart and photographed on 16-mm film for projection onto 24-inch chart paper.

To match the two crt-chart combinations, Kevin Hughes mounted the two 16-mm projectors side by side and blanked off the overlapping portions of the beams.



Two for Tees. Harbormaster can check movements of all ships in Tees estuary on display that puts data from pair of overlapping radars onto a projected chart.

France

Chamber made

Thin-film makers may be sputtering more and more now that a French engineer has found a way to lay down almost any binary compound on a substrate using a reactive technique.

Direct-current sputtering has been used for more than a decade, mainly to deposit metallic conductors. In the past two years, the process has been extended to insulators like glass and quartz by radio-frequency techniques. Researchers have also spotted a third technique — reactive sputtering — that adds a chemical reaction to the process. But they've had trouble getting it to work.

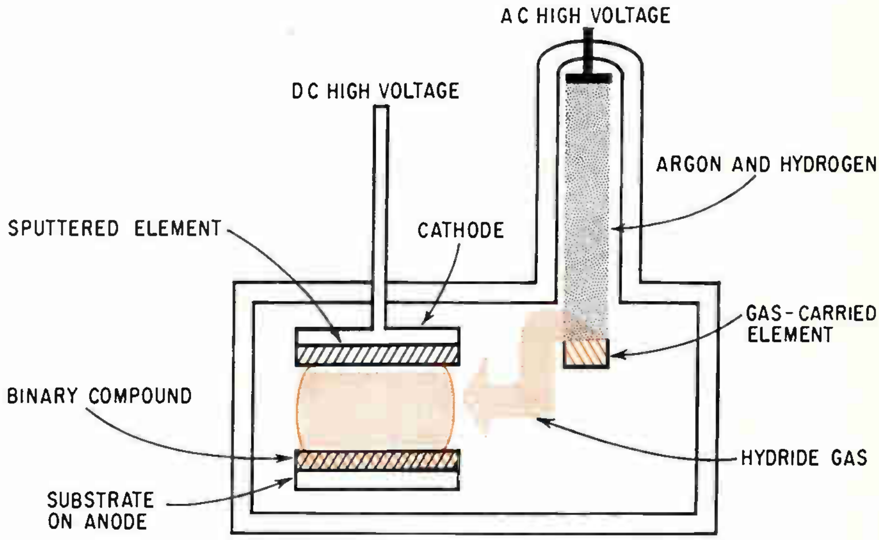
In both d-c and r-f sputtering, the material destined to form the thin film is made the cathode in a discharge chamber. Ions in the discharging gas bombard the cathode and the dislodged molecules shower onto the anode to form a thin film. In both processes, the thin-film material is limited to compounds that can be readily put onto cathodes. In reactive sputtering, by contrast, the wanted compound is literally made in the sputtering chamber. The sputtered cathode material and a gas-carried second material combine chemically, close to the anode, and then form the film.

Inside job. Hydrides turn out to be excellent carriers for the second material. But hydrides of elements like antimony, arsenic and selenium are hard to handle because they are unstable. Jean Pompei, an engineer at La Radiotechnique-Coprim-RTC, has solved the problem by forming the hydrides inside the sputtering equipment.

Pompei's apparatus has two gas-discharge chambers. In the first one, a mixture of argon and hydrogen is discharged by an alternating current. This produces a jet of plasma over a plate coated with one of the two elements that make up the eventual thin-film compound —the antimony, say, for indium antimonide.

The hydride thus formed in the first chamber passes directly to the second. There, the hydride-argon mixture is discharged a second time and the compound's second element sputters off the cathode—indium in the case of indium antimonide. The sputtered indium atoms react with the ionized hydride to form indium antimonide.

Versatile. Chemical composition and physical structure of thin films deposited by the double-discharge technique can be closely controlled.



Two-step. Double discharge is key to French technique for reactive sputtering of binary compounds. Hydride forms when argon and hydrogen discharge in first chamber. Sputtered cathode material and hydride-carried element combine to form compound in second discharge chamber.

And the process has the advantage of using the same two gases—argon and hydrogen—no matter what the composition of the film. The type of compound formed can be varied with little trouble by changing the target plate in the first chamber and the cathode material in the second.

Pompei concedes that the process has its shortcomings. A major one is that film-thickness can be no more than 5,000 angstroms. And semiconductor films produced by the technique can't be doped.

Color for computers

A company set up under a scheme to give a country a strong domestic computer industry has to maintain a certain style. And Systèmes et Périphériques Associés aux Calculateurs, the peripherals producer formed for France's Plan-Calcul, came through handsomely at the International Office Equipment Show in Paris this month.

