Electronics®

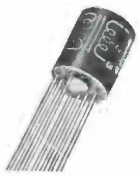
September 18, 1967
$1.00
A McGraw-Hill Publication

Below: IC's cut cost and improve reliability of plotter, page 114

HI-FI

Transistor output; matches any PP transistor to 4, 8, 16 Ω speaker. Primary 48, 36, 12 Ω C.T.; 20 ⁓ to 20 KC; 40 watts.

MINIATURE MIL TYPE



Metal case hermetically sealed to MIL-T-27B. Gold Dumet leads spaced on 0.1 radius, for printed circuit application.

CHOPPER

Magnetic shielded plus electrostatic shield for voltage isolation of 2×10^4. Primary 200K C.T. to within 0.1%. Secondary 50K.

HIGH POWERED AUDIO

Low distortion 2.5 KW output transformer, PP 450 TH's 18,500 ohms C.T. to 24/6 ohms, 20 KV hipot. 520 lbs.

CATHODE FOLLOWER OUTPUT

Provides equal voltages to 5 loads. Primary inductance maintained to 5% with 20% change in DC unbalance and 30% change in AC voltages.

HI-FREQUENCY CARRIER TO MIL-T-27B

Electrostatically shielded, humbucking, +30 dbm level. Within .5 db 250 cycles to 110 KC. 600/135: 600 centertapped to .1% tolerance.

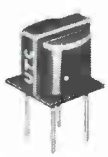
HYBRID TRANSFORMER

Two transformers each 600 Ω primary. 40K Ω C.T. secondary 250 cycles to 5 KC within ¼ db. 40 db isolation over band.

MICROMODULE

Life tested per micromodule specs.: no failures. 10K Ω C.T. to 10K Ω, 100 mw from 400 ⁓ to 20KC.

SUBMINIATURE MOLDED TRANSFORMER



Grade 3 with printed circuit leads for transistor application. 150 Ω to 150 Ω at 10 dbm level. Size ½ x ½ x ½"; weight 5 grams.

BOLOMETER TRANSFORMER

Primary 10 ohms, secondary 530K ohms, 230:1 ratio, response from ½ cycle to 25 cycles. 120 db magnetic shielding, plus full electrostatic shielding.

ULTRA-MINIATURE

Electrostatically & magnetically shielded output transformer ⅛ D. x ¼" H. Pri. 15K CT, Sec. 8K CT; max. level 50 mw; audio range response. To MIL-T-27B, grade 4.

UTC ® PIONEERS IN MINIATURIZATION

"SPECIAL" CUSTOM BUILT AUDIO TRANSFORMERS TO YOUR SPECIFICATIONS

Exceptional quality and reliability is provided in all UTC designs. Over 30 years of engineering knowledge and experience substantiated by extensive field performance assure the highest quality and most reliable components in the industry. Complete environmental testing facilities are incorporated to prove out new designs. Full analysis and evaluation of materials are conducted in UTC's Material and Chemical Laboratories. Rigid quality control measures coordinated with exhaustive statistical findings and latest production procedures results in the industry's highest degree of reliability. Range covered in Audio Transformers is from 0.1 cycles to 400 MC . . . microwatts to 50 KW.

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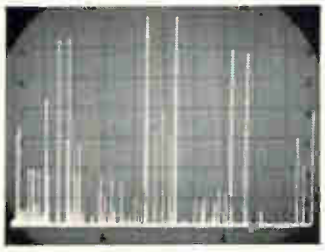
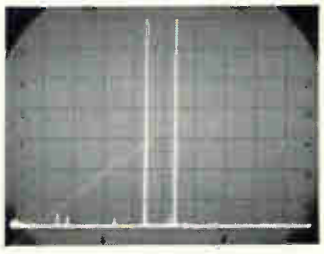
Hewlett-Packard has changed the picture...

from this:

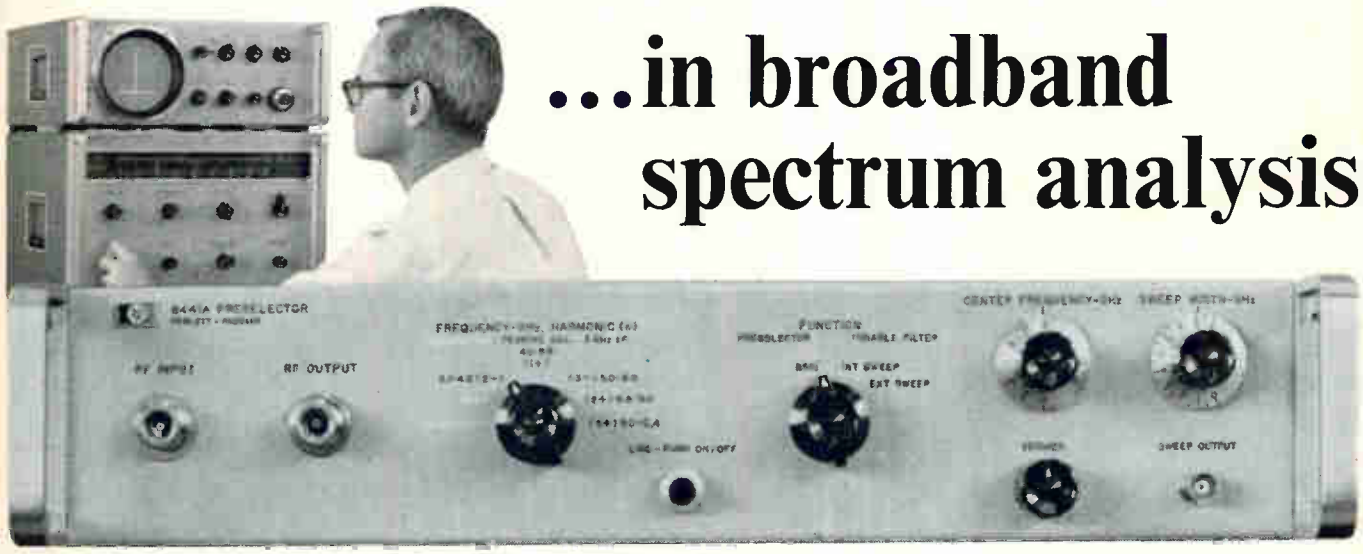


Normal wideband spectrum display of high-level multiple signals. (2 GHz spectrum width, 10 dB/cm vertical display.)

to this:



Virtual elimination of normal intermodulation products produced by strong multiple signals at the analyzer input.



...in broadband spectrum analysis

The new HP 8441A Preselector offers an effective solution to the cluttered-screen problems often encountered in broadband spectrum analysis. Used with the HP 851/8551 Spectrum Analyzer, the preselector covers 1.8 to 12.4 GHz with simple, straight-forward operation. Broadband and multiple signal displays are now far easier to interpret.

The preselector is an electrically tuned RF filter preceding the analyzer's RF input. It electrically tracks the analyzer's sweep and therefore passes only the instantaneous frequency to which the analyzer is tuned as it sweeps through its selected scan. The rejection of other strong signals prevents the generation of distortion products in the analyzer's mixer. Elimination of these distortions from the display increases the analyzer's effective dynamic range because the analyzer can now handle input signals of higher levels. This permits easy comparison of large and small signals.

Because it rejects interfering signals, the preselector is an indispensable tool in such applications as RFI measurements and test of frequency multiplier chains. Ask for Application Note 63B, which describes the uses of this new and versatile instrument. Call your local HP field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

HP Model 8441A Preselector

Frequency Range: 1.8 to 12.4 GHz, electrically tuned.
Nominal 3 dB bandwidth: 40 MHz.
Rejection: At least 35 dB for out-of-band signals.
May be internally or externally tuned or swept.
Price: $2950.

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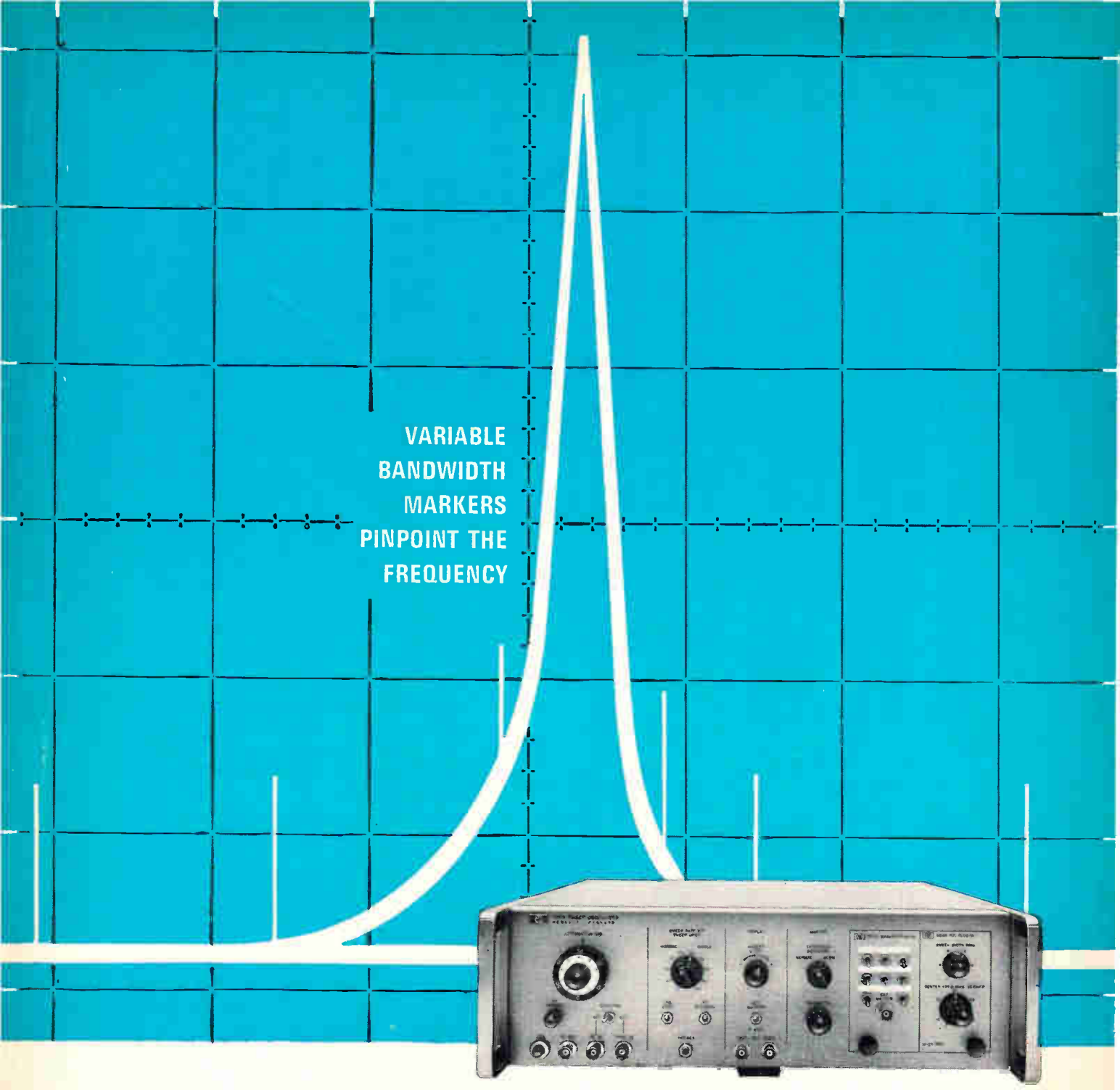
SPECTRUM ANALYZERS



Sweep Oscillator gives top performance in the 100 kHz to 110 MHz range

All solid-state Hewlett-Packard 3211A Sweep Oscillators with RF and marker plug-ins meet virtually all of your swept frequency testing requirements. Variable bandwidth markers permit accurate, well defined marking under a variety of test conditions.

The main frame of the 3211A contains everything you could hope to find in a sweeper. RF plug-ins operate at fundamental frequencies with good linearity and spurious mixing products are eliminated. Plug-in markers offer not only variable bandwidth, but also Z-axis or pulse-type marking. An accurate 59-db attenuator makes the unit a valuable tool for testing both high- and low-gain circuits.

Priced at less than $1,000, the 3211A is ideal for general testing in the video to VHF range where flat, linear output and an accurate marking system is required. Typical applications are: alignment, calibration and design of FM tuners and receivers and testing filters, amplifiers, transformers, resonant circuits and IF sections of TV receivers, radar and communications systems. For complete specifications, contact your local Hewlett-Packard field engineer or write Hewlett-Packard, Green Pond Road, Rockaway, N.J. 07866.

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SWEEP OSCILLATORS

1073B

Circle 2 on reader service card

Electronics

Volume 40, Number 19 September 18, 1967

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Electronics Abroad

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Technical articles

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II. Application

III. Manufacturing

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Readers Comment

Brazen impudence

To the Editor:

The brazen impudence of the present — and recent past — FCC commissioners has never been more adequately documented than in the alleged quotation of Commioner Lee [June 26, p. 143] when he said, "We finally changed our minds and decided that we had jurisdiction over CATV because it has the potential to destroy local broadcasters. Although CATV does serve previously unserved markets, and has a useful place in the communications industry, the FCC is trying to protect the status quo of the broadcasting industry."

Why is there something evil about the "potential to destroy local broadcasters?" Isn't it self-evident that such a potential exists only to the extent that the broadcasters do not provide what the customs want? Why not minimize the potential with service, instead of regulations. Or better yet, why doesn't the FCC enforce the existing standards upon which licenses are granted but which are never heeded except by lip-service and some large stations—which is why people prefer them on the cable to the local money-grabbers.

"Although CATV does serve previously unserved markets . . ." is another admission of the failure of both the commission and the industry to serve an important segment of America and then, when something ingenious is done about the contrived situation, to try and legislate the solution out of existence to protect the vested interests.

". . . the FCC is trying to protect the status quo. . . ." May I ask a question? Where did the Congress slip that sentence into the Communications Act? It is *not* the duty of the FCC to protect the status quo of anything; rather it is their sworn duty to see that the public is served and that the quality of that service is continually improved. Their present obstructionism to improved public service should be a matter of grave concern to the Congress.

Finally, let me point out how very glad we should be that this insolent attitude did not prevail in governmental bureaucracy when

New from Sprague!

This Resistor has 5 Times the Resistance of a Conventional Metal-Film Resistor of Equal Size!

Type	Wattage Rating	Size	Maximum Resistance
Extended-Range Filmistor Resistor	1/10	.095″ D. .250″ L.	1.5 MΩ
Conventional Metal-Film Resistor	1/10	.095″ D. .250″ L.	0.3 MΩ

This Resistor is 21 Times Smaller than a Conventional Metal-Film Resistor with Equal Resistance Value!

Type	Maximum Resistance	Wattage Rating	Size
Extended-Range Filmistor Resistor	1.5 MΩ	1/10	.095″ D. .250″ L.
Conventional Metal-Film Resistor	1.5 MΩ	1/2	.250″ D. .750″ L.

Both Resistors are one and the same...they're Sprague's new EXTENDED-RANGE FILMISTOR® METAL-FILM RESISTORS

Substantial saving of space in all wattage ratings—1/20, 1/10, 1/8, 1/4, 1/2, and 1 watt—with absolutely NO SACRIFICE IN STABILITY!

New manufacturing techniques at Sprague Electric have made possible a major breakthrough in resistance limits for metal-film resistors. Extended-Range Filmistor Resistors now offer, in addition to accuracy . . . stability . . . reliability . . . extended resistance values in size reductions which were previously unobtainable. Size and weight advantages of Filmistor Resistors now make them the ideal selection for applications in high-impedance circuits, field-effect transistor circuits, etc., where space is at a premium. Many designs which previously had to settle for the higher temperature coefficients of carbon-film resistors in order to obtain required resistance values can now utilize the low and controlled temperature coefficients of Filmistor Metal-Film Resistors.

Other key features are ±1% standard resistance tolerance, low inherent noise level, negligible voltage coefficient of resistance, and tough molded case for protection against mechanical damage and humidity.

For complete technical data, write for Engineering Bulletin 7025C to Technical Literature Service, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts 01248.

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TOROIDAL INDUCTORS
ELECTRIC WAVE FILTERS
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BOBBIN and TAPE WOUND MAGNETIC CORES
SILICON RECTIFIER GATE CONTROLS
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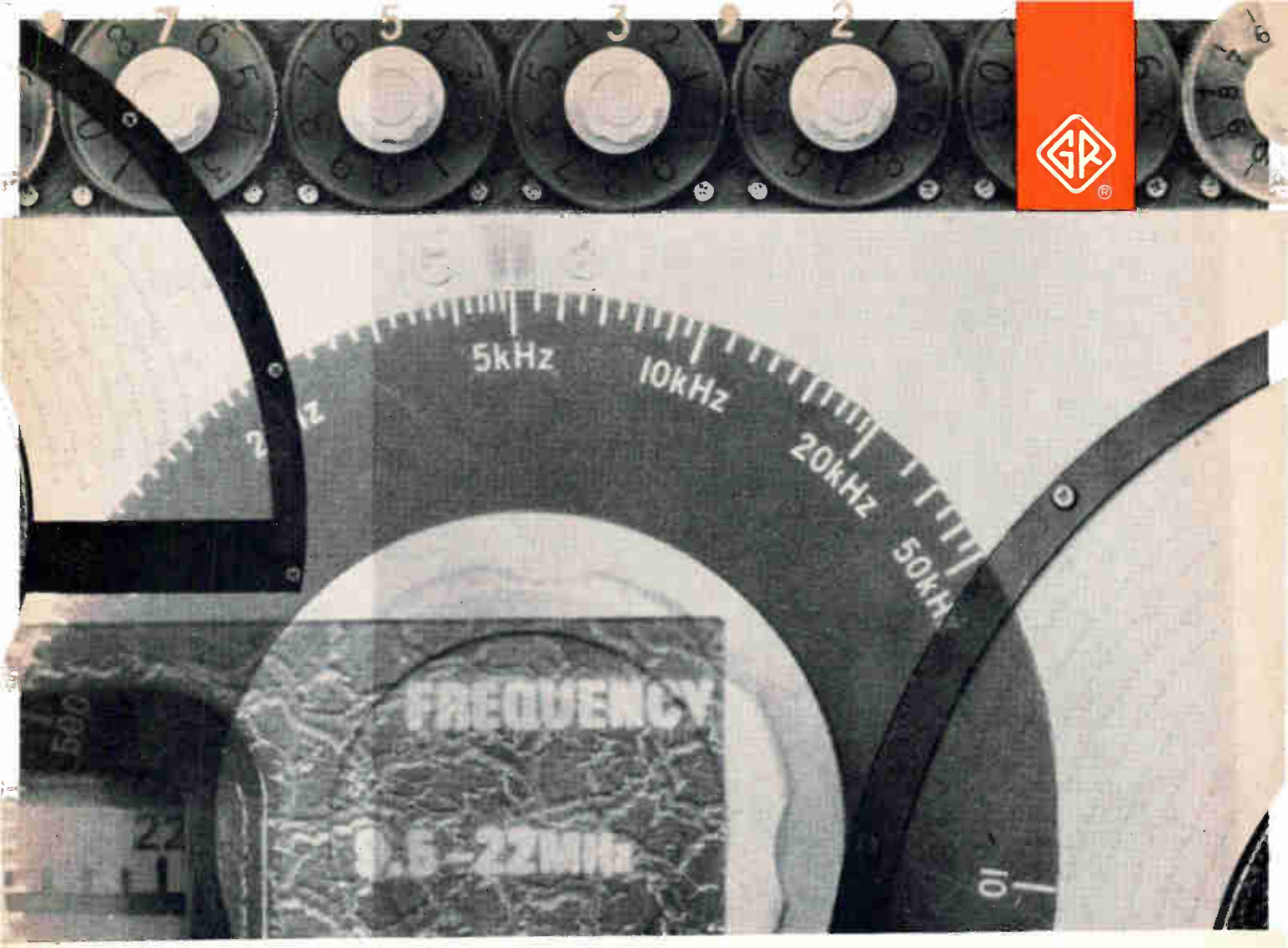

Dial GR for Sine-Wave Signals

Over 100 different models of GR oscillators, signal generators, and synthesizers are listed in our catalog. These sine-wave signal sources provide a wide choice of frequencies, power outputs, and modulation and sweeping capabilities. For instance:

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If you need a high-resolution signal source with a wide choice of operating features, you can satisfy your need with one of the 80 versions of our frequency synthesizers. Their modular construction makes it possible to order any of the four basic models with from three to seven manual step-decade modules, programmable modules, and with or without a continuously adjustable decade module that provides additional resolution and sweep capability. Upper frequency limits of the four basic models are 100 kHz, 1 MHz, 12 MHz, and 70 MHz with maximum possible resolutions of 0.0001, 0.001, 0.01, and 0.1 Hz, respectively.

The newest addition to our ensemble of sine-wave sources is the 1026 Standard-Signal Generator. This unique instrument puts out ½ *watt* into 50 Ω (10 V behind 50 Ω, 5 V when modulated), has excellent output leveling, and has true single-dial tuning over its entire 9.5- to 500-MHz frequency range. The ease of operation and outstanding performance of the 1026 in the most critical applications must be experienced to be appreciated. Request a demonstration and see for yourself.

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Type 1026 Standard-Signal Generator, $6500 in U.S.A.

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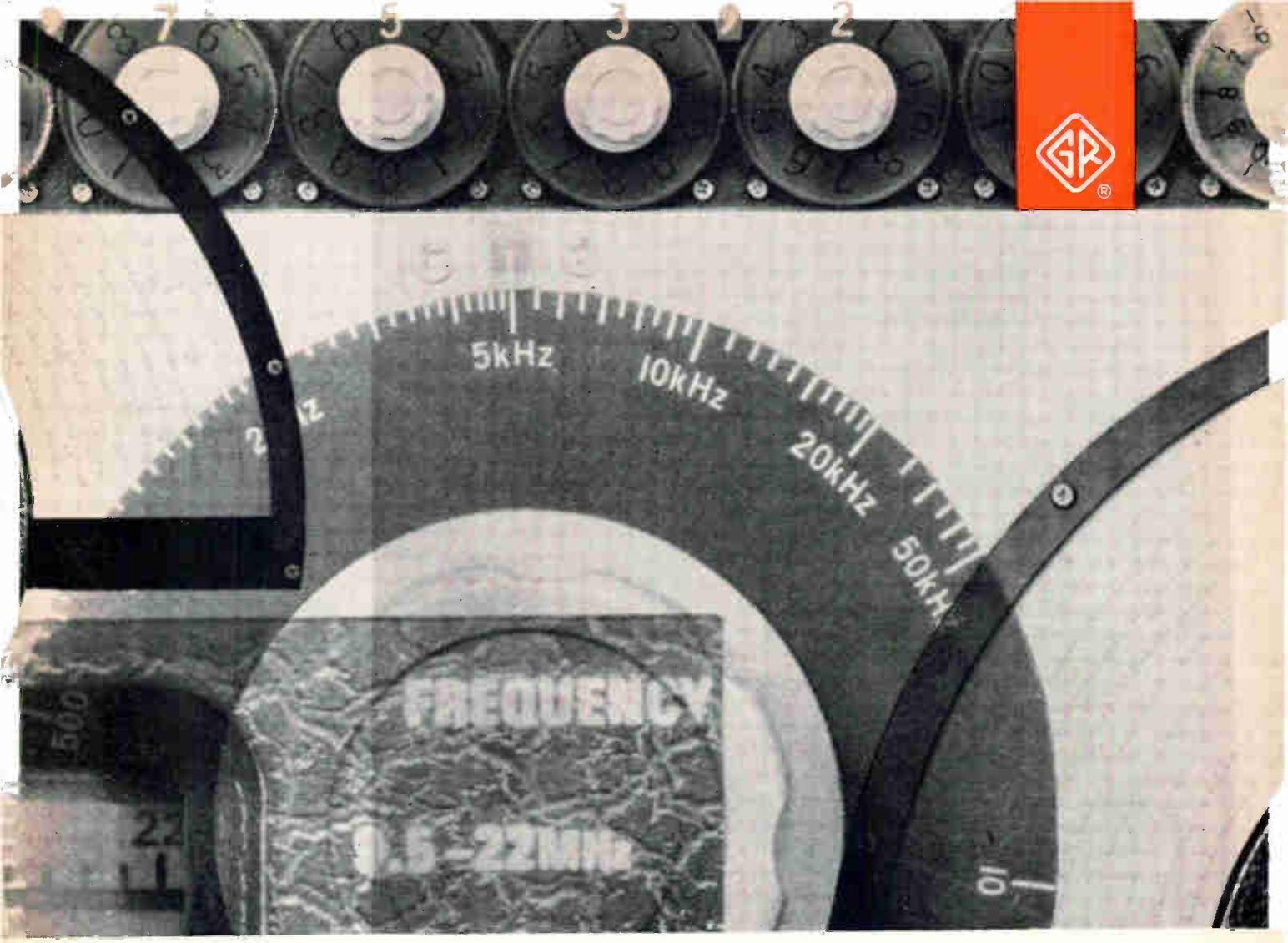

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GENERAL RADIO

Circle 6 on reader service card

Henry Ford started making automobiles. If it had we would still be riding horses (have to protect the status quo, you know) and billions of horseshoes would be stockpiled in warehouses all around the country.

If the established communications media can not, or will not, provide what the public wants, and CATV can, then the old must perish before the onslaught of the new. And if as a consequence the FCC dies too, so be it. We don't have to preserve the status quo in government either.

Richard G. Devaney
Kingsport, Tenn.

Direct application

To the Editor:

We agree with the general trend of thought of the editorial "Partners in progress: doctor and engineer" [July 10, p. 23]. It is our opinion that engineering techniques should be applied directly to the problems of disease and disablement. This would be more effective than the present practice of trying to apply engineering techniques to the problems posed by doctors. Can you imagine how far Thomas Edison would have gotten on his "light" project if he would have been forced to work with the gas company to produce a brighter, more efficient gas flame!

Dr. Joseph Battocletti
Kenneth Kayser
Badger Meter Manufacturing Co.
Milwaukee

Research as a luxury

To the Editor:

Your editorial [July 10, p. 23] omits one very great difficulty in the cooperation of engineers with physicians: money.

Many physicians do research as an avocation—a labor of love. They do it for free or for a nominal sum. A doctor can afford this, since his principal source of revenue is elsewhere.

He may consider that since he, the physician, is donating time, surely other professionals, like engineers, should do the same.

There are signs of change however. Many hospitals do have engineers on staff; physicians budget for engineering on their grants, much more so than in the past.

Really, I have observed that in the past five years there has been an order of magnitude change for the better in this important region.

H.H. Schwartz
Montreal, Canada

It takes three kinds

To the Editor:

The difficulties with IC voltage regulators for automobiles [June 26, p. 23] missed an important point.

You stated "Application of electronics in areas that have been traditionally nonelectronic is a job requiring two kinds of people: those who understand electronics technology and those who understand the application."

You omitted the integration people, those who understand the interaction of environments and electronics. They are needed even for introducing IC's into automobiles.

Of course, it is well known that one of the important environments is the electromagnetic environment. Therefore, one of the integration people should be an electromagnetic compatibility engineer since electrical "noise" is ever present.

Anthony G. Zimbalatti
Hempstead, N.Y.

People

The Eastern operation of Sylvania Electronic Systems in Needham, Mass., has often been out of phase with the rest of the industry. Sometimes the aberration was a happy one; in 1963, when most of the defense electronics industry was hurting, Sylvania Systems East was hiring. But during 1966 and early this year the plant was laying off while most were hiring.


William Wheeler

"We are now stabilized, and have been for months," says **William S. Wheeler,** the new vice president and general manager of the Eastern division of Sylvania Electronic Systems, an operating group of Sylvania Electric Products.

Stabilization was achieved before Wheeler took over, but keeping the company in phase with projected growth curves becomes the responsibility of the 45-year-old vice president. The major involvement in the division's recent history was in the Minuteman program, principally as contractor for the ground electronics. Everyone knew that the Minuteman program had peaked, but the downward turn was steeper and faster than expected. Sylvania, like others, was also caught in the cancellation of several large strategic-type programs.

Shift in emphasis. "We've swung over more to the tactical systems. They're smaller, but there are more of them," says Wheeler.

The division is still doing work in strategic-weapons control, such as Minuteman, but it is also teamed with Burroughs as a contender for the Army's tactical weapons-control system, Tacfire. Wheeler sees long-range growth in training systems for complex defense equipment. His division is a prime competitor in the satellite earth station business, in over-the-horizon radar, and phased-array antennas. Other areas of concentration will include search-location-rescue equipment such as Syl-

Designed Sealed Delivered

Helipot's New Model 77P Cermet Trimming Potentiometer

Here's the new Model 77P, the first low-cost, general purpose trimmer with a sealed housing and cermet resistance element! DESIGNED to wider performance parameters than any other adjustment potentiometer in its price range. It is directly interchangeable with competitive Models 3067 and 3068–SEALED to permit p.c. board solvent cleaning and potting without trimmer contamination or failure–DELIVERED from local stock at the low list price of $1.95. In large quantities, Model 77P sells for as little as $1.10. ▪ Compare Model 77P specifications with those of unsealed trimmers, then call your local Helipot representative for an evaluation sample.

	 Helitrim Model 77P	 Model 3067 Wirewound	 Model 3068 Carbon
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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People

vania's rescue radio, the PRC-63.

Wheeler is hard at work trying to reduce the number of projects his division will get into. "In today's defense business," he says, "I don't know of any company which does not make a substantial financial contribution of its own in contract-definition work. So you can't jump into all of them. You can only afford so many at a time."

Trying to give solid state devices an inside track with railroad equipment, the General Electric Co. has put **F. William Gutzwiller** in the engineer's seat at its Transportation Systems division in Erie, Pa. Gutzwiller previously was manager of semiconductor applications at GE's Auburn, N.Y., facility. A member of the team that developed the first commercial silicon controlled rectifier, Triac, and other thyristors, he specializes in semiconductor applications, particularly in power systems.

F.W. Gutzwiller

Gutzwiller was a prime mover in developing SCR's and electronic subsystems for motor controls, lighting systems, toys [See related story on page 46], and other areas once the exclusive preserve of relays, vacuum tubes, and mechanical and other conventional devices.

Express. "My new mission," says Gutzwiller, "is to bring solid state electronics to railroad cars and locomotives, diesel-engine drives, motor-control systems, and oil-well drilling and earth-moving equipment." Traditionally, makers of such equipment have been wedded to mechanical, hydraulic, pneumatic, and electrical systems. Winning them over to solid state devices won't be a simple task.

One of his first assignments is to develop electronic motor-control systems for the Northeast Corridor experiment, a Government-sponsored project to explore the feasibility of running high-speed trains between Boston and Washington.

MACHLETT

AT WCBS-TV MACHLETT ML-5681 HIGH POWER TRANSMITTING TUBES HAVE JUST LOGGED 170,000 HOURS.

Where prime time requires prime performance specify Machlett transmitting tubes. Available now: The new Machlett short form catalog, from The Machlett Laboratories, Inc., 1063 Hope Street, Stamford, Connecticut 06907.

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These 14 New Devices Make RCA

the Triac Leader of the Industry

Now, RCA offers you the industry's broadest line of Triacs, with an unmatched choice of ratings and triggering characteristics in space-saving packages ...all at truly economical prices! Triacs are today's most modern, effective component for ac phase-control and load switching. Because they can perform the functions of two SCR's, Triacs make possible new economies in full-wave power circuit design and cost for industrial and commercial applications.

So for efficient, inexpensive solid-state control of motors, lighting, and heating, look to RCA, the Triac Leader. Your RCA Sales Representative will be happy to give you more details, including price and delivery. Also, ask him about RCA's complete line of SCR's. For additional technical data, write RCA Commercial Engineering, Section RN9-3, Harrison, N.J. 07029. See your RCA Distributor for his price and delivery.

*Priced in quantities of 1,000 and up.

Current Rating I_T(rms)	Low Voltage (100V)	120V Line (200V)	240V Line (400V)	Package
2.5A (I_{GT} = 3 mA max)	40525	40526	40527	modified 3-lead TO-5
2.5A (I_{GT} = 10 mA max)	40528	40529	40530	modified 3-lead TO-5
6A		40429	40430	TO-66
6A		40485	40486	modified 2-lead TO-5
6A		40431 (with integral trigger)	40432 (with integral trigger)	modified 2-lead TO-5
15A		TA2834	TA2835	TO-66

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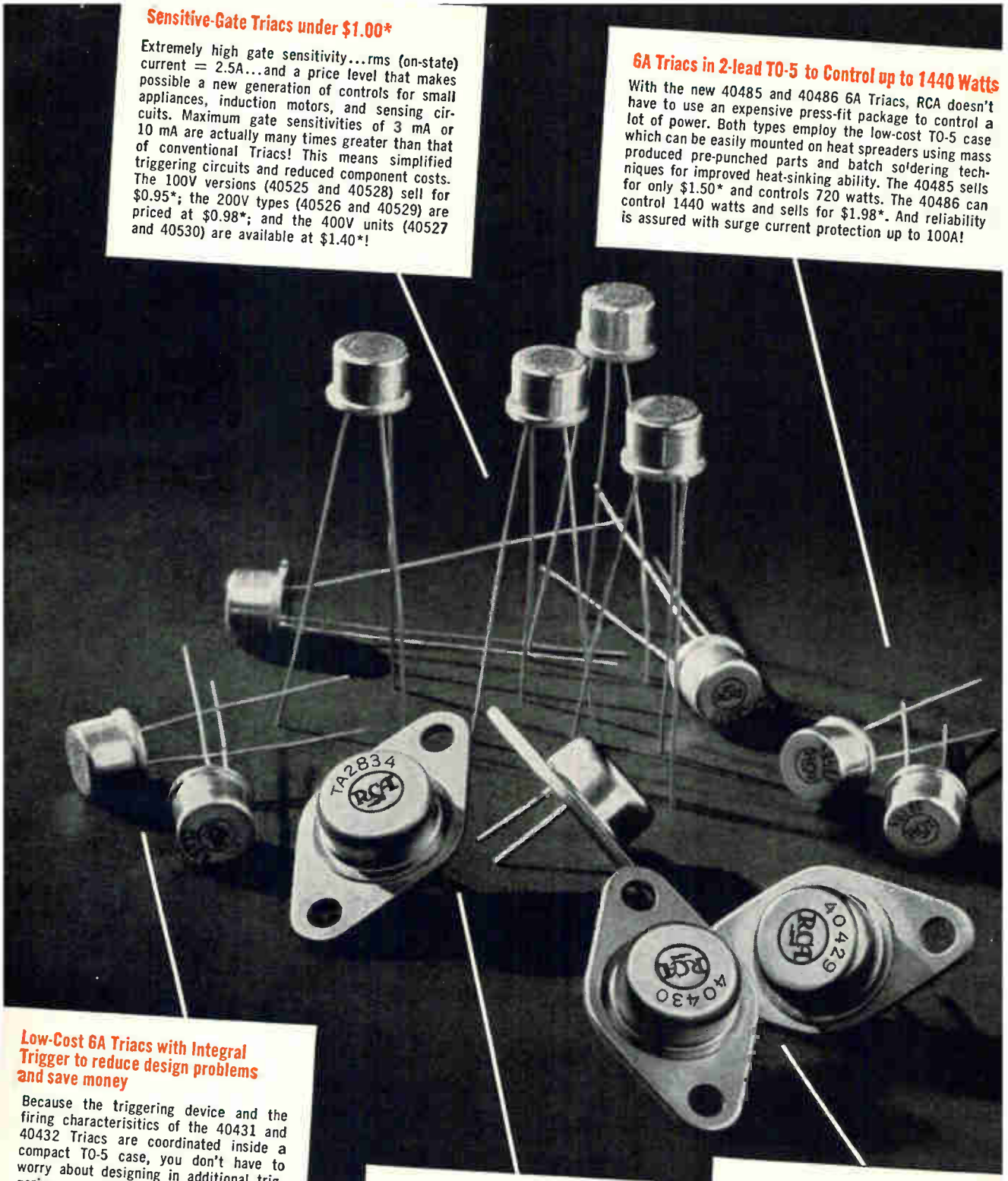
RCA® The Most Trusted Name in Electronics

Sensitive-Gate Triacs under $1.00*

Extremely high gate sensitivity...rms (on-state) current = 2.5A...and a price level that makes possible a new generation of controls for small appliances, induction motors, and sensing circuits. Maximum gate sensitivities of 3 mA or 10 mA are actually many times greater than that of conventional Triacs! This means simplified triggering circuits and reduced component costs. The 100V versions (40525 and 40528) sell for $0.95*; the 200V types (40526 and 40529) are priced at $0.98*; and the 400V units (40527 and 40530) are available at $1.40*!

6A Triacs in 2-lead TO-5 to Control up to 1440 Watts

With the new 40485 and 40486 6A Triacs, RCA doesn't have to use an expensive press-fit package to control a lot of power. Both types employ the low-cost TO-5 case which can be easily mounted on heat spreaders using mass produced pre-punched parts and batch soldering techniques for improved heat-sinking ability. The 40485 sells for only $1.50* and controls 720 watts. The 40486 can control 1440 watts and sells for $1.98*. And reliability is assured with surge current protection up to 100A!



Low-Cost 6A Triacs with Integral Trigger to reduce design problems and save money

Because the triggering device and the firing characterisitics of the 40431 and 40432 Triacs are coordinated inside a compact TO-5 case, you don't have to worry about designing in additional triggering components. You benefit further from reduced circuit and assembly costs, plus improved packaging densities! So if your ac-load control circuits require a trigger, why not have it built-in for you? The 40431 controls 720 watts at 120V and costs $1.80*; the 40432 controls 1440 watts at 240V and costs only $2.48*.

15A Triacs for Load Control up to 3600W

RCA developmental types TA2834 and TA2835 Triacs extend solid-state control way up into the kilowatt range. These powerful TO-66 units have surge current protection up to 100A, plus all of the other design benefits of RCA's lower current Triacs. Possible applications include power supplies, heating controls, motor drivers, and many other industrial and commercial usages.

6A Triacs in Popular TO-66 Package

Need full-wave control of up to 1440 watts in a TO-66 package? RCA 40429 and 40430 Triacs are your answer... they feature high gate sensitivity, symmetrical triggering characteristics (I_{GT} = 25 mA max), and surge current protection up to 80A. The 200V 40429 costs $1.50*, the 400V 40430 only $1.98*.

Meetings

Meeting of the Radio Technical Commission for Aeronautics; Statler Hilton Hotel, Washington, D.C., **Sept. 19-20.**

International Broadcasting Convention, Electronic Engineering Association; Royal Lancaster Hotel, Lancaster Gate, London, **Sept. 20-22.**

Automotive Conference, IEEE; Howard Johnson's Motor Lodge, Detroit, **Sept. 21-22.**

Symposium on Microelectronics Applications, IEEE; Garden City Hotel, Garden City, Long Island, N.Y., **Sept. 21-22.**

Power Generation Conference, American Society of Mechanical Engineers and IEEE; Statler Hilton Hotel, Detroit, **Sept. 24-28.**

International Electronics Conference and Exposition, Canadian Region of IEEE; Automotive Building, Canadian National Exhibition, Toronto, **Sept. 25-27.**

National Petroleum Industry Conference on Magnetic Materials and their Applications, IEEE; London, **Sept. 26-28.**

Electronics Show, Electronic Industries Association of Japan; Minato International Trade Fair Grounds, Osaka, Japan, **Sept. 28-Oct. 4.**

Conference, IEEE; Marriott Motor Hotel, Philadelphia, **Oct. 2-4.**

International Telemetering Conference, International Foundation for Telemetering; Marriott Twin Bridges Motor Hotel, Washington, **Oct. 2-4.**

Industry and General Applications Group Meeting, IEEE; Pittsburgh Hilton Hotel, Pittsburgh, **Oct. 2-5.**

Active Sonar Classification Symposium, Department of the Navy; Naval Postgraduate School, Monterey, Calif., **Oct. 3-5.**

Ultrasonic Symposium, IEEE; Bayshore Inn, Vancouver, Canada, **Oct. 4-6.**

Engineering Management Conference, IEEE; Jack Tar Hotel, San Francisco, **Oct. 9-10.**

Machine Tool Conference, IEEE; Cleveland Sheraton Hotel, Cleveland **Oct. 9-11.**

Systems Science and Cybernetics Conference, IEEE; Statler Hilton, Boston, Oct. 11-13.

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

Short Courses

Symposium on physics and nondestructive testing, Physics Department and the Nuclear Science Center of Louisiana State University, Baton Rouge, Sept. 19-21; $50 fee.

Modern electroanalogic simulation techniques in engineering design, College of Engineering and the College of Applied Science and Engineering of University of Wisconsin, Madison, Sept. 25-26; $50 fee.

Process dynamics and control, Purdue University's School of Engineering, Lafayette, Ind., Sept. 25-30; $150 fee.

Calls for Papers

Technical Meeting and Equipment Exposition, Institute of Environmental Sciences; Chase-Park Plaza Hotel, St. Louis, April 28-May 1, 1968. **Oct. 1** is deadline for submission of abstracts to Technical Program Committee, Institute of Environmental Sciences, 940 E. Northwest Highway, Mt. Prospect, Ill. 60056.

International Solid State Circuits Conference, IEEE; Sheraton Hotel, Philadelphia, Feb. 14-16, 1968. **Oct. 23** is deadline for submissions of abstracts to Roger Webster, Texas Instruments Inc., P.O. Box 5012, MS 9, Dallas 75222.

Computer Conference, American Federation of Information Processing Societies; Convention Hall, Atlantic City, N.J., April 30-May 2, 1968. **Oct. 30** is deadline for submission of drafts and abstracts to T.R. Bashkow, technical program committee chairman, 1968 SJCC, Department of Electrical Engineering, 1312 S.W. Mudd, Columbia University, New York 10027.

* 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.

high density packaging expert goes too far!

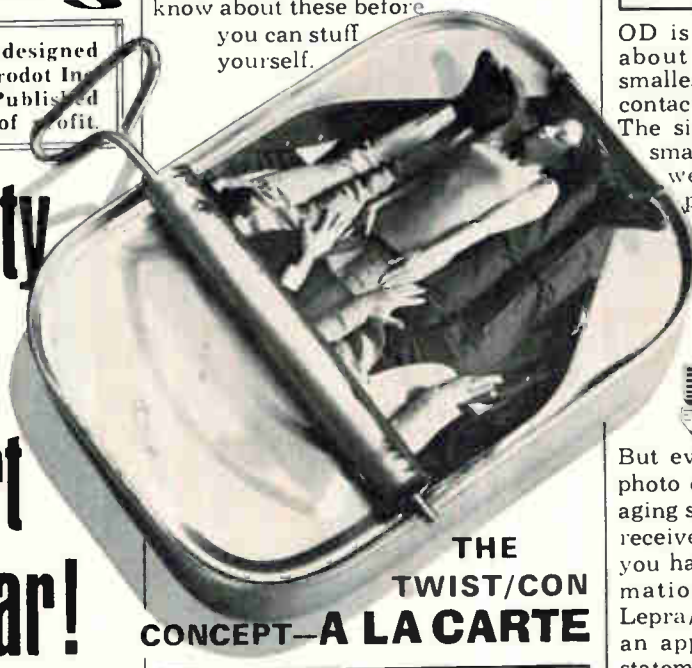
Let's face it. The reason our connectors lend themselves so superbly to high density packaging solutions is that they are—in and of themselves—outstanding examples of high density packaging. That's a long winded way of saying that we make smaller connectors than anybody. And it takes some pretty far out designers to jam 420 contacts on one teeny square inch of connector surface (see Twist/Con).

One of these far out types—Algonquin G. Squozen in our design group—has a hobby. In his spare time he dreams up all sorts of high density packaging solutions. Trouble is there isn't always a problem to fit the solution. A classic example of Algonquin's creative work is shown on this page. Study it carefully because it will help you to

WIN A WHOLE BASKET OF GOURMET FOODS!

(Everything from imported sardines and paté de foie gras to Beluga caviar. Shipped to you direct from Vendome's Gourmet Foods in Beverly Hills, Calif.)

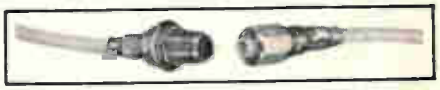
Now that we've whetted your appetite, a few well chosen words about the entree—our connectors. You'll need to know about these before you can stuff yourself.



THE TWIST/CON CONCEPT—A LA CARTE

It all started like this: We eliminated the contact spring member normally found in socket contacts by creating a breathing helical spring principle on the pin contact. Smaller. More durable. More economical. The result was the best family of rack/panel and strip connectors on the market. *Some of the high density applications for TWIST/CON include connections for IC's, interconnecting of printed circuit boards, edge-on connections for p.c. boards, and on modules with connectors welded to hybrid circuits.* Single pins are being used for high density line splices. TWIST/CON is usable with 22 AWG to 30 AWG standard wires. ***Next, we applied the TWIST/CON principle to***

LEPRA/CON—WORLD'S SMALLEST FULL 50 OHM COAX



OD is ⅛ inch and mated length is about one inch. That makes it the smallest. And the completely protected contacts also make it the most reliable. The size means you can use a much smaller OD cable for even greater weight/size reduction in your package. ***The price is as low as $1.07 in nominal quantities.*** You can get straight plugs, jacks, bulkhead jacks, right angle plugs, or printed circuit receptacles. Screw-on or slide-on versions in entire line. ***That's the menu for today.***

BIG WINNERS!

But everybody who enters receives a photo of Squozen's high density packaging solution. Five lucky entrants will receive the cases of gourmet foods. All you have to do is (a) study the information about our Twist/Con and Lepra/Con connectors, and (b) write an appropriate caption or problem statement for the sardine can, working in at least one of the two connectors we've talked about. Contest closes October 1, and is not valid anyplace where it is considered illegal, immoral—or fattening.

MICRODOT INC.

MICRODOT INC., 220 Pasadena Avenue, South Pasadena, California 91030

Dear Microdot:

- ☐ Enclosed find my entry in your high density packaging contest
- ☐ Enough of this foolishness. Just send me literature on (circle) TWIST/CON LEPRA/CON *all* your connectors
- ☐ I have a connector application for high density packaging. Get somebody over here.

Name_____

Title_____

Firm_____

Address_____

City_____

State_____ Zip Code_____

Telephone_____ Ext._____

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Meeting preview

New heights

Since its inception, the International Electron Devices Meeting has always provided prestigious technical programs, and this year is no exception. In fact, the upcoming meeting, scheduled for Washington from Oct. 18 to 20, is surely the best ever on two counts: the breadth of the subjects to be considered and the technical importance of the papers.

As usual, those attending will find it impossible to sit in on all the sessions; at least three and sometimes six will be going on at the same time. The perennial topics are solid state devices, integrated electronics, and electron tubes; the newer categories cover display and pickup devices, quantum electronics, and energy conversion devices.

In the display-and-pickup group, J. R. Hansen and R. J. Schneeberger of Westinghouse Research Laboratories will describe a recording device based on liquid crystals that change color as an impressed electrostatic field is varied. The device provides a multicolor image in real time.

In another of the 18 papers in this category, C. E. Land of Sandia Laboratory will tell how ferroelectric ceramics are used to modify the transmission characteristics of a film when electric fields are applied. Land says the technique could permit the storage of as many as 1 million bits per square inch.

Yielding LSI. One of the deterrents to the applications of large-scale integration has been low device yields. A.G.F. Dingwall of RCA will discuss recent advances in processing that have boosted yields to the point where the interconnection of LSI arrays is feasible. Beam leads, new mounting and bonding techniques, and other routes to LSI will also be covered at the meeting.

Three-quarters of the 24 papers in the quantum electronics category are on lasers—both carbon dioxide and ion.

The subject of the other papers is photodetectors, including silicon carbide, indium antimonide, and gallium arsenide-cesium types.

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Call on your nearby Tektronix Field Engineer when you need assistance in selecting the proper oscilloscope for your measurement problem, or when you need help in operating or maintaining it.

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Don Hofmann of Philadelphia, Pa.— One of the Tektronix Field Engineers serving you from 43 U.S. Field Offices and in more than 20 countries around the world.

At these prices, you try one of these sh scheme now and then.

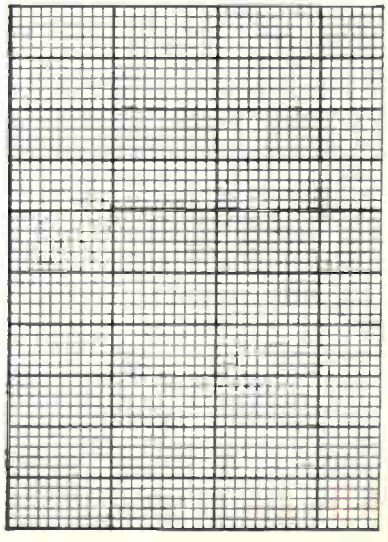
nobody will holler if ft registers on a wild

MM500 50 bit shift register $9.85 in 100 lots— It's very fast, uses low power, and, similar to all our other shift registers, has the lowest operating voltage around. It's organized as a dual 25 bit element. The unit uses −10 volt VDD supply voltage and 16 volt clock amplitudes. Power dissipation at 10kc is a typical 28 μw/bit. And guaranteed operation is at 1 MHz in a temperature range of 0°C to 70°C.

MM502 100 bit shift register $14.80 in 100 lots— Power dissipation for this one at 10kc is a typical 16 μw/bit. Otherwise, specs are about the same, except there are 50 more bits. This one is organized as a dual 50 bit unit.
They're available right now at any of our distributors, or call National Semiconductor Corporation, 2975 San Ysidro Way, Santa Clara, California 95051 (408) 245-4320.

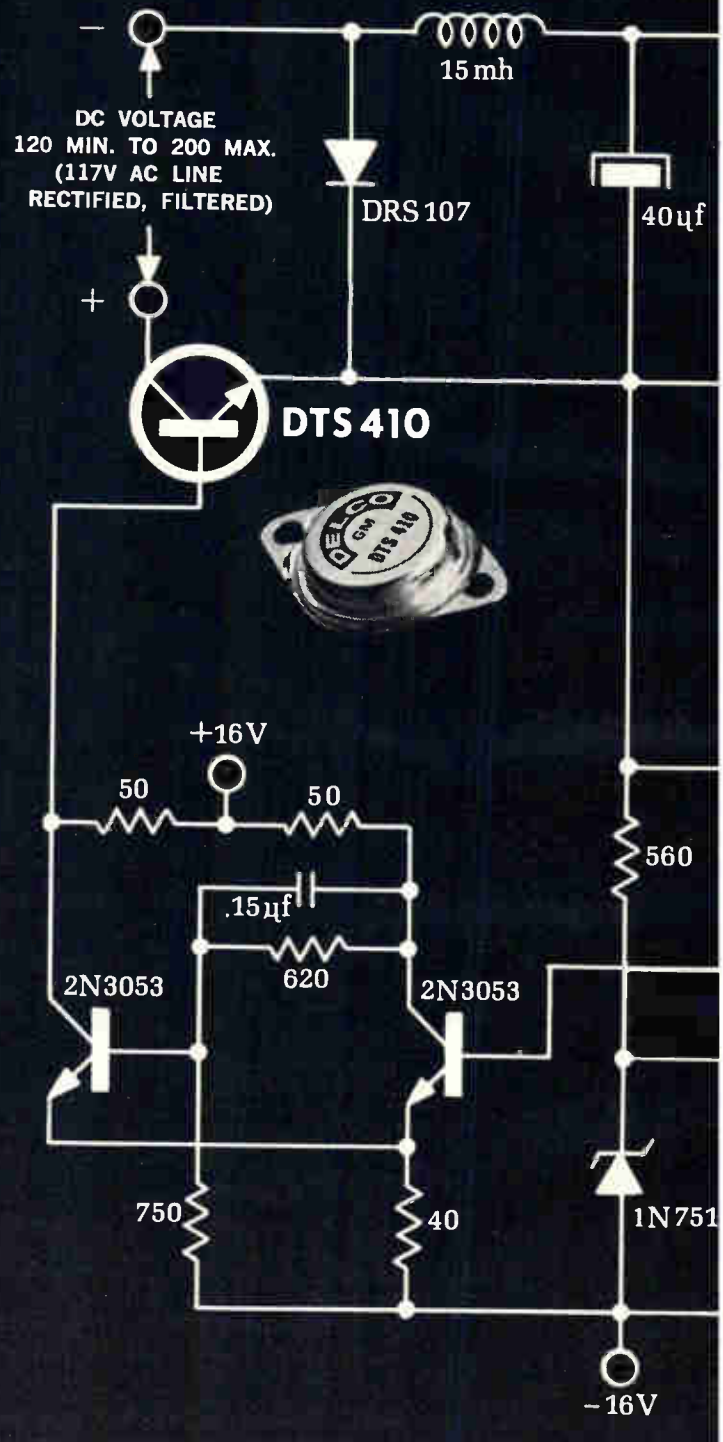
National Semiconductor

Wild scheme goes here.