Sperac, a joint venture of Compagnie Française Thomson Houston-Hotchkiss Brandt and the Compagnie des Compteurs, introduced at the show its first major new product—a cathode-ray-tube display that flashes letters, numbers, and symbols on the screen in as many as nine colors.

Sperac maintains that no other company in Europe offers a color crt display. In the U. S., the International Business Machines Corp. and others have color crt display units in development. American peripherals makers, though, apparently are working toward graphic displays rather than the less-complex alphanumeric unit Sperac offers. [See related story, p. 165.]

Easy to spot. Sperac can trot out a number of reasons for adding color to an alphanumeric crt readout. Used with a keyboard to query a computer, the display can put the questions in one color and the answers in another. In process control systems, the display could flash critical changes of state in color to warn the control system operator.

The company already has an order from a French steel maker for a system that will monitor the flow of orders through the plant. A network of 10 keyboard-equipped color crt units, Sperac says, costs between $8,000 and $9,000. For a comparable black-and-white system, the tab is $6,000 to $7,000.

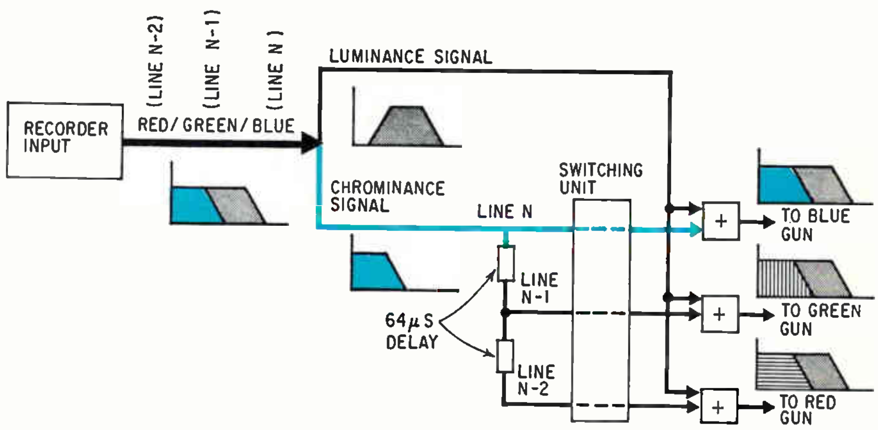
Versatile. In large part, the relatively low extra cost for color is possible because Sperac uses for the display a standard color tube in a noncoded video receiver. A fixed-program signal generator drives the receiver on command from a text memory linked to the computer.

Actually, Sperac offers two signal generators. One is based on a diode matrix; the other uses integrated-circuit logic and has a three-dimensional memory that stores 64 characters. The read time is about 1 microsecond.

The text memory uses ferrite cores and has a read-write time of 1.5 μs. Since its speed is slower than that of the signal generator, the text memory stores characters in pairs as they come from the computer.

Characters in the text memory are defined by six bits for black-and-white display. Two additional bits are needed for four-color display and three additional bits for nine colors.

A variety of combinations of signal generators, text memories and display receivers is possible. A single signal generator, for example, can drive several receivers each with its own text memory. Or a series of receivers, without text memories and keyboards, can be linked to a common generator and text memory.



Tripal play. Tripal video tape recorder develops simultaneous signals for the three guns in a color receiver by passing line-sequential chrominance information through a pair of delay lines and a switching unit. Luminance signal is common for all three guns.

West Germany

PALette

The trade-up to color won't be as costly for European users of video tape recorders as originally thought.

This month, Deutsche Philips GmbH will start selling for about $1,750 a black box that turns its industrial black-and-white VTR into a color recorder. In the U.S., at present, the only color VTR available —high-cost studio units excepted— is the Ampex Corp.'s VR-7500C, which sells for $4,500.

Deutsche Philips, a subsidiary of Holland's NV Philips' Gloeilampenfabrieken, says it will cut the price of its color adapter once quantity production gets under way and will offer versions for home recorders soon. Grundig Radio-Werke GmbH and others have "low-cost" color recorders in the works. And the brass at Loewe-Opta GmbH is thinking about building a receiver with a color recorder built in.

The flurry of color VTR activity in West Germany was touched off by Walter Bruch, head of the television research laboratory at AEG-Telefunken AG. Bruch, inventor of the PAL (for phase alternating line) color transmission system adopted by most West European countries, developed a technique that makes it possible to squeeze chrominance information into a "monochrome" bandwidth of 2.5 megahertz. Deutsche Philips and the others have based their low-cost recorders on the technique, which Bruch calls Tripal.

One-by-one. For Tripal recording, the composite color video signal is decoded into red, green and blue signals. But rather than recording all three for each line of the tv picture, Bruch's method stores just one color signal per line. Red, green and blue color information is recorded sequentially on successive lines in a single channel.