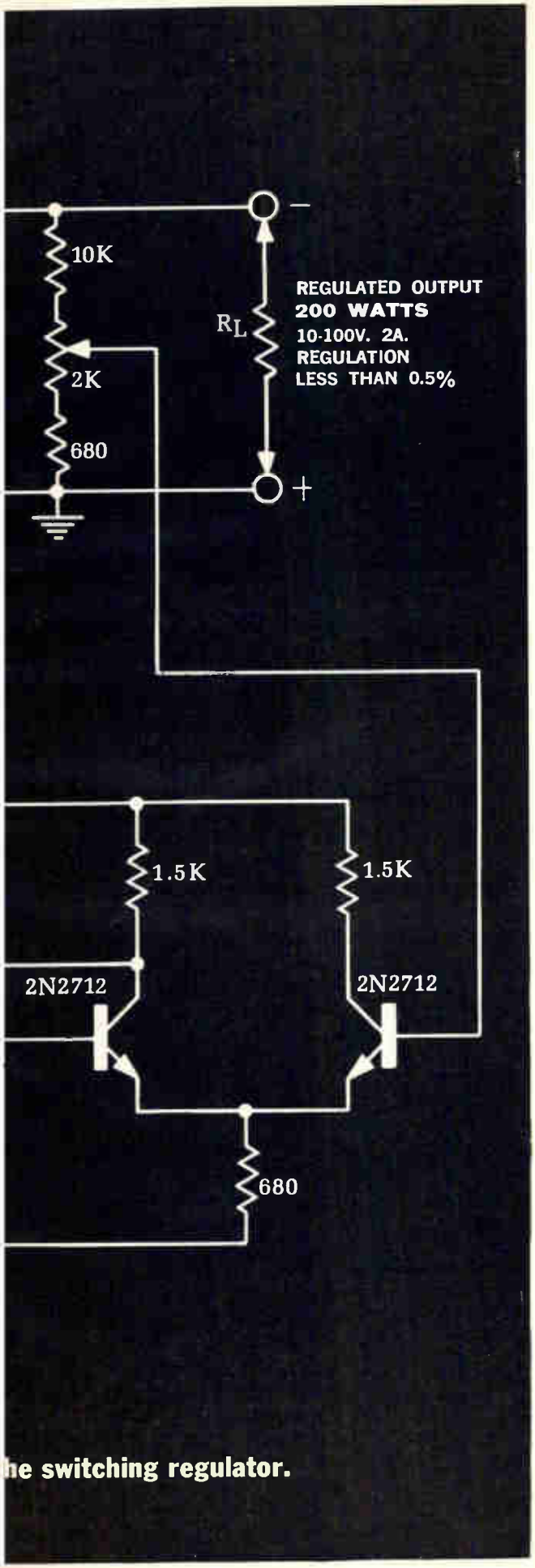


To get high energy circuitry at the lowest cost:

start here.



Application of Delco high voltage silicon power transistors



Start with circuit designs using Delco high voltage silicon power.

The simple switching regulator in the diagram at left turns out 200 watts (2 amps) output at efficiencies exceeding 85%. And it does it with just one series element working directly from rectified line voltage: the new Delco DTS-410 transistor at *just $1.95 each**.

Or if you need regulation of 250 volts DC and 400 watts output, the DTS-411 may be your answer. Cost? Just $3.15 each*. And for extra-high voltage applications, there's the DTS-423, now priced at $4.95 each*.

Now combine our new low prices with these other cost-cutting advantages of Delco high voltage silicon power transistors: you can reduce the number and complexity of input, output and filtering components. This means more compact circuitry, greater reliability and lower assembly costs.

These NPN silicon transistors are packaged in a rugged TO-3 case for low thermal resistance. Inside, they are mounted to withstand mechanical and thermal shock because of special bonding of the emitter to base contacts.

There's no need to be concerned about delivery. They are available right now in production quantities. Call us. Or order samples from your Delco distributor.

For details on the switching regulator circuit ask for application note number 39.

*Prices shown are for quantities of 1,000 or more.

TYPE	V_{CEO}	V_{CEO} (sus)	I_C Max	h_{FE} Min @ I_C V_{CE}=5V	Power Diss Max
DTS-410	200V	200V (min)	3.5A	10 @ 2.5A	80W
DTS-411	300V	300V (min)	3.5A	10 @ 2.5A	100W
DTS-423	400V	325V (min)	3.5A	10 @ 2.5A	100W

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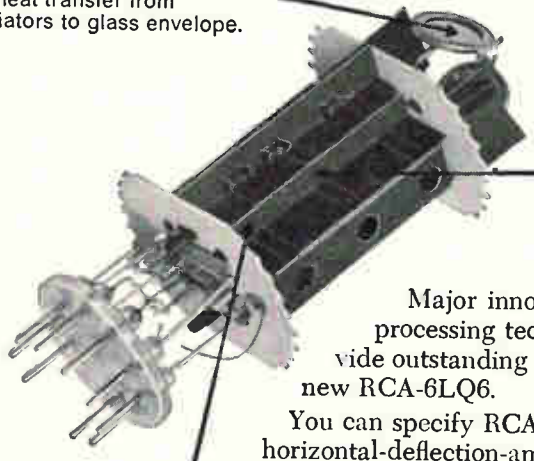
RCA's new 6LQ6 Novar Beam Power Tube for Horizontal-Deflection Service in Color TV

withstands 200 W plate dissipation for 40 seconds

Position of getters and subsequent flash improves heat transfer from screen-grid radiators to glass envelope.



Cavity plate designed for better heat dissipation.

Cavity plate made of heavy-gauge carbonized nickel and subjected to special vacuum-firing process. Combination of material and special processing reduces level of occluded gas and minimizes gas emission during periods of high-overload-temperature.

Larger diameter of screen-grid wire reduces screen-grid temperature and improves high-voltage cutoff characteristic.

Major innovations in materials, design and processing techniques make it possible to provide outstanding heat dissipation capability in the new RCA-6LQ6.

You can specify RCA's new 6LQ6 for the demanding horizontal-deflection-amplifier socket of your color-television chassis *with full confidence* that it will provide dependable, high-level performance from tube to tube and throughout life.

The 6LQ6 is a direct replacement for the 6JE6A and 6JE6B.

For complete information on the new RCA-6LQ6 family of Novar Beam Power Tubes, call your nearest RCA District Office or write to RCA Commercial Engineering, Harrison, New Jersey 07029.

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Editorial

No mutual benefit

In Wall Street this summer, brokerage firms had so much business they couldn't handle the paper work for all the stocks that were bought and sold. Trading on the New York Stock Exchange passed 10 million shares a day so often that the Exchange had to shorten the trading day. One of the reasons for the gargantuan volumes—only a few years ago a five-million-share day was considered a bonanza on the Exchange—is that the mutual funds are doing a lot more trading. They've grown so big that they have huge resources of cash and many have changed their main objectives from buying stocks with long-term growth possibilities to buying and selling shares over the short term, hoping to pick up a few points per share.

What they are doing is having a deleterious affect on many electronics firms.

Instead of studying the long-term prospects of a company's stock, the mutual funds are more interested in what it will do this week, next week, or this month. By next month, they'll be on to another stock. To someone raised amid conservative financial men, what the mutual funds are doing would better be called gambling than investing. Only the kindest observer can even call it speculation because the funds sometime operate on the slimmest of tips or the most unconfirmed rumors.

To better serve this adventurous spirit, many Wall Street firms have established special research organizations to sell information just to the funds. Some of the firms have gotten so specialized that they will have an analyst who follows only integrated circuits, not caring what's happening to discrete semiconductor devices even though they may more affect a semiconductor company's current situation than IC's. Selling good, bad, and terrible information has become big business on Wall Street.

Electronics companies, and especially the semiconductor firms, have been the subject of a lot of such stock dealings this year. For one thing, the concept of integrated electronics has excited the imagination of financial people. It's a young field and nothing looks more attractive to a stock speculator than a ground floor opportunity. Also, profits among the semiconductor companies have been hurt disproportionately by the slump in consumer electronics sales. So their stocks are under scrutiny. And finally, the increase in numbers of conglomerate corporations such as LTV and ITT, companies that are not in one business but in many, has limited the number of companies whose futures and stock performance reflect the success of new technical developments.

All this activity in the investment world would be only of academic interest to engineers, even at the companies involved, if it weren't affecting the day-to-day operations of these companies.

The performance of the stock causes management to tune its operation so the company looks attractive to stock buyers. When profits are hurt, say by a slump in consumer electronics equipment, a semiconductor company can offset the slide by drastically curtailing research and development expenditures. At one semiconductor company whose performance on Wall Street has resembled a rollercoaster during the past six months, a top executive expressed his concern. "Even under the best circumstances, it is difficult to determine how much money should be spent on R&D. But you can't base such expenditures on the daily performance of the stock and hope to survive in the semiconductor business," he says. The company has to pay dearly for the savings in R&D in a few years when it doesn't have the new products that should have evolved but didn't.

The sharp fluctuations of stock also work a devastating effect on key engineers and managers who have stock options. Considering the situation on Wall Street today, another electronics executive asked, "How do those important engineers feel about their options—and the company—when the stock drops 20 or 30 points in one day? Do you think they do their best work when all the incentives have gone down the drain?"

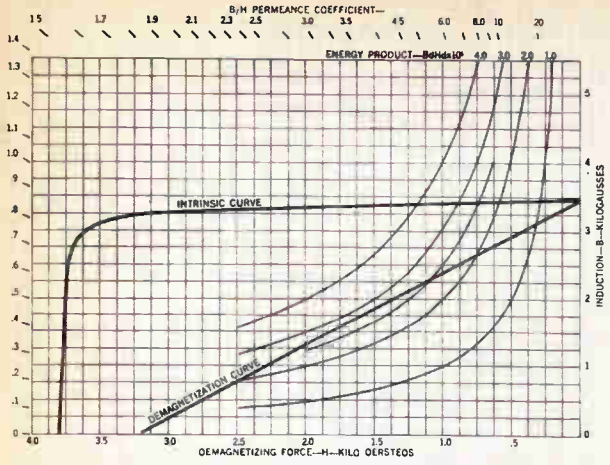
The press to win acceptance among the security analysts sometimes causes companies to make premature announcements of products. Since the announcements are never marked: "Financial community only—security analysts please note and recommend your customers buy our stock," design and application engineers often find themselves trying out products that are not ready for use, do not have anywhere near the reliability needed nor the performance promised. Or they find themselves chasing promises that are never realized in hardware.

To see just how ludicrous the situation has become, you have only to examine how the stock market has reacted to companies that build integrated circuits with metal oxide semiconductor techniques.

The rumor that a company can add four or eight bits of data capacity to an MOS chip can boom the company's stock 8 to 12 points—even though there may not be any customers for or production of such a circuit. When the rumor mill reported that Fairchild Semiconductor Division was having troubles making some MOS IC's, its stock dropped almost 20 points in two weeks, even though there are few customers around now for production runs of MOS circuits. You can appreciate how silly all this is only when you understand that almost all the business in MOS circuits today is research and development contracts, and the total dollar volume is miniscule compared to that of digital IC's sold by the same firms.

All this is leading electronics companies—and the mutual funds that started it—into dangerous territory. Customers of electronics products are growing leary of the official pronouncements that come from electronics companies. Electronics companies are pushing their operations to make their stock attractive on the market rather than to build a stable corporate base and a solid business. And the gambling on electronics stock by funds is making electronics companies unattractive to the investment community, so it is increasingly difficult to start or finance new electronic operations.

For the sake of the future growth and well-being of most companies, more managers are going to have to run their businesses as if Wall Street didn't exist.



With a coercive force of 3200 oersteds, Indox 7 has a higher resistance to demagnetization than any commercially available magnetic material except costly platinum-cobalt. It also has a high peak energy product and high intrinsic coercive force.

New Indox 7 requires no critical materials, is light weight and has high electrical resistance. Indox 7 opens new possibilities for designs and applications where greater resistance to demagnetization is required, or where the magnet length is limited compared to the magnet area.

Indiana General pioneered ceramic magnets, developed the first ceramic magnet for PM motors, and continues it's leadership in magnet technology with this new high in ceramic magnet materials. For a copy of the new bulletin on Indox 7, write Mr. C. H. Repenn, Manager of Sales, Magnet Division, Indiana General Corporation, Valparaiso, Indiana.

INDIANA GENERAL

When it comes to resisting demagnetization, new Indox® 7 is in a class by itself. Summa Cum Oersteds.

Electronics Newsletter

September 18, 1967

Tv for $49.95?

Industry insiders say that General Electric is working feverishly to produce **the industry's first under-$50 black-and-white 12-inch television receiver** in time for the Christmas market. Dubbed the Adventurer, the transistorized receiver will sell for $49.95.

Computer uses easily programable read-only memory

A flexible memory control technique that replaces conventional read-only memories has been incorporated in a research computer built by Automatic Electric. Conventional read-only memories cannot be easily altered; **the new technique uses separate, replaceable printed-circuit cards for each instruction.** Automatic Electric, the manufacturing arm of General Telephone & Electronics, **will probably design the concept into its line of process control equipment within a few years.** A paper on the new memory will be presented at the Fall Joint Computer Conference, Nov. 14 to 16.

Under the new method, called Picoprogram control, the complete sequence of steps taken to execute a particular instruction is stored on a single printed-circuit card. Different instructions—such as "compare" and "store"—address different cards; the cards for similar instructions—such as "add" and "subtract"—are physically distinct but resemble one another closely. **The instruction repertoire of the machine can thus be changed simply by changing cards, making the computer extremely flexible.**

Conventional third-generation computers have read-only memories in which a sequence of addresses prescribes the sequence of steps. Different instructions use different sequences, but the sequences for similar instructions overlap considerably. This minimizes the total number of words in the read-only memory—the number need not be much greater than the number of different instructions. But the overlapping also means that almost the entire memory has to be changed if the instruction repertoire is changed.

Also, if any particular step generates an error, the new machine stops in its tracks without completing the instruction in progress and this vastly simplifies trouble-shooting.

Bell System plans automatic checkout

Within the next three or four years the Bell System will begin to install **automatic equipment to locate and diagnose failures in its nationwide communications network.** Work on the computer-operated checkout system should be completed within 10 years.

Essentially all of the Bell System's fault-location and switching, to sidestep an out-of-commission line or microwave transmitter, is currently done manually. Top Bell engineers are quick to point out that, although **some automatic checkout systems are being used for a few test functions, they leave much to be desired.**

Navigation system: accurate to 30 feet

Westinghouse thinks it has a sure candidate for the Air Force's 621B satellite navigation program [Electronics, Aug. 21, p. 40], which seeks to provide quick, accurate fixes for supersonic craft. The potential Westinghouse entry, so far just an in-house study of accurate navigation techniques, has design goals that make it a natural for 621B: accuracy

within 30 feet, simultaneous use by an unlimited number of planes, continuous service, rapid fixes (about a tenth of a second), immunity to interference, and service to the polar regions.

The Westinghouse investigation revolves around the use of interferometric antennas placed on widely separated satellites in synchronous orbit. Families of satellites—three or four to a family—provide two interferometers that establish a line of direction; the craft's position is determined from them. **The reason for the accuracy is the wide spacing of the antenna satellites (about 5.5 miles), which provides greater sensitivity.**

Design-it-yourself oscilloscopes have that common touch

By offering something no other oscilloscope maker has—commonality of internal parts, a refinement of the venerable plug-in technique—Measurement Control Devices Inc. is keeping its line competitive with the big instrument makers'. **MCD offers seven chassis and a wide choice of interchangeable printed circuit boards. The result is innumerable combinations that can be tailored to a user's specifications.**

Major benefits, says the Philadelphia firm, are savings when building the circuit boards and purchasing parts; assembly according to sales; quick response to orders for custom scopes; and modifications accomplished simply by changing a value of some component on one of the signal-conditioning or amplifying p-c boards.

Bell System to use new magnetic alloy

A newly developed magnetic alloy will replace Vicalloy in the permanent memory portion of the electronic switching systems being installed in U.S. telephone exchanges. Developed at Bell Telephone Laboratories, the alloy of cobalt, iron, and gold is described as **more ductile than Vicalloy and therefore more easily made into complex shapes, fine wires, or tape.** Some of the Vicalloy magnets in the electronic switching systems' twister memories have lifted from the cards because of the mechanical stresses exerted during erasure and rewrite processes.

Three Bell Labs researchers told the International Congress on Magnetism in Boston last week that the magnetic properties of the new alloy change only slightly under high tensile loads and that the gold content will permit more careful control (by heat treatment) of the magnet's coercive force, which is the energy necessary to change the flux from positive to negative [For more on the Magnetism Congress, see page 45].

NASA challenged on medical spin-offs

Although there has been considerable criticism of NASA's manned space programs, there has been little argument with NASA's contention that those programs produced valuable biomedical spin-offs. **However, there's a growing feeling that the space agency does more talking about such benefits than is warranted by results.**

The latest challenge came at the Engineering in Biomedicine Conference in Washington from John Lyman, a professor of engineering at the University of California at Los Angeles. **He said that engineers working on space and defense projects don't look for biomedical spin-offs.** Except for such concepts as microminiaturization, he pointed out, little of medical value has been gleaned from manned space programs. **And much of his audience agreed.**

All components
shown actual size

Only the new Allen-Bradley Type S cermet trimming resistors have all these features

Type S
shown twice actual size

for side adjustment

for top adjustment

The Allen-Bradley Type S is a one turn cermet trimmer in which you will find incorporated a wider range of features than in any other trimmer now on the market. Here are a few of the more important features.

- **COMPACT**—body is ⅜" dia.
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- **50 OHMS THRU 1 MEGOHM**
- **THE SEALED UNIT** is immersion-proof
- **TEMPERATURE COEFFICIENT** less than 250 ppm/°C over *all resistance values* and *complete temperature range*
- **UNIQUE ROTOR DESIGN** provides exceptional stability of setting under shock and vibration
- **SMOOTH CONTROL,** approaches infinite resolution
- **PIN TYPE TERMINALS** for use on printed circuit boards with a 1/10" pattern
- **VIRTUALLY NO BACKLASH**
- **WIDE TEMPERATURE RANGE** from −65°C to +150°C
- **RATED** ½ watt @ 85°C
- **EXCEPTIONAL STABILITY** under high temperature or high humidity
- **MEETS OR EXCEEDS ALL APPLICABLE MIL SPECS**
- **COMPETITIVELY PRICED!**

You'll find the new Type S trimmer equal to the traditional Allen-Bradley quality. You really ought to know more about the Type S. Won't you write for detailed specifications? Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Ave., New York, N. Y., U.S.A. 10017.

A-B QUALITY

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QUALITY ELECTRONIC COMPONENTS

75-08-7E

CERAMIC MAGNETS

A-B ceramic magnets
used in the 500 *Selektronic* shaver shown actual size.

Remington takes advantage of the high energy of Allen-Bradley ceramic permanent magnets to achieve the small size required for the ideal performance of their 500 *Selektronic* shaver

This custom designed ceramic magnet is the result of cooperative efforts by Remington and Allen-Bradley engineers. Despite the complex geometry of the magnets, Allen-Bradley was able to achieve high volume production at reasonable cost.

Allen-Bradley MO5-C ceramic permanent magnets are radially oriented and can be furnished in segments for d.c. motors measuring no more than ¾" diameter up to a maximum rating of 10 hp. Coordinated and adequate manufacturing facilities at Allen-Bradley and tight quality control assure delivery in quantity —on time!

Allen-Bradley application engineers will be pleased to cooperate in the design of your motor magnets to obtain optimum performance. Allen-Bradley Company, 222 W. Greenfield Ave., Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Ave., New York, N. Y., U.S.A. 10017.

TYPE MO5-C CERAMIC PERMANENT MAGNETS Typical Characteristics—stated values have been determined at 25° C.

Property	Unit	Nominal Value
Residual Induction (B_r)	Gauss	3300
Coercive Force (H_c)	Oersteds	2300
Intrinsic Coercive Force (H_{ci})	Oersteds	2400
Peak Energy Product (B_dH_d max)	Gauss-Oersteds	2.6×10^6
Reversible Permeability	—	1.09
Curie Temperature	+°C	450
Temperature Coefficient of Flux Density at B_r	%/°C	−0.20
Specific Gravity	—	4.85
Weight per Cu. In.	Lb.	0.175

The 500 *Selektronic* shaver features a unique dial which adjusts the shaving heads to four shaving positions for any combination of skin and beard, plus TRIM position for sideburn trimming and CLEAN position for instant cleaning. The shaver operates on its rechargeable energy cells or from an electric cord.

A-B

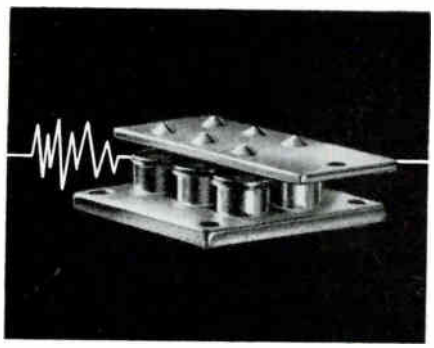
ALLEN-BRADLEY
QUALITY MOTOR CONTROL
QUALITY ELECTRONIC COMPONENTS

74-07-7CE

Semiconductor Report

NEW MOTOROLA DEVICES FOR NEW DESIGN IDEAS

STOP HIGH ENERGY TRANSIENT DAMAGE WITH NEW ZenGard* SUPPRESSORS



Protect entire electronic systems subject to damage or destruction from random power surges up to 12 kW with the new line of MPZ5 series ZenGard transient suppressors!

Their compact size (each occupies less than 2 cubic inches) belies their impressive advantages over conventional suppressors:

- predictable temperature sensitivity and relatively constant breakdown voltage over a −65° to 175°C operating range
- inherent parameter stability over long-term use
- absolute non-existence of ringing
- low 50 μA quiescent current

Sharp reaction time and clamping factors $\left(\frac{V_z(max)}{V_z(min)} \text{ see table}\right)$ as low as 1.25 mean significantly lower overshoot voltages, consequently less chance of component degradation and burn out.

Economical, ZenGard transient protection for virtually any high energy application (1000 W units have been supplied to hi-rel requirements) is made possible by the Motorola-originated Multi-Cell† technique of mounting individually matched zener diodes on a common heat sink. The same desirable, sharp, controlled reverse breakdown characteristics as Motorola's other 250 mW to 50 W zener diodes are ensured.

Evaluation units available now! . . . non-standard voltages, lower clamping factors and higher power units can be supplied to specific needs!

Type	DC Power Dissipation	Nom. Oper. Volt. V_{OP} @ I_Z Volts	Max. Zener Volt. PW 1.0 ms V_Z @ I_Z		$V_{Z(max)}$ @ I_{ZM} Volts
MPZ5-16B & A	350 W	14	20, 24	200 A	16 @ 0.4 A
MPZ5-32C, B, & A		28	40, 45, 50	100 A	32 @ 0.2 A
MPZ5-180C, B, & A		165	205, 225, 250	20 A	180 @ 0.02 A

FAST PHOTO SENSORS AID LIGHT-ACTIVATED DESIGNS

A tiny photo detector — type MRD200 — and a sensitive phototransistor — type MRD300 — now provide opportunities to simplify light-activated designs!

Functional and compact (only 0.060" diameter), the MRD200, two-terminal unit serves where small size, precise alignment and high density arrays are required such as high-speed tape and card readers and rotating shaft information encoders.

It displays linear characteristics over the dynamic range–ideal for reading film sound tracks. Total t_{on} and t_{off} is only 6.5 μs (max.) allowing faster reading than any mechanical contacts. And, its extremely narrow field of view minimizes crosstalk.

With equally fast rise and fall time, the MRD300 utilizes a TO-18 case with external connections for added control and excels in applications where high sensitivity is essential. It responds to modulation well above the audio spectrum.

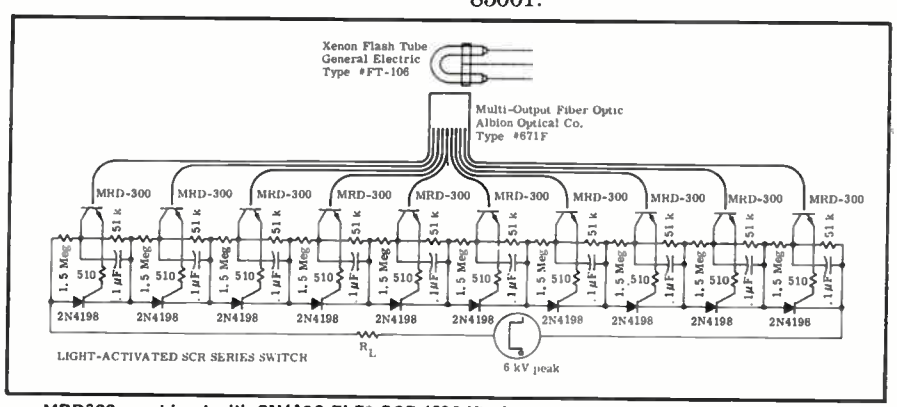
Both units operate from 1 V to 50 V power supplies and are compatible with most transistor circuits. Low leakage permits use in direct-coupled designs for low-signal-level operation.

Evaluate them now! . . . Send for *Introduction to Optoelectronics* and a new data sheet!

Use the reader service card for complete data on these products or write Motorola Semiconductor Products Inc., Box 955, Phoenix, Arizona 85001.

Type	Radiation Sensitivity mA/mW/cm² (typ)	Illumination Sensitivity μA/lum/ft² (typ)	Dark Current μA (max)
MRD200	0.5	5.0	0.025
MRD300	1.6†	10†	

†Base open



MRD300 combined with 2N4198 ELF* SCR (600 V) gives total t_{on} of 300 ns. Single light source coupled by multiple-output fiber optic bundle transmits light to photo transistors. Fast t_{on} is accompanied by gate isolation advantage.

*Trademark Motorola Inc.
†Patents Pending

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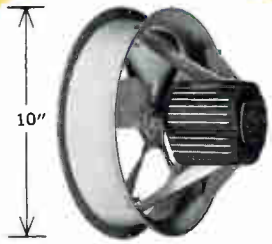
–where the priceless ingredient is care!

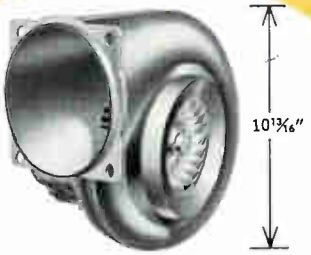
Circle 29 on reader service card

Circle 31 on reader service card→

ROTRON FANS AND BLOWERS MOVE AIR ANYWHERE!

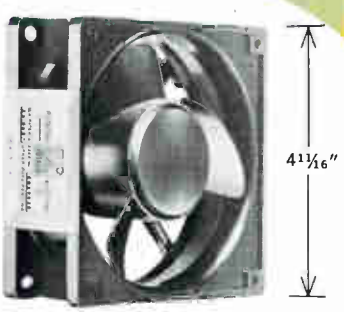


PROPELLER FANS — Move large volumes of air at low static pressures for flushing electronic enclosures or ventilating shelters. Highly reliable and compact. Many variations: • 30-1500 cfm • 50/60 Hz or 400 Hz, single or three phase • From 4¼″ to 8½″ diameters • Dual frequency 60/400 Hz available • MIL spec and computer quality • High altitude Altivar® motors available.



CENTRAXIAL BLOWERS — Unique "centraxial" impellers. Far more efficient and economical than squirrel cage blowers of similar capacity. For high quality commercial equipment ranging from office copiers to large capacity computer disc memories. • 14-545 cfm • Wheel sizes from 2″ to 7″. • Convenient mounting options • Working pressures to 3″ wg. • 115 VAC, 60 CPS, single phase; 230 VAC, 50 CPS, single phase; 208-230 VAC, 50-60 CPS, three phase. • No maintenance. • Lubricated for life.

RADIAL WHEEL BLOWERS — These blowers meet specialized cooling and air sampling requirements demanding higher pressure and lower flows than conventional squirrel-cage blowers: • 13-39 cfm • Working static pressures to 5″ wg • 50/60 Hz and 400 Hz, single or three phase • MIL spec • High altitude Altivar® motors available. • Long-life ball bearing induction motors.



TUBEAXIAL FANS — Integrated designs provide maximum airflow in minimum axial depth. High aerodynamic efficiency and quiet operation. Choose from the widest line in the industry including the Sprite®, Muffin®, Sentinel®, Skipper®, Whisper®, "Spartan," Tarzan®, Feather®, Saucer® and Caravel® fans delivering from 35 cfm to 575 cfm. Unit sizes from 3⅛″ to 10″. MIL spec and commercial units. High altitude motors available. 50/60 Hz or 400 Hz, single or three phase. MIL-B-23071 qualification.

SQUIRREL CAGE BLOWERS – Move moderate volumes of air against high static pressures in a wide variety of applications such as RF transmitters, computer consoles and avionics equipment. Simplex, duplex, and space-saving inverted designs available for every application. • Long-life ball bearing induction motors • 50/60 Hz or 400 Hz, single or three phase • Wheel sizes from 1½" to 7". MIL spec and computer quality • Convenient mounting options • 10-2600 cfm • Working static pressures to 5" wg • High altitude Altivar® motors available.

VANEAXIAL FANS – Rotron-pioneered Aximax® fans feature time-tested reliability in severe environments. These tiny fans cool tightly packed airborne and ground-based electronics equipment with minimum size and weight: • 22-157 cfm (400 Hz) • 1¾" to 3" diameter • MIL-E-5272C qualification • 4-14 oz. weight • 1¼" to 3" wg static pressure. Diameters from 1¾" to 3".

CABINET COOLING PANELS – For flushing 19" rack mounted equipment, these panels offer Rotron standards of quality and reliability in 5½" & 7" heights. Large capacity, washable filters insure clean air • 155-400 cfm • Ball bearing induction motors • MIL spec or commercial quality • 50/60 Hz or 400 Hz, single or three phase • Quiet operation.

HIGH PRESSURE/VACUUM AIR MOVERS – Used in computer peripheral equipment, perform pneumatic functions such as magnetic tape buffer storage, card and document handling, and for air sampling and air handling applications. Long reliable life and low noise level. "Spiral"® and "Duplex Spiral" provide high performance in a compact, economical package. Multi-stage blowers offer a wide range of performance characteristics: ball-bearing induction motors, 50/60 Hz and 400 Hz, single or three phase, pressures to 55" wg (2 psig), 17-385 cfm, no RFI, no maintenance, MIL spec and computer quality.

Whatever the air moving application . . . chances are Rotron has just the fan or blower you need. If we don't, we'll develop one for you. No one else offers so broad a line or so deep a capability.

If you would like to learn more about any of our fans and blowers, or our free laboratory facilities and application engineering assistance, drop us a line. We'll be happy to send you our Quick Reference Catalog describing our complete line and our capabilities in air moving devices.

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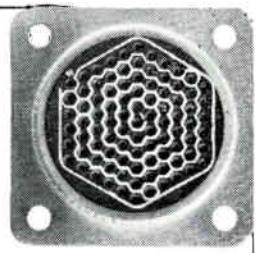
Doing business with Arco can get you into some pretty tight spots.



We carry Deutsch subminiature connectors.

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Environment Proof is what we call it.

Tough New Arrival

The Stackpole Series 100 miniature rotary switch is here! New, compact 1⅛" diameter body size. Totally enclosed to protect against exposure, contact contamination and production damage. Explosion-proof. Ideally suited for today's rugged demands and space applications.

Reliability and long life are assured by Stackpole's unique mode of switching—field proven in the larger Series 600 switch. Internal intermixing of electrical functions and interconnection of decks and terminals provide unprecedented switching versatility. Inherently economical — Stackpole enclosed rotaries are competitively priced with open deck, clip type switches. This new versatility and economy encourage complete freedom of design and afford the use of enclosed rotary switches for all applications.

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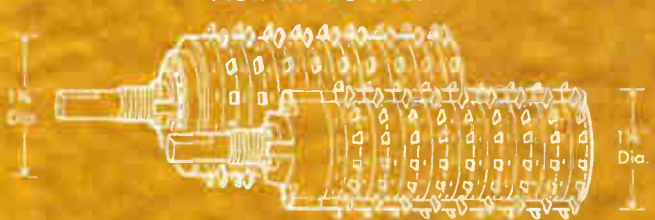

Sample switches, made to your exact specifications, are shipped in 2 to 3 days and production quantities in 2 to 3 weeks. For prompt quotations and samples, send your wiring diagrams or specifications to: Electro-Mechanical Products Division, Stackpole Carbon Company, St. Marys, Pa. 15857. Phone: 814-834-1521. TWX: 510-693-4511.

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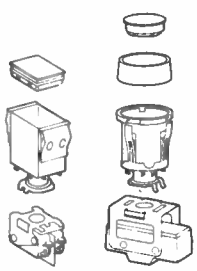
Ever since MICRO SWITCH introduced the first modular pushbutton switch with lighted legends, the line has been expanding. New modules, new assemblies, new ideas now offer you more opportunities to work out custom answers to today's panel requirements.

In addition to the popular Series 2 which started the modular trend, the line now includes Series 2N and Series 2C200. All three offer unequalled freedom of design—in sheer number of possible control and display combinations—in ease of installation—and in panel appearance.

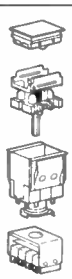
MICRO SWITCH gives you another bonus: application experience. Our specially trained field engineers will be glad to discuss your requirements. They are backed by the industry's most elaborate research and development facilities.

For information, contact a Branch Office or Distributor (see Yellow Pages, under "Switches, Electric") or write for literature.

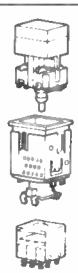
MICRO SWITCH—the line providing unequalled freedom of design with all this versatility



Series 2 offers both rectangular and round display, permitting shape-coding of stations or group functions. Snap-in mounting. Solenoid pull-in and/or hold-in coil for remote control.



Series 2C200. Snap-in mounting. Relamp without tools. Available with RFI shield, and solenoid pull-in or hold-in coil for remote control.



Series 2N. Shock-resistant spring-lock mounting. Hold-in coil. Relamp without tools. Molded-color housings.

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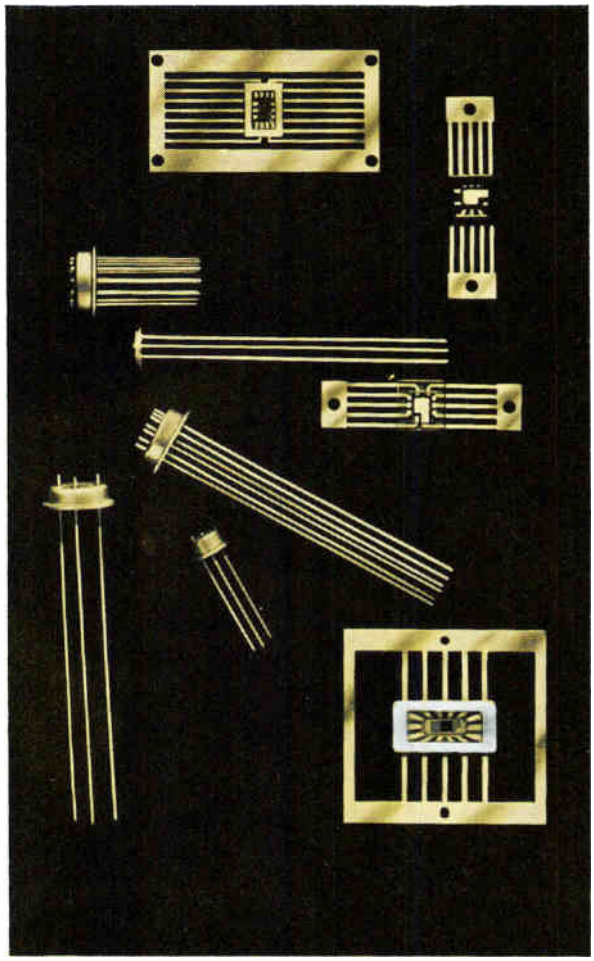

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Circle 38 on reader service card

At .0008″ dia., Craftsmanship is paramount

LEAD-BONDING CAPILLARY TUBES OF TUNGSTEN CARBIDE, with bore sizes as small as .0008", are made possible by Tempress' unique ability to machine and polish ultra-hard materials in microdimensions. This has brought a new efficiency to semiconductor manufacturing. Bonding tips are held in shank by a magnetic system, permitting instant replacement, even while heated. Heated shank maintains constant tube temperature from 0° to 450°C. This unique system for thermal compression bonding of leads to semiconductors has brought important savings in time, tools, and materials to the nation's leading semiconductor manufacturers. Equally fine craftsmanship is applied to the Tempress line of diamond scribers, lead-bonding wedges, diamond lapping points, and other miniature semiconductor manufacturing tools.

TEMPRESS

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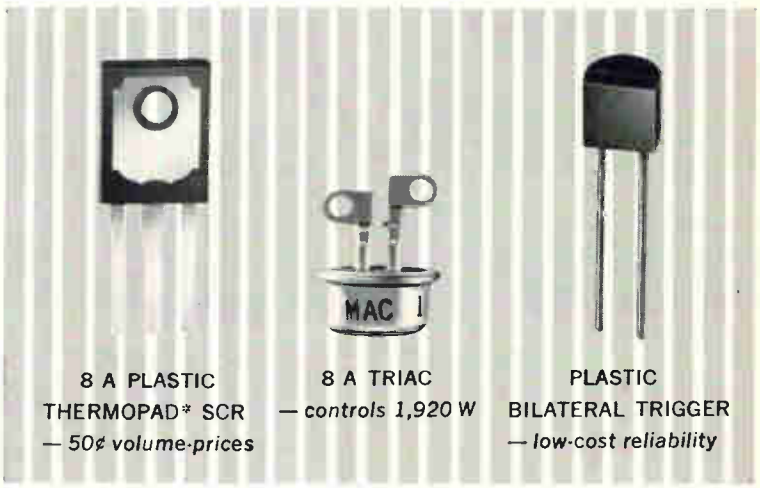

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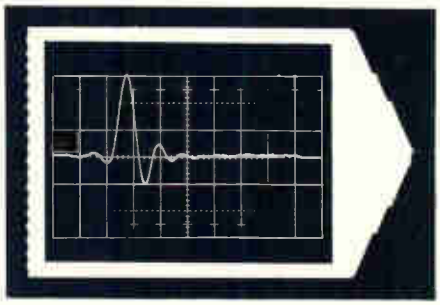


Typical Photograph of Crosscorrelation Function of Input and Output Signals of Complex Passive Network Driven by White Noise.

For more information call (609) 924-6835 or write Princeton Applied Research Corp., Dept. D, P.O. Box 565, Princeton, N. J. 08540.

PRINCETON APPLIED RESEARCH CORP.

Electronics Review

Volume 40
Number 19

Computer

Little brother

When the Hewlett-Packard Co. introduced its 2116A computer at last year's Fall Joint Computer Conference, it stressed that the machine was specifically designed to handle data from instrumentation systems. And so it was. But at the upcoming FJCC, Nov. 14 to 16, H-P will unveil a companion to the 2116A, a stripped-down version with almost the same capability but costing considerably less. And now the company makes no bones about its intentions. "The elaborate software program we developed for the 2116A suits it for a much bigger market—the general-purpose market," says Tom Perkins, marketing manager of H-P's Dymec division. The announcement marks Dymec's entry into the field of general-purpose computers.

The new machine, called the 2115A, will be available early next year at a price of about $16,500 including a teleprinter, and will compete with the Digital Equipment Corp.'s PDP-8. Its introduction runs counter to the recent trend among makers of small digital computers, who have generally been tying their products into instrumentation systems [Electronics, April 17, p. 161]. Hewlett-Packard found that half its sales of the 2116A were for general-purpose computation.

Bilingual. The 2115A retains a feature of the 2116A that made it especially attractive for instrument systems: input-output channels are controlled by plug-in cards, rather than by resoldering. But H-P is offering both Fortran and Algol compilers with the new computer to make it useful for problem-solving as well. Algol will also be available with one 2116A, and H-P may offer still another language, reportedly the General Electric's Basic, at a later date.

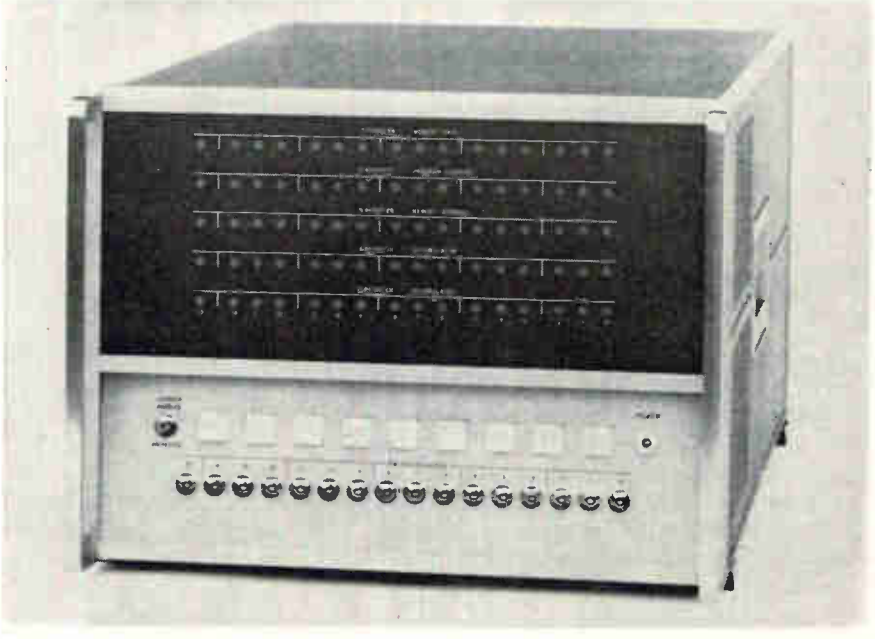
At its price, says Perkins, the 2115A affords an attractive alternative to time-sharing for general-purpose computing. Hewlett-Packard itself currently uses about 20 remote stations linked to a GE computer in Berkeley, Calif., but Perkins says the 2115A will almost certainly be used to augment this computational capability.

Narrowed ranges. The 2115A looks like its big brother, differing from it only in physical size and in a few specifications. Operating temperature limits are only 15° to 45°C, against the 2116A's 0° to 55°; cycle time is 2 microseconds instead of 1.6; all other speeds are also 25% slower; core memory is 4,096 or 8,192 bits instead of 4,096 bits expandable to 32,000; and the 2115A will accept only eight input-output plug-ins at a time, down from the 2116A's 16. Both machines have 16-bit word lengths.

By cutting down on memory space and the racks for plug-in boards, and redesigning the power supply, H-P managed to pack the 2115A into a box 16¾ inches wide, 12½ inches high, and 24⅜ inches long. Since its logic structure is the same as the 2116A's, however, any program written for the larger computer will work with the smaller.

The 2115A is by no means a final step. "We envision a family of computers using the same software package," Perkins states. He clearly implies that H-P has set its sights on producing an even less expensive general-purpose computer.

Logical steps. Dymec, which makes data acquisition systems, got into computers 2½ years ago when Kay Maglesby, the division's engineering director, saw that if Hewlett-Packard were to continue as a leader in the instrumentation field, it would have to produce machines



New market. Hewlett-Packard's 2115A represents the company's first move into the general-purpose computer market. Machine is a stripped down version of the 2116A.

capable of handling increasingly complex instruments. Dymec began at that time to develop a small process control computer. "The aim was to make one that would operate as simply as a microscope," Maglesby says. The resulting 2116A had an extremely sophisticated software package for a small computer, a factor that may have added to its cost but also allowed for the development of a family of machines.

But the 2116A was designed to operate in the severe environments that its associated measuring instruments had to endure. The cost of providing a 0-to-55° temperature range contributed considerably to the 2116A's main-frame price of $22,000.

The 2115A, on the other hand, is designed for more friendly environs. And to emphasize its commitment to the computer field, H-P is providing the smaller computer with a retinue of peripheral devices for its FJCC debut. These include:

- A high-speed disc memory with 180,000-word storage, made by Data Disc Inc. (with an optional direct access module so that memory can be transferred directly from disc core);
- An extended arithmetic unit, with plug-in hardware to replace software routines, that can speed some operations by a factor of 10 and save some core space;
- A high-speed line printer built by the Data Products Corp.;
- A high-speed card reader from Soroban Engineering Inc.

Manufacturing

Retreading bad IC's

Considering integrated circuit manufacturing costs and the number of imperfect circuits that have to be thrown out, it's no wonder that IC makers continually search for ways to boost yield. National Semiconductor is using a new way to keep down its throwaway rate: retreading rejects with a laser resistor-trimming technique.

The circuits are hybrid IC operational amplifiers with loose specifications—high-input offset voltage, for example. For good performance, this specification should be as low as possible. By trimming one of the circuit's two input resistors, the Danbury, Conn., firm is cutting offset voltage to almost nothing.

Results have been so encouraging that the firm may market hybrid op amps with offset voltage well below 1 millivolt—a level formerly approached only by discrete component op amps. Offsets as low as 50 microvolts already have been easily achieved experimentally.

Unyielding. National Semiconductor turned to the new technique because of the difficulty encountered in achieving the specified 1 mv offset for its premium op amp, the 7560A. Most of the IC's had offsets of 4 to 10 mv. As a result the company was forced to sell these op amps as its second line, the 7560, at half the $45 price of the premium model.

The laser system has doubled the yield of 7560A's. This, in turn, has resulted in delivery time being cut to one month.

Each IC is placed in a jig in the trimmer, power is fed to the IC, and an operator vaporizes the resistor material until the required offset level is reached. This fine tuning during circuit operation is possible only with the laser technique. Other methods, such as sandblasting or sending voltage or radio-frequency surges through resistors, can either contaminate or overheat other circuit components. Builder of the laser trimmer was Spacerays Inc. of Burlington, Mass.

The system uses a pulsed-ruby laser, and is part of a family of four trimmers now being marketed by the firm. The trimmers can be adapted to either manual or automatic operation, and can also be used for discrete cermet, wirewound, and thick- or thin-film deposited-carbon or metal resistors.

Busy signal. Western Electric in North Andover, Mass., has also purchased a Spacerays trimmer and may use it in the production of precision voltage-divider IC's in the Bell System's forthcoming T2 pulse-code-modulation telephone carrier system.

Western Electric is now trimming glass-encapsulated, deposited-carbon resistors with the device. Indications are that the company has achieved tolerances well below 1% in some tests. Before trimming, the resistors were often more than 10% off the mark.

Advanced technology

Righter light

Solid state lasers now have a chance of achieving the efficiency of carbon-dioxide lasers, which can convert more than 30% of their input to coherent light. If they succeed, the major reason will probably be a new breed of pump lamp developed by the Xerox Corp.'s subsidiary, Electro-Optical Systems of Pasadena, Calif.

Eos has done what others have tried and failed to do: it has built a pump lamp with an emission spectrum that can be tailored to the absorption spectra of various laser crystals. In one of the company's experiments, it matched a lamp to neodymium-doped yttrium aluminum garnet (Nd-YAG), one of the most efficient laser crystals available.

Waste not. Commonly used xenon arc lamps emit 95% of their light at wavelengths Nd-YAG can't absorb; EOS's lamp can put 30% to 50% of its output on or near the absorption lines of Nd-YAG. The company's light source engineering department, under its manager, David Pollock, used a mercury arc lamp to which had been added small equal amounts of the iodides of sodium, potassium, and rubidium.

Both Raytheon and EG&G, one of the nation's largest pump tube suppliers, tried to develop such matched light sources and failed. Stanford University and the National Aeronautics and Space Administration also met with mixed results.

These researchers may have been stymied by absorption of light by atoms of the very elements used to generate desired wavelengths.

In most laser pump lamps, light originates in highly energized atoms in the electric arc along the axis of the tube. But to reach the laser rod, the light must pass through a layer of cooler atoms near the glass tube envelope; these cooler atoms absorb much of the desired light.

Eos found that by adding the desired elements as iodides, this reabsorption didn't occur. Light could still be generated in the hot area of the arc whose energy would break up the iodide molecules, freeing the atoms to emit at the desired wavelengths. The additives stay in molecular form in the cooler area near the envelope and therefore do not absorb the desired wavelengths.

The company's lamp blankets three of Nd-YAG's four absorption wavelengths: 5,000, 5,800, 7,400, and 8,100 angstroms. These absorption lines are bigger targets than they appear to be; EOS has found them to be about 200 angstroms wide, and adding a small amount of chromium to the rod broadens the lines even further.

The 5,800-angstrom line is served by one mercury and two sodium emission lines at 5,780, 5,880, and 5,890 angstroms. The 7,400-angstrom line is pumped by two potassium lines at 7,500 angstroms and 7,600 angstroms. The 8,100-angstrom line benefits from rubidium's 7,950-angstrom emission and sodium's light at 8,195 angstroms.

Waiting. All this potential is going to waste. Vietnam work has pushed laser research into the background—so far in fact that the new tube has yet to be tested in a laser.

But lamps like it may soon see service as reconnaissance light sources in Vietnam. Eos has several classified contracts for lamps that would emit only at specific wavelengths to supply covert illumination for tactical photography.

Attractive memory

When it was discovered several years ago that europium oxide (EuO) was ferromagnetic—the atoms line up in a common direction in a saturating magnetic field—it was predicted that EuO film would be valuable for a laser-beam addressable memory since the laser's heat affects the material's magnetic state. What made it attractive was the fact that EuO is one of a few materials that is both an electrical insulator and transparent to many optical frequencies.

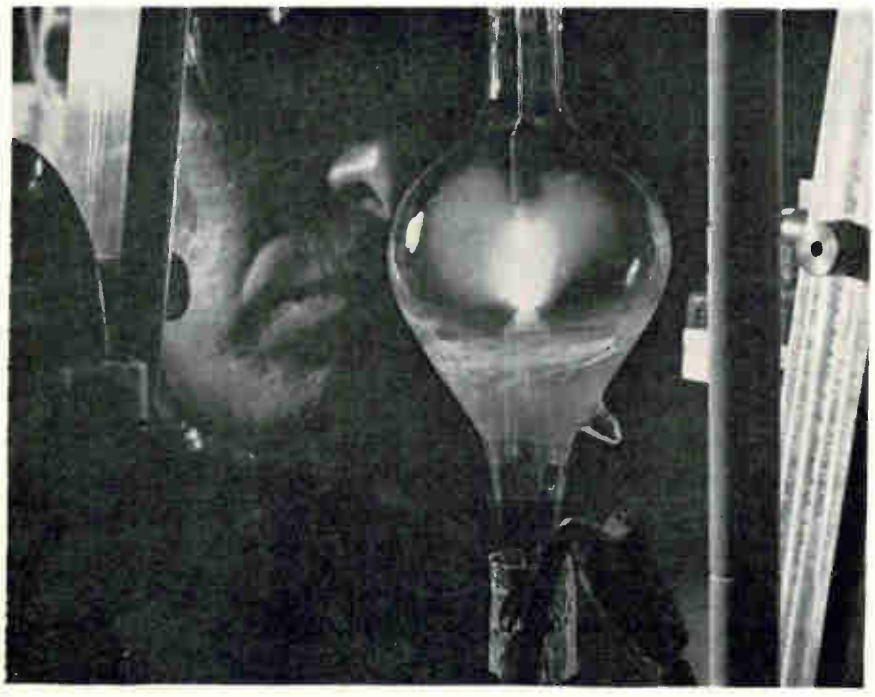
Last week in Boston at the International Congress on Magnetism, two researchers reported success with the material. "It can maintain small magnetization reversals, and it requires low energy for readout purposes," said George Y. Fan of IBM's Yorktown Heights, N.Y., Watson Research Center.

In most efforts on laser memories, the beam writes on a photosensitive material. The EuO film memory under development by Fan and J.H. Greiner at IBM employs heat writing and a magnetooptic readout.

It operates at liquid nitrogen temperature, but IBM is working on selective doping, which could lessen this inconvenience. The doping method may substantially increase the material's Curie temperature—the point at which ferromagnetism disappears and the magnetic moments become disordered.

Heat wave. While in a magnetic field, the EuO film is cooled below the Curie point, making it ferromagnetic. When the saturating field is removed, the film remains ferromagnetic. Then a small biasing field is applied in the opposite direction and when a focused laser beam hits a spot on the film, the temperature of that spot is raised above the Curie point and the ferromagnetism is destroyed. When the spot cools down, the ferromagnetism returns but the direction of bias field at that spot has been changed with respect to the rest of the film.

For readout, laser light is transmitted through the film or reflected by it. In either case, magnetooptic effects are detected. The difference in the state of magnetization at a spot changes the plane of polarization of the readout light, and this either lets light through or blocks it. In the experimental setup, a photomultiplier detects these ones and zeroes after the signal is trans-



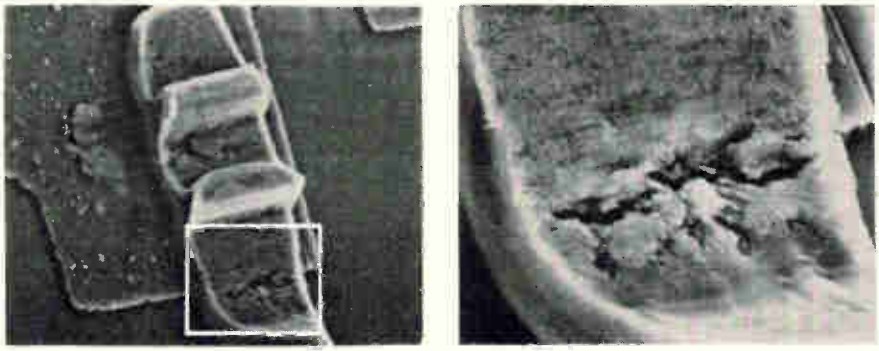
Forerunner. Prototype of laser pump lamp tailored to emit at absorption wavelengths of specific laser crystals; such matching promises higher laser efficiency.

mitted through the polarizer.

Quick reading. With thermal writing, says Fan, a low-power semiconductor laser beam can provide nanosecond nondestructive readout of a small bit size. The researchers have written bits of less than 3 microns in diameter with a 10-milliwatt laser in 10 nanoseconds.

In high-speed reading experiments, says Fan, a good signal-to-noise ratio was achieved by a 1-milliwatt gallium arsenide laser pulse of a few nanoseconds duration. Initial experiments indicate that the magnetooptical effects in EuO—particularly the change in polarization of light when directed at a magnetized film—are greater than in garnets. "And the greater the polarization change," Fan points out, "the better the signal-to-noise ratio."

Fan sees a potential for this type of storage in a medium, dense, high-speed memory, which would offer a unique combination of size and speed.



Flaw. Scanning electron miscroscope at 1,000 × magnification (left) and 3,500 × discloses fault in gold lead ultrasonically bonded to gold pad. This fault would not be detectable by optical methods.

Close look in 3D

Within five years, NASA officials believe, every circuit made for a space mission will probably undergo a super-inspection by nondestructive microscopic techniques that aren't available today. The agency's Electronics Research Center is working on two tools for nondestrictive screening of monolithic integrated circuits: holographic mircroscopy and scanning electron mirror microscopy.

"It's no good that 99 out of 100 IC's are flawless. All must be screened and all must be flawless," points out Kenneth G. Carroll, a staff physicist at the Cambridge, Mass., center.

The microscopic techniques being refined for nondestructive screening of tiny circuits will also yield new kinds of information on blood cells and in other areas of the life sciences.

In fact, the application of holographic microscopy to molecular biology preceded the present attempt to develop this tool for detecting circuit flaws and processing defects.

"Through holography, a living cell can be examined in great detail before and after it splits, or before and after it moves," says Raoul F. vanLigten, a research scientist at the American Optical Co., Framingham, Mass. "Holographic microscopy offers a similar possibility for integrated circuits. When you energize a chip, the result is similar to a living cell in motion. You can compare it, in three dimensions and in great detail, with itself as it was before the change was made."

Below the surface. VanLigten, who has been working on holographic microscopy for biological applications since 1965, has a NASA contract to explore the tool for inspection of IC's. Two approaches, using lasers, are planned: output in the visible spectrum and in the infrared. Since silicon is transparent to infrared radiation, this technique is expected to go beyond surface symptoms and disclose what is going on inside an activated circuit.

Many microscopic techniques developed in recent years can be employed to compare circuits with the norm. Stress will be put on the possibility of obtaining signatures in the form of interference patterns, formed when a coherent wavefront carrying information about a standard reference circuit is made to interfere with one bearing information on a circuit under inspection.

"The patterns will be like contour maps. Bumps caused by thermal expansion at hot spots, for example, will cause changes in the interference fringes," says vanLigten.

Unique approach. Signatures of a different nature are expected from a scanning electron mirror microscope. The unique technique, being explored under a NASA contract by the Advanced Metals Research Corp. of Burlington, Mass., would add a scanning feature to the electron mirror microscope to combine high resolution with nondestructive inspection.

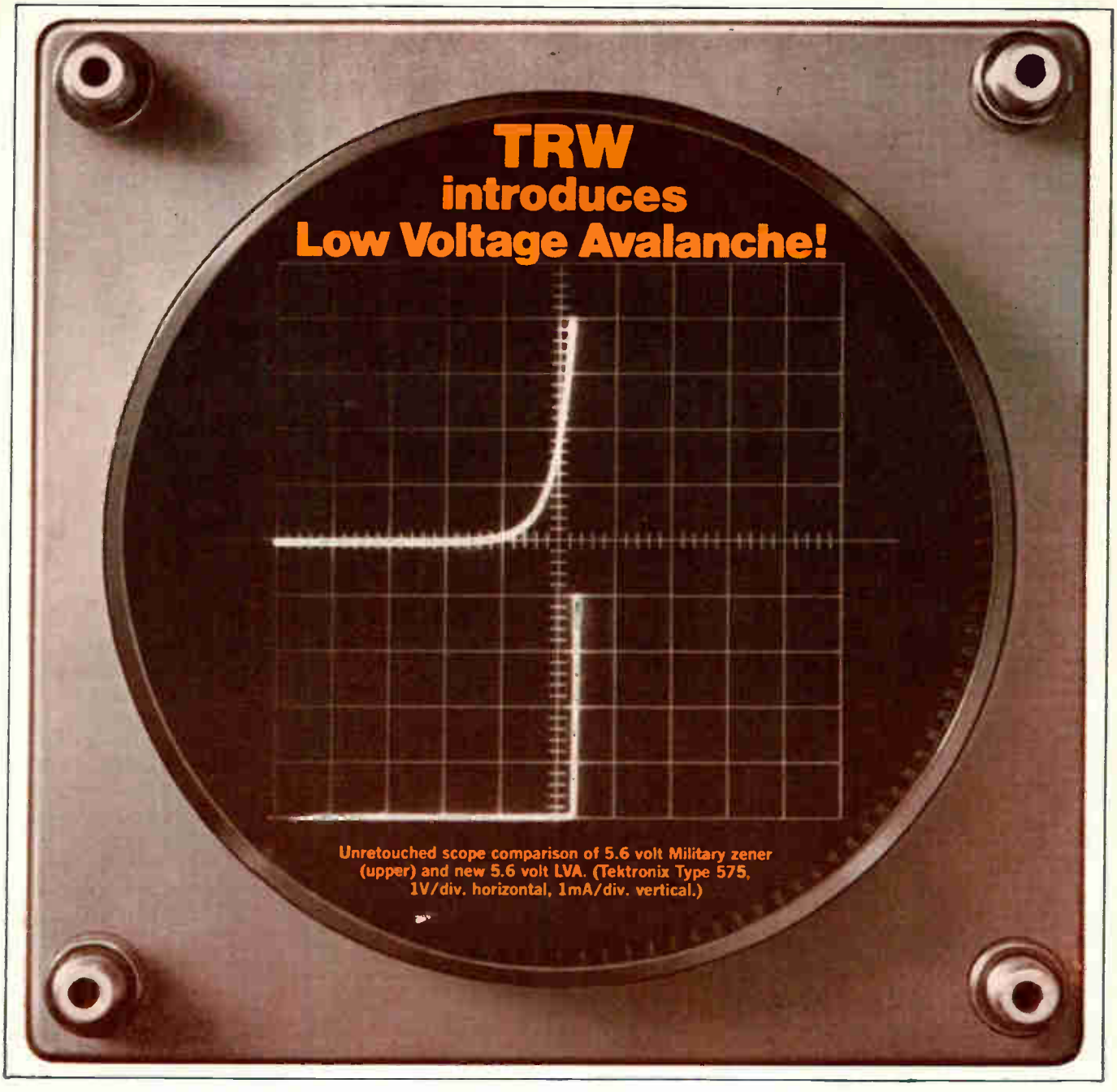
With this technique there is no bombardment of the sample by the electron beam. The sample is kept slightly negative to the beam, which is reflected from an equipotential field located above the surface.

Voltage between sample and ground sets up an electric field, which is an electron mirror of the sample. The instrument will scan the field and measure the gradients. These slopes will be displayed on a television-type monitor to provide a signature of the sample. It's believed that the fine-scanning beam will provide a resolution of better than 500 angstrons, 1/20th of a micron.

Consumer electronics

Toying with SCR's

The silicon controlled rectifier, already in light dimmers, power tools, sewing machines, washers, food



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If you'd like to compare, write for test samples and applications data on company letterhead to TRW Semiconductors, Ray Koch, 14520 Aviation Boulevard, Lawndale, California 90260. Phone (213) 679-4561. TWX 910-325-6206. *TRW Semiconductors Inc. is a subsidiary of TRW INC.*

TRW®

blenders, auto turn signals, and a host of other consumer devices, is turning up inside a turtle.

In a simple but ingenious application, Remco Industries Inc. of Harrison, N.J., one of the leaders in the multimillion-dollar toy industry, has put a 27-cent SCR into a toy turtle that's going to list for $14.95. The trick is that the SCR is turned on and off—making the toy move and halt—by voice command.

Whoa. A short burst of sound in the 800-hertz range turns on the SCR through a sound transducer. The SCR starts and stops a battery-operated motor that drives a gear train which propels the turtle. Thus, it can start moving at a shout of "Go!" or stop at a shout of "Stop!" It even responds to a whistle supplied with the toy.

Pat Tomaro, Remco's engineering vice president, said that the company wanted a toy that would operate via an audio signal and a small current. "We tried out a relay-operated circuit," he says, "but it was too costly and slow to react." He consulted General Electric where applications engineers suggested the SCR approach.

Capsule operation. The SCR can be turned on by a small current from gate to cathode, and turned off by removing the load current or dropping it below the SCR's minimum holding value. The SCR cannot be turned off by removing the gate current.

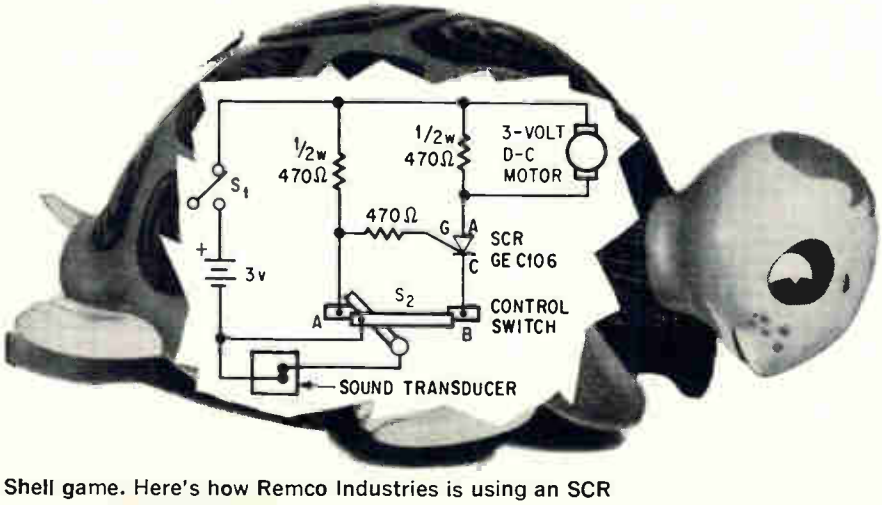
In the accompanying schematic, the SCR's gate is shown grounded through the switch assembly and the sound transducer. When activated by a sound, the transducer momentarily breaks the ground and the SCR turns on to energize the motor. As the motor starts, it trips a shaft that moves the lever of the make-before-break switch, S_2, from A to B, routing the SCR's load current through the transducer. Upon activation a second time, the transducer opens the load circuit, the motor turns off, and the switch lever is reset to position A. The cycle is repeated as often as the transducer is operated.

The turtle operates from a pair of D-size dry cells that provide about 40 hours of operation.

On the go

Transistorized auto ignition systems require no servicing and hold a fairly flat performance curve over a period of time because they maintain a fairly constant ignition voltage. But there are some serious drawbacks: at high engine speeds the systems lose power, and they're generally inefficient at low speeds. In addition, they have trouble restarting flooded engines in cold weather. While some individual designs overcome some limitations, the only real improvement is the quite expensive capacitor discharge system.

O.K. Nilssen, director of research for Motorola's Automotive division,

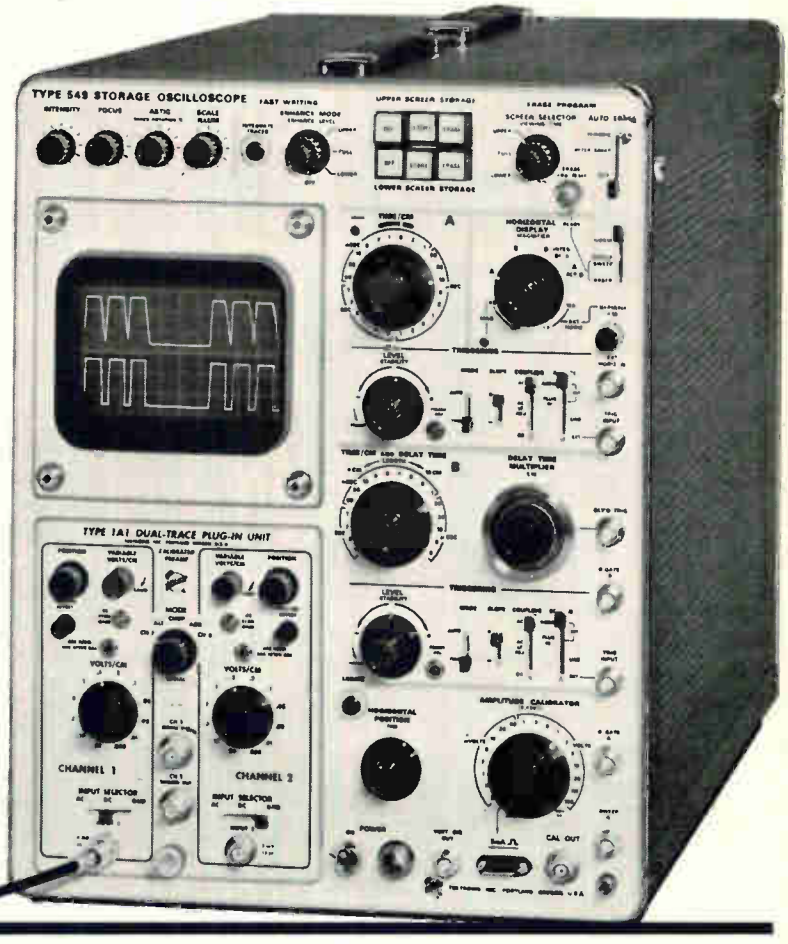


Shell game. Here's how Remco Industries is using an SCR to start and stop a battery-operated motor inside a toy turtle.

variable viewing time 5 cm/μs stored writing speed

split-screen displays

all in the Tektronix Type 549 Storage Oscilloscope



Waveform display showing train of pulses. Upper screen in the stored mode shows three pulses with falltime of the pulse trailing edge showing system deficiency. Lower screen in conventional display mode shows the same pulse train with corrections applied to provide a well formed pulse shape. Pulse width shown is 8 μs with risetime of 0.1 μs. Vertical deflection factor is 0.5 volts/cm. Horizontal deflection factor is 10 μs/cm. Repetitive sweep used for both displays.

The Type 549 allows up to one hour of continuous visual storage, giving you ample time in most applications to measure and analyze stored waveforms. Stored displays can be erased in less than one-quarter of a second.

Split-screen displays

Unique with Tektronix storage oscilloscopes, split-screen displays bring you many advantages in waveform-comparison applications. You can use either half of the 6 cm by 10 cm display area for stored displays, the other half for nonstored displays, with independent control of each half. You can also use the entire screen for either type of display.

Variable viewing time

Variable viewing time — an outstanding feature of the Type 549 — allows you to automatically store displays, view them for a selected time, then automatically erase them on either or both halves of the screen. Two modes of operation are possible. In the After-Sweep Automatic Erase Mode, the selectable viewing time of 0.5 s to 5 s begins at the end of each complete sweep. After the viewing time, the display is automatically erased and the cycle begins again when the next sweep is triggered by a signal.

In the Periodic Automatic Erase Mode, the sequence of storing, viewing time and erasure is continuous and independent of the sweep or signal. In this mode, the viewing time can also be varied from 0.5 s to 5 s.

There is no degradation of stored traces during the selected viewing time, in either mode, and you can retain or erase displays manually whenever desired.

Bistable storage advantages

With bistable storage oscilloscopes, such as the Type 564 and Type 549, the contrast ratio and brightness of stored displays are constant and independent of the viewing time, writing and sweep speeds, or signal repetition rates. This also simplifies waveform photography. Once initial camera settings are made for photographs of one stored display, no further adjustments are needed for photographs of subsequent stored displays.

Tektronix bistable storage cathode ray tubes are not inherently susceptible to burn-damage and require only the ordinary precautions taken in operating conventional oscilloscopes.

Plug-in unit adaptability

Vertical deflection characteristics of the Type 549 are extremely flexible through use of any of the Tektronix letter- or 1-series plug-in units. These include multi-trace, differential, sampling, and spectrum analyzer units. Depending upon the plug-in being used, bandwidth of nonstored displays extends from DC to 30 MHz.

Among other features of the Type 549 are 5 cm/μs stored writing speed, calibrated sweep delay from 1 μs to 10 s, sweep speeds to 20 ns/cm, amplitude calibrator from 0.2 mV to 100 V and a locate zone for easy positioning of stored traces.

Type 549, without plug-in units $2475

Type 1A1 Dual-Trace Plug-In Unit . . . . . $ 625

DC to 30 MHz at 50 mV/cm; DC to 23 MHz at 5 mV/cm.
2 Hz to 14 MHz at 500 μV/cm, single-channel.

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For a demonstration, contact your nearby Tektronix field engineer or write: Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005.

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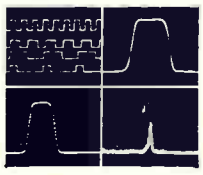


. . . in all Tektronix 530-540-550-series plug-in oscilloscopes

Electronics Review

and J.F. Ziomek of Ford Motor's Product Research office have developed a new design for transistorized ignition systems that is an improvement over current designs. In a paper scheduled for delivery at the IEEE Automotive Conference in Detroit this week, they describe a simple ignition system using a saturable transformer in the positive feedback path of a one-shot transistor switch.

This approach, they claim, reduces power dissipation in the ignition coil as well as in the other circuit components because of its low current drain during stall. It also provides high electrical efficiency, and does not lose power at high engine speeds.

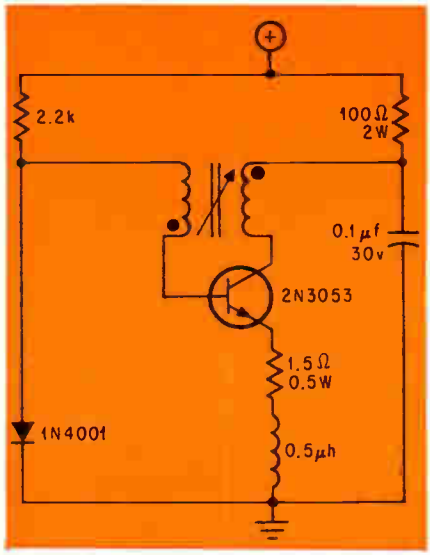
Their conclusion: the new ignition system can give 100,000 road miles of trouble-free operation.

Despite these improvements the auto firms are still reluctant to switch to transistorized systems because they are nearly twice the cost of conventional units.

Good timing. In another paper to be delivered at the conference, R.L. Ronci of Ford discusses a new breakerless trigger for a transistorized ignition. It eliminates periodic setting of the breaker point gap—there are no points—and engine retiming.

He has developed a relatively simple oscillator circuit capable of high average current drain achieved by using a transformer feedback arrangement. When there's no oscillation, the transistor is biased slightly into conduction. The small collector current established by the diode and the emitter resistor provides enough gain to start the circuit oscillating.

Once begun, oscillations build up without further cam movement beyond the critical point corresponding to unity loop gain. The circuit is put into the distributor housing in place of the breaker points. Rotation of the cam in the air gap of the trigger transformer causes the circuit to go into and out of nonlinear oscillations, producing a square wave through the 100-ohm resistor. The breaker trigger also can be used as a proximity switch for general automotive and industrial control applications.



Service free. Breakerless trigger would end point resetting and retiming.

Components

Flip side

In a development that can double the capacity of magnetic tape, a physics professor at Madison College in Harrisonburg, Va., has hit on a way to record on both sides of the tape without any loss in recording quality.

Researchers have tried for years to find a way to record on both sides of magnetic tape, but they have been stymied by the fact that the magnetic flux from one side interferes with the other.

The professor, Siegfried S. Meyers, began with the premise that he couldn't eliminate the flux feedthrough, so he worked on a way to keep it away from the opposite side of the tape.

Turnabout. Ferrite, highly permeable to magnetism, was chosen as a center strip between the two sides. When magnetic flux from one side reaches the center strip it finds it easier to pass through the ferrite, so it is effectively turned.

Meyers asserts that with the interference blocked, the recording and playback quality on both sides is equal to that of conventional single-sided tape.

Mylar film was applied by conventional processes and coated on the outside with standard magnetic oxide.

Early efforts along this line re-

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Frequency Synthesizer
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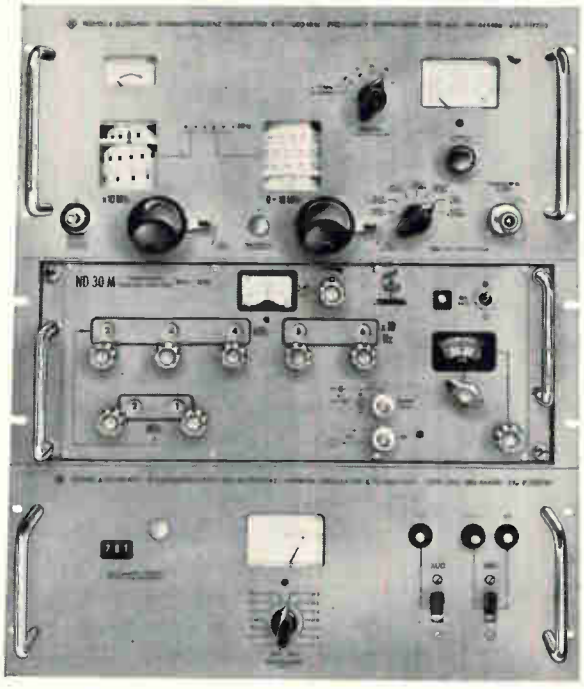

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Type XUC/ND30M provides frequencies to 1 GHz with 3 V output and 80 dB suppression of spurious signals. Heretofore only low frequency synthesizers with a built-in X10 multiplier stage (which increases spurious and noise) were available. Now, with a **TRUE** UHF frequency synthesizer, Type XUC/ND30M supplies signals without this degradation in spectral purity.

Generation of higher frequencies can be accomplished in two ways using the XUC/ND30M:

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Circle 51 on reader service card 51

sulted in a product that was too thick to be practical. The problem was solved by cutting down on the thickness of the Mylar. Further, the new tape requires no redesign of recording equipment; the operator need only rewind the tape or twist it to record or play back on the opposite side. Meyers notes, however, that recorders could be built with heads to pick up and play both sides simultaneously or separately.

Meyers estimates production costs at "not significantly more" than those of conventional tape. He believes the major market will be the entertainment field, but says the tape could also be of considerable value in computers and spacecraft, where storage space is at a premium.

He developed the process while working with Doris V. Stage, a chemistry professor at Madison, on an in-house grant to study photomagnetic phenomena. They have filed for a patent on the process and Meyers says several manufacturers have expressed interest in producing the tape.

Military electronics

Drawing the line

The Pentagon's decision to build a wall of barbed wire and sophisticated sensors just south of the demilitarized zone in South Vietnam to stop enemy infiltrators opens a new multimillion-dollar electronics market. If the Vietnam electronic wall proves effective, similar techniques may be employed in South Korea to upgrade the barrier there along the DMZ.

Under the plan announced by Defense Secretary McNamara this month, a stretch of already-cleared jungle 2,000 yards wide and 15 miles long will be bugged to detect enemy attempts to cross the demilitarized zone.

But the line could eventually be extended another 30 miles to the Laotion border and then through Laos, 115 miles to the border of Thailand.

Little ears. Although the Defense Department won't discuss details for obvious security reasons, many features of the system can be predicted.

Detection must be covert, and the system will therefore use only sensors that are buried or camouflaged; this eliminates big radars from consideration. The sensors must be already operational, or nearly so, to meet the three- to six-month deadline set by the Pentagon. Also, facilities must be available for large-scale production.

The system will consist of many short links because most sensors operate best at short range, and because the division of the barrier into small sectors will make it easier to pinpoint attempted breakthroughs.

Each sector will be guarded by at least two kinds of sensors so that a false alarm by one can be canceled or clarified by the other. Also, a variety of sensors will be employed in a random mix so the discovery of one won't reveal the nature of the others. And there will be a large number of decoys.

Booby traps. An elaborate telemetry network will tie every sensor to a central control station, and also, in some cases, to a mine or other kind of destructive trap. Thousands of telemetry receivers, fuses, and servo controls will be needed for the traps.

A battery of displays will be installed in the central station. If simple displays are used, reports will be ambiguous. To avoid numerous sorties by troops to confirm alarms, the shortcomings of each type of sensor might be programed into a computer with instructions to check one sensor's blind spots against information from other sensors. Since many combinations of detection devices are possible, programing the the network will be a big job.

A number of anti-intrusion sensors are already, or nearly, operational. They include active-infrared, seismic, pressure, magnetic-strip, acoustic, and simple break-wire devices [Electronics, Aug. 7, p. 46].

The Army's Ft. Monmouth is directing the project.

The only diodes we know of that are bottled-in-bond.

As a matter of fact, "bottled" is sort of a crude word for the way we fuse our diodes in glass. But it *is* a way to illustrate an important point.

In the Unitrode diode, the silicon die is metallurgically bonded at 1150°C to two terminal pins of exactly the same diameter and thermal coefficient.

This gives you a bond that is stronger than the silicon itself. So much so that the silicon will break before the bond does. Then the bonded unit is placed in a hard glass sleeve which is fused at 850°C to the entire surface of the silicon, giving you a voidless, monolithic structure.

It's true this is a lot more complicated than bottling, but it accomplishes a lot more than bottling, too.

In the first place, the unit is almost indestructible. The machine hasn't been built that can fail a Unitrode diode in acceleration, vibration, and shock tests.

And then, because both pins and glass match the silicon's thermal coefficient, even the tiniest Unitrode diode can withstand a one microsecond surge of 600 amps. And the largest (which is pretty small, too) can take 4000.

Every Unitrode can handle as much energy in the avalanche as in the forward direction, and still meet initial spec limits after 2000 hours of life-testing.

What else?

Well, you can apply full PIV at high temperature to a Unitrode diode for weeks at a time, and it's just a waste of good current, because it doesn't move it.

All of which isn't to say that some of the other things that are bottled-in-bond haven't got some pretty interesting characteristics. But they're hardly in competition.

There's one thing they do have in common, though. "Bottled-in-bond" on the label usually means you can rely on the quality. We try to build the same idea into our parts. It's true, we end up with a product that may be better than some applications really need. But we're willing to accept that. You can't sell everybody . . .

Can we tell *you* more about our parts, or send you samples? We're at 580 Pleasant St., Watertown, Mass. 02172. Telephone: (617) 926-0404. TWX (710) 327-1296.

UNITRODE®

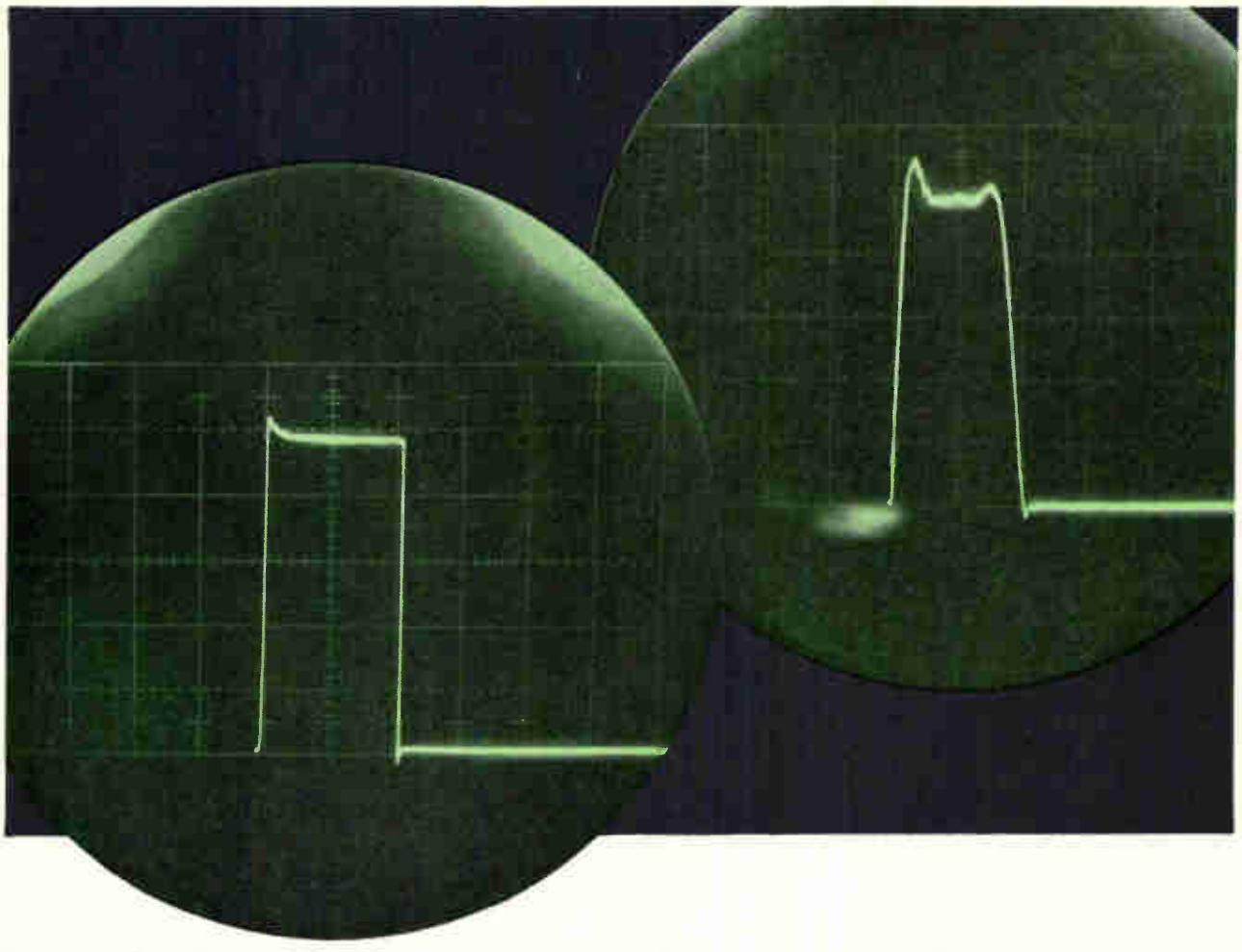
Electronics Review

For the record

Car tests. Using what its maker bills as the first computer system for checking auto health, two diagnostic centers have opened in Elizabeth, N.J., and Chicago. The developer is Universal Testproducts, a subsidiary of Allen Electric and Equipment Co. of Kalamazoo, Mich. At the centers, an Allen 1280 digital computer produces a printed readout grading the car good, failing, or marginal in 150 tests ranging from air conditioner to windshield washers. On another front, the Pontiac Motor division of General Motors plans to offer its 3,400 dealers a new electrical diagnostic system called Sercon (for service connection). It plugs into bulkhead connectors and checks out a car's major wiring in a single test instead of having a mechanic check the battery, horn, and so on individually.

On track. Drivers on superhighways may soon be leaving the driving to electronics. Two independently developed automatic control systems, which will be described at the IEEE Automobile Conference in Detroit next week, can keep a car on course and properly spaced in high-speed traffic. At Oklahoma State University, engineers have tested a guidance control system that features an electronic eye which tracks a line painted down the highway. The system steers and brakes the vehicle. Meanwhile, an Ohio State University team has developed a system, using infrared radar, for automatically spacing cars.

Light touch. The fast-spinning turbine spools of jet engines may soon be balanced and freed from vibration and the job will be done with lasers. For $69,000. Spacerays of Burlington, Mass., is building a prototype production line balancing system for the Allison division of General Motors, a major jet engine producer. The pulsed laser system will remove excess metal from turbine spools as they rotate at operating speed; these spools are the largest, heaviest candidates to undergo laser dynamic balancing yet.



Two 100-megawatt modulator waveforms can't indicate your best choice in a switch tube.

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We've been just as busy in ceramic hydrogen thyratron R&D. For Type 8479/KU-275A, we perfected a new keep-alive electrode. It allows the tube to switch up to 100 megawatts and maintain less than 0.15 microseconds variation in anode delay time over a wide range of operating conditions. The result: a "repeatable" tube for the largest linear accelerators.

By applying a new gradient technique from our F-1087 100-KV thyratron development, we are developing a tube that will have almost four times the current carrying capability as the KU-275A... and with even greater voltage hold-off.

And we're doing a lot more in the gas-and-power-tube field to benefit your design needs. Ask us for general information or specific answers. Write: Dept. EL, Electron Tube Division, International Telephone and Telegraph Corporation, P.O. Box 100, Easton, Pa. 18043.

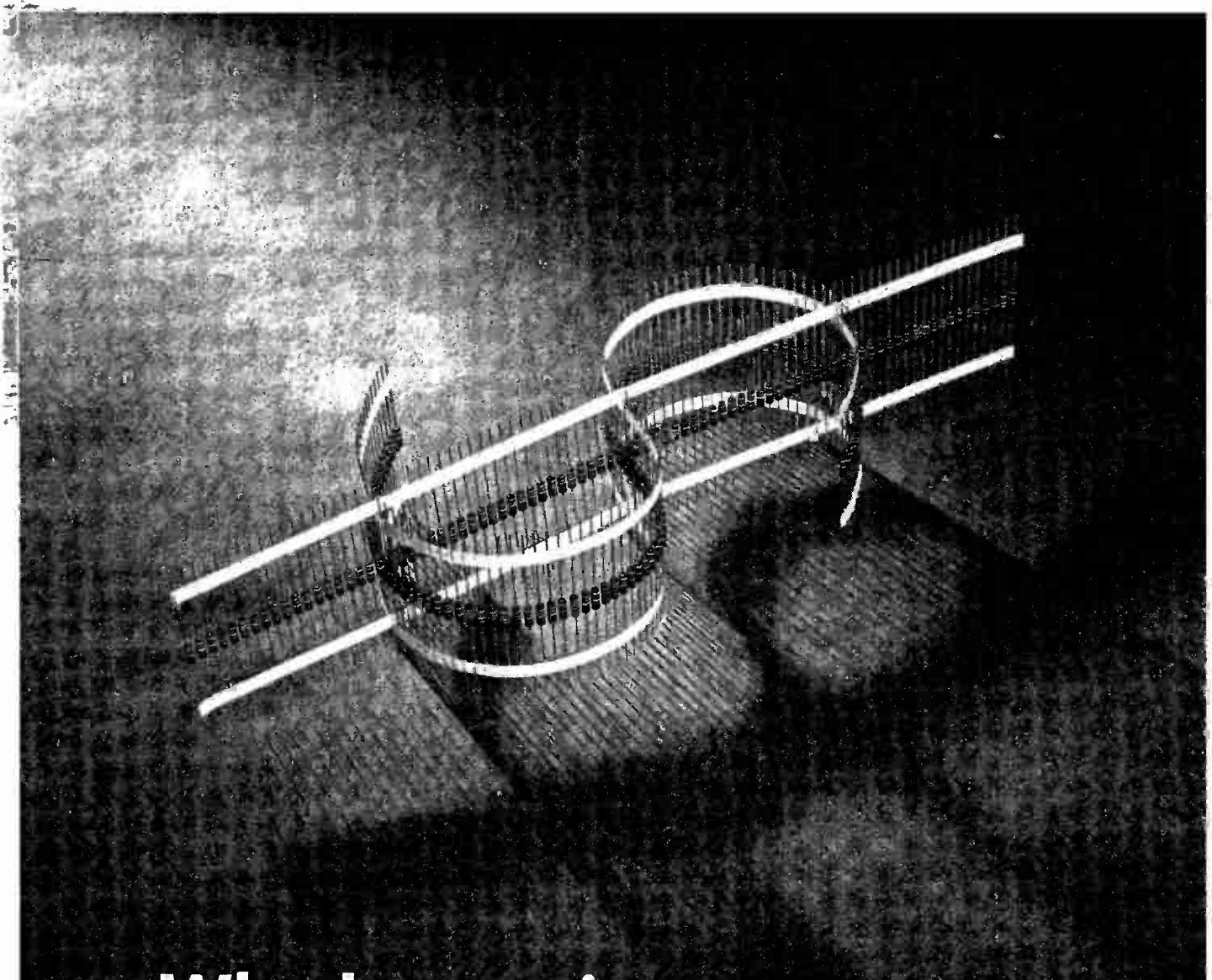
ELECTRON TUBE ITT

Electronics Review

Day in court. The Radio Corp. of America has successfully defended its ownership of one of the basic color-television patents. The 65-page ruling of the Federal District Judge Caleb N. Wright in Wilmington, Del., went against Philco-Ford, whose attorneys have not yet decided whether to appeal.

Radar award. The Radio Corp. of America will get an initial $2.5 million Air Force contract to build the FPS-95, an over-the-horizon radar to be installed at undisclosed sites overseas as part of the 466L/440L electromagnetic intelligence system [Electronics, May 1, p. 48]. The office of the Air Force Secretary predicts the total value of the contract will run to about $8 million. In the competition for the order, RCA beat out General Electric, ITT, and a unit of Sylvania Electric Products.

Happy landings. Space agency officials this month nervously sat through two missions that experienced technical hitches but finished strong. Surveyor 5, despite fuel system problems that seemed for a while insurmountable, soft-landed on the moon within 18 miles of its target site. The television cameras aboard immediately began to transmit high-resolution pictures described as "best yet from a Surveyor," and the magnetized leg of the craft picked up a generous supply of magnetic particles from the lunar surface. Over the same weekend, communications problems and a tropical storm in the recovery area caused Biosatellite B—with a passenger list that included plants, beetles, wasps, and fruit flies—to be returned to earth after two days in orbit instead of the scheduled three. An Air Force plane snared the encapsulated specimens in mid-air and flew it to Hawaii. The purpose of the mission was to determine the effects of weightlessness and radiation on living organisms. NASA's relief after the tense weekend was more than understandable as each of the satellite's predecessors had failed; Surveyor 4 crashed on the moon in July and the first Biosatellite wound up stranded in orbit last December.



Why buy price at any cost

To pay too little is to obviously speculate. To spend too much is to be foolishly extravagant. The real value of any purchase is determined in performance, not price. Resistors are like this also.

For years, Stackpole fixed composition resistors have been the standard of value for many leading manufacturers of electrical and electronic equipment. Engineers have become familiar with the testing and evaluation that go into each Stackpole resistor order. Purchasing people know they can expect prompt delivery. And management is assured of complete, in-depth service backed by sixty years of experience.

It's for reasons like these that Stackpole resistors are selected to maintain top performance on so many established products and on a growing number of brand new ones. Such confidence and loyalty cannot be based on price alone, but instead come from the kind of dependability that builds a reputation for your product.

Uniformity is a known characteristic of Stackpole resistors. Unique production methods coupled with thorough testing assure you absolute performance. You can rest assured that the Stackpole resistors you order today will be identical in every way, order after order.

Are you getting what you pay for in a resistor? Why not investigate the value Stackpole resistors can give you. Quality, economically priced and backed by the recognized name . . . Stackpole. There are four sizes to choose from: 2, 1, ½ and ¼ watts.

For samples or a copy of our new booklet, "How to spot a quality resistor", write: Stackpole Carbon Company, Electronic Components Division, Kane, Pa. 16735. Phone: 814-837-7000 — TWX: 510-695-8404.

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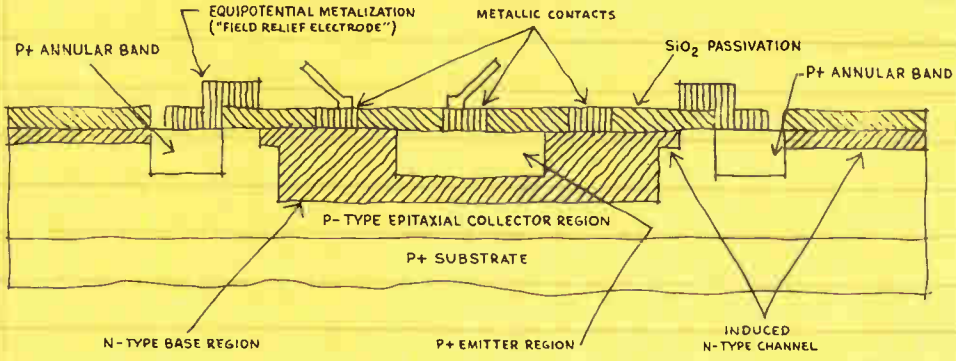

*Field Relief Electrode — Patent #3,302,076
Annular Structure — Patent #3,309,245 and #3,309,246

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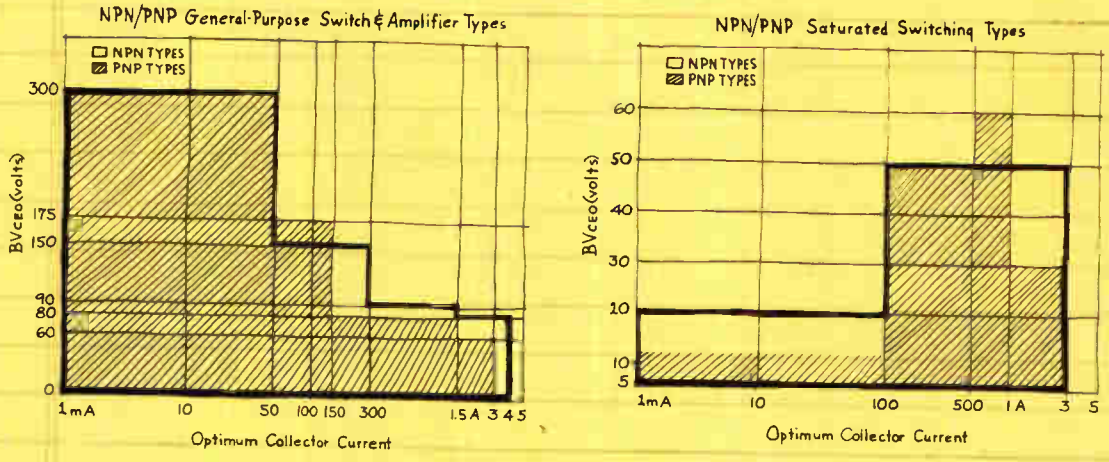

No matter what your application, chances are Motorola has a Silicon Annular transistor to fit it. The charts above are indicative of the broad voltage and current ranges covered. All are fabricated using the Annular Process, Field Relief Electrode or both. Result: State-of-the-art devices -- free of failure due to surface or bulk defects!*

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*Includes all 38 MIL-qualified switches and 34 low-power, general purpose transistors.

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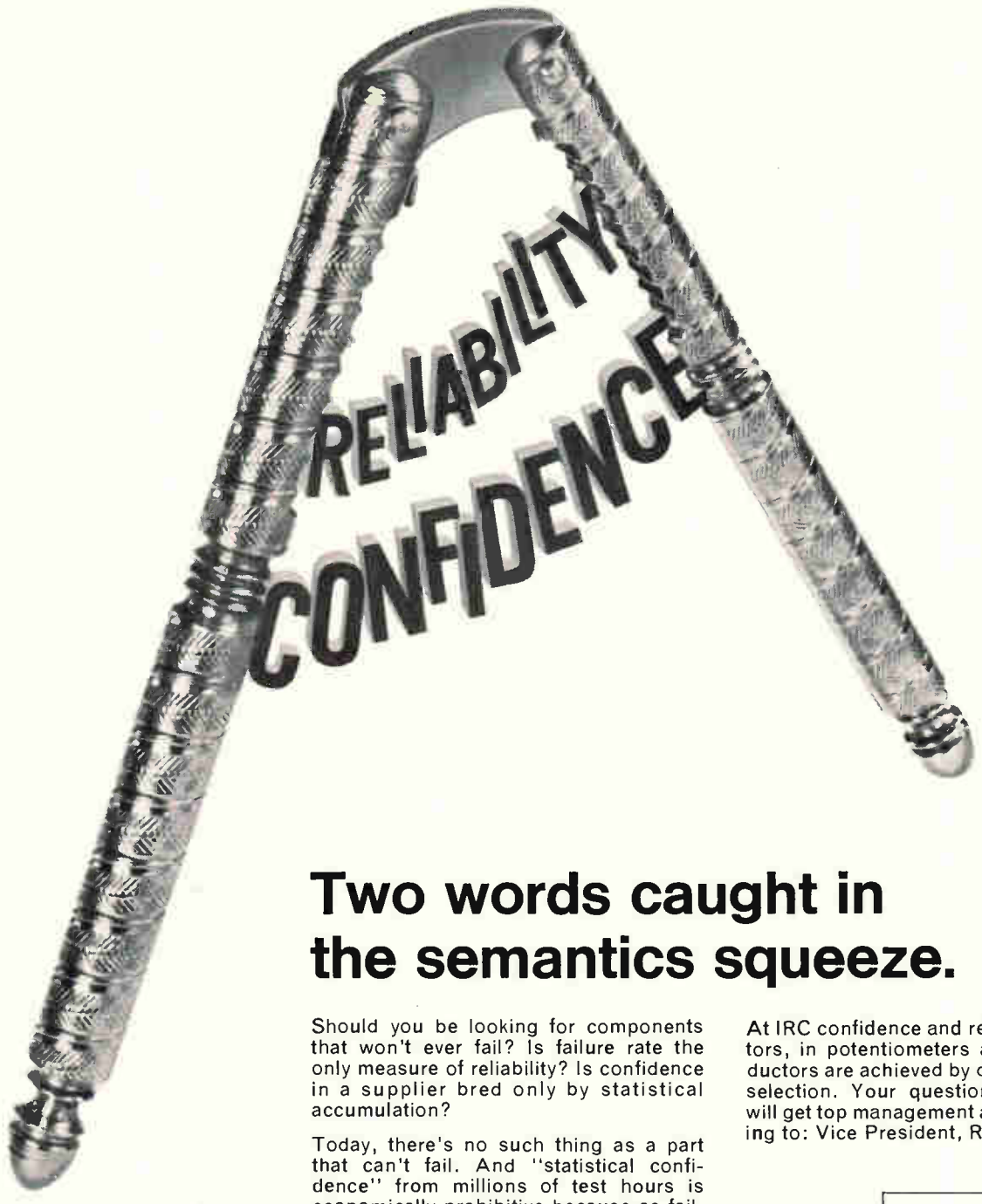


Two words caught in the semantics squeeze.

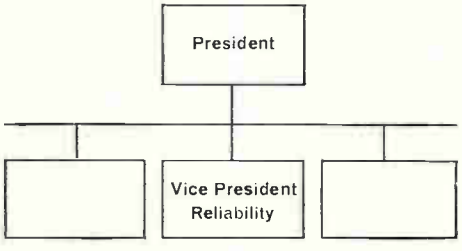
Should you be looking for components that won't ever fail? Is failure rate the only measure of reliability? Is confidence in a supplier bred only by statistical accumulation?

Today, there's no such thing as a part that can't fail. And "statistical confidence" from millions of test hours is economically prohibitive because as failure rates decrease, the cost-of-proof increases sharply.

It comes down to plain old confidence . . . in us and in our production system.

Call it reliability. Call it confidence. We think it's both. And our Director of Reliability makes sure you get it. He's involved in everything from basic designs to final inspection to assure you of homogeneity and performance repeatability.

At IRC confidence and reliability in resistors, in potentiometers and in semiconductors are achieved by discipline, not by selection. Your questions on reliability will get top management attention by writing to: Vice President, Reliability.



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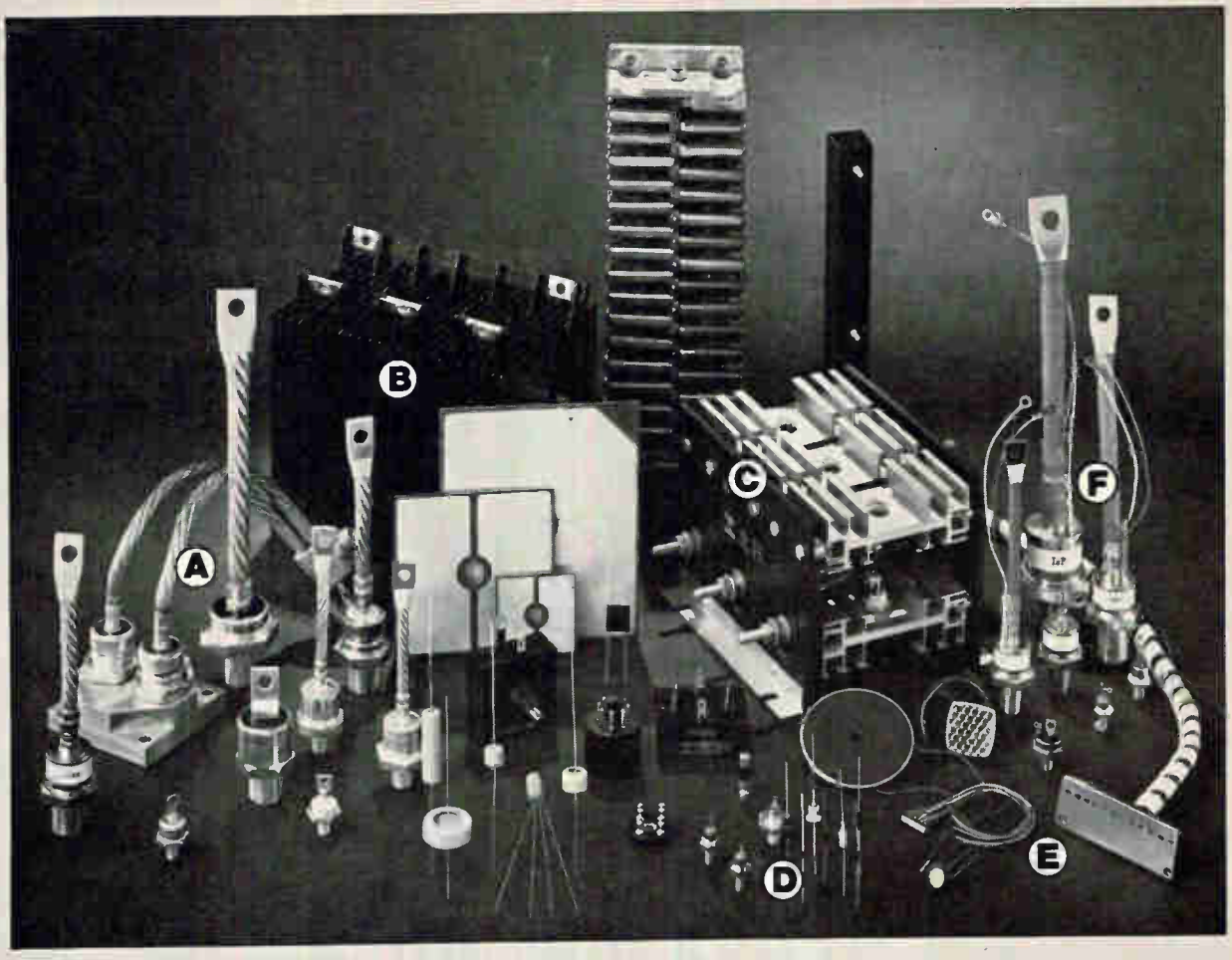

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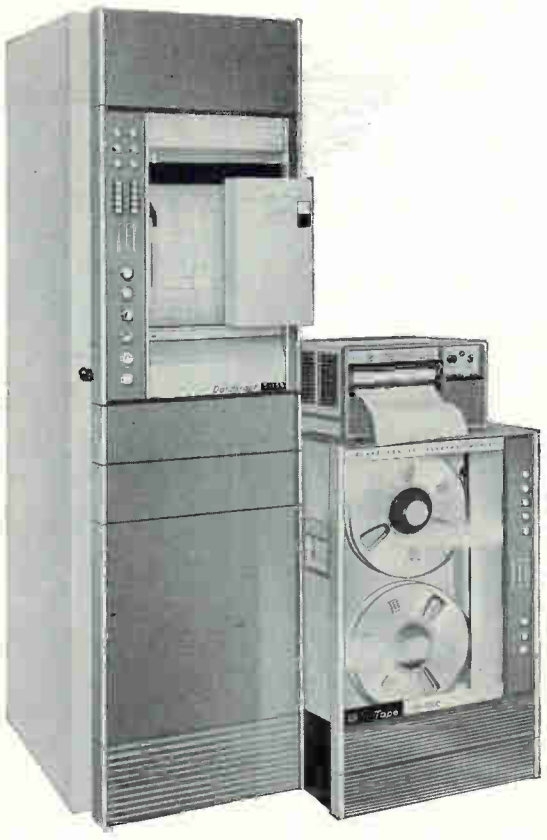

High impedance comes to oscillography

For the first time, you can attach a recording oscillograph directly to a data tape recorder or telemetry system *without* attenuation or external signal conditioning equipment.