Along with the single-color information for each line, the high-frequency components of the composite video signal are recorded to get a luminance signal. Since just one color signal—and a partial one—is handled at a time, a bandwidth of 0.6 Mhz will do for the chrominance channel. It is tucked into the low-frequency end of the Tripal composite signal, whose bandwidth is 2.5 Mhz and can be handled by monochrome recorders built for home use.

Bright idea. If color signals were fed sequentially to the three guns in the receiver's picture tube, the viewer's eyes would average out the red, green, and blue over three lines and the colors would look all right. But with only one gun in action for each line, the picture wouldn't be bright enough.

To get around this, the Tripal system develops signals for all three guns for every line during playback. Three simultaneous color signals are obtained by running the sequential signals through two 64-microsecond delay lines.

When a line recorded with, say, blue color information is played back, the chrominance input from the recording head is switched onto the blue gun. The green information from the previous line—held up 64μs by the first delay line—is fed to the green gun. At the same time, the red signal that was present two lines before the blue has passed through both 64μs delays and is switched onto the red gun.

Only the lower-frequency color information is delayed and switched. The higher-frequency luminance signal for each line is fed to all three guns.

True blue. Deutsche Philips maintains that the color reproduction with Tripal recording matches that of studio units. However, the horizontal resolution suffers a bit because of the 2.5-Mhz bandwidth typical for home VTR's. And the vertical resolution is limited be-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cause three lines are always mixed. But the line-for-line luminance signals keep the vertical resolution tolerable for industrial and home recorders.

Japan

Fast-blooming hybrids

Japanese capacitor makers proved their adaptability at the annual Japan Electronics Show this month. Realizing that integrated circuits are fast making conventional components passé, most are rushing into production of hybrid thick-film circuits.

To be sure, the country's semiconductor producers turned up at the Osaka show with a panoply of monolithic IC's. But most were digital circuits for computers. A few monolithics designed for the sound-intermediate-frequency amplifier of television sets were in view. Export-oriented set makers, however, are queasy about monolithics. Still to be settled is the question of whether Texas Instruments Incorporated can block exports of equipment incorporating monolithics to the U.S. by a patient action. [Electronics, Sept. 18, p. 157].

The odds. Capacitor makers going into production of thick-film hybrids for consumer electronics equipment think they've got a safe bet. If Texas Instruments manages to keep Japanese monolithics out of the U.S., the market will go to the hybrid-makers by default. If TI loses out in its patent squabble with Japanese semiconductor makers, the thick-film hybrid producers figure they can best producers of monolithics in price and delivery.

Resistor manufacturers, oddly enough, haven't jumped onto the thick-film bandwagon en masse. The apparent reason: most resistor makers aren't as strong financially as capacitor makers. What's more, capacitor makers have the advantage of know-how in ceramic substrates—on which thick-film circuits are laid down—and they supply their own capacitors, the most costly passive component.

Competing. Most leading Japanese capacitor makers had lines of thick-film hybrids for consumer electronics gear on their stands at the Osaka show. In most units, the active components were encapsulated transistors or diodes. The thick-film producers, though, are thinking about shifting to chips.

An exception is the Mitsumi Electric Co.; it already uses chips supplied by the Hong Kong plant of Fairchild Semiconductor. Mitsumi may graduate to production of its own chips to get an edge on the competition. Although it produces a line of digital circuits, Mitsumi sees consumer electronics as its main market. The company currently supplies thick-film preamplifiers to two producers of stereo sets.

On the rise. Tokyo Denki Co., a subsidiary of the Tokyo Shibaura Electric Co., says its hybrid-circuit sales now run from 30,000 to 40,000 units a month and are on an uptrend. About 70% of the circuits are digital, but Denki expects linears will soon dominate. Denki is dickering with its parent company to supply circuits for tv sets.

Other producers seeking business in thick-film hybrids are the Murata Manufacturing Co., Hokuriku Electric Co., Nichicon Capacitor Co., and Kyodo Electronic Laboratories Inc. Kyodo, however, is concentrating on sense amplifiers for computer memories.

Watching. Sitting on the sidelines so far is the Matsushita Electric Industrial Co., a giant in both consumer electronics and components. Matsushita, apparently, won't make its move until the situation in monolithics clears up. The company could jump into thick-film production fast.

Another company that's waiting it out is the Sony Corp. Like Matsushita, Sony could move into hybrid IC's fast.