Result: a dramatic saving in weight, power and rack space. For example, in a 14-channel system, this would represent a weight reduction of approximately 60 pounds and a saving of 7 inches in space.

The advance has been made possible through the use of five new CEC high impedance galvanometers: Type 7-601-0001 (0 to 100 Hz); Type 7-602-0001 (0 to 500 Hz); Type 7-603-0001 (0 to 1000 Hz); Type 7-604-0001 (0 to 2000 Hz); Type 7-605-0001 (0 to 3000 Hz).

Now consider the advantages which these galvanometers share in common. D-C sensitivity: ±1.414 volts will produce ±2 inches, ±5% deflection. Input impedance to high impedance galvo: 100,000 ohms minimum.

And here are the oscillographs!

CEC's new 5-124A-H and 5-133-H are not only the first high impedance oscillographs—but are "first" in other ways as well.

The portable 5-124A-H is the ideal answer to a host of industrial problems. It provides up to 18-channel print-out recording, 10 speed ranges, and record-drive systems with 16 options from 0.25 ipm to 128 ips. And—with CEC's DataFlash Takeup Accessory, the 5-124 A-H requires only *1 second to readout.*

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The 5-133-H offers 5 recording modes —3 direct writing and 2 develop-out, and is available in 12-, 24-, 36- and 52-channel configurations. Graphic reasons why the new 5-133-H is the logical choice for FM data analysis, telemetry discriminator output recording and communications applications.

For complete specifications and all the facts about these new high impedance oscillographs, write Consolidated Electrodynamics, Pasadena, California 91109. A subsidiary of Bell & Howell. Ask for Bulletin Kit 351-X4.

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It's just 7 inches high by 19 inches wide by 18 inches deep for standard rack mounting.

You can buy one for less than $1,600, and that includes one of our 40 plug-in oscillator modules.

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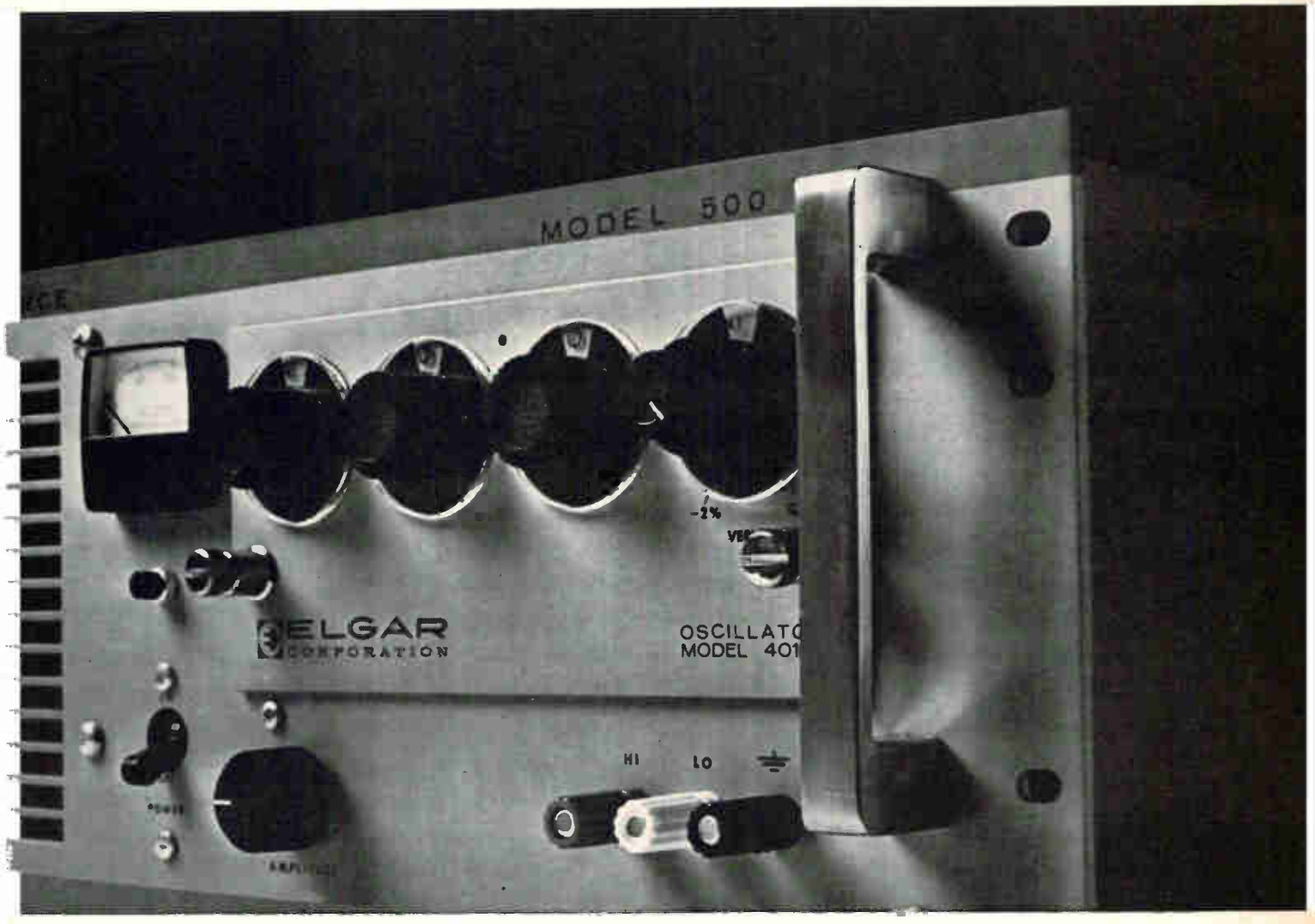
Well, what are you waiting for?



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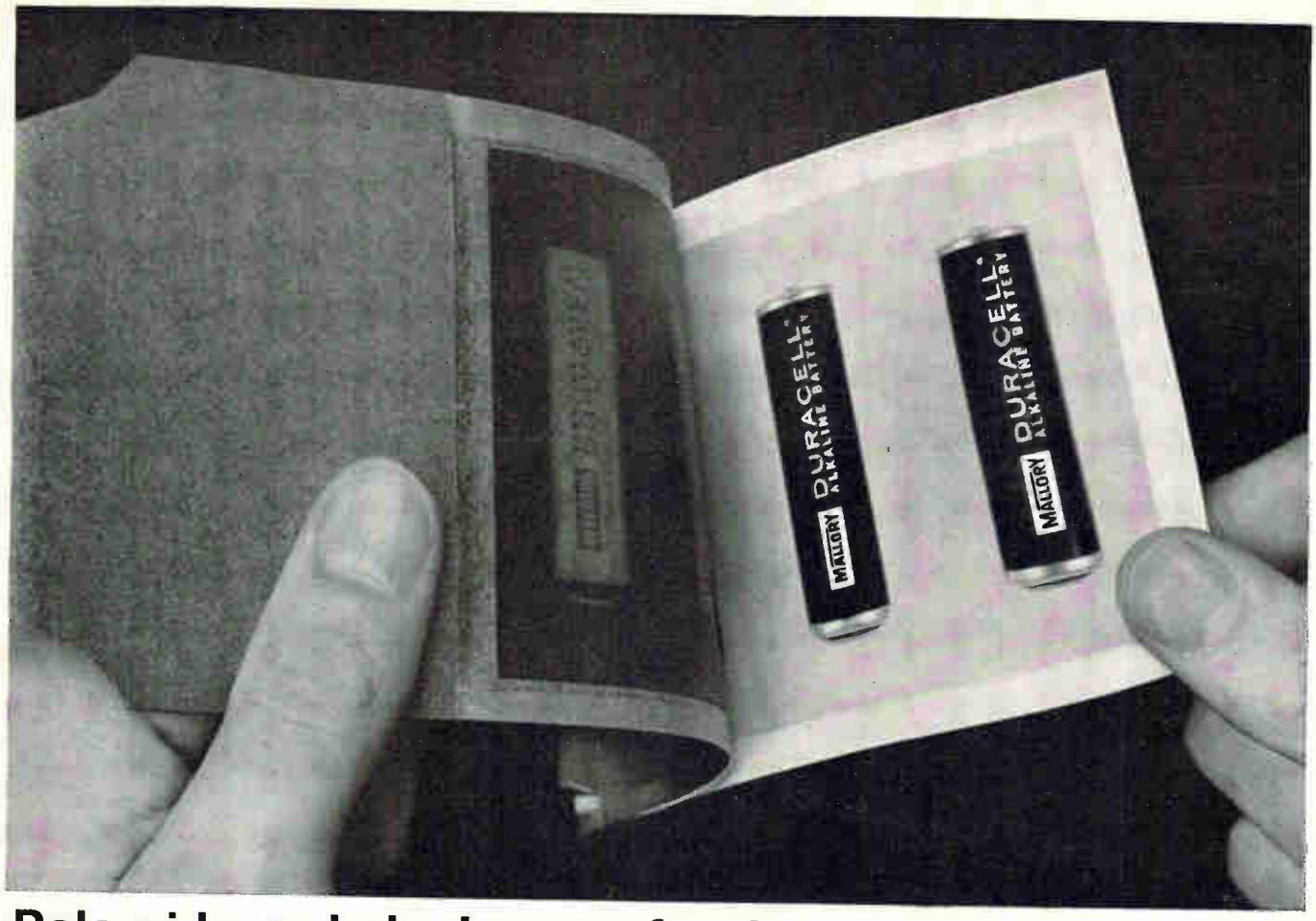


Polaroid needed a battery for the Swinger that wouldn't blow its cool.

Mallory made it.

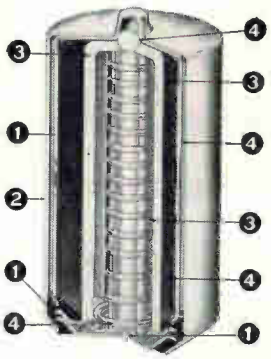
What can we do for you?

Polaroid needed a battery for the Swinger, its new 15-second film camera. A battery to power the Swinger's flash unit by night. A battery that could also work in its electric eye system by day. Yet a battery that could keep its cool—last for at least a year's average service.

Mallory made it. The battery—a Duracell® alkaline battery. It packs enough energy in its penlight size to flash over 1400 bulbs (an ordinary battery would flash less than 500). It provides steady, reliable power for the electric eye system. And it can be stored for 2 years and still retain 85% of its original capacity.

POWER IN A FLASH

Getting ordinary batteries to release their stored energy when that energy is needed in a hurry isn't always easy. By-products of the reactions that provide the electrical potential usually don't get a chance to get out of the way when current flow is heavy. Yet more and more of today's battery applications are calling for quick, heavy bursts of power—in flash bulbs, triggering devices, alarm systems and such. The Mallory answer to this need is the Duracell alkaline battery. Through a combination of a superior electrolyte (KOH) and improved anode design, Duracell alkaline batteries can deliver their energy to meet heavy drains in an instant. They can keep up a heavy output much longer than ordinary batteries. And they're available almost everywhere.



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4. Specially-designed contacts and internal structure carry current more reliably—reach deep into the battery to meet heavy drains.

OVER 1000 DIFFERENT TYPES

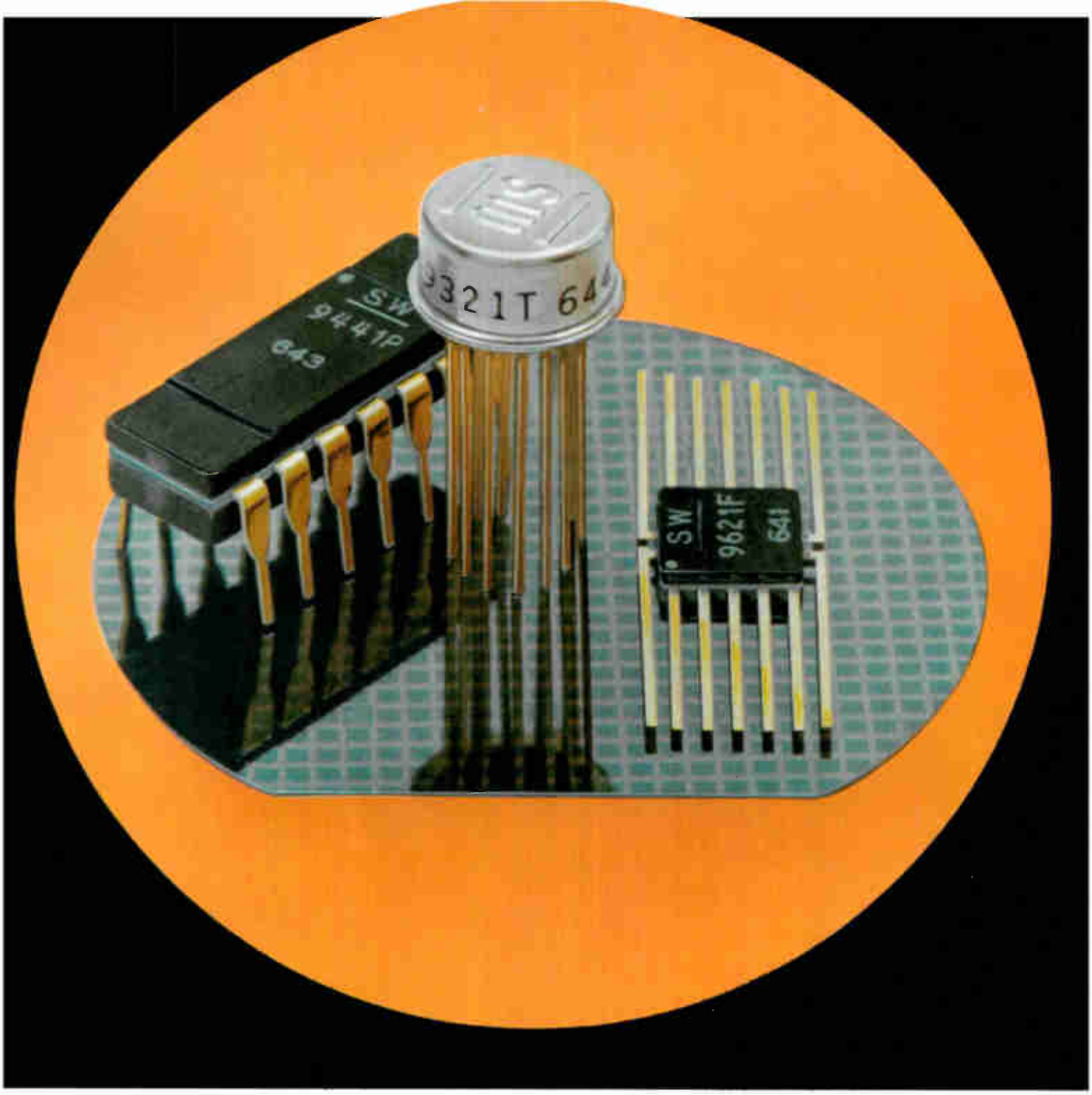
Mallory currently makes over 1000 batteries of all sizes and capacities. If we're not actually producing the battery you need, we'll be glad to work with you in designing a new one. Please write the Technical Sales Department, Mallory Battery Company, a division of P. R. Mallory & Co. Inc., South Broadway, Tarrytown, New York 10591. Or call us at 914-591-7000. (In Canada: Mallory Battery Company of Canada Limited, Sheridan Park, Ontario.)

It's good business to do business with Mallory MALLORY

®Registered trademark of P. R. Mallory & Co. Inc.
"Swinger" is a registered trademark of the Polaroid Corporation.

Circle 64 on reader service card

Circle 65 on reader service card →



The die is cast!

We're committed to the manufacture of the industry's finest line of 930 DTL integrated circuits.

Our customers know they could buy these monolithic integrated circuits elsewhere, but here's why they don't.

No one else has a better or more modern facility devoted exclusively to the manufacture of microcircuits.

No one else has demonstrated better yields.

No one else has provided better delivery.

No one else offers better prices on the same quality products.

And no one else has a more substantial name behind them than the "Stewart-Warner" name—for more than eighty-five years a leader in the manufacture of quality products.

Our customers are pleased with the superior quality of our products. If you try them, we know you will be pleased, too.

Why not talk to one of our representatives? And, meanwhile, let us send you our 20-page "Composite Data Book" with the industry's most complete coverage of 930 series Flat Packs, Dual In-lines, and TO-5's.

STEWART SW WARNER
MICROCIRCUITS, INC.
SUBSIDIARY OF STEWART WARNER CORPORATION

730 EAST EVELYN AVENUE, SUNNYVALE, CALIFORNIA 94086 / TELEPHONE: (408) 245-9200

If Freon® is the "high-priced" cleaning agent

...how come it paid for itself in one year at Hazeltine?

Nearly all the printed circuits produced by Hazeltine at its plant in Riverhead, New York, go to customers in the space industry... who demand flawless components in spotlessly clean circuits.

Until two years ago, Hazeltine cleaned its printed circuits manually in other solvents. This system was effective, however, it was not very efficient... too expensive and time-consuming. In the spring of 1965, a new Branson printed-circuit-board cleaning system using FREON* TMC was installed. This new system cleaned 50 pieces of equipment in the same time it took the old system to clean one. The total outlay for the new equipment was less than $5,000. By the following spring it was completely amortized. Since then, FREON has been *making* money for Hazeltine.

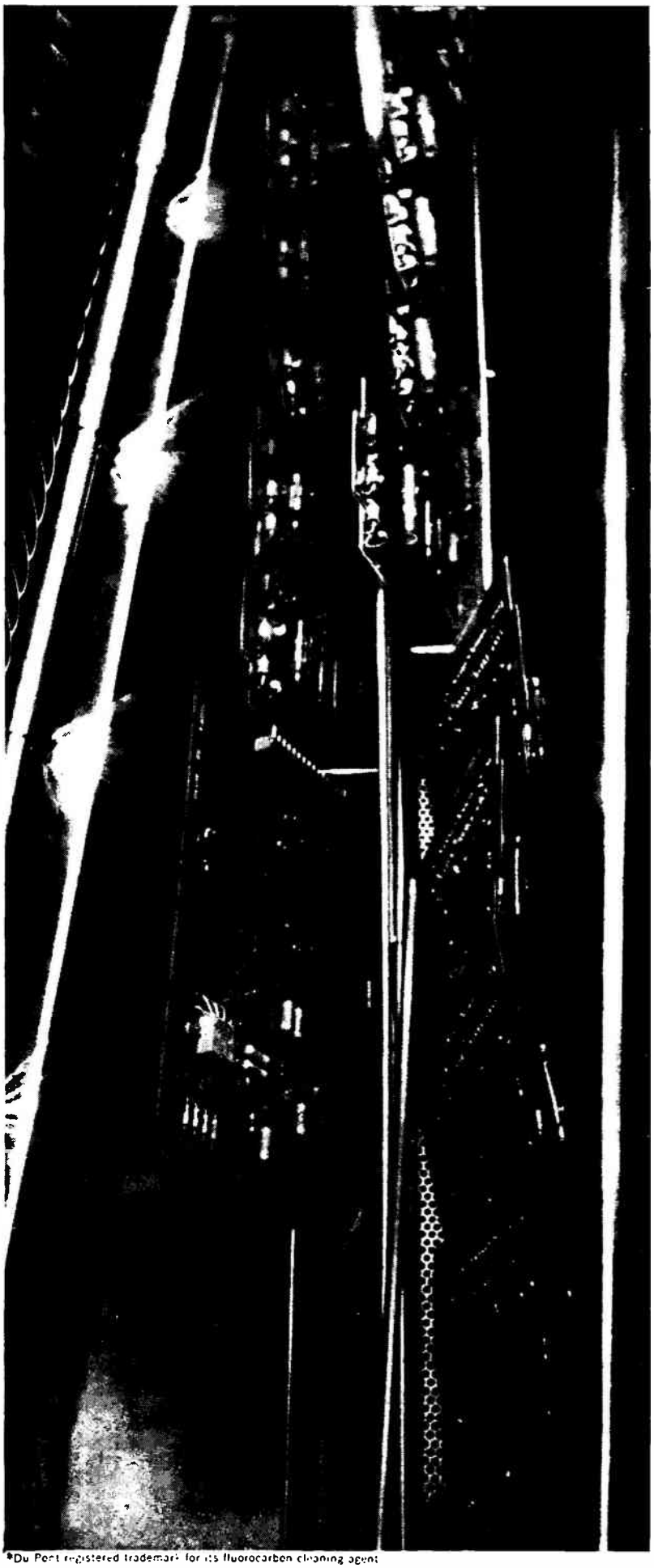
The entire cleaning operation is done with the dissipation of only three gallons of FREON a day, compared with 28 gallons of the former solvent, which had to be discarded daily because of contaminant buildup. The reason for the better than nine-to-one advantage is that FREON itself can be cleaned. A small distilling and filtration tank reclaims FREON and returns it to the vapor degreaser crystal-clear.

How fast can FREON, the "high-priced" cleaning agent, pay for itself in *your* operation? Your first step in finding out is to write: Du Pont Company, Room 5321, Wilmington, Delaware 19898. (In Europe, write: Du Pont de Nemours International S.A., FREON Products Division, 81 route de l'Aire, CH 1211 Geneva 24, Switzerland.)

FREON® solvents

DU PONT

Better Things for Better Living... *through Chemistry*



*Du Pont registered trademark for its fluorocarbon cleaning agent

Washington Newsletter

September 18, 1967

Navy okays LSI for data system

The Navy is about to launch what is believed to be the first application of large-scale integration in operational military hardware. Preliminary studies by prime contractor Litton Industries convinced the Naval Air Development Center that using LSI in the AN/ASW-27 two-way digital data link is feasible. Navy representatives and engineers from Litton's Data Systems division met last week in Van Nuys, Calif., to decide where large-scale integration could be used and what functions should be allotted to specific chips.

FAA reconsiders Comsat plan for airlines' satellite

Comsat's proposed aeronautical services satellite, twice shot down by the FAA, has a new lease on life. **Reason: a new proprietary technical approach by Comsat has considerably reduced the estimated price tag.** The FAA returned two preliminary proposals by Comsat—the first time for cost and technical reasons, the second time for cost alone [Electronics, Aug. 7, p. 65]. Comsat has quietly submitted a detailed proposal for the satellite which would relay vhf communications between transoceanic airliners and ground stations. A decision by the FAA is expected in about two months. Comsat told the FAA that the satellite could be operational by 1970.

Improved avionics for Navy's A-6A

Improving the mean time between failures (MTBF) of the search radar and the computer on the A-6A Intruder is a key goal of the $4.5 million redesign contract awarded to Grumman. Replacement of the craft's Litton computer with an IBM 4-Pi Model CP [Electronics, June 26, p. 59] is expected to boost the MTBF from 20 hours to as much as 2,000 hours. Norden, current radar supplier, will improve the MTBF on its radar from the present 10 hours to 90 hours. Grumman figures that even with the improvement the avionics will still cost a bit less than the current $2 million a plane. The Navy contract is seen as an indication that more A-6A's will be ordered, especially since production plans for the troubled F-111B are still nebulous.

U.S. seeks peace as cable-satellite war heats up

The White House has told the FCC to arrange a quick, quiet settlement of the escalating battle between cable and satellite interests. **The Government doesn't want a full-blown squabble in the U. S. just when it's promoting international satellite communications to strengthen the U. S. position before renegotiating the Intelsat agreement in 1969.**

AT&T and other U.S. carriers want a new 720-circuit cable (TAT-5) between Rhode Island and Cadiz, Spain, to be in service by 1970 at a cost of about $75 million. Comsat hotly opposes the measure and it's speeding plans for Intelsat 4 [Electronics, Aug. 21, p. 59], a 10,000-circuit satellite to go in service about the same time. Planning for the new cable, progressing secretly between the carriers and Spain, Portugal, Italy and Great Britain for several months, brought some sharp behind-closed-doors criticism from satellite backers.

The carriers and Comsat have now both prepared economic justifications of their systems and the FCC is likely to order all rates reduced so both systems will have enough traffic.

Washington Newsletter

Pay tv hearings sop to Congress

Don't look for any shift in the Federal Communications Commission's plan to approve over-the-air pay tv as a result of hearings opening Oct. 2 [Electronics, June 12, p. 47]. **The FCC sessions are expected to represent little more than an effort by the agency to placate Harley O. Staggers (D., W. Va.), chairman of the House Commerce Committee,** who complained that the commission was planning to authorize over-the-air pay tv without consulting him. The FCC isn't expected to issue formal approval until next year, thus giving critics in Congress time to have their say.

Aide who quit takes temporary Government post

Even though Chalmers W. Sherwin said he wasn't "enthusiastic about going back to work for the government" when he quit the Commerce Department after being bypassed for its No. 1 science job [Electronics, Aug. 7, p. 65], the government apparently is still enthusiastic about him. Sherwin has been hired as a consultant by the President's Office of Science and Technology to devise equipment and software standards for his ambitious plan to make national and international data retrieval systems compatible.

The job will be finished in about three months but Sherwin, who played a key role in linking the NASA and Defense Department computer systems that store research data, is being wooed for a permanent job in the science and technology office.

One for all

NASA is eyeing a unified space applications mission—combining a number of earth-sensing missions on a single unmanned satellite—as an approach that should appeal to a budget-minded Congress. **IBM's Space Systems Center will submit its report to NASA in mid-October on the feasibility and the tradeoffs necessary.** The proposed system [Electronics, Jan. 23, p. 60] would combine such earth-sensing applications as earth resources, navigation, geodesy, communications and atmospheric sciences.

Industry wins delay on FCC study

The industry has wangled a four-month extension from the FCC for its comments on computers in communications. **The complexity of the FCC probe and its far reaching implications are likely reasons for the delay.** The FCC first asked for comments 10 months ago and set an October deadline. At the request of the major trade associations—including the Electronic Industries Association—the agency has pushed back the deadline to Feb. 5, 1968.

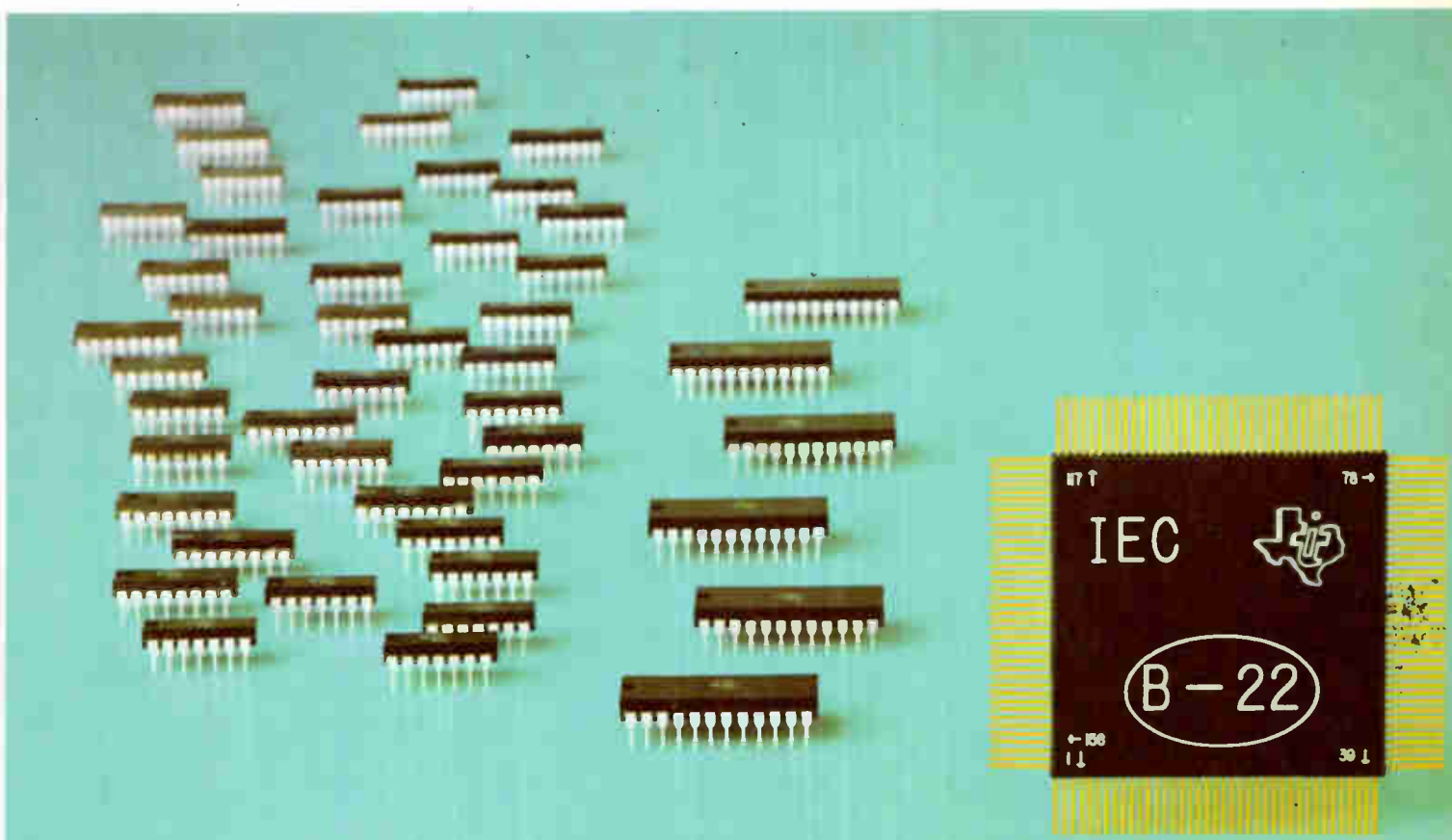
Senate majority claimed for SST

Backing for the supersonic transport has firmed in the Senate, despite the continuing opposition of critics led by Senator William Proxmire (D., Wis.). **An informal poll, according to Senator Henry Jackson (D., Wash.), shows that more than 80 of the 100 senators will back Government funding of the SST program.** The House recently trimmed $56 million off the appropriations bill but approved $142 million, enough to keep the program on schedule [Electronics, July 24, p. 50].

The present timetable calls for the Senate to get the supersonic transport bill late this month or early in October.

TTL Trends

from Texas Instruments



Today's Series 54/74 ICs point the way to the next dramatic step in solid state... MSI and LSI integrated equipment components.

Although vastly advanced in circuit complexity, this next generation of semiconductor devices will have much in common with today's Series 54/74 circuits (shown at left above), including utilization of the same basic TTL logic building blocks. In this and other ways, IECs will be natural extensions of today's Series 54/74 family of 39 functions and 180 device types.

By far industry's most complete logic line, Series 54/74 has been consistently expanded since the introduction of a few basic devices in 1964. The new high-speed and low-power circuits shown on the following pages are further additions to this growing family.

This provides you with new design opportunities now... and it also assures you a better interface with the TTL trends of the future.

New TTL additions to industry's most complete logic family

Industry's broadest family of TTL integrated circuits is now more complete than ever. To help you simplify designs, improve performance and reduce overall costs, we have added new circuits to our Series 54H/74H and 54L/74L lines.

New Series 54H/74H high-speed circuits feature 6 nsec propagation delay

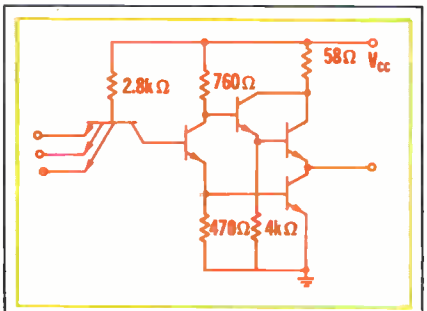
New additions bring the number of circuits in this line to the 18 shown on page C.

Series 54H/74H circuits offer the highest speed available in saturated logic today...six nanoseconds per gate.

This means that, by using 54H/74H in the critical logic paths of your digital systems, you can achieve advanced levels of performance with minimum design complexity.

The circuits may also be combined with standard speed and low-power TTL circuits in a single system . . . giving fast response while keeping overall system power consumption low.

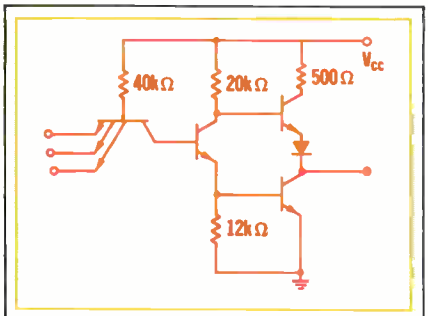
Check number 100 on the attached TI information service card for comprehensive data sheet.



Typical Characteristics	Gate	Flip Flop
Propagation delay	6 nsec	17 nsec
Power dissipation	22 mW	80 mW
Noise immunity	1 V	1 V
Temperature range		
Series 54H	−55°C to +125°C	
Series 74H	0°C to 70°C	

New Series 54L/74L low-power circuits feature 1 mW per gate power drain

Six new additions bring the number of circuits in this line to the ten shown on page D.

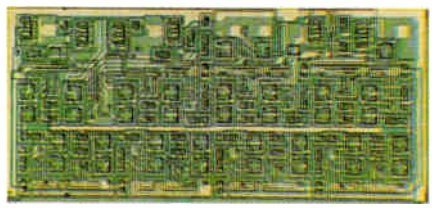


Typical Characteristics	Gate	Flip Flop
Propagation delay	33 nsec	47 nsec
Power dissipation	1 mW	3.8 mW
Noise immunity	1 V	1 V
Temperature range		
Series 54L	−55°C to +125°C	
Series 74L	0°C to 70°C	

At 1mW per gate, Series 54L/74L circuits offer a ten-fold power savings...yet are approximately twice as fast as other circuits with similar power dissipation.

This line is specifically designed for space systems, avionic systems and other applications where power consumption and heat dissipation are critical.

Check number 101 on the attached TI information service card for comprehensive data sheet.



Complex-function ICs help you reduce costs

You cut costs two ways when you use Series 54/74 complex-function integrated circuits in your designs. Overall savings in excess of 50 percent are often possible!

First, you pay less per circuit function! Since a major portion of all IC manufacturing costs are in the package assembly, fewer packages mean reduced costs to you.

Second, fewer packages also help you realize big savings at your plant...in inspection, handling, assembly, and inventory costs.

You also simplify designs because TI has already done a lot of the design work...and you improve reliability because more circuits per package mean fewer soldered joints and plug-in connectors.

Series 54/74 family is industry's most complete

Your new system can perform better and cost less when you employ Series 54/74 ICs, since you have the broadest choice of speed, power dissipation and cost-per-function available. Now you can tailor the characteristics you desire into your system...to a degree never before possible.

Any way you look at it, today's best buy in digital integrated circuits is Series 54/74 from TI.

Back in 1964 we told you:

This is a super/reg™ synthesized zener diode.

It enables you to build a precision power supply in minutes using any DC power source.

Typical super/reg zener impedances of 2 to 8 milliohms—lowest ever yet achieved—makes possible .01% regulation and .5mv ripple.

Voltage-adjustable as much as ±10%, as small as a millivolt, with no derating or degradation. The "third terminal" lets you trim the output.

.01%/°C temperature compensation at high power levels; thermal stability 100-times greater than that of the standard zener.

Zener voltages from 5.6 to 56 V.

75 watts dissipation rating, 50% higher than any other available zeners.

Looks, mounts like any other diode. Standard TO-36 case.

Performance-proven reliability; patent-pending design. Suitable for MIL applications.

Write or call for complete data and application bulletin.

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Now there are 104 super/reg® instant answers to your power regulator needs.

We figure if you've got something good, why stop there. Why not go ahead, expand the line, and give designers practically unlimited capability.

And that's what we've done — 104 times. Nobody else comes close.

Super/regs come in shunt and series versions. Just connect rough DC from whatever source you have — semi-filtered, half-wave rectified transformer output, or even a battery — you get instant, precision DC power where you need it: at the load itself.

Super/reg precision miniature regulators are uniquely designed for maximum heat transfer and power-handling capability. Ultra-compact configurations provide maximum flexibility over a wide range of voltage levels. Point-of-load installation eliminates distribution-line losses and cross-talk.

Write for complete data sheets and applications bulletins.

We've got 104. And if the mail is slow, we may have 105.

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Tel:(516)681-0400.

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triolab®

General Instrument proudly announces

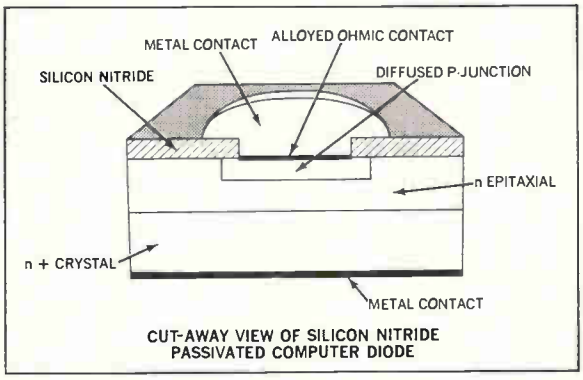
the industry's first silicon nitride computer diodes

now in production

It has long been generally recognized that semiconductor devices passivated with silicon nitride rather than with silicon dioxide would demonstrate unprecedented reliability.

Until now, however, the problem to be overcome was the difficulty of adequately handling and controlling the nitride process in mass production. General Instrument has solved that problem and is producing the industry's first line of silicon nitride passivated diodes.

The inherent reliability of silicon nitride is derived from its total imperviousness to the movement of sodium ions and extreme chemical inertness. Therefore, many of the most common modes of diode failure are eliminated. Unstable reverse breakdowns, excessive leakage currents and contamination occurring during chip handling and packaging no longer present reliability problems.



CUT-AWAY VIEW OF SILICON NITRIDE PASSIVATED COMPUTER DIODE

Superior electrical characteristics are now combined with this built-in reliability in General Instrument's line of high-speed silicon nitrided diodes in miniature DO-35 or DO-7 packages for computer applications.

Write for full information. (In Europe, to: General Instrument Europe, Via Turati 28, Milano, Italy).

GENERAL INSTRUMENT

GENERAL INSTRUMENT CORPORATION · 65 GOUVERNEUR STREET, NEWARK, NEW JERSEY

"Tougher than military"

Recently-completed reliability tests, such as the one for temperature-cycling shown here, have proved the ruggedness and durability of TI's plastic dual-in-line package for integrated circuits. Now you can take advantage of reduced initial costs—plus big savings in handling, assembly and testing—*without compromising essential reliability.*

Many of the tests in TI's plastic package reliability program far exceeded the requirements of applicable military specifications (such as MIL-STD-750A and 202C). For example, evaluations were made for shock to 5500 G, constant acceleration to 100,000 G, temperature cycling from −65° to +250°C and flammability to +1100°F. Units were exposed to salt, moisture and detergent bombs. They were vibrated at 60 G over a 100 to 2000 Hz range. They were subjected to solder-heat tests at 350°C. They were also life-tested for a total of 479,000 successful device-hours. Check No. 104 on the Service Card for the complete report.

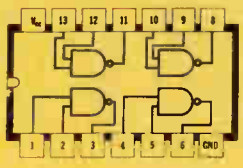
What does this mean to you? It means that whether your application calls for Series 74 (industrial temperature range) or Series 54 (full-military temperature range) you can now specify, *with complete confidence*, the plastic "N" package for our entire family of TTL standard and high-speed circuits. TTL performance, reliability and convenience are now yours...at a new low cost.

TEXAS INSTRUMENTS
INCORPORATED

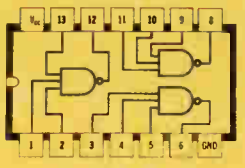
F

High-speed TTL

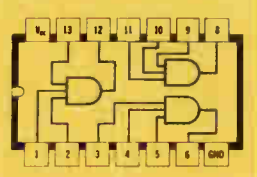
SN74H00N
Quadruple 2-input NAND gate



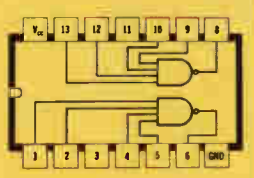
SN74H10N
Triple 3-input NAND gate



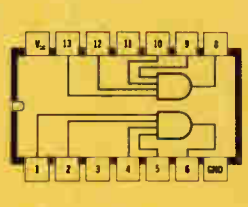
SN74H11N
Triple 3-input AND gate



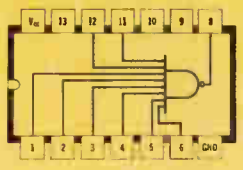
SN74H20N
Dual 4-input NAND gate



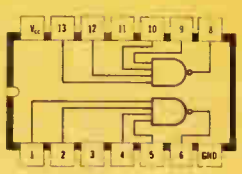
SN74H21N
Dual 4-input AND gate



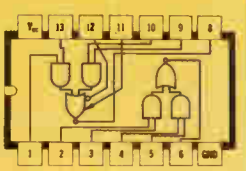
SN74H30N
8-input NAND gate



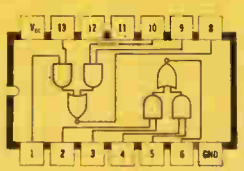
SN74H40N
Dual 4-input NAND buffer



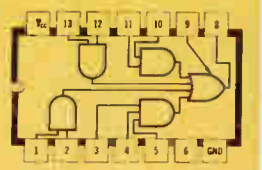
SN74H50N
Expandable dual 2-wide 2 input AND-OR-INVERT gate



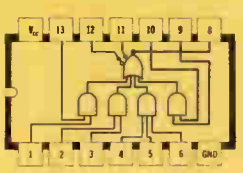
SN74H51N
Dual 2-wide 2-input AND-OR-INVERT gate



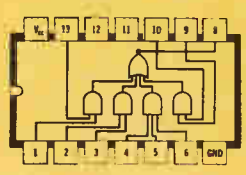
SN74H52N
Expandable 4-wide 2-2-2-3-input AND-OR gate



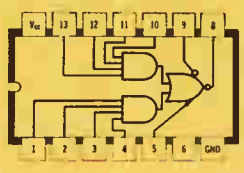
SN74H53N
Expandable 4-wide 2-2-2-3-input AND-OR-INVERT gate



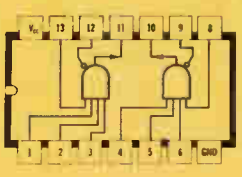
SN74H54N
4-wide 2-2-2-3-input AND-OR-INVERT gate



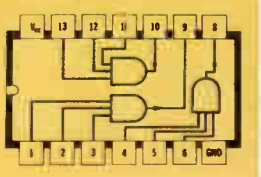
SN74H55N
Expandable 2-wide 4-input AND-OR-INVERT gate



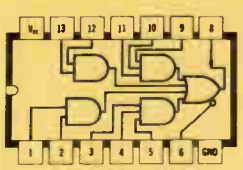
SN74H60N
Dual 4-input expander



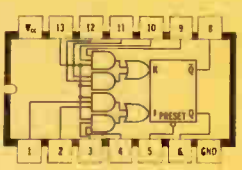
SN74H61N
Triple 3-input expander



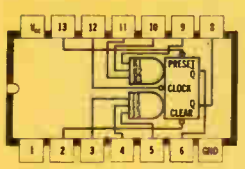
SN74H62N
4-wide 3-2-2-3-input AND-OR expander



SN74H71N
J-K flip-flop with AND-OR inputs



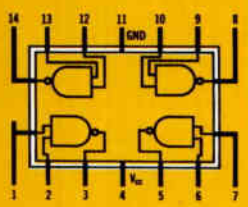
SN74H72N
J-K master-slave flip-flop



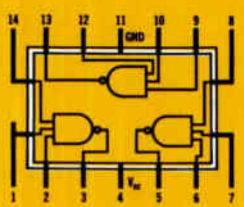
Series 54H/74H offered in both dual-in-line and flat packages

Low-power TTL

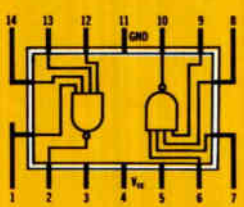
SN54L00R/SN74L00R
Quadruple 2-input NAND gate



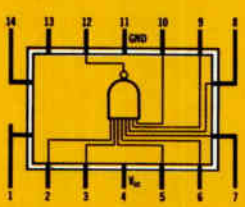
SN54L10R/SN74L10R
Triple 3-input NAND gate



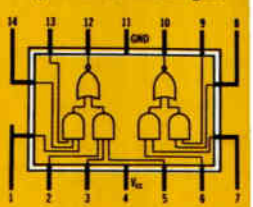
SN54L20R/SN74L20R
Dual 4-input NAND gate



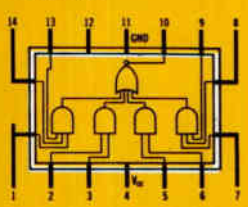
SN54L30R/SN74L30R
8-input NAND gate



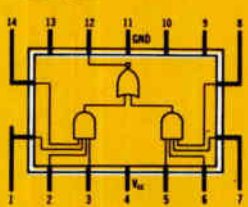
SN54L51R/SN74L51R
Dual 2-wide 2-input/2-wide 3-input AND-OR-INVERT gate



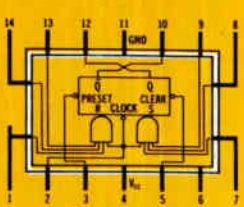
SN54L54R/SN74L54R
2-2-3-3 Input AND-OR-INVERT gate



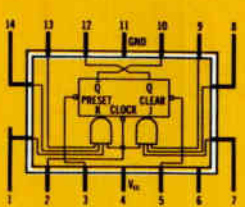
SN54L55R/SN74L55R
2-wide 4-input AND-OR-INVERT gate



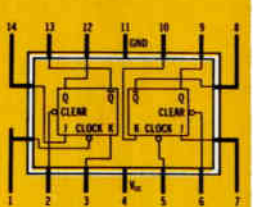
SN54L71R/SN74L71R
R-S master-slave flip-flop



SN54L72R/SN74L72R
J-K master-slave flip-flop



SN54L73R/SN74L73R
Dual J-K master-slave flip-flop



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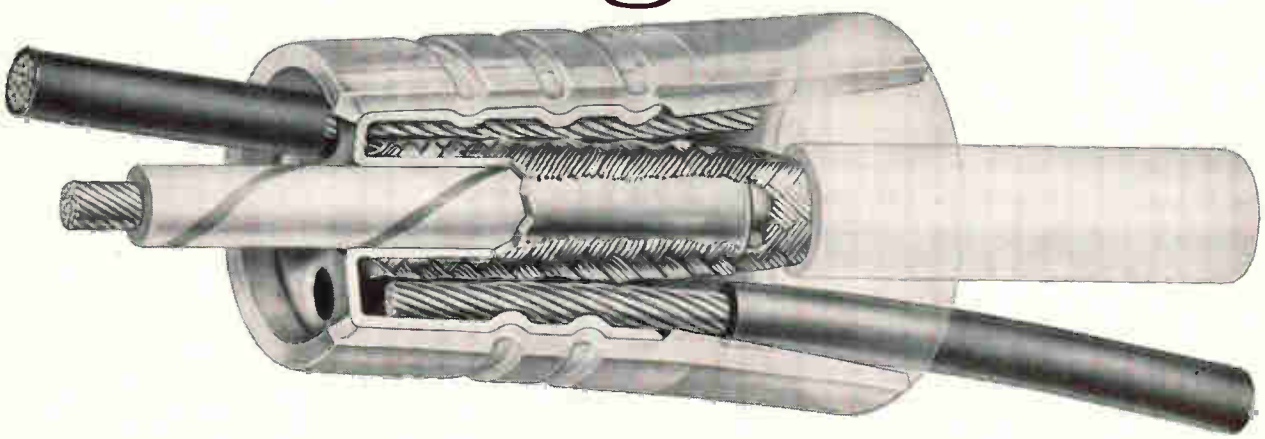

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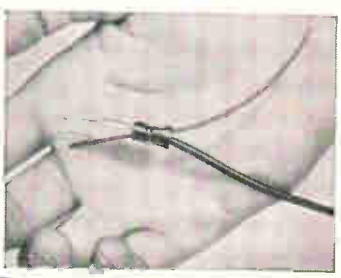

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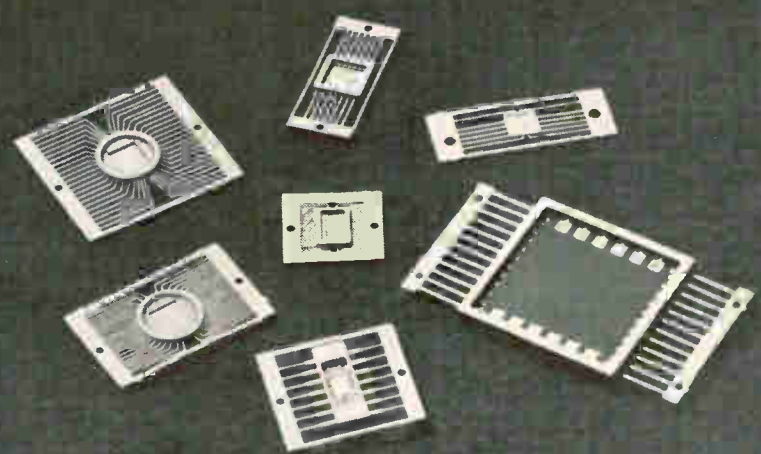

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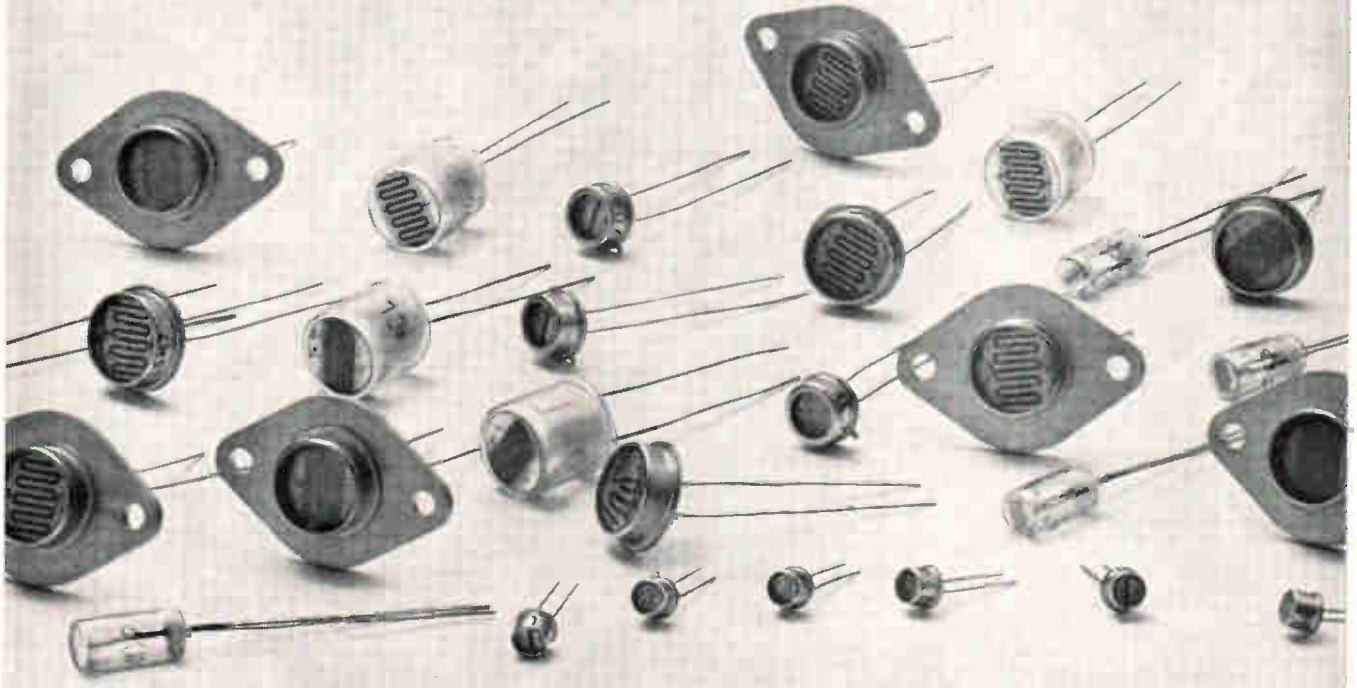

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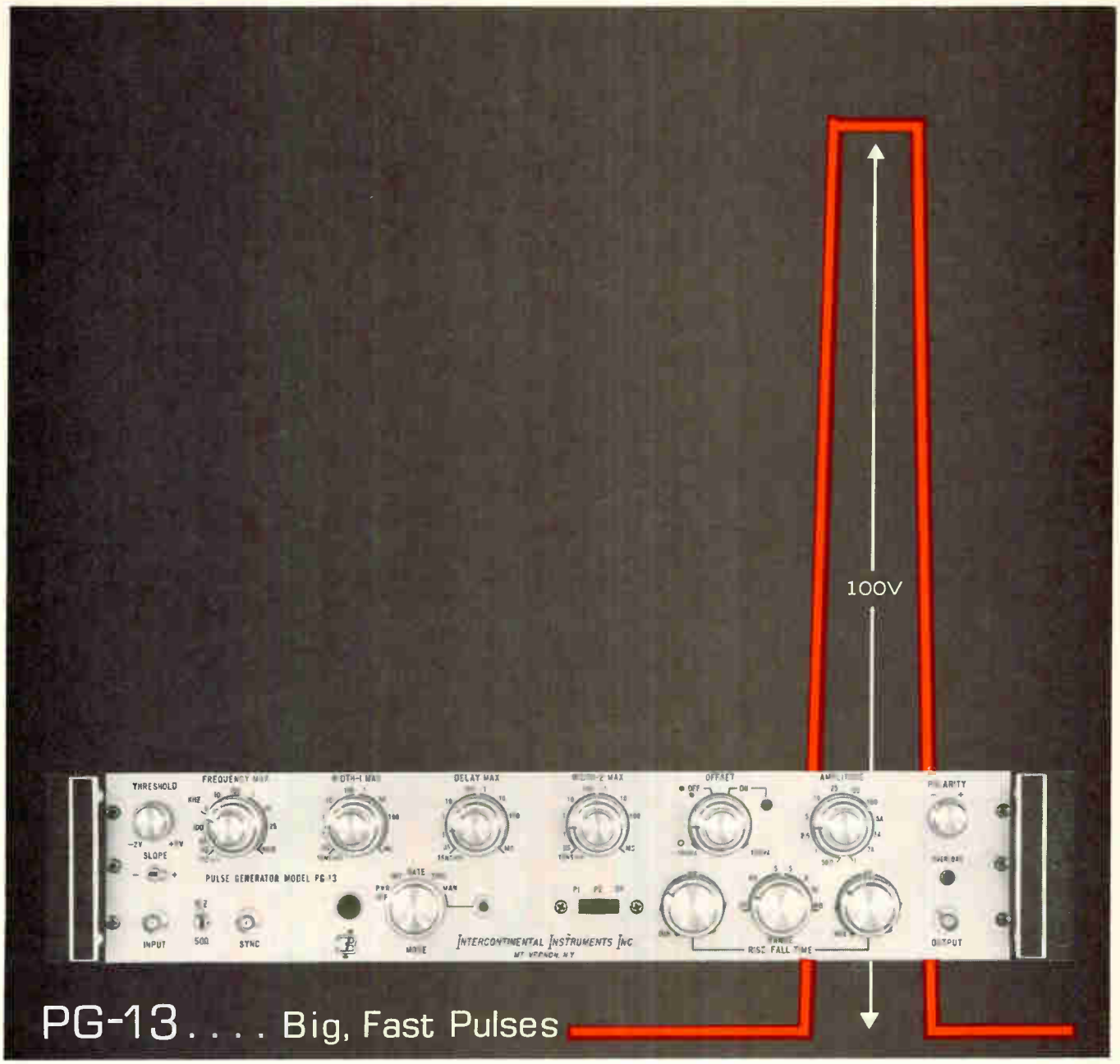

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This is why, in brief part:

The PG-13 is all solid-state (rack height 3½"). Operates in either voltage or current modes; in the voltage mode the range is ±100 mV to ±100V from a 50 ohm source; in the current mode it is ±50 mA to ±2A from a 1K, min, source. PRF, 1 Hz to 25 MHz. Single or double pulses plus sync. Instantaneous overload protection and a front panel warning light. Can be gated or triggered up to the max rep rate. Manual one-shot. DC-offsets either direction to 100 mA. Independently variable rise and fall times, 10 ns to 50 ms. PRF, rise, fall, amplitude, width (of either pulse independently), offset and delay are all variable continuously.

The PG-13 is one of the 3-I/Chronetics new generation pulse generators.

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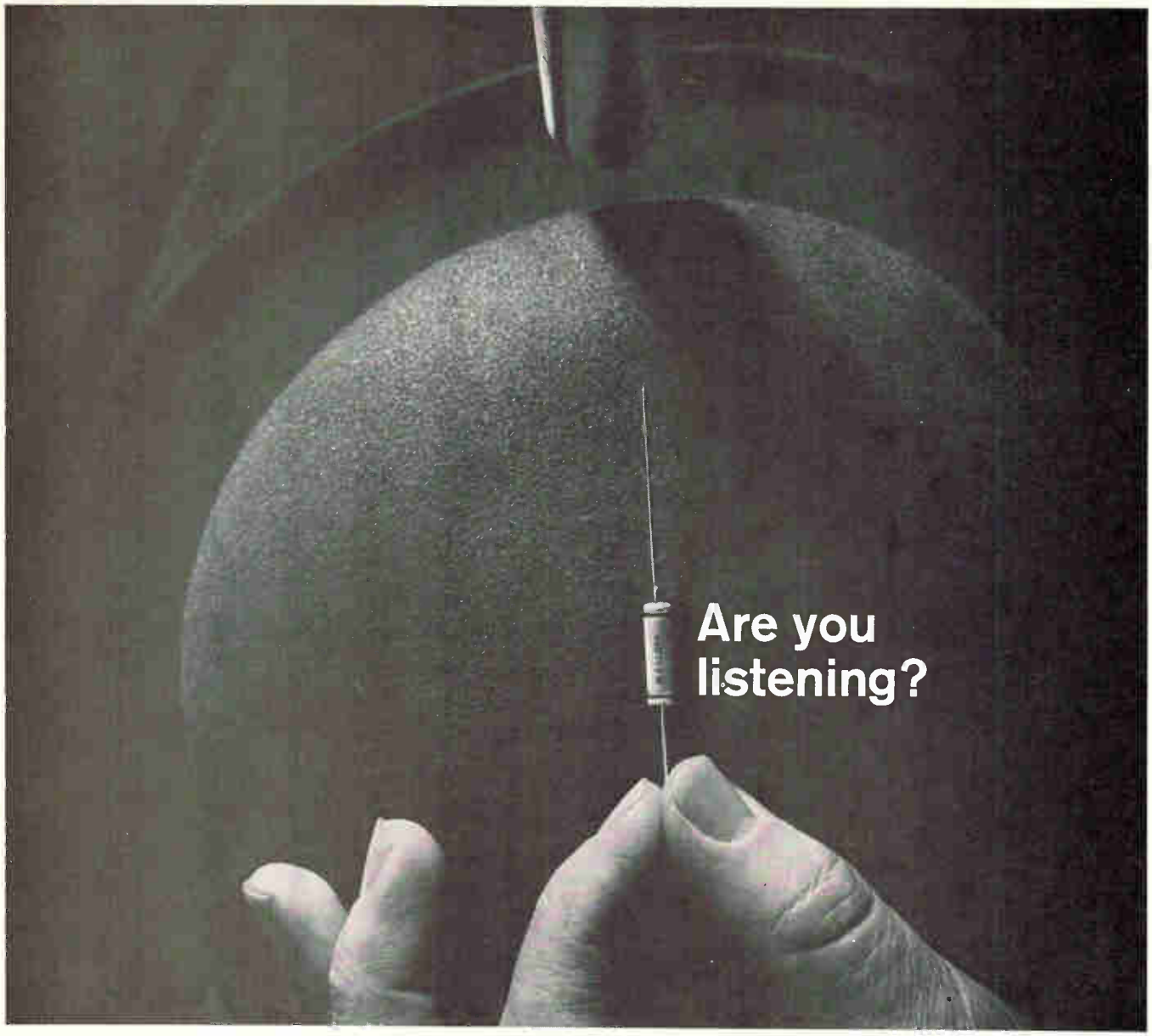

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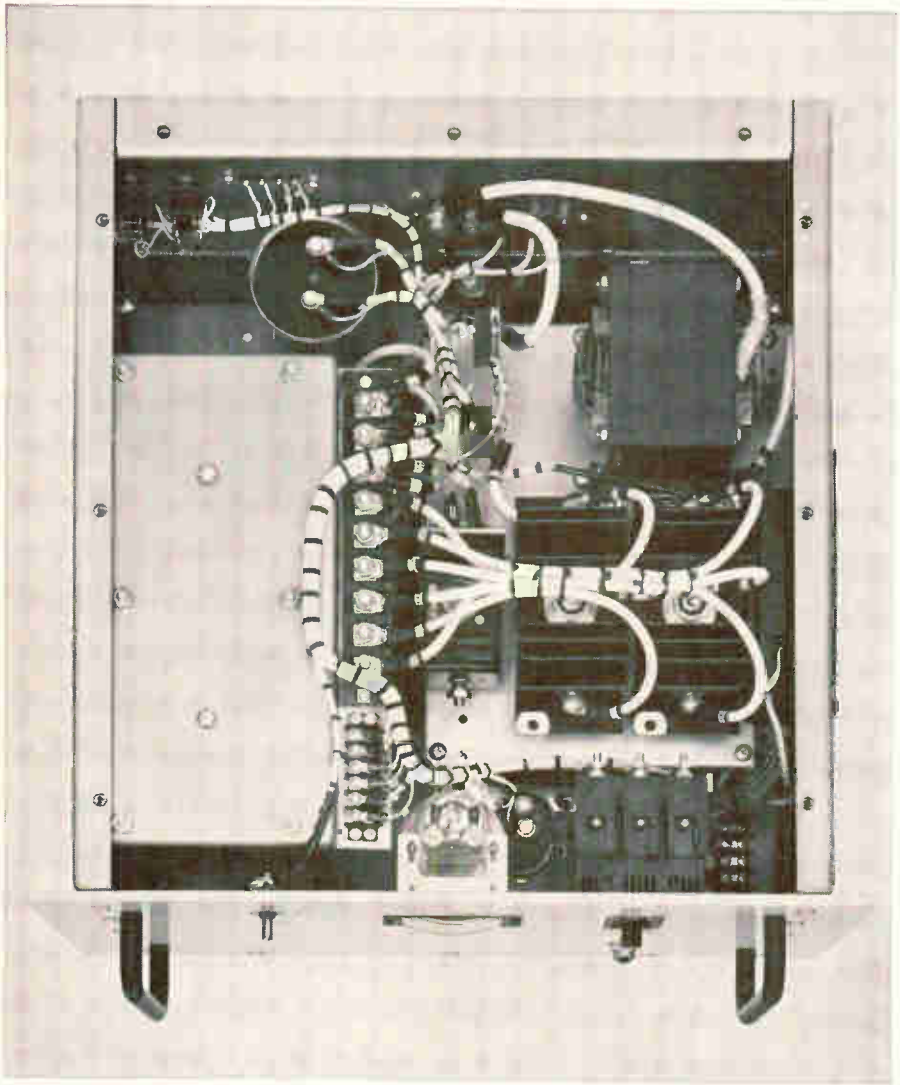

This unit was designed for communications equipment and is available in 25 amp. stages from 25 to 150 amps. It can be operated in parallel, has a remote sense feature, an inverse time circuit breaker and internal fan cooling. Overload capacity is 200% for 5 minutes; 400% for 4 seconds. Environmental capability encompasses a temperature range of −20° to +130°F. This equipment is designed for standard rack mounting and is compatible with the system into which it will be designed.

Like other Tung-Sol designed and built power supplies, this one meets precise performance requirements and high reliability standards. The price doesn't sound as though it was custom built.

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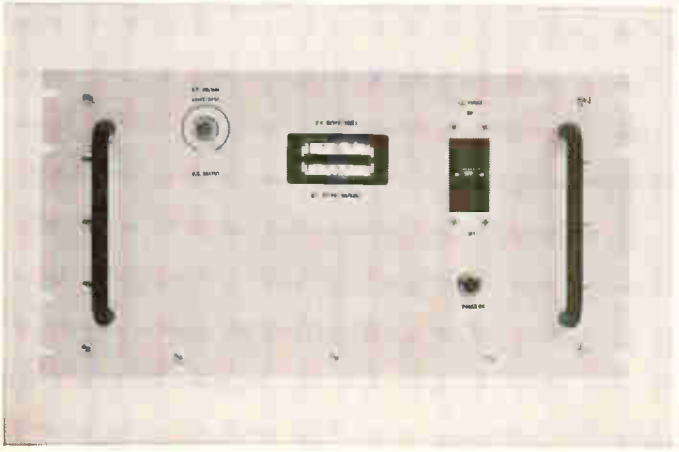
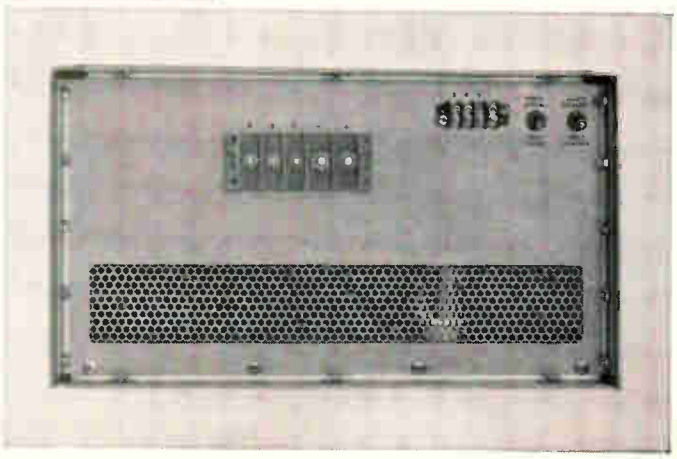




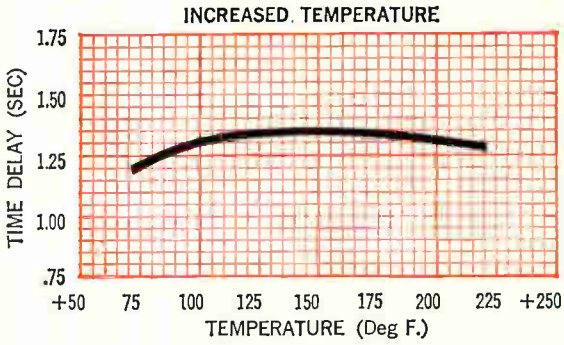
Adlake Mercury Displacement Relays —Application Data

Operates Under a Wide Range of Temperature Conditions

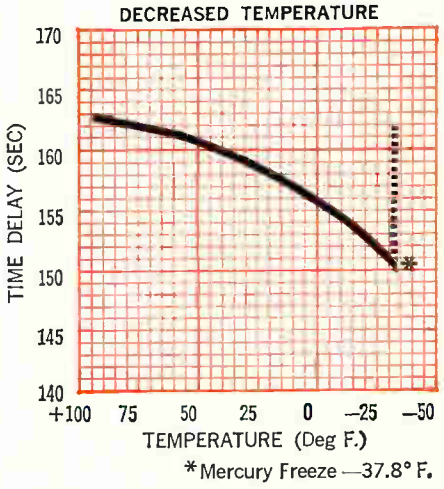
Varying ambient temperatures have little or no effect on Adlake Mercury Displacement Time Delay relays. From the graphic illustrations, ambient temperatures up to 200° F or down to —37.8° F (freezing point of mercury), the change in timing is less than 10%.

Adlake relays have been subjected to temperatures well below —37.8° F for extended periods. Upon raising the temperature to a point above the freezing point of mercury, the relay will again become operative. The relay will not suffer any damage as a result of the extended exposure to low temperature. This portrays the ruggedness of Adlake Relays due to their simplicity of design.

Mercury Displacement Relays — Temperature vs. Time Delay



Effect of increased temperature on time delay characteristics. Curve is typical for a normally open, slow-make relay having nominal time delay of 1.25 seconds.



Effect of decreased temperature on time delay characteristics. Curve is typical for a normally open, slow make relay having nominal delay of 160 sec.

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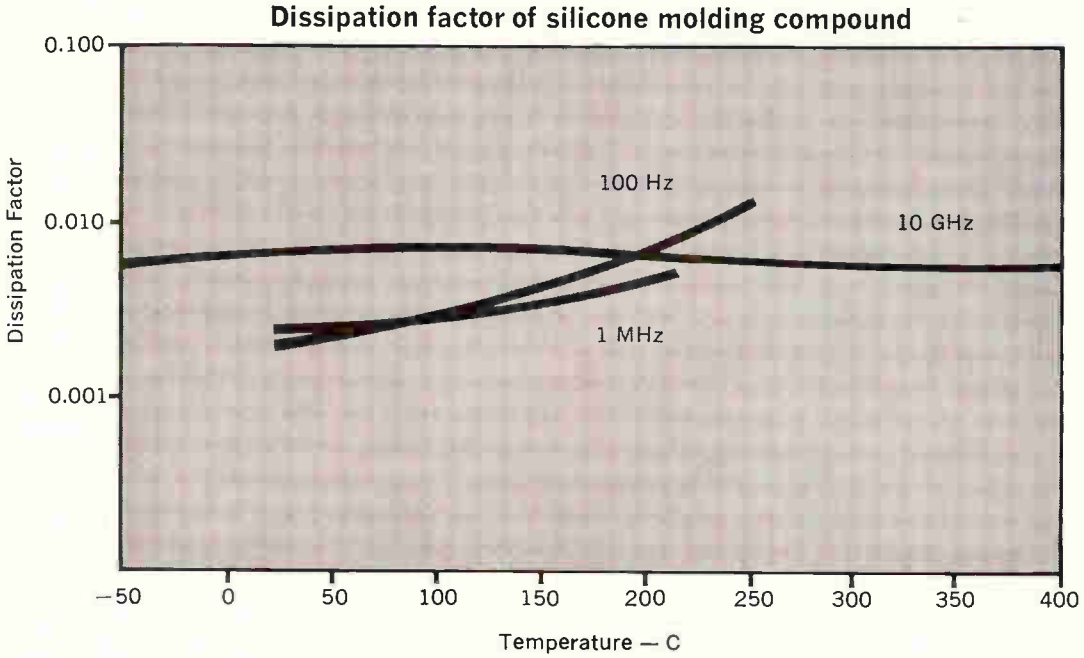
Why the **big** swing to silicone molded devices?



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.

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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. 3721, Electronic Materials Division, Dow Corning Corporation, Midland, Michigan 48640.

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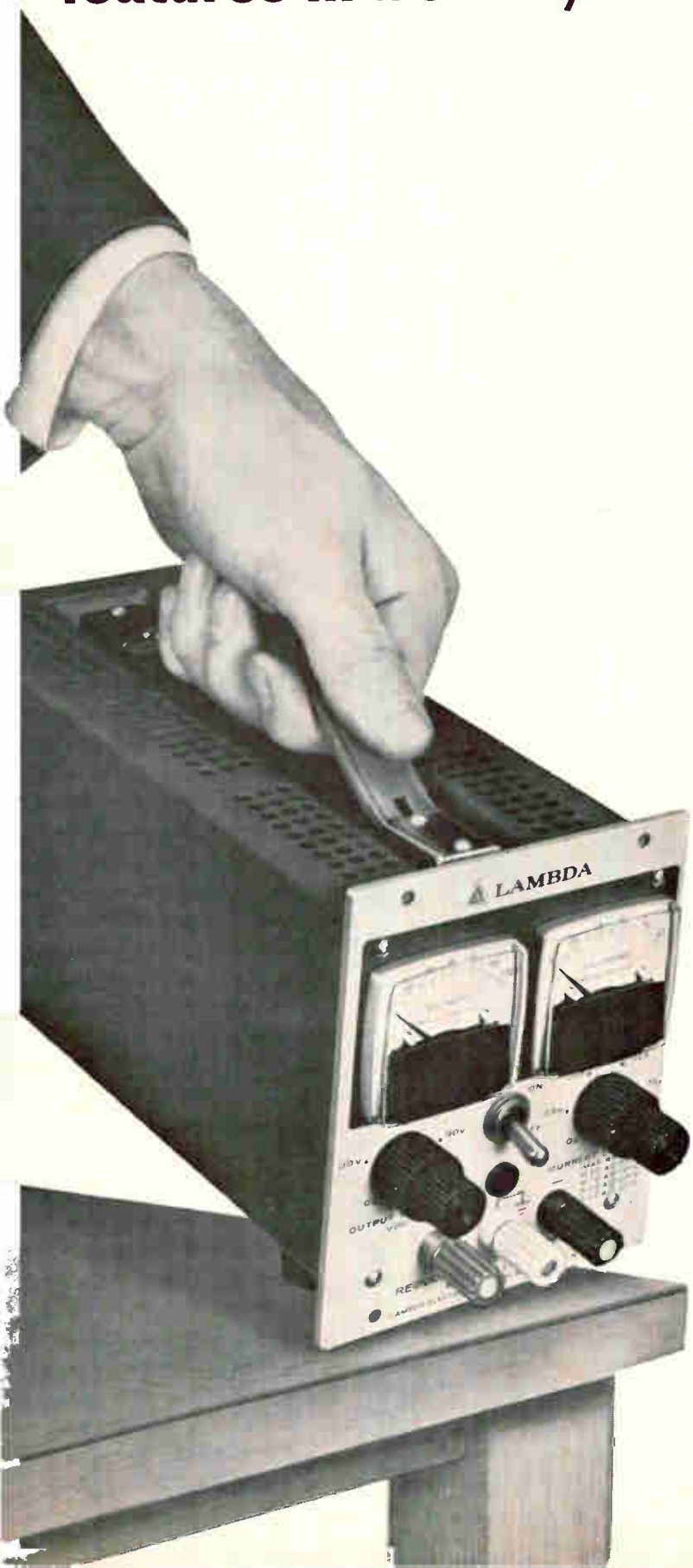

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- Both coarse and fine adjustment of voltage and current.
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LP 413	0-60 VDC*	0.45A	0.41A	0.37A	0.33A	129
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Circle 87 on reader service card

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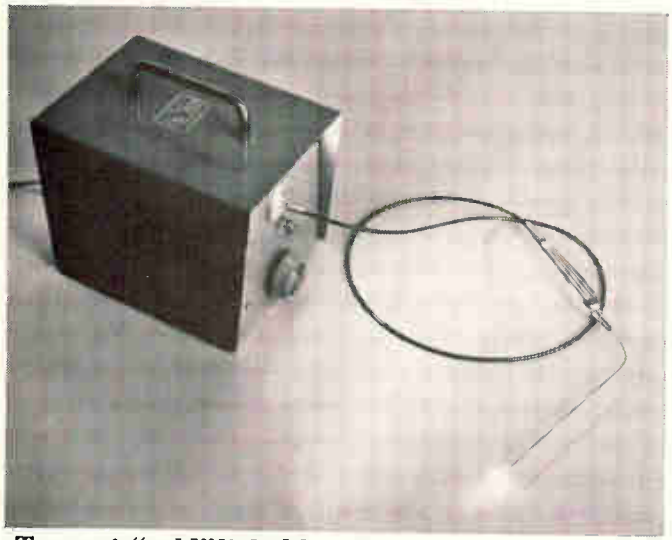

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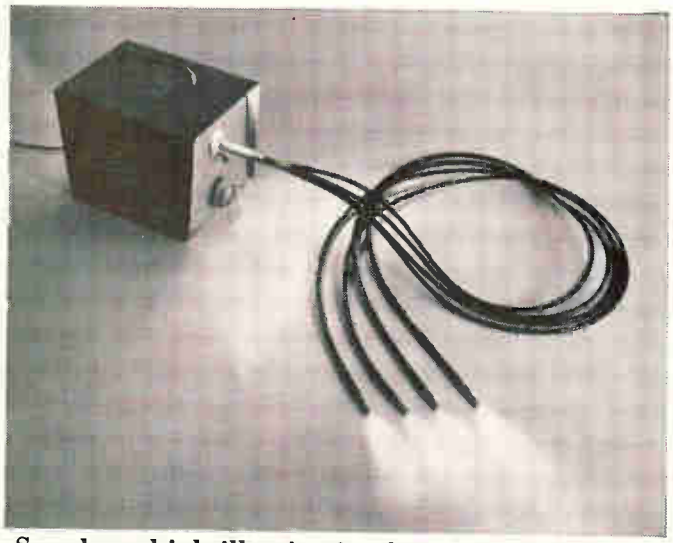

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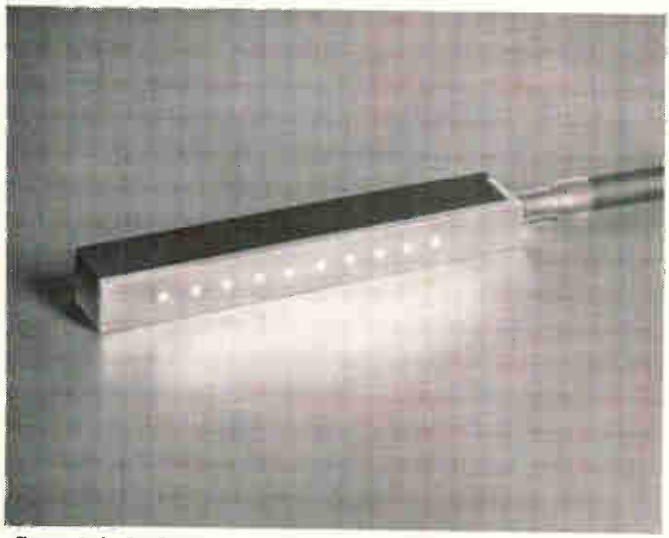

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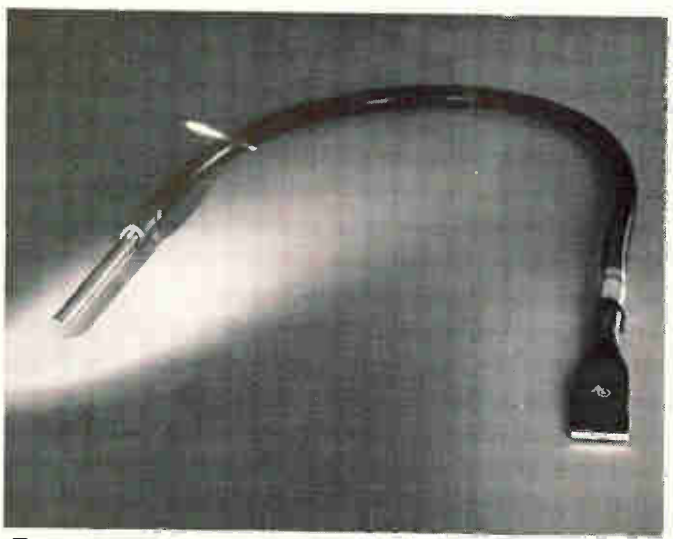

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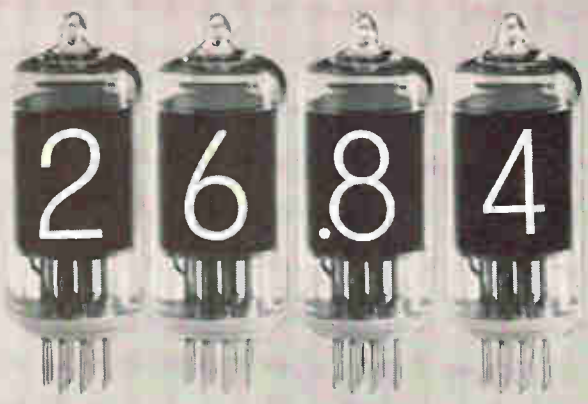

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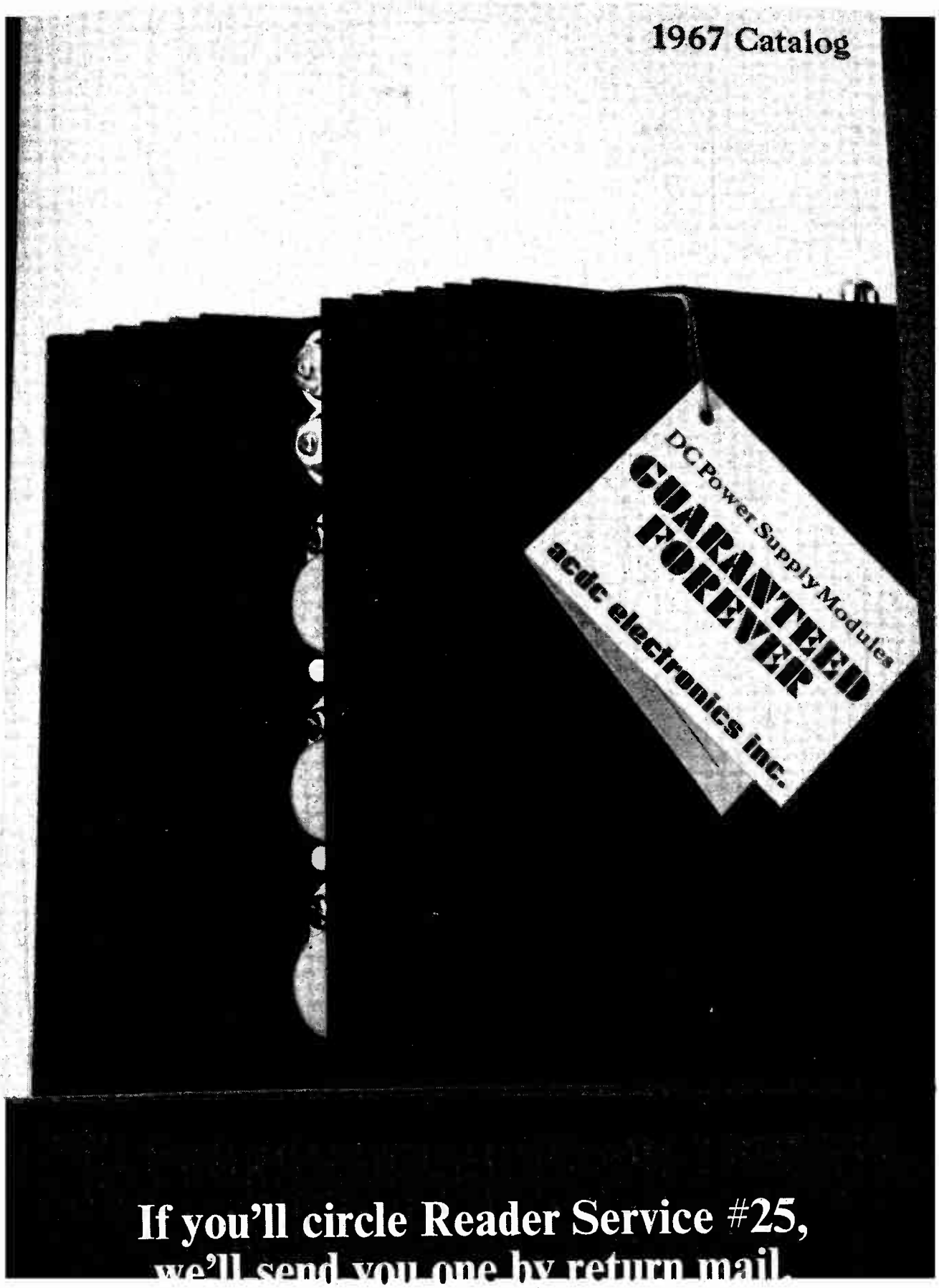

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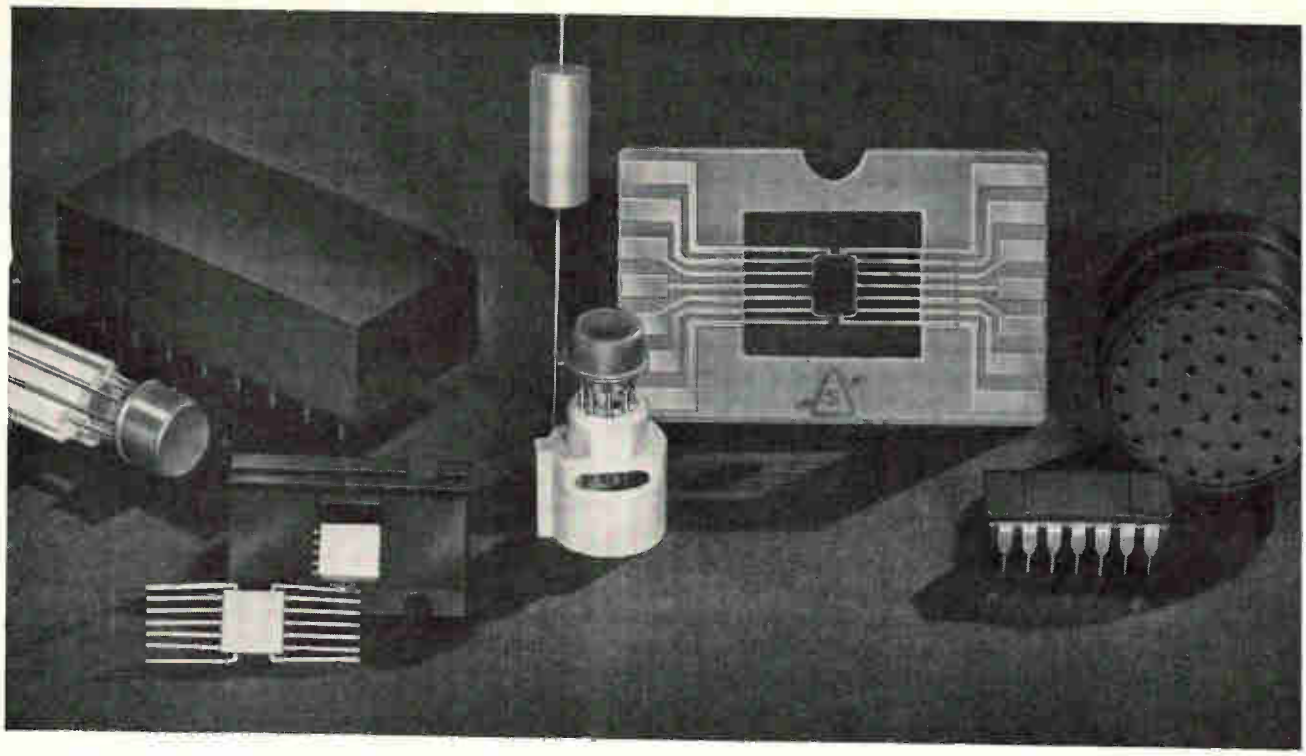

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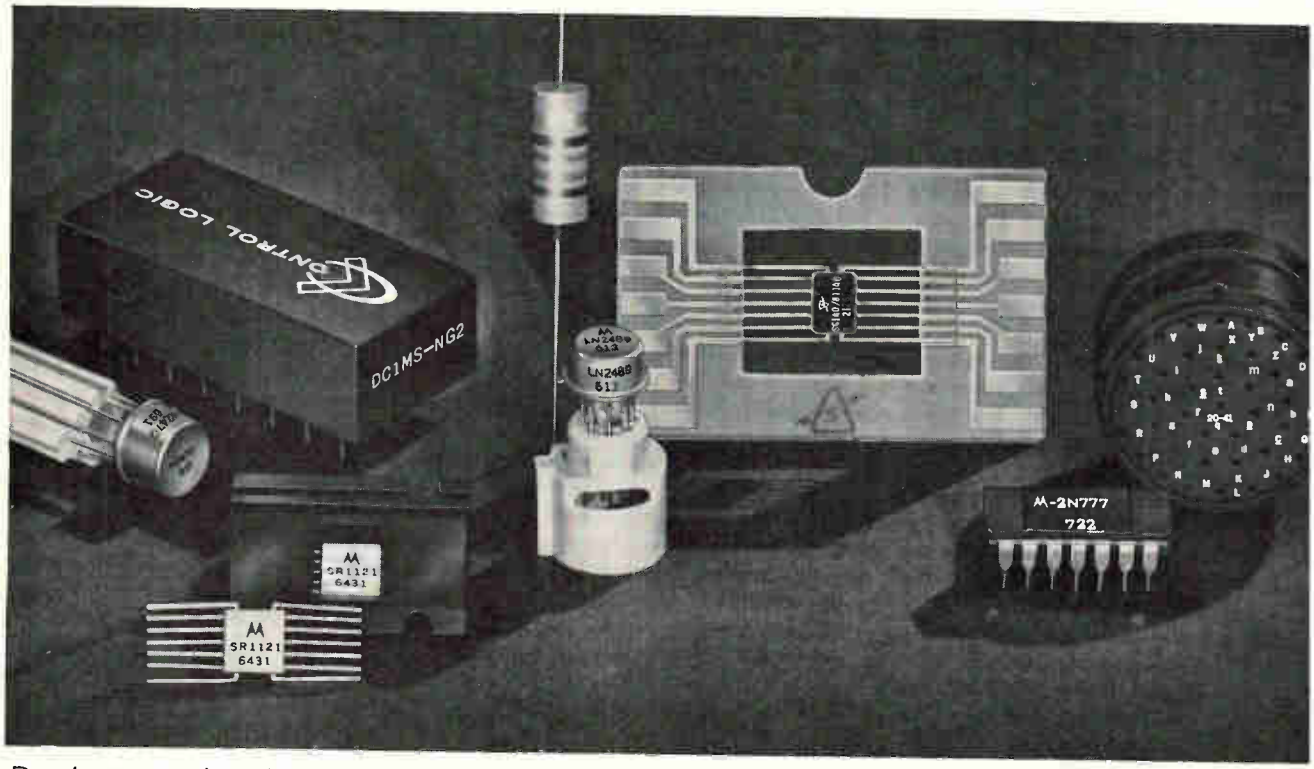

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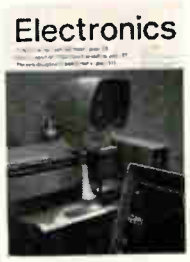
Technical Articles

Linear IC's: part 3 Differential amplifiers at work
page 96

The differential amplifier is one of the most versatile components electronics engineers have, and happily, it lends itself to easy fabrication by integrated techniques. Once in integrated form, it finds new applications that range from narrow band to video.

Integrated circuits in action: Cutting costs on the factory floor
page 114



The user of integrated circuits often doesn't care what family of circuitry he uses as long as it does the required job. So the designers of a coordinate-measuring machine that inspects machined parts used both diode-transistor logic and transistor-transistor logic in an amiable mixture: low cost DTL gates drive high performance TTL flip-flops. The resulting product, which replaces one built of discrete semiconductors, is a shining example of what integrated electronics can do to an industrial machine: the new unit weighs one-sixth as much as one made of discrete units and costs only half. Yet its performance is as good or better than its predecessor. The cover photograph shows the new small-sized inspector at work.

Weaving a braided memory that's fast and inexpensive
page 121

A new technique that reduces parasitic capacitance makes the braid memory even more attractive because it boosts cycle times to as fast as 300 nanoseconds. In addition, specially designed looms can now weave the memories efficiently. The combination converts the braid memory developed at Massachusetts Institute of Technology [May 1, p. 88] into a practical commercial device.

Problems of heat removal chill progress in IC's
page 129

All too often after a design has weathered the tests of logic, electrical function, and costs, it fails the environment test mainly because of its inability to withstand temperatures in a system environment. This happens because too many designers don't understand the intricacies of thermal management. Integrated electronics make great space reductions possible and the temptation is to squeeze the system into as small a space as possible. But under such conditions traditional methods of cooling fail to perform as expected and trouble results.

Coming October 2

- **Microwave stripline for IC's**
- **Using K-trees for theoretical design**
- **A digital-data modem**

Linear IC's: part 3 Differential amplifiers at work

With some juggling of components and connections, the basic differential-amplifier configuration serves in linear circuits for operations ranging from narrowband up to video

By J. P. Keller

RCA Electronic Components & Devices Division, Somerville, N.J.

When you talk about linear integrated circuits, you focus on their primary building block: the differential amplifier. The versatility and signal-processing advantages afforded by this configuration account for its popularity, and differential stages are found in nearly all linear IC's, from simple audio amplifiers to multifunction, high-frequency communications networks.

The circuit can perform linear and complex functions from d-c to 300 megahertz; it amplifies, mixes, detects, limits, modulates, compares, and controls.

Its frequency response can be tailored to the processing of narrow pulses or broad signals. The choice of load components, such as tank circuits or resistors, peaks or flattens the gain characteristic over selected frequency ranges.

A primary function of the differential amplifier is the amplification of differential-mode input voltages and the suppression of interfering common-mode input signals. In the differential mode, two unlike signals applied to the double-ended input result in an output proportional to their difference; in common mode, like signals result in a negligible output. In practical terms, the circuit selects, compares, and amplifies low-level signals in noisy environments.

The amplifier consists of two symmetrically arranged half-circuits, and a balance exists to the degree that these halves match. Balance thus reflects how alike the transistors are, and how alike they remain through environmental changes. This matching in linear IC's is an order of magnitude closer than the best match possible with discrete components.

Balance is enhanced by the arrangement of the output; each half-circuit response can be summed at the output in such a way that unwanted changes (such as increased leakage) offset one another, and desirable changes (higher gain with rising temperatures, for instance) complement each other.

The circuit provides excellent electrical tracking, maintaining balance in the face of changes in signal levels and temperature. It also provides uniform linearity in the reproduction of input signals, and can compensate for such changes as temperature variations and power supply shifts.

The amplifier features d-c coupling and avoids the use of large resistors. Capacitive elements aren't needed on the chip, and biasing and coupling are generally simplified.

The author

Jean P. Keller is a specialist in linear integrated-circuit design and application at RCA's Somerville, N. J., facilities. As a member of EIA's committee for standardizing microelectronic devices, he helps generate formats for active analog circuits.

By any other name

There are many designations for the sundry linear IC's that employ differential configurations [Electronics, Aug. 21, p. 76], but most of the circuits can be categorized, arbitrarily, as either video or narrowband amplifiers. A video-type differential amplifier has a flat gain-versus-frequency response extending from d-c well into the very-high-frequency region. Narrowband units exhibit a bell-

shaped gain response that rapidly converges to cover a very narrow frequency spectrum—typically a megahertz or less.

The two categories embrace all major IC differential-amplifier types—wideband, pulse, r-f, and ordinary comparator circuits. The video amplifier is characterized by diffused resistors in the collector leg, the narrowband by collectors that are uncommitted and available for external connection.

Though the video and narrowband types include units at opposite ends of the linear IC scale, they aren't antithetical. Either form can be converted into the other by the rearrangement or addition of external components.

This duality stems in part from common monolithic fabrication. The video is really a more complex version of the narrowband type. Passive components determine the gain-vs-frequency response; resistive elements provide a flat response, and capacitive elements introduce frequency breakpoints that narrow the response.

A narrowband amplifier can be converted to a video amplifier by the simple addition of external collector resistors. Conversely, capacitive coupling of a video amplifier converts it to a narrowband amplifier. Also, a video-type amplifier with high input and output impedances is suitable for use in parallel tuned-input and tuned-output applications, jobs for a special class of narrowband amplifiers.

Both circuits typically offer single-ended and double-ended output connections. In single-ended or push-push operation, the output is taken from one collector; in double-ended or push-pull operation, it is taken from two collectors. The single-ended mode eases interfacing but has a higher net feedback capacitive element. In double-ended operation, the capacitive effect is reduced, isolation is higher, and the frequency response is a little wider. Although harder to interface with, the double-ended mode doesn't require a bypass capacitor for coupling to another circuit, whereas single-ended operation does.

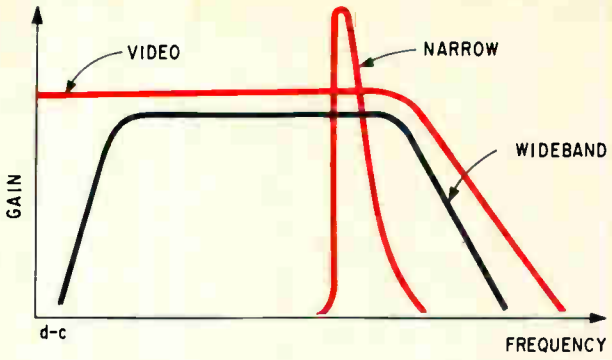
On a pedestal

An ideal differential amplifier would have these characteristics:

- Zero output with zero input (zero offset)
- A gain constant with temperature and time, and independent of input level (zero drift)
- An output that is an exact amplified reproduction of the input
- An infinite bandwidth
- Perfect balance

Among the real-life limitations that thwart the attainment of this ideal, the most common is drift. Besides reflecting changes in gain with temperature and time, drift can be viewed as an over-all performance index indicating circuit capabilities and imbalances.

Drift is largely due to changes in the transistor elements' parameters, mainly $\partial V_{BE}/\partial t$ and $\partial h_{FE}/\partial t$. Here V_{BE} is the d-c base-to-emitter voltage, h_{FE} the d-c gain, and t the temperature. In differential amplifiers built in IC form, the problem of drift is mitigated by the fact that parameters change with temperature in a uniform and predictable manner. With discrete-component designs, an extremely good match is difficult to get, and users invariably pay a premium price for matched elements. With integrated circuits, a close match between the transistor pairs on a common substrate is intrinsic.



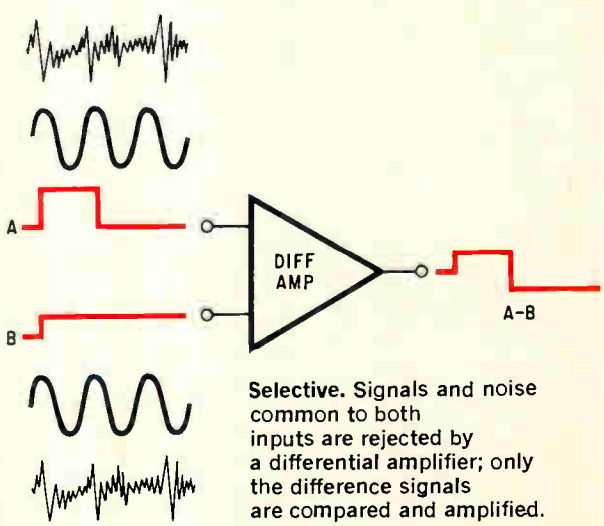
Delineation. Gain-versus-frequency characteristic of differential amplifiers is used to distinguish major types.

The basic circuit at the bottom of page 98 can be used to develop equations governing the d-c and small-signal behavior of a video-type differential amplifier. Observe that emitter resistors R_{1a} and R_{1b} are both zero. The expressions for the collector currents, I_{ca} and I_{cb}, are:

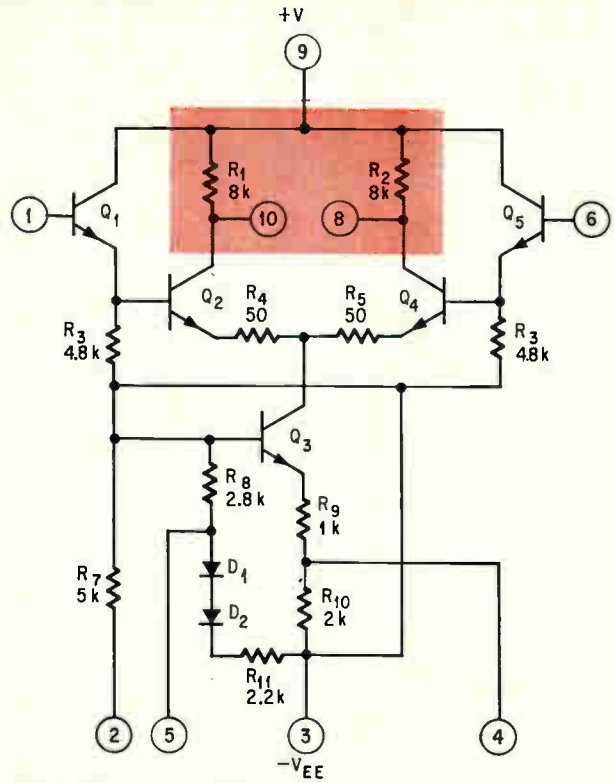
$$I_{ca} = \alpha_{1a}\, I_o/(1 + e^{\frac{V_{1a}-V_{1b}}{h}})$$

$$I_{cb} = \alpha_{1b}\, I_o/(1 + e^{\frac{V_{1a}-V_{1b}}{h}})$$

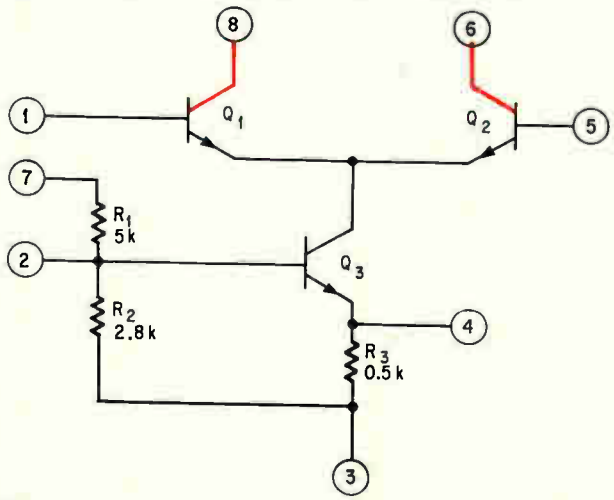
Here, $h = KT/q = 26$ millivolts at 25°C, and α is the emitter-to-collector current transfer ratio; base resistance r_{bb} and emitter contact resistance r_{ec} are neglected. Alpha is used instead of the more familiar beta (h_{FE}) to simplify the expressions. When $V_{1a} = V_{1b}$ and $\alpha_{1a} = \alpha_{1b}$, then $I_{ca} = I_{cb}$;



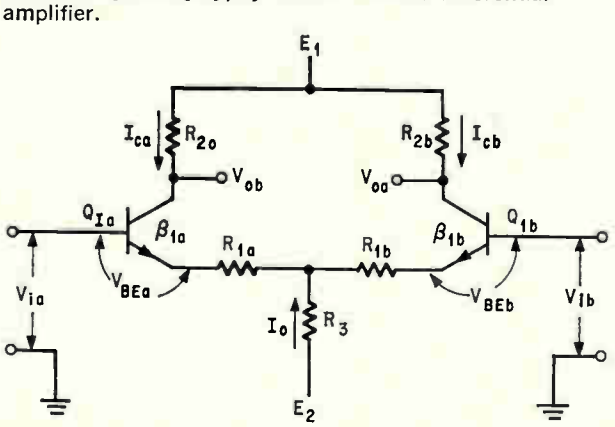
Selective. Signals and noise common to both inputs are rejected by a differential amplifier; only the difference signals are compared and amplified.



Video. Presence of diffused resistors, R_1 and R_2, in collector legs of the amplifier marks video-type IC.



Narrowband. Uncommitted collectors of transistor elements Q_1 and Q_2 typify the narrowband differential amplifier.



Building block. Differential amplifier provides linear IC's with balance (symmetry) and application versatility.

the differential transistors are balanced, and half the total current I_o flows through each transistor. This condition represents the quiescent operating point for a linear differential amplifier.

When $V_{1a} \neq V_{1b}$, the differential-amplifier input voltage is defined as $V_{1a} - V_{1b} = V_{BEa} - V_{BEb}$. When V_{1a} is made more positive than V_{1b}, I_{ca} increases and I_{cb} decreases until $V_{1a} - V_{BEa} = V_{1b} - V_{BEb}$. This is called the threshold condition.