Color's bright

Like their U.S. counterparts, Japanese color television set makers see a rosier outlook these days. Sales for the year will be consider-

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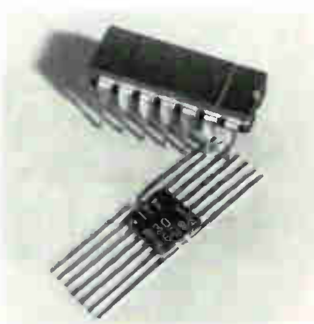

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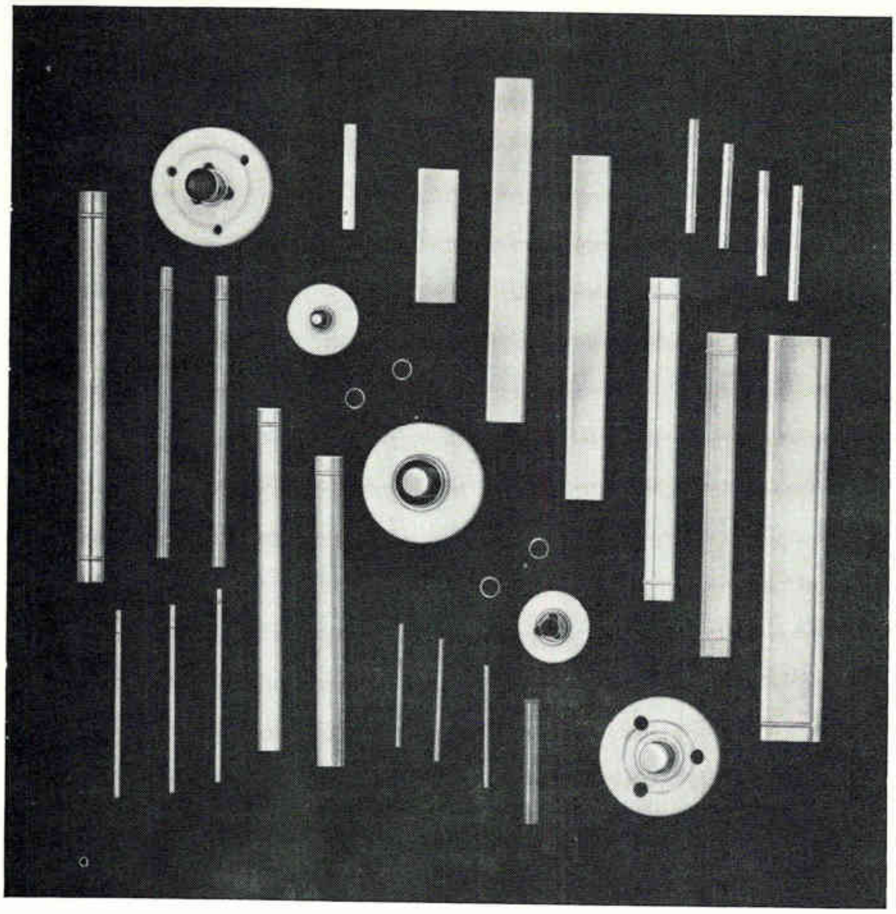

ably better than anticipated a few months ago.

The industry late this summer reached an output of 100,000 sets a month for the first time. As a result, the Electronics Industries Association of Japan predicts that color-set demand will reach 1.1 million in 1967. That's a 10% boost over the association's estimate made at the beginning of the year and twice last year's deliveries.

Best at home. A booming domestic market underlies the new estimates. Color-set exports, in fact, are running about 30% below what the industry association predicted in January. But domestic sales have zoomed beyond earlier expectations. Instead of 500,000 sets, the outlook now is for 750,000. The estimated export total for 1967 is 350,000 sets, nearly all to the U.S.

Sales of black-and-white receivers, too, figure to turn out better than the industry group earlier figured they would. The January estimate was 3.34 million sets for the domestic market and 1.9 million for exports. Both figures have been revised upward—to 3.5 million and 2 million, respectively.

Off the mark. The radio market, though, won't be as good as the industry thought at the outset of the year. Deliveries will run about 37.2 million sets, some 2.4 million fewer than the original estimate but nonetheless nearly 10% over the 1966 figure. The gain in dollar value will be even better since unit prices of exported radios are edging up. Japanese producers are turning to high-quality sets and leaving the cheap-set market to producers in Hong Kong, Taiwan, and elsewhere.

Around the world

Italy. Telecommunications equipment makers will get a big lift from the government's investment plans for 1968 to 1972. Nearly $6 billion is earmarked by the plan for state-controlled industries, and some $1 billion of it will go to modernize the country's telephone and telegraph network.

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October 16, 1967

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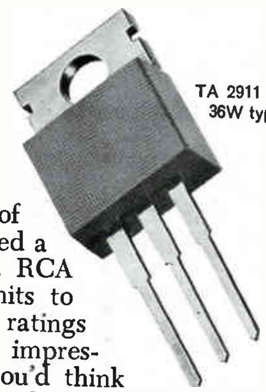
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