At this point, the current through Q_{1a} is at a maximum ($I_{ca} \approx I_o$) and Q_{1b} is off. When V_{1b} is made more positive than V_{1a}, the process reverses. Maximum current then flows through Q_{1b}, and Q_{1a} is cut off. These characteristics, shown on page 99, give the amplifier its application flexibility.

On the slopes

The transfer characteristics are linear on both sides of the operating point. At room temperature, this linear region corresponds to an input-voltage swing of approximately 50 mv peak to peak. The maximum slope of the curves occurs at the operating point and defines the effective transconductance of the differential amplifier.

The slope at any other point depends on the value of the total current, I_o, supplied by the constant-current sink. The slope of the transfer curves can be changed without altering the linear region by varying the value of I_o, implying that automatic gain control is inherent in the differential amplifier when I_o is controlled.

The transfer characteristics and the slopes are also functions of the gain (beta) of the transistors, of temperature, and of two physical constants, q and K; q is the electron charge and K is Boltzmann's constant. Since gain and temperature variations are predictable, so is circuit performance in various applications.

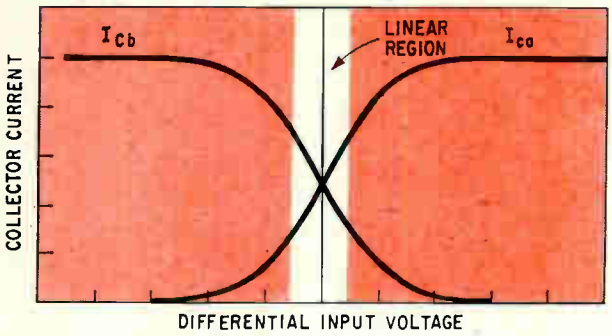
The differential amplifier is a natural limiter; when input excursions exceed $\pm 4KT/q$ (approximately ± 100 mv in the model), no further output rise occurs.

The output current of any amplifier is the product of the input voltage and the transconductance. In the differential amplifier, the transconductance is proportional to the controllable current I_o. If I_o is simply made a multiplicand and the input waveform a multiplier, the circuit can be used for mixing, frequency multiplication, modulation, or product detection.

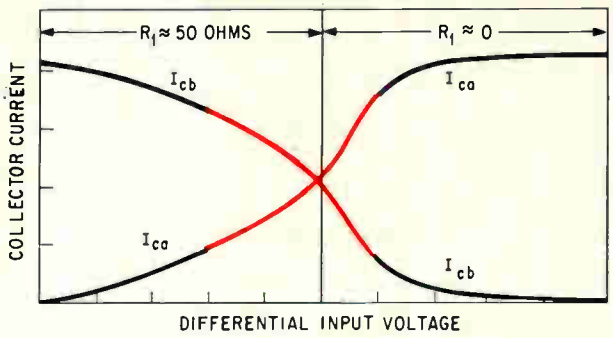
Also, because half the input voltage and half the source current I_o are present in each transistor of the differential pair at the operating point, the effective transconductance value of the amplifier is one-fourth that of a single transistor for a given value of I_o, and the circuit gain, consequently, is also less.

In the double-ended differential amplifier, the load is placed between the two collectors and the output voltage is measured between them. The output voltage, therefore, is twice that obtainable with single-ended operation.

Since the dynamic range of the input is limited,



Transfer. Linear region of differential-amplifier transfer characteristic is 114 millivolts wide; as input signals exceed that range, limiting action comes into play.



Shaping. Emitter degeneration, introduced by placing a resistor component in the emitter circuit, alters the shape of the transfer characteristic and the linear range.

it is sometimes desirable to increase the linearity range of the transconductance parameter before limiting occurs. This can be achieved by emitter degeneration—making R_{la} and R_{lb} the same finite value. These emitter resistors reduce the transconductance and, hence, the gain, but further linearize both the transfer characteristic and the transconductance. Typical results when employing emitter resistors are shown above at the right.

Separating the modes

In both double-ended and single-ended amplifiers, the differential-mode (DM) signal is out of phase at the two inputs, and the common-mode (CM) signal is in phase between the two amplifier input terminals and ground.

When a DM signal is applied, the voltage at one terminal increases and the voltage at the other decreases by an equal amount. If the transistors are operated in the linear region, the collector current of one transistor increases while that of the other transistor decreases; the changes are offset at the common emitters.

When a CM signal is applied, the voltage at both input terminals increases and both collector currents rise. These currents are then additive, a negative feedback is developed across the common-emitter resistor, and the CM gain is substantially reduced.

Because DM and CM signals can be present simultaneously, differential output is more difficult to analyze than, for example, the output of a single-ended cascade amplifier. Taking into account unavoidable imbalances in the circuit symmetry (for example, resistor ratios other than unity, and h_{FE} and V_{BE} differences), unwanted DM outputs may result from a CM input. Additional gain relationships must be defined to reflect this limitation:

$$A_{cd} = \frac{V_o(CM)}{V_i(DM)} = \text{DM-to-CM transfer gain}$$

$$A_{dc} = \frac{V_o\,(DM)}{V_i\,(CM)} = \text{CM-to-DM transfer gain}$$

Subscripts o and i refer to output and input signals, respectively; A is a gain term.

As the DM output signal alone is desired, the A_{dc} factor should be minimized. A performance parameter, the common-mode rejection factor, CMR, can be defined as the ratio of the CM input voltage to the DM input voltage that produces the same DM output voltage. Mathematically, the common-mode-rejection ratio, CMR, equals A_{dd}/A_{dc}, where A_{dd} is the differential-mode gain.

Predictions of the circuit's behavior can be made in this fashion:

- For analysis, the network is split into two equivalent half-circuits;
- Circuit imbalances are accounted for by adding interaction generators, resulting in two additional half-circuits;
- Sets of equations are derived through the analysis of these four half-circuits.

Typical results of such a procedure are shown on page 100. These relationships express balanced and unbalanced differential-amplifier performance, and can aid in systems design.

Characterization in toto

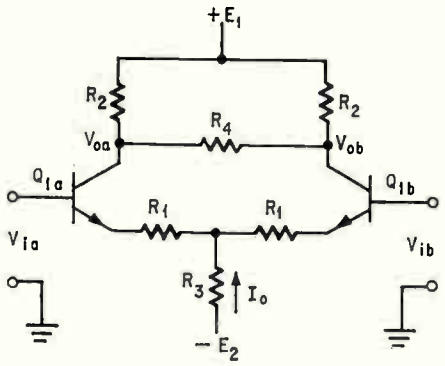
In a discrete amplifier, circuit behavior is predicted by characterizing individual components with respect to changes in temperature and frequency. To do this with an integrated circuit, however, would require the employment of techniques used to study distributed elements, such as transmission lines, assuming that their values as discrete components could be measured or calculated.

To get around this problem, the integrated-circuit amplifier is characterized by its total external effect rather than by the magnitude of its individual components. Usuing y or s parameters, circuit behavior can be completely and accurately determined; the measurement includes both desired and parasitic elements within the circuit.

Unfortunately, these parameters are a function of the amplifier connection. For example, the y parameters for the basic differential-amplifier configuration differ from the y parameters for the same IC connected in cascade. Power gain, noise figure, and automatic gain control (agc) characteristics are also functions of the application, and supply voltage as well. However, it's rarely necessary to build specialized circuits to measure the latter

Governing equations: a matter of balance

The performance of the differential amplifier configuration reflects the degree of balance between each half-circuit. Below are the relationships governing over-all circuit performance in cases of perfect match and of imbalance. The δ term indicates a small imbalance in a particular parameter; SE and DE refer to single-ended and doube-ended operation, respectively.



1. Collector current, I_o (R4 = ∞):

$$I_o = \alpha I_o/[1 + e^{\frac{q}{KT}(V_{1a}-V_{1b})}]$$

2. Transconductance, g_m:

$$g_{m(SE)} = q\alpha I_o/4KT \quad (R_1 = 0,\ R4 = \infty)$$
$$g_{m(DE)} = q\alpha I_o/2KT$$
$$g_{m^1(SE)} = g_{m(SE)}/[1 + 2R_1 g_{m(S.E.)}] \quad (R_1 \neq 0,\ R4 = \infty)$$

3. Common-mode gain, A_{cc}:

$$A_{cc} = \alpha_1 R_2/(R_1 + 2R_3)$$

4. Differential-mode gain, A_{dd}:

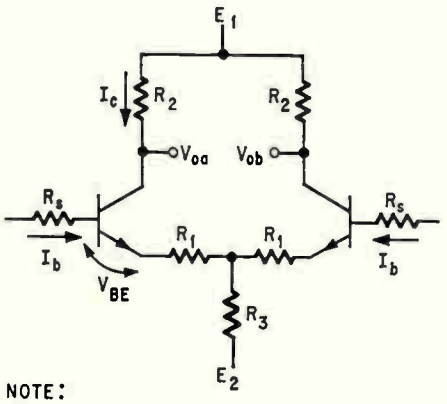
$$A_{dd} = \alpha R_2 R_4/2R_1(R_2 + 0.5R_4)$$

5. Common-mode input impedance, Y_{cc}:

$$1/Y_{cc} = (\beta_1 + 1)\,(R_1 + 2R_3)$$

6. Differential-mode input impedance, Y_{dd}:

$$1/Y_{dd} = (\beta_1 + 1)R_1$$



NOTE:
R_1 INCLUDES EMITTER CONTACT AND BULK RESISTANCE, r_{ec};
R_s INCLUDES BASE SPREADING RESISTANCE, r_b'.

7. Differential-mode rejection factor, DMR:

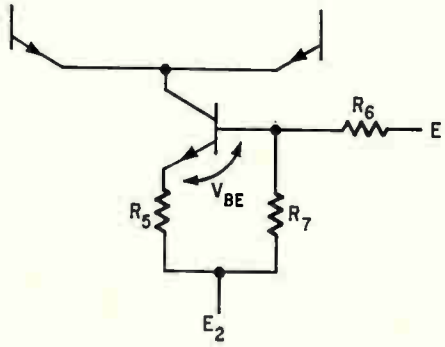
$$\frac{1}{DMR} = \left(-\frac{\delta R_1}{R_1}\right) + \left(\frac{R_1+2R_3}{R_1}\right)\left[\frac{R_4}{2\alpha_1(R_2 + 0.5R_4)} + \frac{\delta R_2}{R_2} + \frac{\delta\beta_2}{\beta_1(1+\beta_2)}\right]$$

8. Common-mode rejection factor, CMR:

$$\frac{1}{CMR} = \frac{R_1}{R_1 + 2R_3}\left[\frac{\delta R_2}{R_2} - \frac{\delta R_1}{R_1} + \frac{\delta\beta_1}{\beta_1(1+\beta_1)}\right]$$

9. Input voltage imbalances, ΔV_o:

$$V_{oa} - V_{ob} = \frac{R_s R_2 I_c}{(\beta_1 + 1)}\left[-\frac{\delta I_b}{I_b} - \frac{\delta R_s}{R_s}\right] + \alpha_1 R_1 R_2 \delta V_{BE} + I_c R_1 R_2\left[\frac{\delta R_2}{R_2} + \frac{\delta a_1}{\alpha_1} + \frac{\delta R_1}{R_1}\right]$$



10. Constant current source, I_o:

$$I_o = \frac{R_6}{(R_6 + R_7)}\,[R_7(E - E_2) - V_{BE}(R_6 + R_7)]$$

two factors; the relationships are depicted on data sheet curves.

Equations 1 through 6 in the panel on page 100 are applicable to balanced conditions, and equations 7 through 9 show the effect of small imbalances in a given parameter. For example, equation 9 indicates the effect of imbalances in I_b, R_s, V_{BE}, R_2, β, and R_1, especially on the collector operating point. Changes in the offset current will be most pronounced with a high source resistance, R_s, for instance. The effect is lessened if a high-current-gain (h_{FE}) transistor is used or if low-collector-current (I_c) operation prevails. Similarly, imbalances in R_1, R_2, h_{FE}, and V_{BE} must be minimized if high common-mode rejection is the goal.

Another factor relating to improved common-mode rejection is the common-emitter resistor, R_3. The performance of the system would be enhanced by making R_3 as large as possible, but the resistor's value is limited by the magnitude of the supply voltage, E_2. Nevertheless, the effective resistance can be increased without boosting E_2 by replacing R_3 with a constant current source—a current sink. This procedure, shown on top of page 102, presents a d-c resistance equal to R_3, but a finite a-c impedance many times its d-c value. The a-c-to-d-c impedance ratio of R_3 can be further increased by negative feedback of the CM component; common-mode rejection as high as 140 decibels has been realized with this technique.

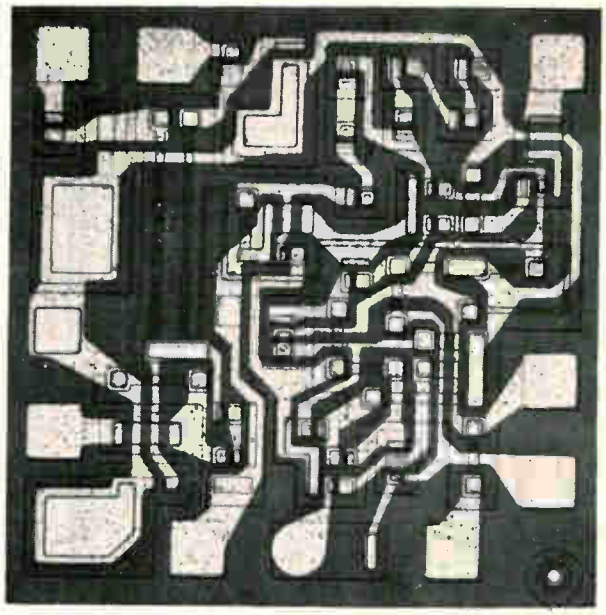
Use of a current sink offers other advantages. For one thing, modification of the current in the sink can yield automatic gain control, or squelch. Since I_o is not only a function of the resistors but also of E—the potential at which the divider is returned—a change in E will change I_o.

Also, the current sink compensates for changes in temperature-sensitive parameter values—mainly V_{BE} and h_{FE} drifts—if nonlinear forward-biased diodes are used in the current-sink biasing network. Good over-all temperature tracking of differential-amplifier gain is a result.

Because the collector impedance of the constant-current source, Q_3, is high, the a-c signal is delivered to the emitter of Q_{1b} from Q_{1a} because the impedance looking into the emitter of Q_{1b} is low.

The differential amplifier in this case operates as a common-collector stage driving a common-base stage, a configuration that holds certain advantages. The reverse and forward transconductance and the input admittance are lower than those of a single transistor, and the output admittance is higher. In terms of frequency response, the presence of the collector capacitance, C_c, produces a major corner (frequency breakpoint) where the reactance magnitude equals that of the resistive component. This capacitance limits the upper frequency response in double-ended configurations, but can be ignored in single-ended modes.

Also, good isolation exists between input and output in single-ended operation, resulting in a higher 3-db point, and the upper frequency is limited only by the collector-to-substrate capacitance, the input capacitance, and the distributed capacitance of the resistors. These capacitances are lumped together in the IC, so designers can deal with a simple over-all effect.

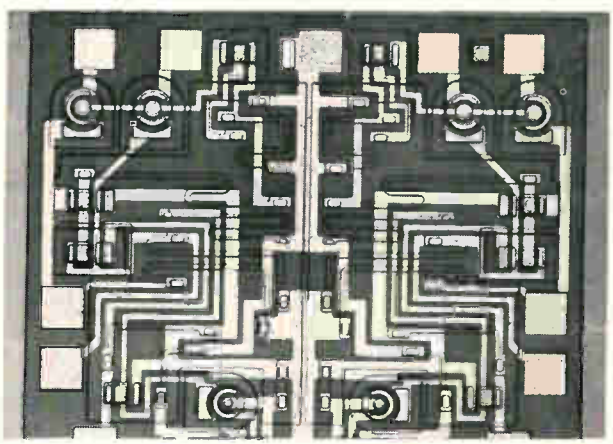


Backbone. Operational amplifiers, biggest sellers among linear IC's, typically employ two or three differential amplifier stages.

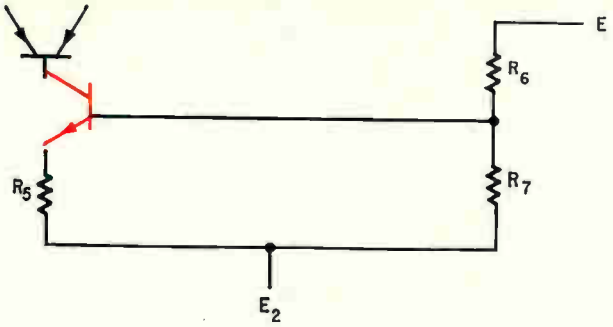
Applications in video

A typical video-type amplifier application—a wideband, RC-coupled feedback amplifier—demonstrates the systems-oriented role differential stages can play. The IC used, the Radio Corp. of America's CA3000, is a multi-stage differential amplifier preceded by input emitter-followers and controlled by a constant-current source. This IC has a push-pull input and output capacity, a minimum input impedance of 70 kilohms, and a low-frequency output voltage swing of more than 10 volts.

Operation from either one or two power supplies is optional. The magnitude of the supplies and the biasing of the constant-current source de-



Good match. Two stereo preamplifiers on one chip rely on differential amplifier's thermal match for balance.



Current sink. Use of constant current source in place of large resistor in the common-emitter circuit improves common-mode rejection and simplifies monolithic fabrication.

termine the amplifier's gain, output voltage, output-voltage swing, and power dissipation.

Both single-ended and double-ended modes of operation are available, depending on the pin arrangement. The latter affords higher gain but more restricted access. In single-ended operation the IC has a voltage gain of 31 db, an output voltage operating point of +2.3 volts, a voltage swing of ±3.7 volts about this point, and a total power consumption of 40 mw for supply voltages of +6 and −6 volts.

In the arrangement, shown below, employing a pair of CA3000's, the first is connected as a double-ended differential amplifier and the second in a single-ended configuration. The RC interconnecting networks are used for frequency shaping.

The load consists of the internal diffused resistors plus external resistors R_{12} and R_{13}, all 8 kilohms. The total mid-band, open-loop gain is 62 db.

The amplifier has a corner at 1 Mhz caused by the input stage of the second IC. The addition of a capacitor, C_3, staggers the high-frequency rolloffs of the amplifier and improves stability. This capacitor, in connection with the internal resistors, creates a corner at 200 kilohertz.

The low-frequency rolloff is determined by the interstage coupling; a corner exists at 22 hertz because of the combined effect of one internal resistor plus, R_{12} and C_1. Amplifier gain drops at a rate of 12 db per octave as a result of the 1-Mhz corner. The rate can be cut to 6 db per octave over a portion of the gain range by adding a small resistor in series with C_3.

The amplifier's over-all gain and bandwidth can be changed by feedback from the output of the second stage to the input of the first stage. In the mid-band region, the gain of such a feedback amplifier can be calculated by a single expression involving resistor ratios.

As the gain is decreased, the bandwidth is increased. The gain can be reduced by applying a voltage to the agc terminal located in the first stage.

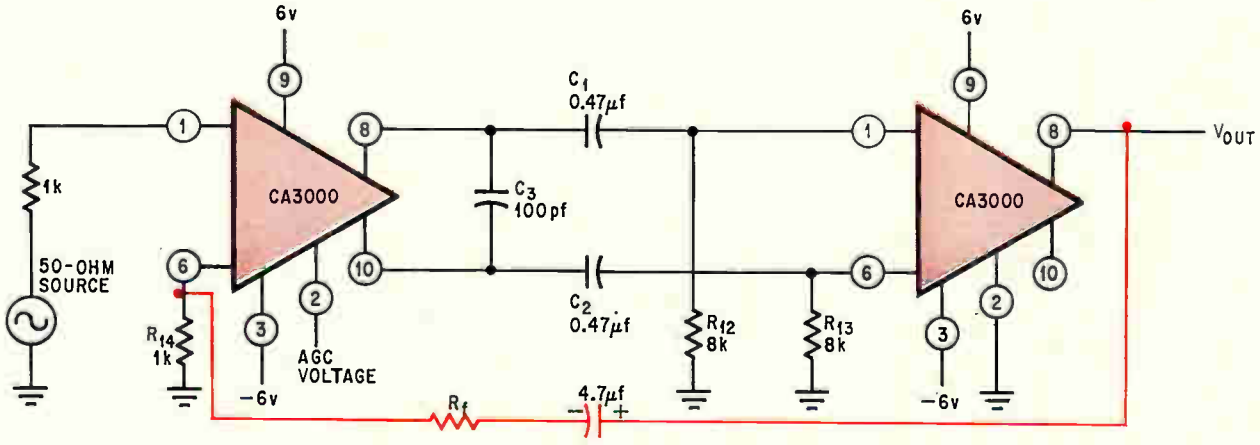
Narrowband operation

The narrowband IC amplifier differs from the video-type amplifier in that its two collectors have no internal load. This permits the use of tuned load circuits in the collectors, and gives the network versatility.

There are many ways the circuit can be connected, as shown on the facing page. Besides amplifying, it can perform gain-control, mixing, oscillating, and conversion functions. In each case, the resistors are determined by the biasing conditions, and the tuned circuits by the desired frequency and bandwidth.

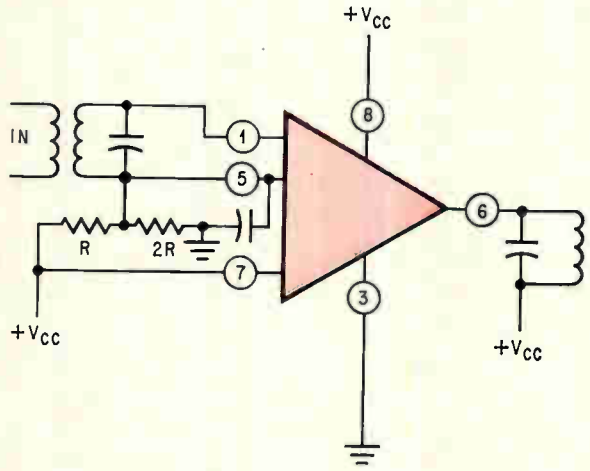
In multistage discrete amplifiers, the feedback influence of load on input and source on output complicate the tuning and aligning process. Because the differential-amplifier and cascode-amplifier configurations in IC form have lower feedback factors, they are suitable for r-f applications without neutralization.

The main problem faced when reducing the gain of any high-frequency amplifier is performance degradation stemming from nonlinearity of the transfer characteristics and from signal-handling limitations. Changes in characteristics appear in the form of cross-modulation—the transfer of modulation from an undesired signal to a desired signal—or intermodulation, the action that produces harmonics of the desired modulation. The use of the cascode connection in recent IC's eliminates

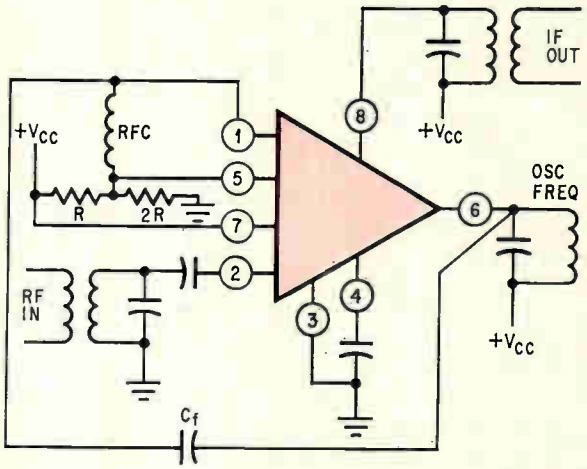


Cascade. Feedback amplifier using two video-type differential amplifying IC's and RC-coupling network. Besides providing 62 db of gain, subsystem has automatic gain control capability.

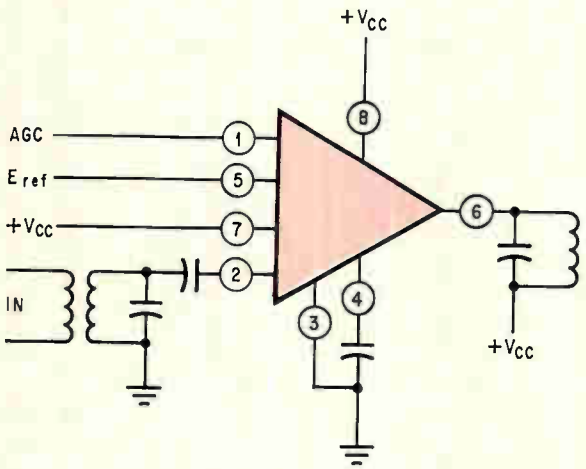
A narrowband amplifier works . . .



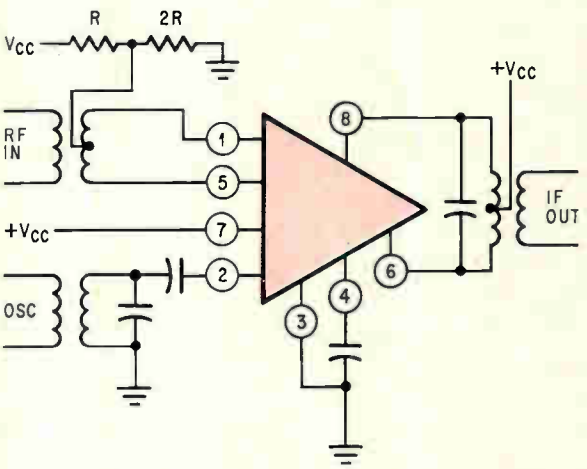
. . . as a balanced amplifier . . .



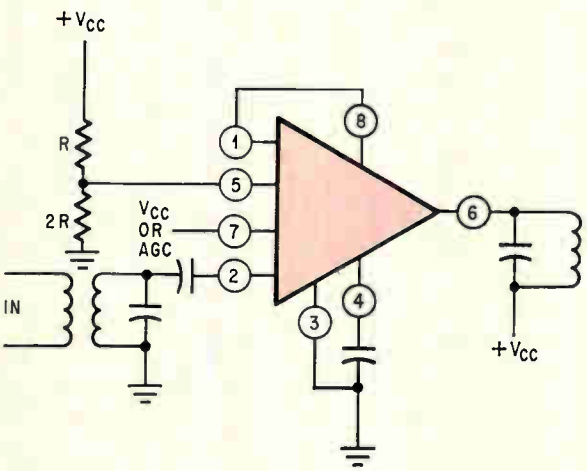
. . . as a converter . . .



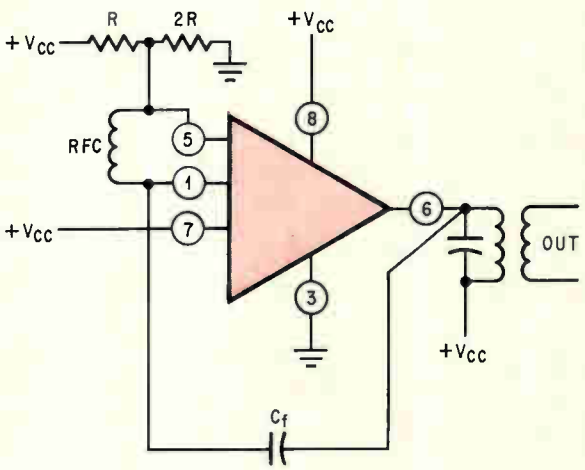
. . . as a cascode amplifier . . .



. . . as a mixer . . .



. . . as an agc circuit . . .



. . . and as an oscillator.

Broad base. The application versatility of the narrowband differential amplifier is largely due to its uncommited collector arrangement. Relatively few changes are required in terms of the lead pins used; designers merely alter the external network connected to the IC to meet various applications. The unit shown here is the CA3020, popularly known as the universal IC.

these difficulties because the current through the input transistor is kept constant throughout the gain-control range.

A typical application for a narrowband differential amplifier is in a medium-gain f-m, i-f strip. Such a network would be used, for example, in a standard receiver with a 10.7-Mhz center frequency and 200-khz bandwidth. The desired voltage output of the tuner is 25 microvolts, with a frequency deviation of ±75 khz, and the level of the recovered audio should be 155 mv at a point 3 db below the knee of the transfer characteristic.

Assuming that audio output required a signal of 2 volts rms across the primary winding of the discriminator transformer, a gain of 98 db is necessary with a 25-μv input voltage. Only two stages of gain would be used.

Coupled by a transformer, two IC's can provide 100 db of gain. To get the same characteristics with a discrete semiconductor design, four or five transistor stages would be needed, along with coupling transformers between each stage.

Tandem

The impedance levels of the RCA CA3028 and CA3012 integrated circuits suit the interface requirements of this arrangement at the input, on both sides of the transformer, and at the load. The 3028 is employed to provide routine differential amplification; the 3012 provides a limiting action as well as i-f gain.

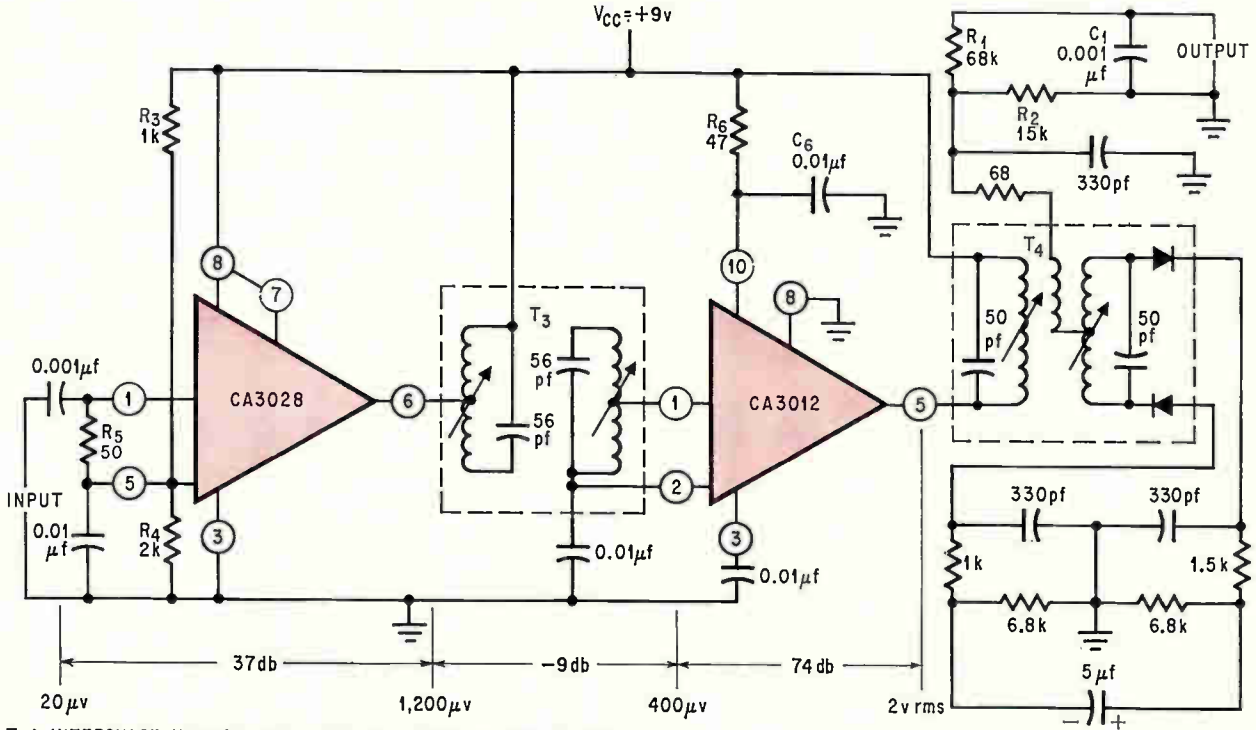
The CA3028 has a typical gain of 39 db with a 3-kilohm load. In the schematic of the proposed amplifier shown below, the networks on the secondary winding of T_4 constitute the standard loading of the ratio detector and provide a symmetrical skirt of the pass-band. R_2 is the detector load, and R_1 and C_1 comprise the de-emphasis network. For minimum distortion, the primary impedance of T_4, R_p, must not exceed the ratio of V_{cc} to I_p. Here, I_p is the maximum current through the T_4 primary, and V_{cc} is the d-c supply voltage. I_p is determined by the nominal load, which is indicated on the CA3012 data sheet curves.

The CA3012 consists of a series of three basic differential amplifiers coupled by emitter-follower stages, a configuration aimed at signal limiting. The supply voltage to each amplifier is controlled internally by voltage regulators formed by two diodes and a transistor.

With the 3-kilohm load of T_4, the voltage amplification is 71 db. For effective limiting with this gain, the CA3012 input voltage should be 400 μv.

Interstage transformer T_3 also reduces the gain of the system. The primary and secondary impedances measured at the taps are 3 kilohm and 1 kilohm, respectively. The insertion loss of T_3, resulting from the transformer itself and the impedance match, is calculated to be 9 db and should be included in the gain calculation.

The voltage gain of the CA3028 is the forward transadmittance, y_{21}, divided by the sum of the output admittance, y_{22}, and the transformer load, y_L.



T_3: INTERSTAGE TRANSFORMER TRW NO. 22486 OR EQUIVALENT
T_4: RATIO DETECTOR TRW NO. 22516 OR EQUIVALENT

I-f strip. Two IC's and associated circuitry are all that's required for a complete 10.7-Mhz intermediate-frequency amplifier strip. The first unit is a simple differential amplifier; the second is a high-gain i-f amplifier with three differential stages.

Key differential-amplifier parameters

Criteria	Application category					
	Comparator	Video	Wideband	Narrowband	Audio	Pulse
Input bias current	*	*	*	*	*	*
Input offset current (for high-impedance source)	*	*	*	*	*	*
Input offset voltage (for low-impedance source)	*	*	*	*	*	*
Input signal level		*	*	*	*	
Common-mode input voltage range	*	*				
Output quiescent point		*		*	*	
Common-mode output voltage	*	*				
Maximum output voltage swing	*	*	*	*	*	*
Single-ended voltage gain (open loop)		*	*	*	*	*
Power gain	*			*	*	
−3-db bandwidth	*	*	*	*	*	*
Distortion		*		*	*	
Common-mode rejection ratio	*	*	*	*	*	*
Single-ended input impedance	*	*	*	*	*	*
Single-ended output impedance	*	*	*	*	*	*
Y- or s-parameters				*		
Noise figure		*	*	*		
Agc range		*	*	*		
Pulse response		*				*
Power dissipation	*	*	*	*	*	*

For this circuit, the voltage gain is calculated to be 37.5 db; input voltage is 15 μv, well within the 25-μv specification originally called for.

As for the other components in the schematic, R_3 and R_4 establish the bias point for one side of the differential amplifier, R_5 balances the other side, and R_6 and C_6 provide the 7.5-volt bias required by the CA3012.

Evaluating parameters

Designing with the four other IC differential-amplifier types—wideband, audio, pulse, and ordinary differential-comparator circuits—usually calls for procedures similar to those used in the general cases of video and narrowband types. However each of the six categories should be treated separately when it comes to evaluating parameters.

Some parameters—input bias current, input offset voltage and current, output voltage swing, impedance levels, and power dissipation—are essential in all six applications. On the other hand, such factors as noise figure, agc range, and distortion are paramount in some applications and unimportant in others.

Pulse response, which reflects rise time, delay time, fall time, and narrowband distortion, is important in video amplifiers as well as in the obvious pulse-amplifying application because video types operate at a d-c level proportional to the pulse input. But wideband applications feature a-c coupling, and the output quiescent point is therefore not a key parameter. Input signal levels are important in all but comparator applications because clipping at the input results in distorted outputs except in that one case.

The table above lists the important parameters for each type of application. Measurement of these parameters requires relatively little in the way of equipment; most of the necessary test gear can be found in the typical laboratory.

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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.

IC operational amplifier makes supply short-circuit proof

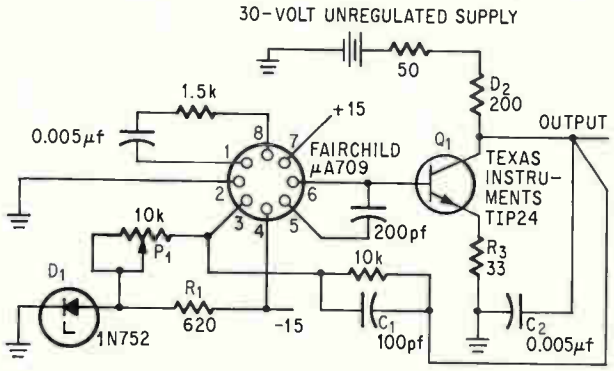
By Robert D. Guyton

Mississippi State University
State College, Miss.

An operational amplifier built with integrated circuits and inserted in a regulated power supply makes the unit short-circuit proof. The supply features variable voltage, low output impedance, low noise, and low a-c ripple. It's inexpensive to build too, with only a few external components.

Power transistor Q_1 is a shunt regulator for the 30-volt supply; its output drives a Fairchild μA709 IC operational amplifier. Zener diode D_1 acts as a voltage reference, and potentiometer P_1 varies the gain of the operational amplifier and, in turn, the output of the power supply through Q_1's base. Capacitors C_1 and C_2, along with IC stabilizing components, prevent low-amplitude, high-frequency oscillations from disturbing the circuit's operation. The +15- and −15-volt sources required by the μA709 are obtained from external low power zeners.

The power supply's output voltage ranges from 6 to 25 volts and is adjusted with P_1. When adjusted for 15 volts, the supply provides load currents from 0 to 60 milliamperes with little change in voltage. Under short-circuit conditions, maximum current is limited to 120 milliamperes.



IC-regulated. Power-supply regulator is built with an IC operational amplifier and a transistor. Output resistance is 0.05 ohms, ripple and noise less than 1 mv.

Resistor R_1 is selected to minimize the power supply's drift, and it controls the current in D_1. It is thus possible to vary the zener temperature characteristic to compensate for the drift of the supply. With an R_1 of 620 ohms, a temperature coefficient of less than 1 millivolt per degree centigrade is achieved.

The design can be modified to yield higher output currents simply by lowering the values of R_2 and R_3 and adding another low-power transistor in a Darlington amplifier arrangement between the IC and Q_1.

FET source follower enhances single-sideband

By Ahti Aintila

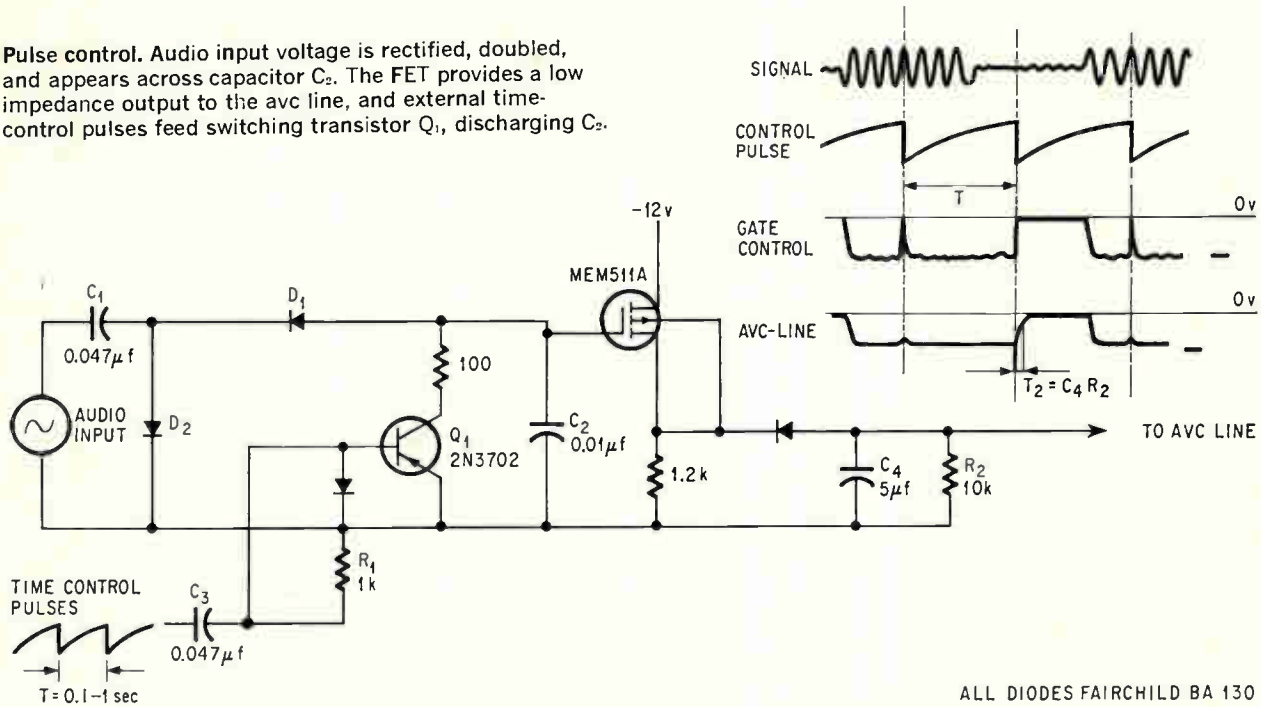
Helsinki, Finland

A field effect transistor in a source-follower configuration gives the fast rise time needed in an automatic volume control for single-sideband reception. The FET enhancement mode of operation provides a threshold action that maintains the receiver's sensitivity to signals buried in the noise.

The demodulated audio signal feeds the voltage doubler, composed of capacitors C_1 and C_2, and diodes D_1 and D_2. The rectified output is developed across C_2, which stores the peak value, and controls the p-channel enhancement mode FET. Then the signal is delivered through a filtering circuit to the avc lines of the receiver.

Time-control pulses that determine the avc's speed are generated in an external unijunction transistor-relaxation oscillator. The optimum repetition frequency depends on the mode of trans-

Pulse control. Audio input voltage is rectified, doubled, and appears across capacitor C_2. The FET provides a low impedance output to the avc line, and external time-control pulses feed switching transistor Q_1, discharging C_2.



ALL DIODES FAIRCHILD BA 130

mission, a-m, ssb, or c-w, and is adjusted accordingly. The pulses are differentiated by R_1 and C_3, and the resulting output spikes turn switching transistor Q_1 on, rapidly discharging C_2. If the received signal is still present, this capacitor quickly recharges. Time constant R_2C_4 is large enough to keep the avc voltage nearly constant during the charge-discharge period. A long time constant is needed to minimize the fluctuation in avc voltage with the received signal. If the signal has disappeared, the control voltage begins to decay exponentially with the next control spike.

Unijunction trigger boosts ignition reliability

By Francis Honey

Denver Research Institute
Denver, Colo.

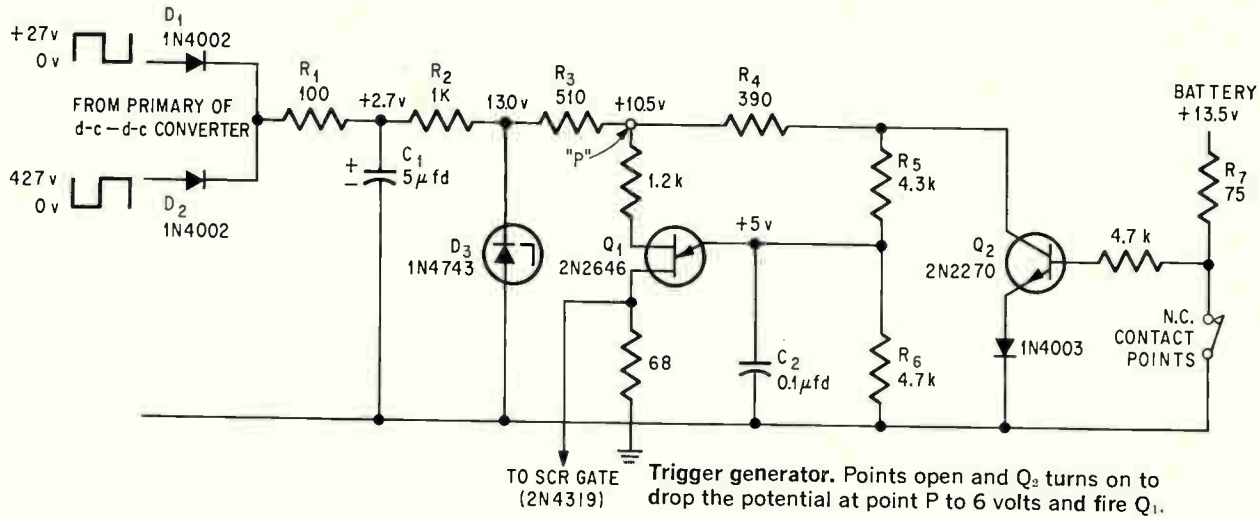
A hot engine or a cold battery in a car can cause intolerable variations in ambient temperature or supply voltage level, which adversely affect the capacitor-discharge ignition system. These difficulties are eliminated by replacing the usual diode-resistor-capacitor triggering network with a unijunction pulse generator.

In most capacitor-discharge ignition systems, a silicon controlled rectifier is the switch that discharges a capacitor into the ignition coil to produce the spark. When the pulses, which trigger the SCR, are generated by a conventional diode-resistor-capacitor network, the pulse quality varies with changes in supply voltage and ambient temperature. The system's reliability is further eroded by the gate sensitivity of the SCR, which also varies with temperature and differs from unit to unit.

The trigger circuit has been incorporated in a special high-energy ignition system designed to meet the stringent requirements of a race-tuned two-cycle engine. During extensive environmental tests, the circuit operated reliably over a temperature range of —30° to +160° Farenheit with simultaneous supply voltage variations of —50 to +30%. The circuit's dependability is largely due to the temperature stability of the unijunction transistor that generates the triggering pulses.

The entire ignition system, which costs less than $50, has been installed on production sports cars. Some of the cars that ordinarily need a tune-up every 5,000 miles have been driven over 30,000 miles without noticeable deterioration in performance when equipped with the new ignition system. Some race cars that previously required several plug changes during a six-hour race have completed an entire season with one set of spark plugs.

In the circuit, the 27-volt supply is obtained from the primary winding of a d-c to d-c converter,



Trigger generator. Points open and Q_2 turns on to drop the potential at point P to 6 volts and fire Q_1.

used elsewhere in the system, which is rectified by diodes D_1 and D_2, filtered with network R_1, C_1, and R_2 and regulated to 13 volts with diode D_3. Sufficient current, supplied from the battery through R_7, assures reliable contact.

With the points closed, transistor Q_2 is cut off and capacitor C_2 charges to approximately 5 volts. When the points open, Q_2 saturates so that the potential at point P drops to 6 volts and fires the unijunction transistor, Q_1. As long as the points remain open Q_2 remains saturated and prevents C_2 from recharging. When the points close again, Q_2 turns off, and the potential at point P rises. Capacitor C_2 is then recharged through resistors R_3, R_4, and R_5 to complete the cycle.

The time constant $R_5R_6C_2$ introduces a delay of one millisecond before C_2 accumulates sufficient charge (approximately 4 volts) to fire the unijunction, Q_1, when the points open; thus, transients caused by contact bounce shorter than one millisecond, do not cause multiple triggers on opening, or unwanted triggers on closing.

Pulse-saving network permits signal switching

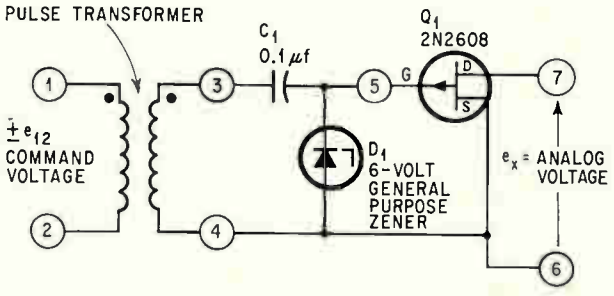
By Charles A. Walton

International Business Machines Corp.
San Jose, Calif.

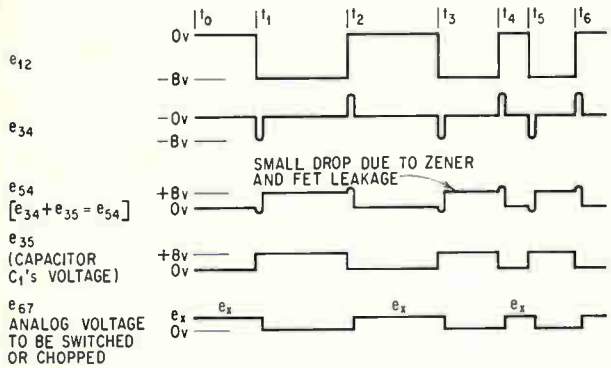
A fast, floating switch that chops analog signals without introducing common-mode noise is constructed by connecting a pulse-saving network across the secondary of a small pulse transformer. Chopping is performed by switching a field effect transistor on and off with the network's output voltage. The circuit's pulse transformer, whose volt-time product is less than 100 volt-microseconds, is capable of maintaining 6-volt on or off signals for longer than 100 milliseconds.

At time t_0, the circuit is quiescent with no charge on capacitor C_1 and no voltage at terminals 3 and 4 of the pulse transformer. A negative 8-volt step, applied across input terminals 1 and 2 at time t_1, saturates the transformer to produce a negative pulse at output terminal 3. The negative pulse forces the potential at point 5 to approach —8 volts. As this potential approaches —8 volts, zener diode D_1 conducts, and clamps point 5 to —0.6; thus, when the negative pulse reaches its peak shortly after t_1, point 5 is clamped at —0.6 volt by the zener while point 3 is held at —8 volts.

When the negative input step reaches —8 volts, shortly after t_1, the transformer's flux collapses and the voltage at terminal 3 drops to zero, completing the negative pulse. However, the voltage across C_1 cannot change instantaneously; hence, point 5 rises toward +8 volts. When the voltage at point 5 reaches 6 volts, zener diode D_1 breaks



Switching action. Voltage at point 5 is either 6 or zero volts, turning Q_1 off or on, respectively.



Waveforms. Negative steps in command voltage e_{12} turn the FET off and positive steps turn it on to pass the analog signals.

down and clamps the point-5 potential. Since the pinchoff voltage at the gate of Q_1 is 4 volts, the voltage at point 5 holds Q_1 off.

The 6-volt potential at point 5 decays very slowly due to low leakage current through C_1, D_1, and Q_1. However, voltage at point 5 can be readily maintained above the FET-pinchoff voltage for longer than 100 milliseconds when C_1 is a Mylar capacitor. The decay time of the potential at point 5 determines the maximum OFF time for the FET. Since the circuit is capable of indefinite ON times, the circuit's response to nonsymmetrical waveforms is limited only by the decay time of the potential at point 5.

When a positive input pulse is applied to terminals 1 and 2 at time t_2, the voltage at terminal 3 is driven toward 8 volts so that point 5 also moves positively. When the voltage at point 5 reaches 6 volts, zener diode D_1 breaks down and clamps the point-5 potential.

Upon completion of the pulse (shortly after t_2), the potential at terminal 3 drops to zero. As the charge on C_1 cannot change instantaneously, the potential at point 5 tries to move toward −2 volts. When point 5 begins to go negative, D_1 conducts and clamps the point-5 potential at zero. With point 5 at zero, Q_1 turns on and passes any analog signals applied to its drain or source terminals. Transistor Q_1 conducts until the next negative pulse.

The pulse transformer is the Pulse Engineering Co.'s model 2228 and the circuit has been operated at rates from 10 to over 1,000 pulses per second.

High speed multivibrator controlled by single ECL

By Akio Tojo

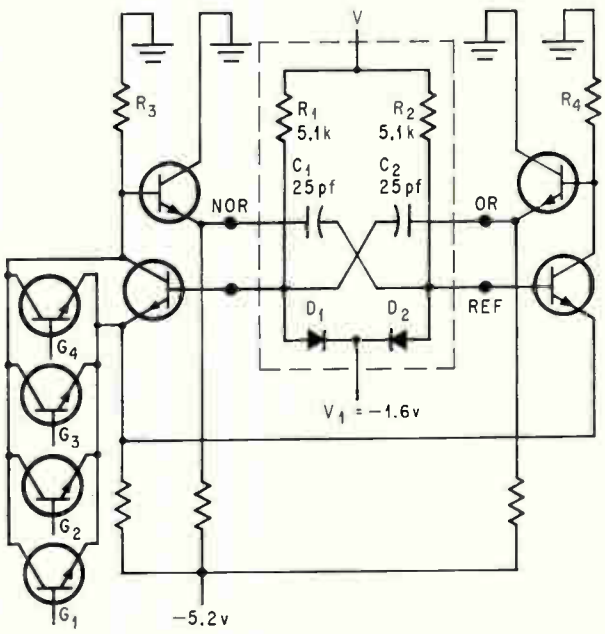
Electrotechnical Laboratory, Tokyo, Japan

An emitter-coupled monolithic logic circuit enables the engineer to design either a simple astable or a monostable multivibrator having fast operation, externally controlled repetition rate, and multi-input start-stop oscillation control.

Voltage V supplies a base-biasing current through R_1 and R_2 for a current conducting switch. The base voltage of a conducting switch is held constant at −1.6 volts plus approximately 0.65 volts, forward diode drop by diodes D_1 and D_2.

With all inputs at their low voltage state the circuit oscillates freely, but when any one of the four input levels, G_1, G_2, G_3, or G_4, is high, oscillation stops. The input voltage for gating is compatible with that of conventional ECL's (−0.75 v and −1.55 v). Assuming the voltage across R_1 and R_2 is large compared with the output level, the circuit's repetition rate is given by:

$$f = \frac{1}{R_1C_2 + R_2C_1} \times \frac{V - V_1}{\Delta V}$$



Astable. In the gated astable multivibrator, variable supply voltage V as well as circuit components control the oscillation frequency. Components outside the dashed box are included in the IC chip, a Motorola MC-301.

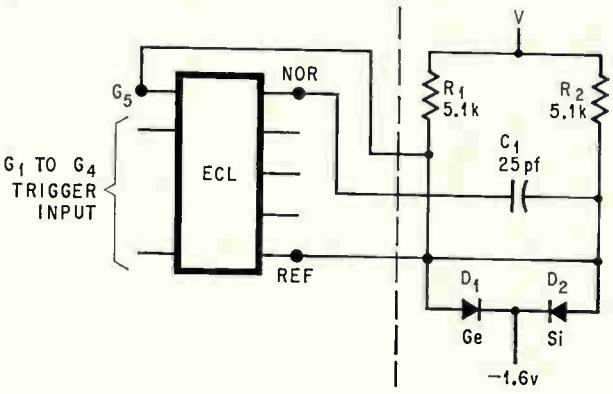
where ΔV is the output voltage swing.

The pulse width of the output waveform is slightly unsymmetrical, because of unequal values

of R_3 and R_4. These are required to maintain identical signal levels at the NOR and OR outputs when the ECL is applied as a logic gate. For symmetrical pulse widths, the value of C_1 should be 10% greater than C_2.

If the ECL is rewired, a monostable multivibrator is obtained. A germanium diode D_1 and a silicon diode D_2 give the appropriate voltage difference between the bases of the conducting and open switches in the quiescent state. A trigger signal applied at any one of four inputs initiates oscillation. The input level is also compatible with the conventional ECL output voltage.

Multivibrators designed around integrated circuits offer exceptionally fast, simple-gated operation. In addition, variations in element characteristics and changes in temperature have little effect.



Monostable. By rewiring the astable multivibrator a monostable circuit results with fewer components. Circuit to the right of the dashed line represents discrete component addition to the ECL.

Waveform generation eased by two timing networks

By Larry Blaser

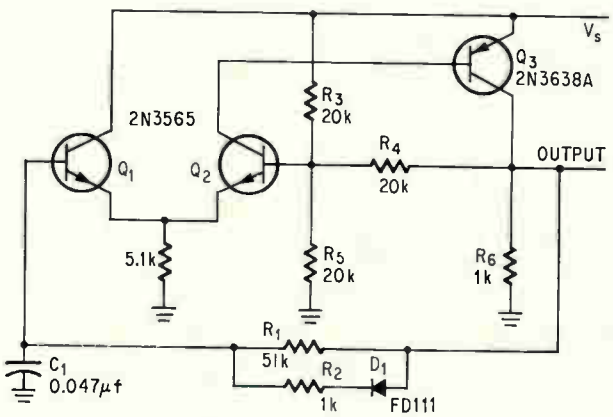
Fairchild Semiconductor Division of the Fairchild Camera & Instrument Corp., Mountain View, Calif.

A nonsymmetrical, free running multivibrator capable of off-to-on-time ratios as large as 500 to 1 are achieved by switching a diode between two timing networks. Time constants of the networks have ratios proportional to the desired duty cycle of the output waveform and the circuit's pulse repetition frequency (PRF) is independent of changes in supply voltage. In addition, the potential at the supply may drop nearly 50% with little effect on the frequency of the output pulses.

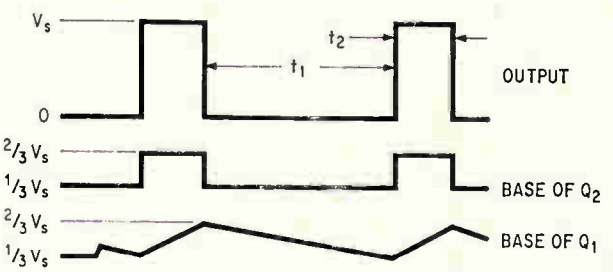
The pulse generator was constructed with inexpensive epoxy transistors and noncritical passive components. To start the cycle, transistors Q_2 and Q_3 are on and capacitor C_1 charges toward the supply voltage, V_s. The current charging C_1 flows through Q_3, D_1, and R_2, and is negligible through R_1. While Q_3 is on, the output voltage is at V_s, as shown in the output waveform diagrams.

When the potential on C_1 reaches ⅔ of the supply voltage (⅔ V_s), transistor Q_1 turns on and shuts off Q_2. With Q_2 off, transistor Q_3 turns off and the output voltage drops to ground, completing the output pulse. With Q_3 off, capacitor C_1 slowly discharges through R_1 and R_6, assuring a long off time. No discharge current passes through the small resistor R_2 as diode D_1, in series with R_2, is reverse biased when Q_3 turns off. Then D_1 switches between resistors R_1 and R_2 to provide a short ON time (while C_1 is charging through R_2 and D_1) and a long OFF time (while C_1 is discharging through R_1 and R_6).

As the potential at C_1 drops through ⅓ V_s, Q_1 turns off, and Q_2 and Q_3 turns on. Thus, the output



Nonsymmetrical multivibrator. Capacitor C_1 is charged through D_1 and R_2 until C_1's potential reaches ⅔ V_s.



Output waveforms. When the potential at the base of Q_1 reaches ⅔ Vs, Q_1 turns on, Q_2 turns off, and the output drops to ground, completing the pulse.

voltage rises to V_s, starting a new output pulse.

The charge times for capacitor C_1 are

$$t_1 \approx R_1 C_1 \ln 2$$

and

$$t_2 \approx \frac{R_1 R_2}{R_1 + R_2} C_1 \ln 2$$

when the values of resistors R_3, R_4, and R_5 are equal. The duty cycle is given by the relation

$$\text{duty cycle} = \frac{t_2}{t_1 + t_2} = \frac{1}{2 + \frac{R_1}{R_2}} \times 100\%$$

and the pulse repetition frequency is expressed by

$$\text{PRF(Hz)} = \frac{1}{t_1 + t_2} \approx \frac{1}{R_1 \left(1 + \frac{R_2}{R_1 + R_2}\right) C_1 \ln 2}$$

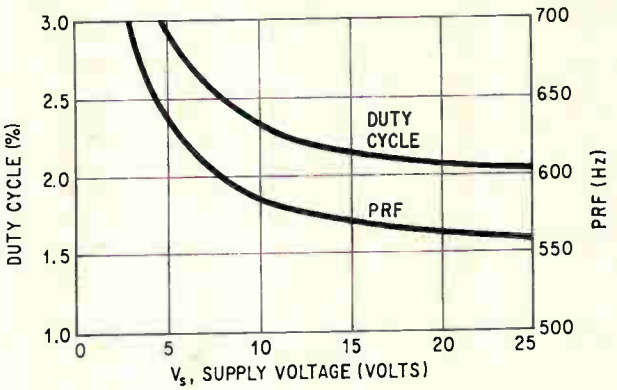
For a low duty cycle, R_1 is chosen much larger than R_2 so the expressions for duty cycle and pulse repetition frequency become

$$\text{duty cycle} \approx \frac{R_2}{R_1} \times 100\%$$

and

$$\text{PRF(Hz)} \approx \frac{1}{R_1 C_1 \ln 2}$$

For reasonable accuracy and reliable circuit operation with a supply voltage between +12 and +24 volts, the value of R_1 should be between 20 and 100 kilohms, and the value of R_2 should be between 0.2 and 100 kilohms. For these R_1 and R_2 values, the duty cycle range falls somewhere between 0.2 and 45%.



Performance curves. Supply voltage V_s may drop from 24 to 12 volts with little change in the output's PRF.

The performance curves illustrate the astable multivibrator's operating characteristics when the values of R_1 and R_2 are made 51 and 1 kilohms to yield a 2% duty cycle. The value of C_1 is 0.047 μf, giving a calculated PRF of 600hz. The measured 10- to 90%-rise time of the pulse is 0.3 microsecond and the fall time is 4 microseconds.

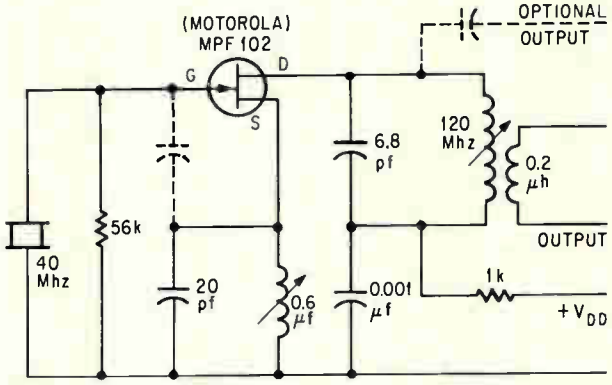
FET cuts down crystal loading

By Fred B. Cupp

Clevite Ordnance, Cleveland, Ohio

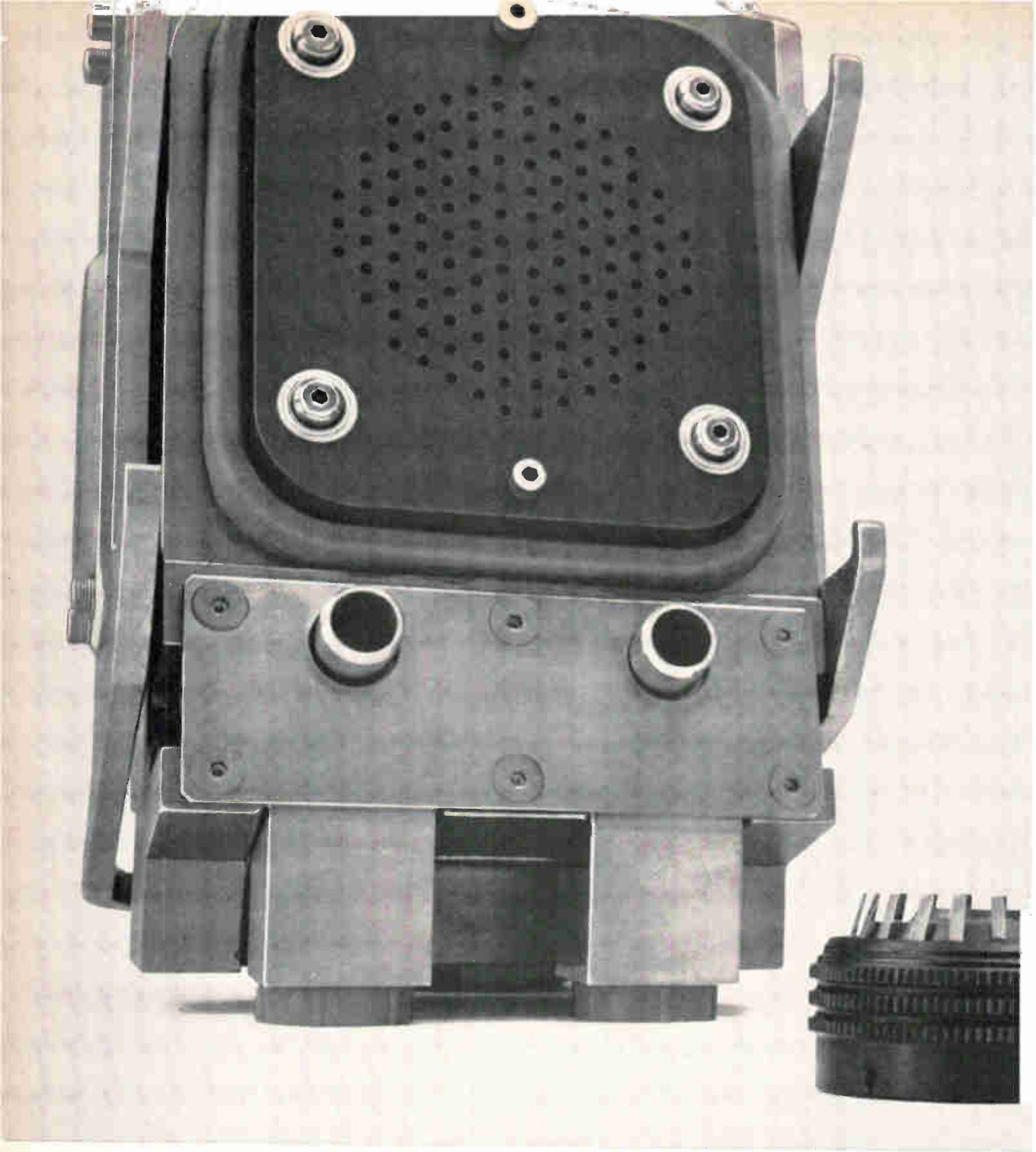
Crystal oscillators can be built with conventional bipolar transistors, but the low input impedance of the bipolar units loads the crystal. Using a field effect transistor with its high gate-to source impedance, however, minimizes crystal loading.

The design is a multiplier stage in a local oscillator injection chain of very-high-frequency/ultra-high-frequency receivers. Oscillation at the desired crystal frequency is achieved only when the tank circuit in the source lead is tuned to about 0.7 times this frequency. This condition must be satisfied to give a phase lag that offsets the phase lead due to the gate-to-source capacitance.



Active element. Use of FET simplifies crystal loading in oscillator-multiplier design. Values shown are suitable for fundamental operation at 40 Mhz, tripling to 120 Mhz.

The drain tank may be tuned to a desired harmonic of the oscillator frequency, such as the third, and the output may be taken from either the drain tank with link coupling, or from the drain lead by capacitive coupling.



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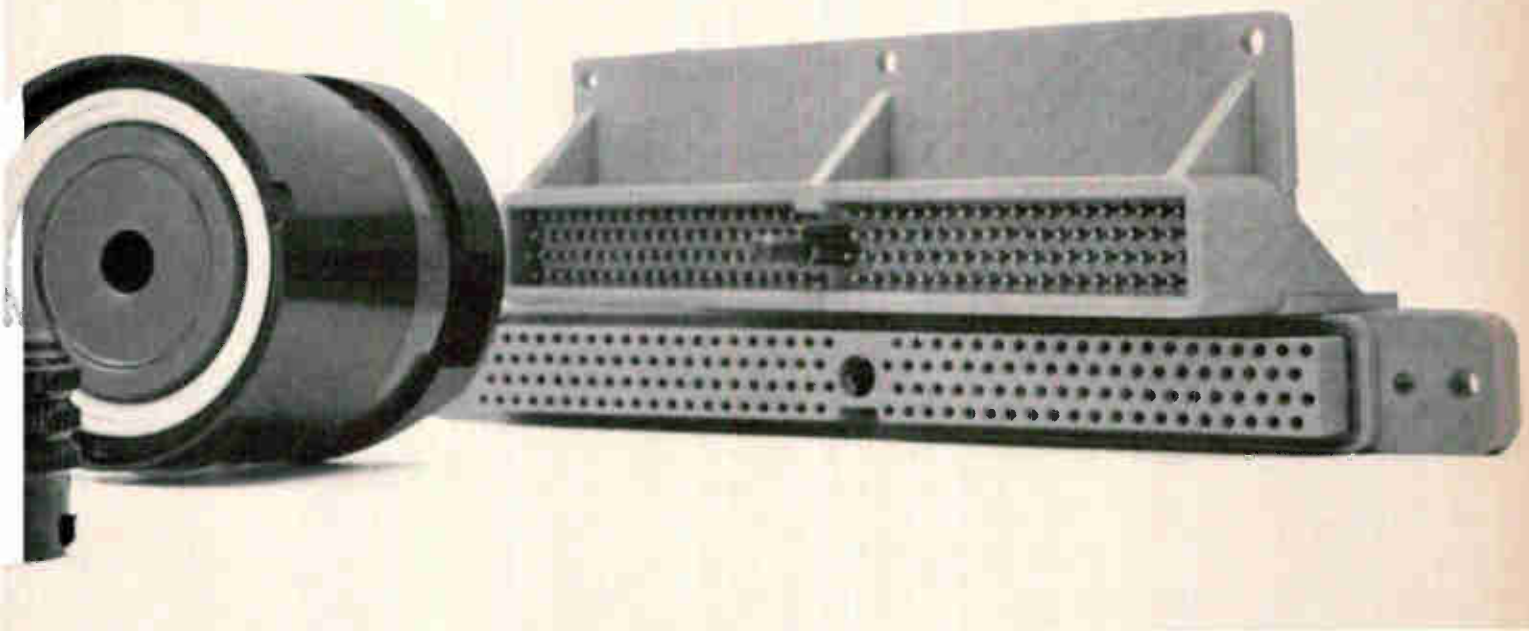

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Integrated circuits in action: part 7 Cutting costs on the factory floor

Marriage of diode-transistor and transistor-transistor logic in a redesigned coordinate-measuring machine provides greater reliability at a sharply reduced price

By Michael French

Potter Instrument Co., Plainview, N.Y.

Makers of industrial equipment are always striving to improve their products. Some work for greater reliability, some aim at price reductions, and others go for a smaller-sized unit. The Potter Instrument Co. tried for all three and achieved a notable success by using IC's and a congenial mixture of logic types when it redesigned its coordinate-measuring machine for inspecting machined parts.

The machine—the Picomm II—sells for less than $8,000, half the cost of its discrete-component predecessor. It now weighs 550 pounds as against 3,400 pounds, and the specifications of the revamped unit match or surpass those of the older system. The electronics, which previously filled three bulky drawers, now are packed into a handsome console that can be carried by hand.

The radical cut in price is possible because only 1/6th the number of parts are needed than before, and labor costs are pushed down because so much less effort is required to count, assemble, insert, and inventory components. Of course, fewer parts mean far less solder and cable connections—both potential trouble spots.

The design of the electronics is an example of how compatible types of IC logic may be used to the best advantage. Instead of relying on a single logic type, the IC's in the measuring machine include diode-transistor logic (DTL) gates driving transistor-transistor logic (TTL) flip-flops. This mix was selected because DTL's are low-priced and the TTL flip-flops are needed to drive high-capacity loads.

The author

Michael French, an electrical engineer with Potter for the past 2½ years, designed the electronics in the Picomm II measuring system. He received his bachelor's degrees in arts and electrical engineering from Brown University in 1962.

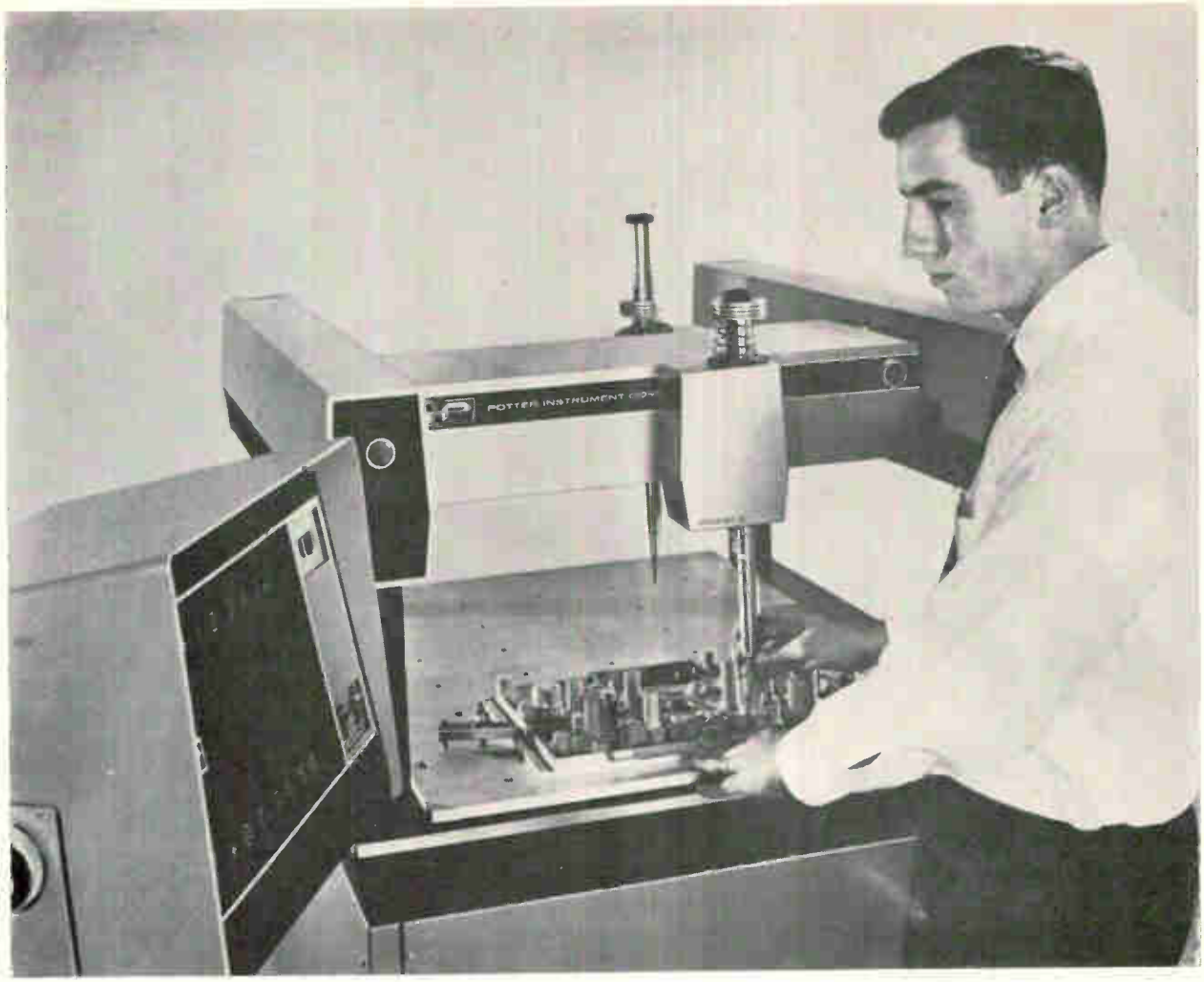
Measuring dimensions.

Inspecting machined parts is a critical function in many production processes. A part turned out quickly by a numerically controlled machine tool may take hours to inspect manually. With a coordinate-measuring machine the job is accomplished in minutes.

The part, or workpiece, to be inspected is strapped down on the work table shown on page 115. A bridge over the table supports a movable probe that can be moved to any point on the workpiece's surface. To increase the size of the work area, the Picomm II mounts a probe on each side of the bridge. The operator switches from one to the other to increase the measuring area from 18 x 18 to 18 x 31 inches.

Starting at a reference point, which can be set anywhere, even off the part, the probe is moved from one critical point to another. As this happens, three transducers connected to the probe sense its movement along the x, y, and z directions. Low-level electrical signals from the transducers are processed and used to indicate the probe's position on digital displays.

D-c amplifiers boost the transducer signals from 50-millivolt to 4-volt levels and they are fed to analog-to-digital converters. The digital output from the converters is then applied to bidirectional decimal counters which activate the displays.



Measuring the part. Probe is placed into machined hole on tape transport panel and its position is automatically displayed on digital readout.

In the Picomm II, there is one display for the horizontal x axis, and another display that is switchable to read out dimensions on either the horizontal y or vertical z axis. The reference point may be set so that the numbers on a readout—referring, for example, to the distance between the centers of two drilled holes—correspond exactly to the dimensions on a blueprint or inspection sheet. The machine inspects printed circuit boards or intricate electronic assemblies, as well as castings and machined parts.

A special optical attachment, used for inspecting circuit boards, enlarges and projects the board pattern onto a viewing screen, shown on the cover. Instead of moving a probe, the operator moves a reticle over the critical points. Dimensions are read out on the digital displays in the same way as with the mechanical probe.

System design.

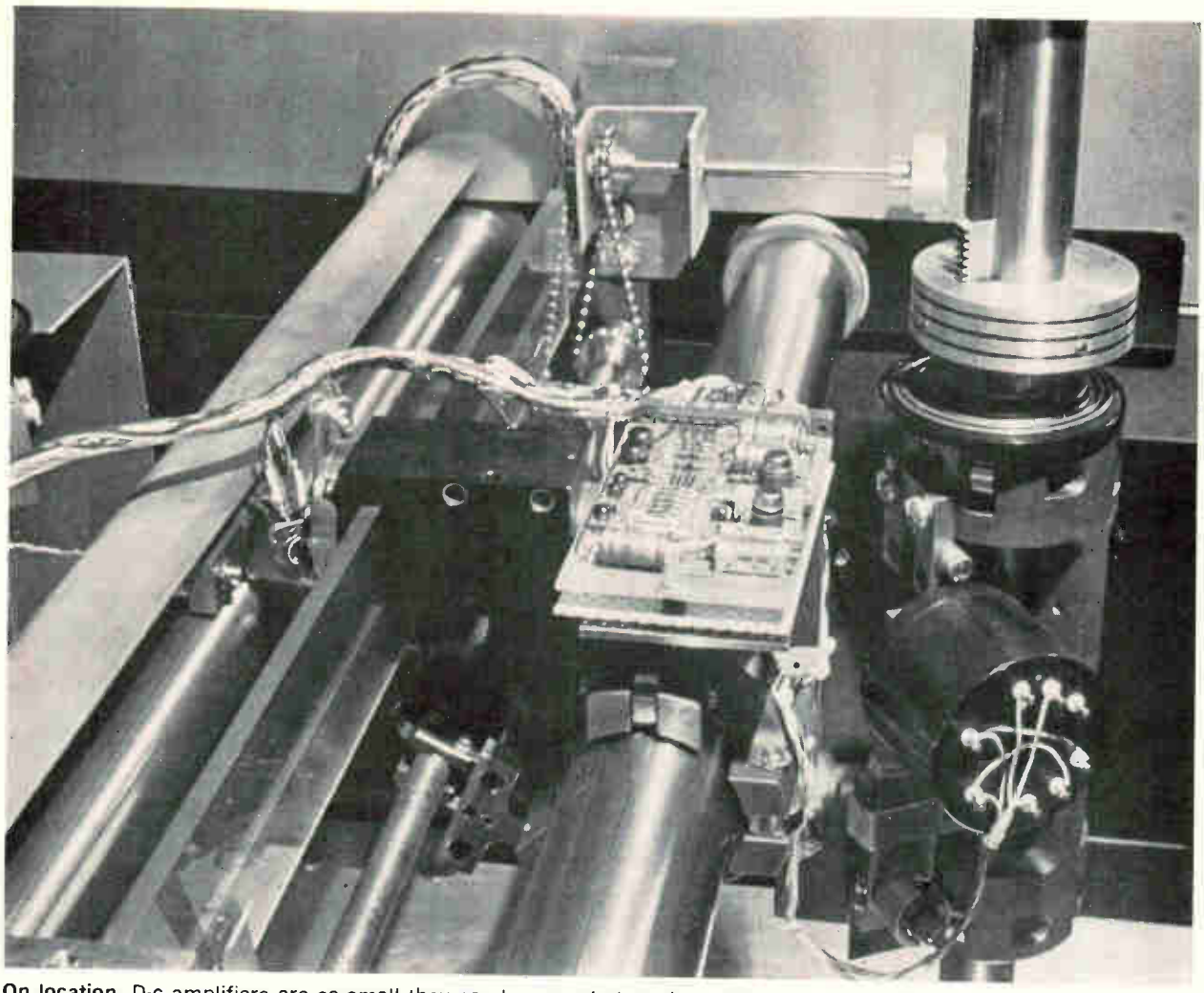
There are two sets of optical transducers—one set for each horizontal axis—as seen in the system block diagram on page 116. A third electromechanical rotary encoder on the z axis, used because it takes up less space than the optical units, senses vertical displacements. The horizontal encoders cover an 18- x 31-inch area; the vertical encoder measures heights to 7 inches.

Each horizontal transducer consists of a strip of glass, 22 inches long by 1½ inches wide, on which are scribed fine opaque lines, 500 to the inch. This glass strip extends the length of the work area. Separated from it by a few thousands of an inch is a 1½-inch-square piece of optical glass also scribed with the same density of lines.

The glass square, together with an incandescent lamp and two photocells, sketched on page 117, rides on the support bridge along with the movable probe. Its lines are always parallel to the lines on the glass strip. Light from the lamp passes first through the glass square, then through the strip and, finally, onto the photocells.

Detecting the sine waves

Outputs from each of the two cells are sine-like waves, due to the variation in light intensity caused by the movement of one set of scribed lines on the other. The frequency of the waves, between d-c and about 20 kilohertz, depends on how fast the probe is being moved. Because of the way the cells are

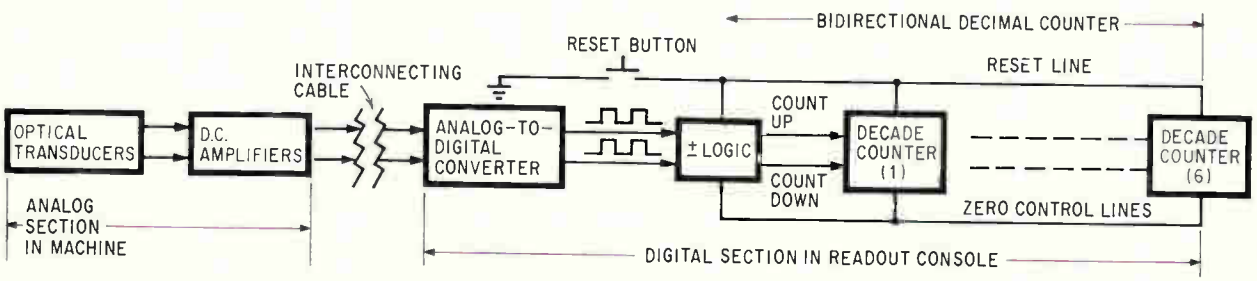


On location. D-c amplifiers are so small they can be mounted on the bridge inches from the optical transducers.

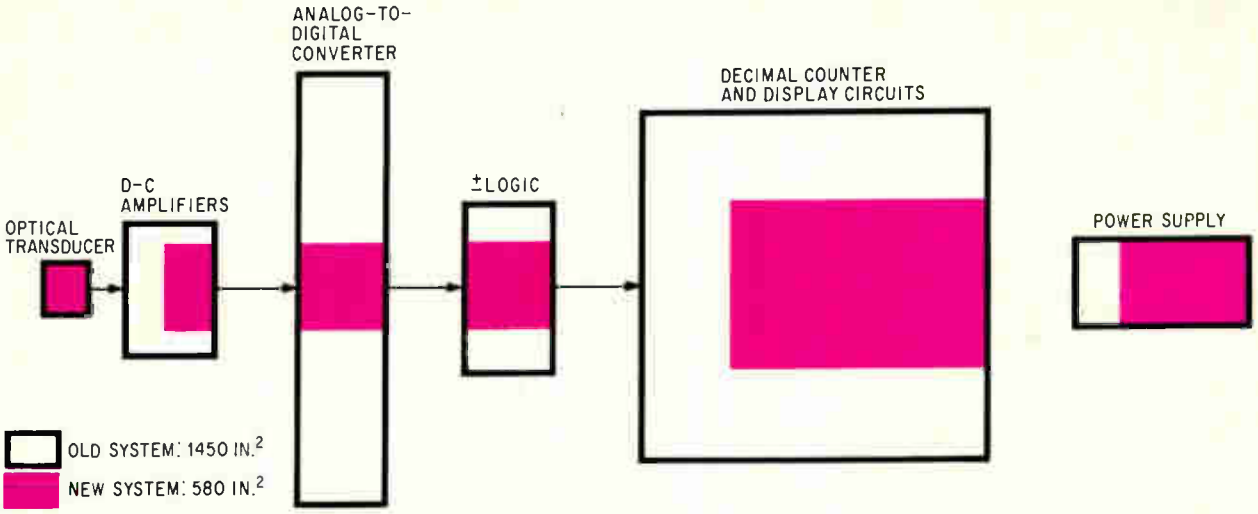
placed, the waves are in quadrature. Thus, for each 0.002-inch displacement of the probe, there are four zero-crossing points of the sine waves, two from each photocell. The resolution of the measuring system, using zero-crossing detectors, is ¼th of 0.002, or 0.0005 inches. Zero-crossing detectors on the outputs of the z-axis rotary encoder similarly produce 0.0005-inch resolution. This is about the limit for this type of encoder.

For higher resolution, the two photocell outputs are mixed in a precision-resistor ladder network to give equal-amplitude phase-shifted signals. If five signals, 0, 36, 72, 108, and 144 degrees apart, are produced there will be 10 zero-crossing points to detect and the resolution will be 1/10th of 0.002 or 0.0002 inches. For a 0.0001-inch resolution, 10 phase-shifted signals and 20 zero-crossing points are produced in the ladder network.

The resistor ladder network is part of the analog-to-digital converter of the coordinate-measuring system. Usually such a converter takes a single analog signal and quantizes it into digital signals representing different voltage levels. However, here the analog-to-digital conversion takes the two data waveforms—the 90% phase-shifted signals from the photocells—and separates them, not by



System design. Both the horizontal x- and y-axis of the machine sense probe movement with linear optical transducers and convert signals to digital form. The z-axis uses rotary position encoder to save space.



Space saver. Picomm II requires only about 40% of the area needed in the discrete component system.

level but by phase. Then their zero-crossing points are detected to produce trains of output pulses for each sine-wave cycle.

Each phase-shifted output signal from the resistor ladder network is fed into IC level-detecting circuits. These are simple DTL gates which switch from their high to low state as the analog input varies. A 0.2-volt swing through the zero-crossing point switches the gate. The level detector on each signal yields a square wave for each sine-wave cycle. The first transition of the square wave turns the flip-flop on, the second turns it off.

Outputs from the DTL gates are fed to TTL flip-flops which produce clean square waves. Series LC networks differentiate the waves and produce positive pulses that are fed to the bidirectional decade counter. Whether the pulses should be counted up or down is determined by a sequence detector consisting of an array of DTL gates.

TTL flip-flops are used because of the capacitive loading—up to 500 picofarads—of the differentiating network. The high output impedance of the DTL gate, which is 2 kilohms compared to the TTL gate's 60 ohms, coupled with this load would degrade the rise time of the output square wave.

System electronics

Integrated circuits are used in the d-c amplifiers, analog-to-digital converters, bidirectional decimal counters, and logic circuitry. These elements contain four types of integrated circuits:

- 946-type two-input quad DTL gates
- 962-type three-input DTL gates, three gates on a chip
- SN7473 dual J-K TTL flip-flops
- NE505 linear operational amplifiers

There is a drastic reduction in both the number and type of circuits that make up the coordinate-measuring system, and the space occupied by the electronics, as illustrated above.

For example, the transistor circuitry in the older system used 2,200 components; the new system has only 331. The 2,200 components consisted of six types of transistors in 254 places, 660 diodes, and about 1,300 resistors and capacitors.

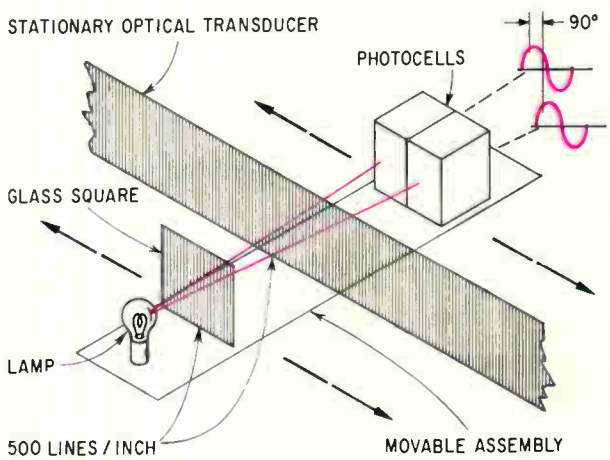
With IC's the same circuits are put together with only 136 IC's, 90 diodes, and 105 resistors and capacitors. The area of printed circuit boards containing the electronics in the new system is 580 square inches; in the old it's 1,450.

Tradeoffs

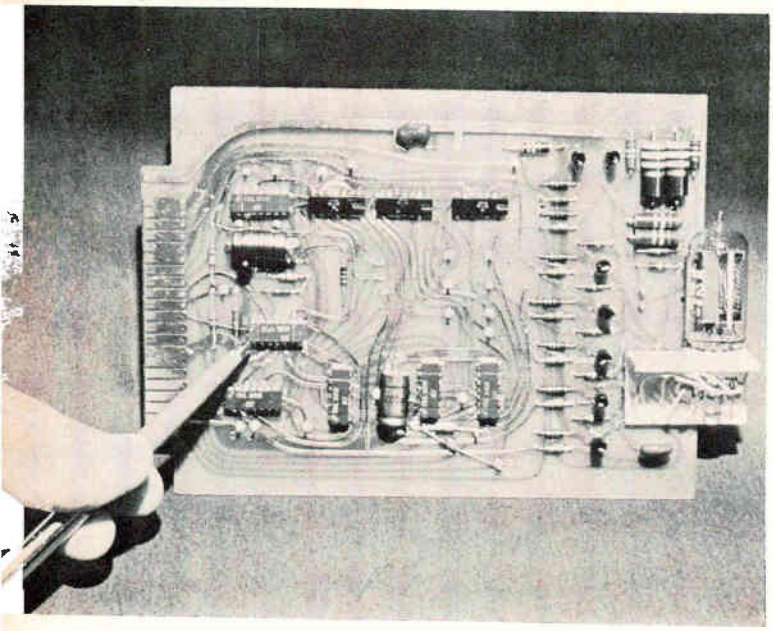
Conflicting factors had to be balanced in choosing a mix of IC's for the Picomm II's electronics; they are noise immunity, speed, and fan out.

The electrically noisy factory environment where the measuring machines operate ruled out resistor-transistor logic (RTL) which is relatively inexpensive. Maximum noise immunity of RTL gates is only about 400 millivolts, which is, unfortunately, of the order of the noise anticipated. Diode-transistor and transistor-transistor logic, with their noise immunities ranging from 800 millivolts to 1 volt, were obviously the better choices here.

In general, noise was much less of a problem in the redesigned IC system because the voltage and



Optical transducers. A variable amount of light passed through a grating of opaque lines impinges on photocells to produce approximately sinusoidal signals spaced 90 electrical degrees apart.



Block by block. Printed circuit boards contain functions like counters and a-d converters.

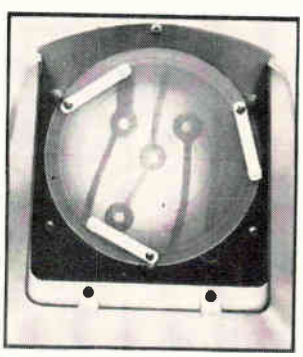
current spikes during switching are smaller than those in the transistor circuits. The small size and great packing density of IC's also reduces noise pickup. Maximum distance between signal circuits is only 6 to 8 inches compared with 2-foot-long lines in the discrete design.

In the IC counter, for example, the maximum noise on the positive supply voltage of the counter with respect to ground is a 60-nanosecond ringing between 0.6 and 0.8 volt in amplitude. In the older Picomm's transistor electronics, the flip-flops generate a 200-nanosecond ringing varying between 2.5 and 3.0 volts.

Noise susceptibility of the transistorized system restricted its maximum speed, so that using the fastest transistors was avoided because noise immunity margins were reduced. With IC's, such considerations are no longer important.

With respect to fan out, TTL's ability to drive 10 to 12 elements rates better than the six-to-eight-element capability of DTL. However, the machine's logic circuitry in only a few cases required a gate to drive more than four elements. Thus, DTL, even with its lower fan out, was adequate.

In addition, the DTL gates allow a wired OR function, something not possible with TTL. For the same reason, Sylvania ultrahigh-level logic circuits, (SUHL) which are a type of TTL and have high speed and good fan out, were rejected.



Auxiliary. Optical attachment projects circuit board being measured on the screen.

Counting speed

The counting speed in the system was set at 1 megahertz, a factor of 10 improvement over the 100-kilohertz speed of the bidirectional counters in the older systems. The faster speed doesn't provide any more measurement resolution, but rather reduces from 10 microseconds to 1 microsecond the minimum time required between pulses so that the counters don't lose count. This, in turn, allows much greater leeway in the adjustment of the machine. A customer's semiskilled personnel can unpack and plug the system together.

Another advantage of the higher circuit speed is that the probe can be moved much faster without losing position count. The maximum speed was increased from 900 inches per minute to 5,000 inches per minute. This top speed is impossible to maintain over any distance, but such a rate can be reached if the stationary probe is moved suddenly, or the moving probe is brought abruptly to rest.

The 1-megahertz speed can be easily handled by the DTL gates, and by SUHL and Motorola emitter-coupled logic (MECL) as well. However, at $1 per package, the DTL was considered the best buy. (In addition, DTL needs but a single supply voltage, unlike MECL, which operates with two levels.) Gates with 6-kilohm output resistors were selected instead of 2-kilohm resistors, also available, because the higher resistance reduced the drain on the power supply and allowed a fan out of six to eight elements, rather than four to six.

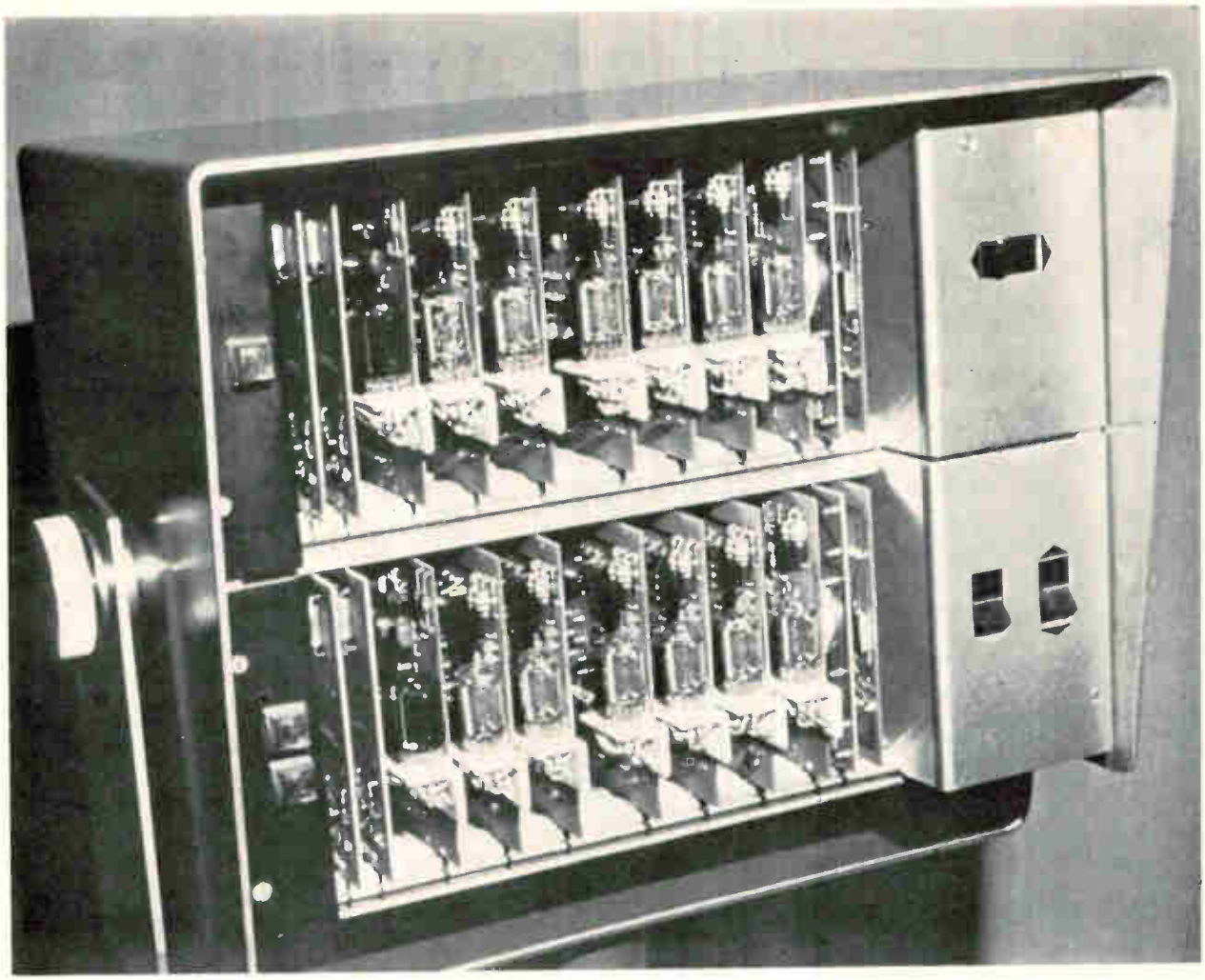
In a few places, transistors had to be used because of very high fan-out requirements. For this purpose, a transistor with characteristics closely matching those of the IC gates was chosen. One such transistor is the 2N3646 with similar switching levels, propagation, and switching times. By matching the discrete transistors with the IC's, interfacing problems were eliminated.

Although the 930-type DTL offers a great variety of gate types, all are inverting—NAND for positive logic, NOR for negative logic. This was at first thought to be disadvantageous because it would require additional circuits. However, externally connecting the outputs of the gates on a chip produces a wired OR configuration with which logic AND and OR functions can be readily performed.

System construction

The electronics is divided into functional blocks contained on 5½- x 7½-inch printed circuit boards. All of the up-down decades in the decimal counters are on a separate board. So are the analog-to-digital converters. The decade boards also contain the high-voltage transistors for driving the display tubes mounted on the board.

Arranging the system in function blocks enhances flexibility. Sections can be upgraded separately, as



Inside look. With front panel removed, each circuit board with its numercial readout tube can be seen.

new components become available, without affecting other circuits.

It's also easy to provide performance options, such as better measurement resolution. For example, to go from a resolution of 0.0005 inches to 0.0002 or 0.0001 inches, all that's needed is a 5½- x 7½-inch circuit board. Each board contains the complete analog-to-digital converter, the resistor ladder network for mixing the output signals from the photocells, the level detectors and flip-flops, and the differentiating networks. Although twice as many signals must be handled for 0.0001-inch resolution as for 0.0002, the IC's still fit on a single board.

The space saved by the IC's also permitted a self-testing circuit to be built on one of the p-c boards. Consisting of a free-running 1-Mhz square-wave generator made of two DTL inverting gates, the circuit triggers all the counting decades in the machine at their maximum rates. Such a circuit would have been too bulky for a discrete-component system.

In discrete components the d-c amplifiers had to be put in the main electronic package, about 6 or 7 feet from the position transducers. Now, the d-c amplifiers—NE505 linear operational amplifiers manufactured by Signetics Inc., a subsidiary of the Corning Glass Works—are small enough to be mounted next to the movable probe on the support bridge, only 6 or 7 inches from the transducers, pictured on page 116.

Another plus for the functional blocks is that semiskilled people can maintain the system. Plug-in function boards are substituted until the faulty one is isolated and replaced.

Most of the IC's in the system are packaged in a 14-pin dual in-line epoxy plastic package. The exception is the NE505 amplifier. So far, this device comes only in a 10-pin TO-5 can.

The dual in-line package was chosen over both the TO-5 can and the flatpacks mainly because it handles easily in production. It's also about half the price of the flatpack and can be flow-soldered onto the p-c board. Its leads don't have to be carefully cut and spread, as with the TO-5 can and, of course, it has more leads than the can has.

So far, the hermeticity of the epoxy packages has been excellent. There have been no failures in 2,500 units operating for the past year in environments of over 100°F.

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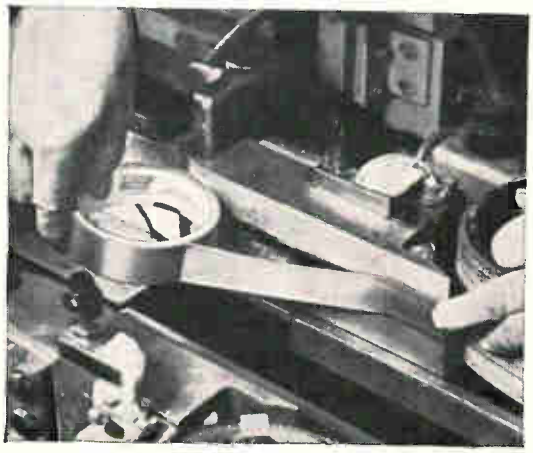

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BORDEN CHEMICAL

Weaving a braided memory that's fast and inexpensive

By reducing parasitic capacitance between the wires, a read-only memory can achieve cycle times as fast as 300 nsec; specially designed loom weaves the braid

By John J. Marino and Jonathan J. Sirota
Memory Technology Inc., Waltham, Mass.

Braid memories have long held out the promise of low cost. But, for the most part, it was an empty promise because of the knotty problem of coming up with a memory fast enough to be practical. Now, with a technique that greatly reduces the parasitic capacitance between the wires in the braid, transformer read-only memory systems are being produced that can operate in cycle times as short as 300 nanoseconds and cost about 2.5 cents per bit. The braid itself costs about 1 cent per bit, and this cost is expected to be cut in half.

Comprising a series of linear-ferrite cores—each with its own winding—and a bundle of word wires, the memories are being manufactured by Memory Technology Inc. The wire braids are woven on a specially designed loom [see "From the loom of MTI . . .," p. 126], assembled onto the cores, which have air gaps, and incorporated into modules. These modules are built into memory systems.

Previous theoretical designs couldn't operate at speeds much under a microsecond, because the capacitance had to be charged at the start of each cycle.[1,2] And prior to MTI's loom, only one machine had been built that could weave braids for memories—but that was an unwieldy laboratory device.[3]

Data in a braid

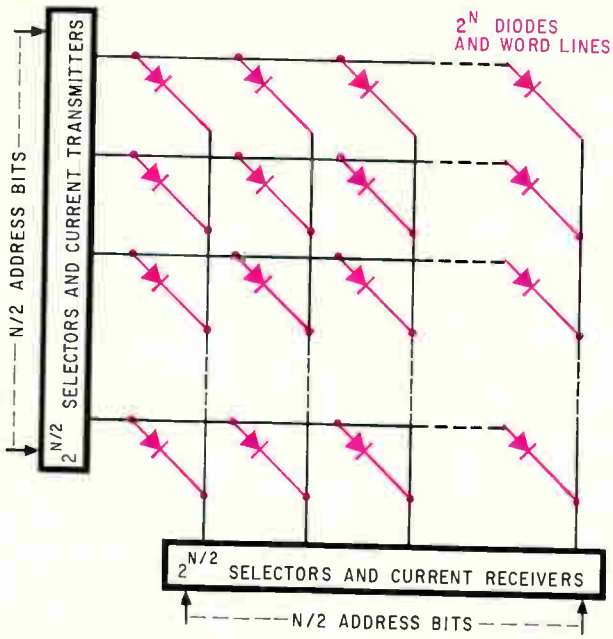
Basically, the memory contains one wire for each word to be stored and one core for each bit of the output word. The linear magnetic material of the core doesn't switch; the core acts like a transformer. Information is stored by the relative position of each word wire with respect to each core, making the memory electrically unalterable or read only. If a particular word wire passes through a particular core, a 1 is stored in the bit position represented by the core. But where the wire is threaded around the core, a 0 is stored.

Binary information is stored this way because of the high inductive coupling of the wire threaded through the core and the multiturn-sense winding. If the word wire is threaded around a particular core, the inductive coupling is low. Thus, when a current pulse passes along a word wire, the threaded cores produce large-voltage pulses on their sense windings, and the bypassed cores produce either small voltage outputs or none at all. By monitoring the outputs of all cores simultaneously, the data is read out.

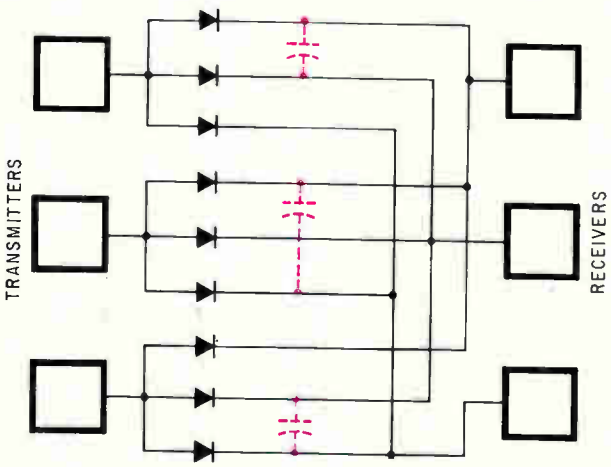
The linear magnetic material used in the transformer memory can be used in cores that contain

The authors

John J. Marino (top) is president and Jonathan J. Sirota is vice president of Memory Technology Inc., a company they founded in 1966 to exploit the braid-memory design worked out at the Massachusetts Institute of Technology. Their nine employees are producing braids in a former watch factory in Waltham, Mass., in which MTI shares space with several other small firms. Marino attended the University of Vermont and was a research engineer at the General Electric Co. and later at MIT. Sirota is a Rensselaer Polytechnic Institute graduate and holds a master's degree from MIT.



Diode matrix. In conventional design, one transmitter and one receiver send current through a single word line. The diodes block parallel paths through adjacent wires for any given transmitter-receiver combination. Matrix is used to minimize the number of components, thus holding down costs. Diodes and word lines are in color.



Parasitics. Grouping of wires in conventional design creates capacitances (in color) distributed over the full length of the lines. It's the capacitance that slows the memory's operation.

air gaps without significantly affecting its magnetic properties. This allows the wires to be woven into a braid to separate them into the 1 and 0 positions for each bit in every word. The braid is then placed into U-shaped cores, which are then capped with ferrite material.

Parasitic capacitance

In the conventional design of word-organized memories, both read-only and read-write, the parasitic capacitance between groups of wires seriously restricts the speed. This is a consequence of the diode matrix that isolates the word lines from one another.

In the simplest matrix, where word currents are unidirectional, one diode is in series with each word line. The lines are then connected into a matrix as shown at left, in such a way as to enable address bits to locate one of 2^n word lines with only $2^{n/2}$ current transmitters and the same number of receivers. With both ends of the word lines separated into groups, the capacitance between the groups stems from the proximity of the wires. Thus, current passing along a wire must first charge the capacitance before reaching the other end.

An obvious way of reducing parasitic capacitance is by connecting one end of each wire to a common point. Such a connection implies an individual transmitter connected to the other end of each line, but this is obviously far too costly. To hold the number of components at an acceptable level, the matrix arrangement must be preserved.

Design for high speed

In MTI's high-speed organization, a two-input AND gate is used in each word line. The two sets of inputs are connected together in a matrix. To minimize the unwanted capacitance, the word lines share a common connection to a current supply at the end opposite the AND gate. Both the inputs must be on for current to pass through a particular gate and word line. A memory containing 2^n lines requires 2^n AND gates and two sets of $2^{n/2}$ selectors.

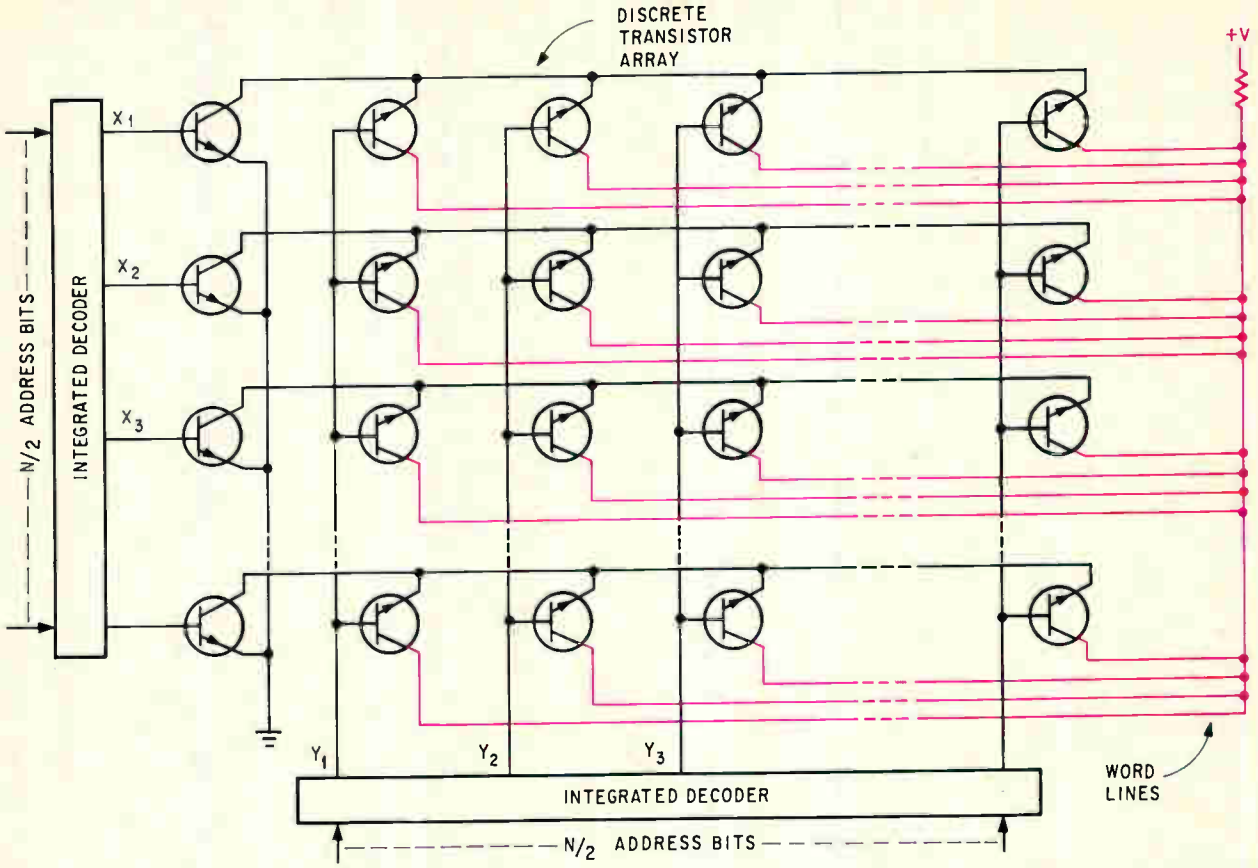
Because of the large number of AND gates, an inexpensive gate design is necessary. The simplest design is a single transistor having its collector in series with the word line and its emitter and base connected to form the matrix. Additional $2^{n/2}$ transistors, controlled by one of the two sets of selectors, serve as current sinks.

In the configuration on facing page, all inputs from both sides of the matrix drive only the bases of switching transistors. Thus, the transistors need provide only a small amount of current, about 15 milliamperes, and can therefore be connected directly to the outputs of commercially available integrated circuits.

Since all the word lines in this arrangement are connected to the same potential at one end, capacitance between lines is kept to a minimum. And it's primarily because of this one design feature that the memory is capable of achieving a high speed. Simplicity is achieved by eliminating the discrete-component transmitters and receivers required in the conventional design. Selectors can be built of integrated circuits.

Braid modules

MTI's memory contains 512 wires and 128 cores. The wires are connected to 32 small termination boards, each containing terminations for 16 wires. Called the braid, this module and a transistor matrix for line selection are mounted on a printed-circuit motherboard to form the braid assembly. This assembly is essentially a 32-by-16 matrix with an AND gate at each of its 512 intersections. Each gate is connected to a wire storing 128 bits of information. One edge of the assembly is the con-



Common connection. A positive signal at X_1 forward- biases the first current-sink transistor. This provides a ground connection for the top row of transistor AND gates. A positive signal at Y_1 permits current to pass through only the first gate. Thus line 1 is selected. The word lines are in color.

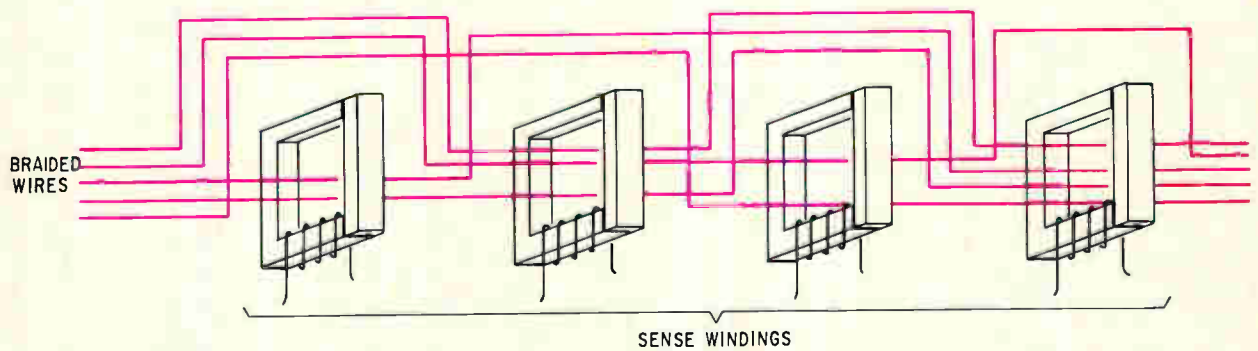
nector, which renders the assembly pluggable.

The assembly is placed on top of the cores, which are mounted on a sense-gate board containing output windings and diode-transistor-logic sense gates. As many as four braid assemblies can be placed on the cores in this manner. Shaped like the motherboard, the sense-gate board also has a connector on one edge. The braid assemblies, cores, and sense-gate board is sandwiched by two pressure plates to form what MTI calls a pluggable "Memory Pac." With four braid assemblies, the Memory Pac has a capacity of 2,048 words of 128-bits each, or a total of 262,144 bits. The motherboards' connectors are for input and the sense-gate board's connector is for output.

Because it is modular, the system is easily maintained. The Memory Pac can be unplugged, disassembled, and any part—cores, braid assembly, or sense-gate board—can be replaced. Even the information in the braid assembly can be modified—by merely removing the braid from the motherboard and replacing it with another.

Many words per wire

Multiple words are stored on each word line for two reasons. First, long wires are just as easily



Transformer memory. In this word-per-line organization, current through any one word wire generates a voltage pulse in the sense wires of those ferrite cores that the word wire passes through. The cores are U-shaped with ferrite caps to complete the flux path.

woven as short ones, and memories made from a few long wires cost less to build than those of many short ones. Second, the probability of a wired-in error is approximately proportional to the number of wires, so that the risk of error is lessened with the multiple-word approach.

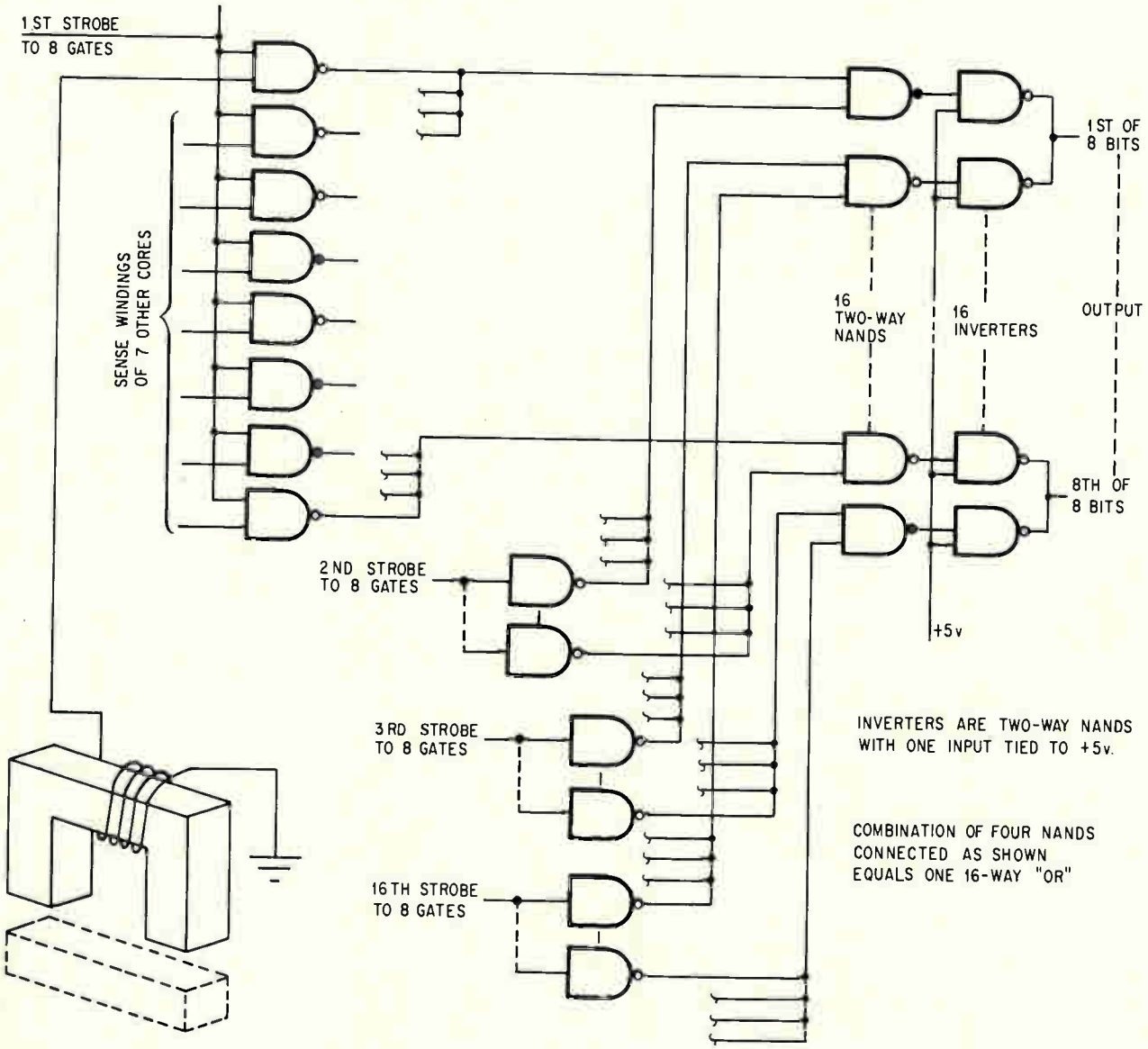
With this arrangement, a single cycle reads out all the words on a single wire. An additional selection circuit at the memory's output routes one of these words to the computer or other digital assembly served by the memory. The remaining words are discarded.

For example, a braid memory containing 4,096 words with 32 bits per word could be made of 512 wires, each storing eight words. Each wire is connected to the collector of one transistor in a 16-by-32 array, the bases and emitters of which are connected to address-selection circuits. To select a word, a 12-bit address is required. Nine of these bits select one wire, causing its transistor to be forward-biased and thus enabling current to flow through the line. The remaining address bits select one of the eight words, which are read out in parallel. The desired word is then routed by the output selector.

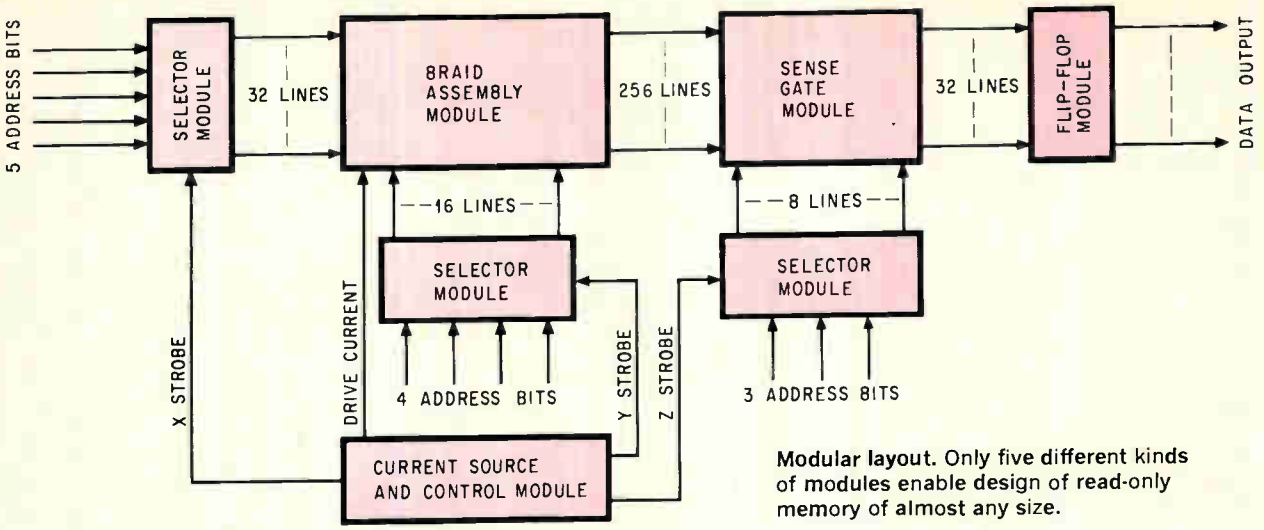
Five different modules

The system at top of facing page can be made with just five basic modules:

- Current source and control—containing a pulsed current source and the circuitry required to produce five different timing pulses for the read-only memory.
- Selector gate—a modified decoder that can have up to eight inputs, and produces both NAND and AND functions at the outputs.
- The braid assembly—consisting of a braid containing up to 512 wires with 128 bits per wire. The matrix of 512 transistor switches used for selection is also included. If a specific system requires



Sense gate module. This one printed-circuit board can sense up to 32 eight-bit words, or one 256-bit word, or anything between.



Modular layout. Only five different kinds of modules enable design of read-only memory of almost any size.

fewer wires, only the necessary transistors would be included here.

- Sense gate—containing up to 128 output sense windings, 128 two-input sense gates, and 128 U-shaped cores. This module together with the braid assembly module and a substrate holding 128 ferrite caps for the U-shaped cores make up one Memory Pac.
- Flip-flop—containing 12 set-reset flip-flops, which hold the data for the computer.

The selector-gate module decodes the input address and produces pulses that drive the word-selection transistor matrix. Each module contains an inverter for each input signal, AND gates to form various combinations of the inputs and their complements, and another inverter for each combination. All eight combinations of the first three input bits are decoded by the selector gate and fed into an AND gate along with either the true or complemented form of the remaining five bits. For the latter, jumpers connect one or the other form into the selector gates on a particular board. Thus, two similar modules could have the same inputs yet produce different output functions because of different internal connections of the five bits. The connections enable this module to be used in any matrix up to a 256-by-256 array.

Sensing the output

The sense-gate module contains the output windings mounted on U-shaped ferrite cores, the sense gates, and the gates required to combine up to 16 sense signals on one line.

In the module, the strobe inputs to eight adjacent sense gates are all connected to one pin. The module, therefore, contains 16 strobe connections that, if kept separate, can provide 16 words of eight bits each. The array on preceding page has 128 signals from the braid under control of 16 strobe lines. The outputs of these gates are combined to produce the eight-bit words. All wired OR connections—outputs of NAND gates tied together—are made with jumpers. By removing the jumpers and connecting together some of the strobe lines, longer words can be read out in parallel.

The sense-gate module can therefore organize the braid memory into any of several formats:

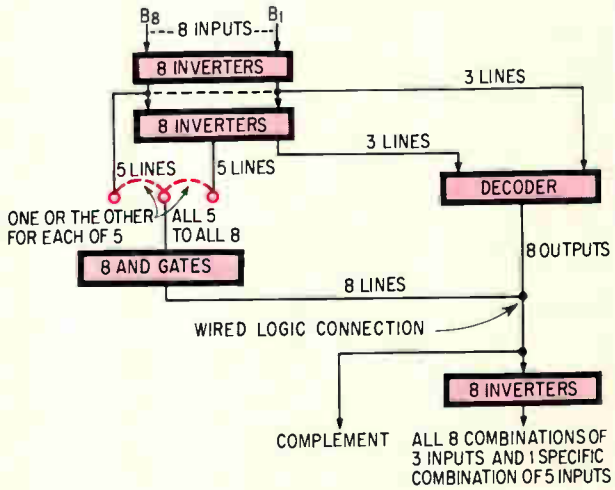
512	words of	128 bits per word
1,024	words of	64 bits per word
2,048	words of	32 bits per word
4,096	words of	16 bits per word
8,192	words of	8 bits per word

MTI also produces a smaller braid memory with a total capacity of about 20,000 bits in which a single 10,000-bit module combines all the functions of the five modules in larger memories. The braid contains 128 wires and 80 cores.

Simple and flexible

The modular approach to braid-memory design provides simplicity and flexibility. And, at the same time, it leads to improved system capability. The Memory Pac concept improves the electrical characteristics of the system by reducing capacitance and inductance, eliminating discrete-component drivers and receivers, and using single-ended selection of word wires.

Also, because it is modular, the memory's size

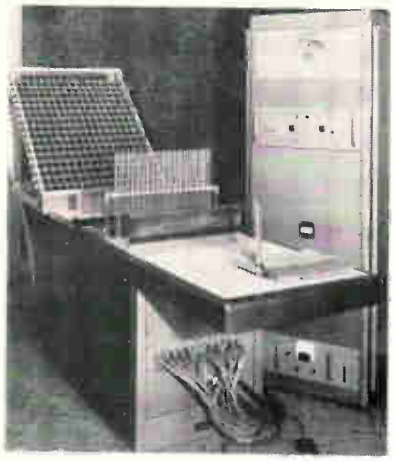


Selector gate module. Plugging jumpers into different positions enables this circuit to be used with memories as large as 256 by 256 bits.

From the loom of MTI . . .

Capable of weaving braids of up to 256 wires each at 60,000 bits per hour, Memory Technology's loom combines modern electronic instrumentation with the centuries-old technique of textile weaving. For a 512-line memory, two 256-wire braids—to be placed onto each leg of the U-shaped core—are encapsulated as a single unit. Heart of the loom's electronics is a paper-tape reader, error-checking circuitry, and power supply.

Data to be stored in the braid is read from the paper tape and stored in a small buffer memory. Binary 0's in the memory cause control rods to be pulled to one side. This motion establishes one separation of 1's and 0's in the braid. A mechanical arrangement measuring about 18 by 10 by 4 inches then lifts the control rods that have been pulled aside. To maintain the separation, the operator inserts a temporary separator between the raised wires and those that are not. Later, a U-shaped core will fit into the space where the temporary separator is inserted.



Compact. MTI's loom for braiding.

The mechanical apparatus also feeds back the separation to the electronic portion, for comparison with the data read from tape. The operator can, if he wishes, set the controls before starting to weave a braid so that if an error occurs, the loom automatically repeats the selection.

The process is then repeated for the next separation.

The predecessor of MTI's tabletop loom was the big Jacquard loom at the Massachusetts Institute of Technology's Instrumentation Laboratory. Unlike that machine, which was designed for textile work and modified for braid weaving, the loom used at MTI was designed specifically for braid work. Controls on the loom are electrical. Because hydraulic or pneumatic equipment isn't needed, the loom's speed and reliability are enhanced.

can be increased simply by adding the appropriate modules. For example, two memories whose capacities differ by a factor of more than 250 can be made from the same modules, as shown in the table below. The large system's capacity prevents it from attaining the same high speed as the small system. However, it can attain a cycle time of 1 microsecond.

Braids in context

The MTI loom, shown above, is weaving braids for applications ranging from microprogram storage in general-purpose computers to constant-function generators in digital filters. And the trend toward using more read-only memories in computers should give the loom plenty of additional work in the future.

Computer designers are turning to read-only memories to simplify the setting up of computers for special applications. The memories reduce the amount of software needed. Braid memories have an edge in this application. Since their construction can be programed automatically, they are easy to make. And, they are less expensive than other forms of read-only memories.

For example, rope memories, another form of transformer memory, cost several times as much as braid memories. The rope design calls for a core that switches, so the core cannot have an air gap and must be annealed before the memory is assembled. As a result, the cores must be made in one piece and the wires threaded through the cores one by one—an expensive procedure compared with weaving.

Braid memories are also more economical than diode arrays, which cost about 10 cents per bit for the array, plus the cost of the sensing and driving circuits. Read-only memories have generally been used in applications requiring no more than 1,000 bits, such as character generators in display systems. However, integrated-circuit techniques are expected to drive down the cost of diode and other semiconductor memories.

The other two major competitors are resistive and capacitive memories, both of which can be made cheaply by etched-circuit techniques. Resistive memories cost only a few cents per bit, but have poor signal-to-noise ratios. Capacitive memories compete on the basis of speed.

Two modular memories

	Small	Large
Capacity, words	512	32,768
Word length, bits	8	32
Current source, control modules	1	1
Selector gating modules	3	8
Flip-flop modules	1	3
Memory Pacs	1	2
each containing:		
Braid assemblies	1	4
Wires per braid	64	512
Sense gates	64	256
Transformer cores	64	256

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2. B.W. Kington and D.M. Taub, "The Design of Transformer (Dimond Ring) Read-Only Stores," IBM Journal of Research and Development, Sept. 1964, p. 443.
3. R.L. Alonso, "Vintage machine produces memories," Electronics, May 1, p. 88.

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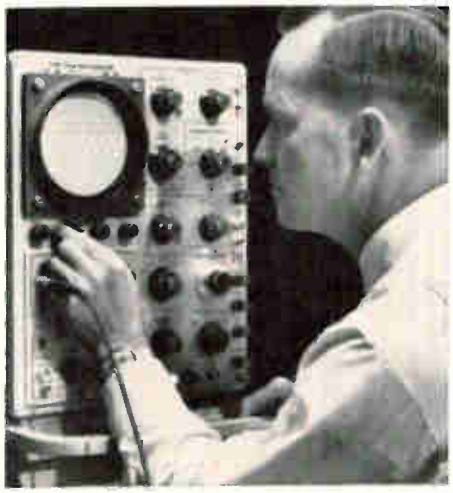

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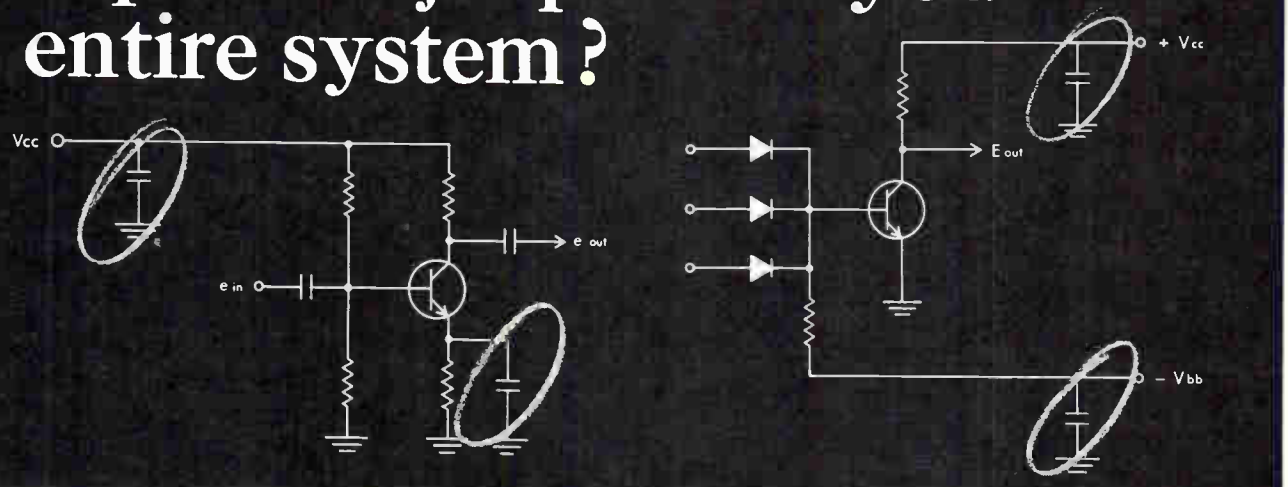

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Problems of heat removal chill progress in IC's

Uncertainties in analysis and gaps in design and test data force designers of integrated electronic systems to use thermal management techniques rooted in the transistor era

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After months of work, a project engineer plunged the new airborne computer into boiling oil to begin testing its ability to operate well in the extreme temperatures of a jet aircraft. In the sealed housing were crammed 2,000 integrated circuits and heat exchangers so efficient the IC junctions couldn't get hotter than 125°C.

But after a year of operational trials, the computer was rejected because of poor thermal design. During most of the test period, the IC's continually heated up to 100°C although the air temperature around the computer rarely exceeded 35°C; 100°C was too hot for long-term reliability. The production contract was won by a competitive design that allowed junction temperatures to rise to 150°C during the brief periods the aircraft traveled at top speed at very high altitudes, but held junction temperatures below 90°C in day-to-day operation.

What went wrong? Whoever insisted on the worst-case design didn't realize that a cooling system can be highly efficient in one environment, but inefficient in another. The convective cooling capacity of the air in the normal environment wasn't considered in the high-altitude design.

While the example is fictitious, the problem is not. Such pratfalls occur because thermal management in integrated electronics systems is not a well-defined field nor is it well understood by specialists in other engineering disciplines. Evidence of this is the fact that even IC manufacturers do not supply packaging engineers with the IC thermal characteristics needed to do a good design job, and that system designers may unthinkingly specify inappropriate packaging configurations and hardware.

Although the IC era is now some five years old, packaging approaches are mostly throwbacks to the transistor era. There have been few fundamental advances. Thermal management techniques now lag so far behind IC developments that they represent a serious impediment to general progress in integrated electronics. Equipment made with today's IC's rarely achieves the hoped-for increases in reliability and decreases in size and weight—which should temper the optimism about tenfold improvements in reliability and packaging density with large-scale integration in the near future.

Accomplishments have been few because most of the effort and money lavished on IC cooling studies has been spent on only part of the problem. Thermal analysis has reached a new high in popularity, while thermal design and tests, needed to prove out designs, are virtually ignored. The reason is obvious—thermal analysis is quicker and less expensive than devising new thermal management systems and adequate test criteria.

Thermal analysis is undependable for accurate design because too many variables are unknown when analysis is made. If a design is based on analysis alone, the uncertainties can easily add up to an error of 25%. This forces overdesign that may make the cooling system bulky and introduce failure-prone mechanical parts. The only way to get an accurate design today is via the painstaking route of analysis, preparation of a thermal mockup, testing the mockup, refining the design, and finally verifying the design in long-term operational tests.

No substantial progress is likely until the industry recognizes that thermal management is at an early stage of evolution. It may then support thermal management programs of the type that made radio-frequency-interference control, reliability, and maintainability well-defined disciplines. Criteria for

analysis, design, and testing must be developed and coordinated, and time and manpower provided for exploring and evaluating new cooling techniques, such as direct immersion in dielectric liquids.

Interface uncertainties

Thermal analyses are not inaccurate because of lack of knowledge about the principles of convective, conductive, and radiative heat transfer. There are dozens of formulas that can be used. Designs based on such analyses are risky, however, because many assumptions must be made about factors that are uncontrollable in equipment production, installation, and operation.

In the first place, a mix of heat-transfer modes is probably involved in a design, and the actual heat-flow paths are always somewhat different from the generalized paths used in an analysis. No general expressions covering all the modes have been devised because the key variables of each mode are different. The thermal resistance of a radiative heat-transfer system varies as the cube of the mean temperature. If convection is employed, resistance depends upon air temperature and the difference between the temperatures of the air and the surface being cooled. In conduction cooling, the main variable is the temperature of the conductive medium.

Moreover, many of the so-called constants in the formulas are actually low-order variables. Selecting the right values of these variables depends in part on the analyst's experience and judgment. Also, form factors in electronic equipment rarely fit the geometric shapes upon which convection formulas are based. Finally, the calculations can be upset by variations in power dissipation from IC to IC, and even by such seemingly minor things as differences in clamping pressures in a conductive cooling path, or in the mounting torque of stud-mounted devices, and by variations in the dimensions and conductivities of hardware in the heat-conducting paths.

Assumptions must also be made about the operating environment. Unless a new avionics system, for example, directly replaces earlier equipment, the thermal interfaces between the system housing and the aircraft must be guessed at.

Suppose the heat is to be radiated from the housing. Usually, the designer has only rough information on view factors (how much of the radiation will be blocked or reflected by adjacent structures), on aircraft skin or bulkhead temperatures, and on emissivities of surrounding surfaces. The mounting method may not have been decided, if the aircraft is a new one, and even if the mounting is specified, the designer must estimate such factors as thickness of conductive greases or adhesives, and how much of the mounting area is covered.

Fahrenheit's laws

Despite their shortcomings, formulas must be used by the designer because cookbook solutions are of less merit. When a designer relies upon the literature, he chooses his thermal resistance values arbitrarily. The raw data available on heat conduction and convection applies only to specific equipment configurations, environments, and uses.

A design that depends upon conduction for heat transfer must allow for contact resistances between materials in the heat path. The data in the literature are for particular alloys, particular mating methods, particular temperature ranges and atmospheres, and so on. The probability of a new design meeting all these particulars is small, yet a change in any parameter significantly changes contact resistances.

Most designers start with the values for thermal resistances that, from experience, approximately fit the contemplated design. Uncertainties are cleared up, when necessary, by bench tests and the use of thermal mockups. Component temperatures can then be calculated by applying the heat-transfer equivalent of Ohm's law.

The equations in the table at the right were most useful to the authors—although they do not appear in textbooks on heat transfer. Commonly used values of the convection variables are tabulated on page 133. No formulas are given for forced convection, since the texts are full of them.

Forced convection

Solutions obtained from forced-convection analysis are almost always less accurate than those obtained for other modes. Among the reasons are:

- Coefficients and exponents are different for flows over exterior and interior surfaces. If the designer considers the cooling air or liquid to be flowing on the exterior of the circuit boards, he'll get one answer. If he considers the flow as being inside the system housing, he'll get a somewhat different answer.
- It is almost impossible to calculate the air velocity at each point in the flow path. Velocity varies with blower speed, cross-sectional area of the flow path, and with smoothness of the surface being cooled. Some components may not be swept by the air stream because it is obstructed.
- The equations are based upon empirical data obtained with regular geometric shapes. Electronic assemblies are rarely perfect planes, spheres or cylinders.

Nevertheless, the designer of IC cooling equipment must frequently rely on forced-convection systems. In compact equipment, free air space may be insufficient for natural convection, and at high altitudes the air is too thin. Natural convection between boards packaged in conventional card files drops by 25% between sea level and 15,000 feet of altitude, and ceases entirely at slightly above 20,000 feet.

The unwary designer can be misled by specifications requiring that the mean time between failures (MTBF) of components be proven in tests at sea level rather than at operational altitudes. Suppose analysis indicates that junction temperatures will not exceed 90°C at operating altitude. Sea-level tests confirm this but the junctions actually heat up

Thermal design formulas

Natural convection

$$\Delta T_{s-a} = QR$$
$$R_v = 4.4(QZ_a)^{-0.2}L^{0.2}(A_sK_a)^{-0.8}$$
$$R_u \approx R_v$$
$$R_d = 1.8R_v$$
$$Z_a = gB_a\rho_a^2/\mu_a^2$$

where,

ΔT_{s-a} = temperature difference (°F) between the surface being cooled and ambient air
Q = heat dissipation, in watts
R = thermal resistance, °F/watt
R_v = natural convection thermal resistance for a vertical surface, °F/watt
R_u = natural convection thermal resistance for a horizontal surface facing upward, °F/watt
R_d = natural convection thermal resistance for a horizontal surface facing downward, °F/watt
L = significant dimension of the surface being cooled, in feet
A_s = area of the surface being cooled, ft²
K = thermal conductivity, Btu/hr-ft-°F
g = gravitational acceleration, ft/hr²
B = coefficient of expansion, 1/°F
ρ = density, lb/ft³
μ = viscosity, lb/ft-hr
a = subscript meaning that the variable is evaluated at air temperature

Radiation

$$R_r = \frac{4.9\times10^8(1/\epsilon_1+1/\epsilon_2-1)}{A_r\,T_m^3}$$

where,

R_r = radiation thermal resistance, °F/watt
ϵ_1 = emissivity of surface being radiated to (net), dimensionless
ϵ_2 = emissivity of surface being radiated from (net), dimensionless
A_r = area of radiating surface for parallel flat surfaces or projected area of non-parallel surfaces, ft²
T_m = mean temperature between the radiating surface and ambient, °R

Since T_m depends on the temperature difference that is being solved for, it is found by an iterative method. The temperature difference is repeatedly assumed and then solved for until the assumed and calculated values are approximately equal. For example, let

T_{amb} = 100°F = 560 °R
$\epsilon_1 = \epsilon_2 = 0.9$
A_r = 1 ft²
Q = 20 watts

then:

$$R_r = \frac{4.9\times10^8(1/0.9+1/0.9-1)}{(1)\,T_m^3} = \frac{5.9\times10^8}{T_m^3}$$

assumed ΔT	T_m	R_r	calculated ΔT
100	610	2.58	52
60	590	2.88	58

therefore: T_m = 59°F

Contact resistance

Thermal resistance across a metal-to-metal interface in a vacuum is approximated by

$$R_{cv} = \frac{(8+e^d)(Y_o\times10^{-3}+16)^{0.34}}{(3\times10^3)(8.9+0.1e^d)} \cdot \frac{(W_o\times10^3+10)^{1.7}}{F(P_a)\,G(S_f)}$$

where

R_{cv} = thermal contact resistance, °F-ft²/watt
P_a = apparent contact pressure, psi
d = distance between clamping points, in.
S_f = surface finish of lower yield point surface, μ in.
Y_o = initial yield point of material on hot side of interface, psi
W_o = initial total flatness, in.
$F(P_a) = 0.5+0.1P_a$ when contact pressures are between 2 and 10 psi
$F(P_a) = 0.85+0.065P_a$ at contact pressures between 10 and 30 psi
$F(P_a) = 1.8+0.034P_a$, at contact pressures above 30 psi
$G(S_f) = 1.0$ for surface finishes between 12 and 46 microinches
$G(S_f) = 0.64+0.03(S_f\times10^6)$ for surface finishes below 12 μ in.
$G(S_f) = 0.79 - 0.0046\ (S_f \times 10^6)$, above 46 μ in.

In air the thermal resistance of a metal-to-metal interface is approximated by

$$R_{ca} = \frac{R_{cv}/W_o}{(W_o+32R_{cv}K_a)}$$

where

R_{ca} = thermal contact resistance in air, °F-ft²/watt
K_a = thermal conductivity of air (evaluated at the mean interface temperature), Btu hr-ft-°F

to 100°C when the planes are flying. The lower MTBF that results may not show up until a number of systems have been in operation for a year or two.

Asking for trouble

Information needed to determine IC junction temperatures—the core of the design problem—isn't available from the IC manufacturers. IC specification sheets contain only the worst-case temperature values, but not thermal transfer characteristics of the IC package.

Thermal characteristics of devices from the same production run can vary as much as 5:1, as indicated on the upper sketch in the diagram on page 132. Different packaging methods can result in a 15:1 variation. This causes problems in reliability analysis as well, since IC failure rates cannot be determined if junction temperatures are unknown. To make sure MTBF is adequate, safety factors must be applied to the cooling system design—in other words, the system must be overdesigned.

IC manufacturers don't want to commit them-

selves to a specific junction-to-case thermal resistance because that may prevent future changes in materials, die sizes, processes, or bonding methods. However, such changes can cause major problems after a thermal design is frozen and a long production run begins. The system contractor could approve thermally unacceptable changes; in fact, most procurement specifications do not cover control of thermal characteristics.

The oversight can be corrected by making reasonable requirements part of the purchase order—for example:

- Junction-to-case thermal resistance shall not exceed 500°C/watt when the only heat-removal surface is the IC package base.
- Thermal resistance of each lead, including lead-to-die bond, shall not exceed 4,000°C/watt/inch measured from the package centerline. This may be ignored if the leads are not used as heat paths.

These particular requirements can assure junction temperatures 30°C lower than the worst case. Reliability will be higher. In some cases, the designer could avoid using an air blower or cooling fins.

Choosing a design

The family of curves on page 133 have helped the authors to weigh qualitative relationships between design options. Similar groups of curves have been developed for different device packages, coolants, and assembly configurations.

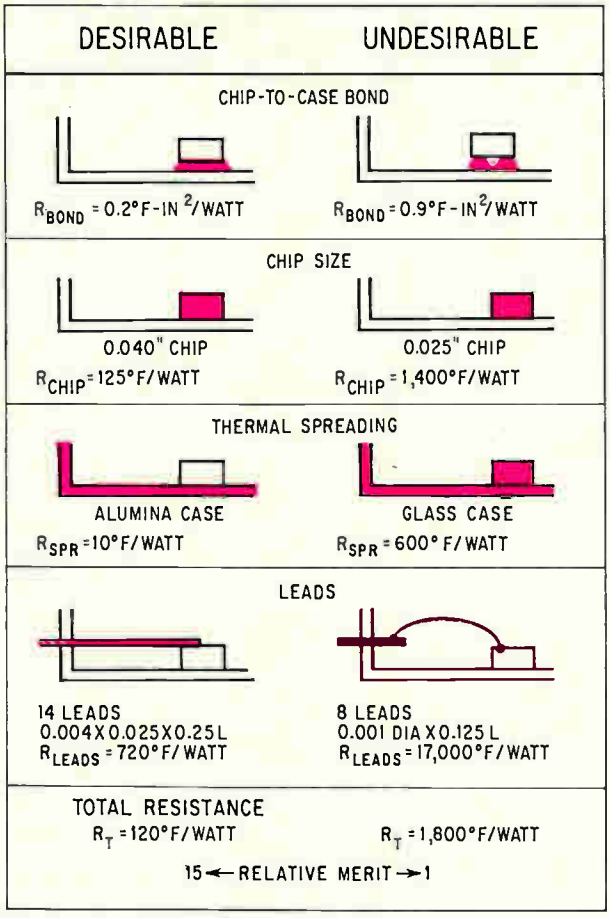
The curves represent the cooling capability of each method when heat sinks are not used. With heat sinks, each curve shifts to the right an amount depending on the type and location of the heat sinks. Each clockwise step from curve to curve represents an incremental decrease in maintainability. Natural convection requires no moving parts, forced convection requires a blower, immersion cooling usually takes pumps, seals, and heat exchangers, and evaporative cooling demands the equivalent of a refrigerating system or a replenishable coolant supply.

Each step from curve to curve also represents a step down in system size, due to higher cooling efficiency. Note the dramatic improvement in efficiency that is possible with liquid cooling. Large-scale integration will probably force further development of immersion and evaporative systems, leading to equipment that is higher in reliability although more trouble to maintain.

With such curves, a designer can quickly weigh tradeoffs. Suppose he wants to make sure that IC package temperature will not exceed 300°F at a power dissipation of 1 watt. If he selects natural convection, he must use heat sinks. If he selects forced convection, he pays a maintainability penalty but gains a safety factor of 50°F, since forced convection holds package temperature to 250°F at 1 watt dissipation.

Thermal mockups

Whenever feasible, the analysis and paper design should be backed up by testing of thermal



Package problems. Thermal characteristics of integrated circuit flatpacks can vary as much as 15:1 because of differences in construction, processes, materials, and dimensions. In each illustration, color shows the part responsible for the thermal resistance value given.

mockups. Subassembly and assembly models such as those on page 134 are used at Loral Electronic Systems so that thermal analyses can be checked early in the development cycle. The models can be built before the circuit designers have completed their work.

The flatpacks in the circuit board mockup contain resistors whose power dissipations equal those of the IC's to be used. The resistors are silicon monolithic types made with the same die size and packaged by the same processes as the IC's they represent. The resistors are connected to appropriate power supplies and test instruments by etched wiring.

Junction temperatures in the model will be essentially the same as in IC's. Resistor values can be monitored to detect heating that would affect an IC's transfer function; silicon resistors have a high thermal coefficient of resistivity. If a resistor becomes too hot, it will fail like an IC because the die bonds or chip metalization is degraded. Package temperatures, heat flows and hot spots are determined by any of the common techniques, ranging from the use of sensors to plotting thermal patterns with infrared scanners.

Assembly mockups are used to determine such

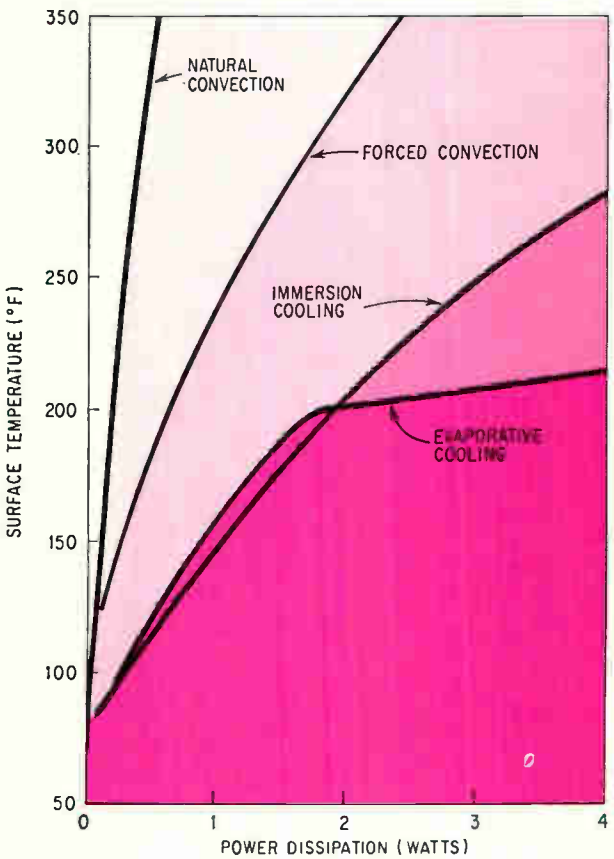
Commonly used values of convection variables

Altitude ft	T °C/°F	ρ lb/ft^3	μ lb/ft–hr	K BTU/hr–ft–°F	B °F^{-1}	$gB\rho^2/\mu^2$ 1/°F–ft^3
Sea level	25/77	0.074	4.5×10^{-2}	0.0149	1.87×10^{-3}	2.24×10^{6}
Sea level	35/95	0.072	4.6×10^{-2}	0.0153	1.77×10^{-3}	1.85×10^{6}
Sea level	55/131	0.066	4.9×10^{-2}	0.0160	1.71×10^{-3}	1.30×10^{6}
Sea level	71/160	0.064	5.0×10^{-2}	0.0166	1.63×10^{-3}	1.22×10^{6}
Sea level	95/203	0.060	5.1×10^{-2}	0.0174	1.52×10^{-3}	8.50×10^{5}
10,000	53/128	0.046	4.8×10^{-2}	0.0161	1.71×10^{-3}	6.54×10^{5}
10,000	68/155	0.044	4.9×10^{-2}	0.0165	1.64×10^{-3}	5.48×10^{5}
10,000	93/199	0.041	5.0×10^{-2}	0.0174	1.52×10^{-3}	4.18×10^{5}
50,000	20/68	0.0086	4.4×10^{-2}	0.0147	1.90×10^{-3}	2.98×10^{4}
50,000	35/95	0.0081	4.6×10^{-2}	0.0153	1.77×10^{-3}	2.34×10^{4}
70,000	10/50	0.0034	4.3×10^{-2}	0.0144	1.97×10^{-3}	5.14×10^{3}
70,000	35/95	0.0032	4.6×10^{-2}	0.0153	1.77×10^{-3}	3.61×10^{3}

factors as adequacy of selected heat sinks and air blowers, and the best circuit board mounting arrangement.

Preferred designs

When a thermal design proves itself adequate in one system it should naturally be considered a candidate for use in similar systems—with appropriate modifications. The use of preferred designs may not advance techniques to the theoretical ultimate, but they make for system effectiveness. Besides, the time and money needed to work up and prove out totally new designs is rarely available.



Tradeoff curves. Quick comparisons between alternate cooling techniques can be made with families of curves. Efficiency rises and size decreases from left to right in this comparison of methods for cooling TO-5 packages.

The mockups on page 134 are two of Loral's preferred designs. The board is a multilayer one, with the top layer used as a heat conducting plane. Heat flows through the metal strips under the flatpacks. The strips are generally aluminum 3/8 inch wide and 0.010 inch thick. Thermal resistance of the configuration is 17% less than a solid alumina substrate 0.050 inch thick, and only slightly more than a beryllia substrate.

Clamped metal-to-metal interfaces transfer the heat from the strips along the board edges to a card file and then to the assembly case. The case is the heat sink. Heat is removed from the case by convection and radiation.

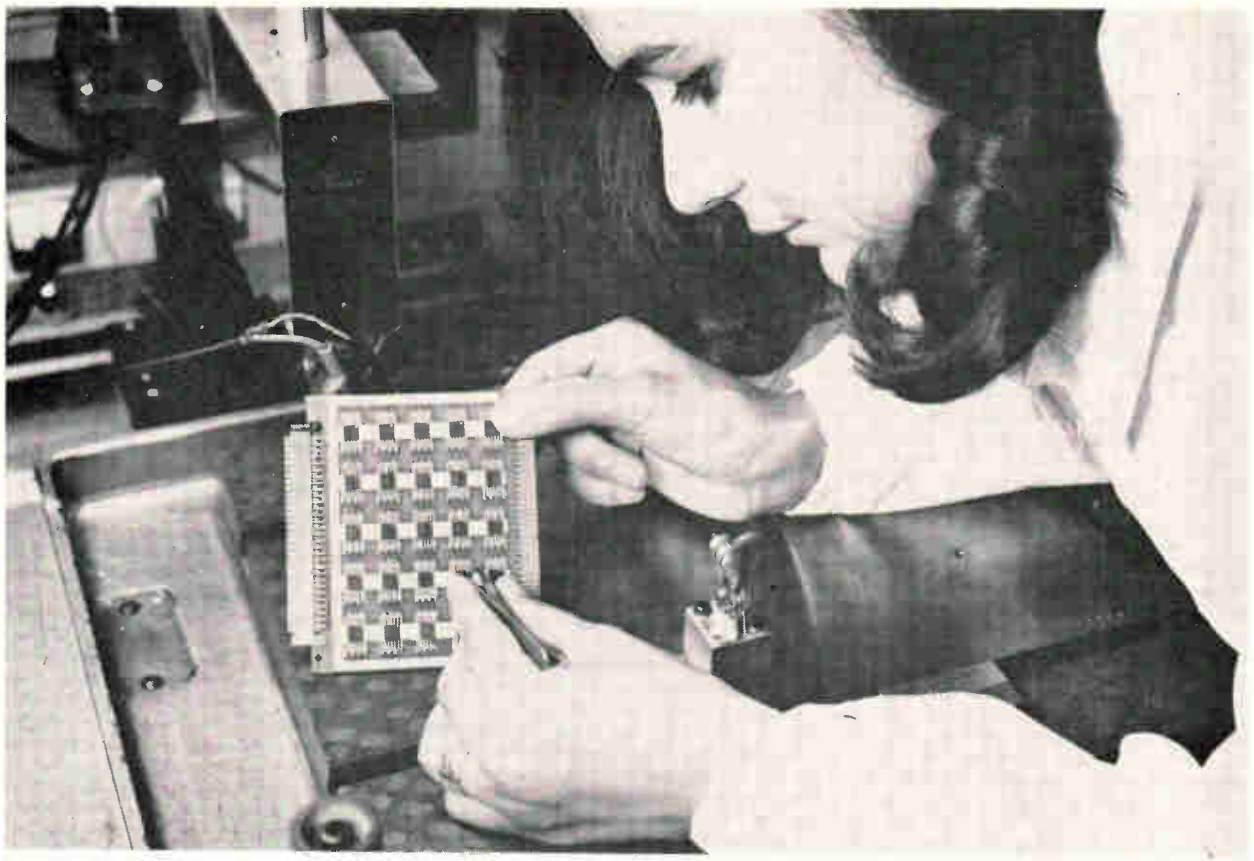
The chevron card arrangment in the second photo on page 134 will, on the average, keep components about 4°F cooler for each 10 watts of power dissipation in a forced-convection system than mounting the cards in the usual way. Conventionally, the cards are mounted in a manner that requires the airstream to make one or more 90° turns. Angling the cards makes them catch the breeze better, but there is a more subtle reason for the better cooling.

Increasing the turn radius to 120° reduces the turn angle to 60°. The drop in air pressure is lower than in a 90° turn, and the air velocity is 30% higher. Therefore, the air can pick up heat from the components more efficiently (air's heat transfer coefficient varies with velocity). The temperature difference between the air and the component surfaces decreases by 6.8%, and the components are correspondingly cooler.

Designs not preferred

Mechanical design of equipment packaging often precedes thermal design, and sometimes parts requiring long lead times are ordered before the thermal design is established. This causes more delay and higher costs than when the two designs are worked out jointly.

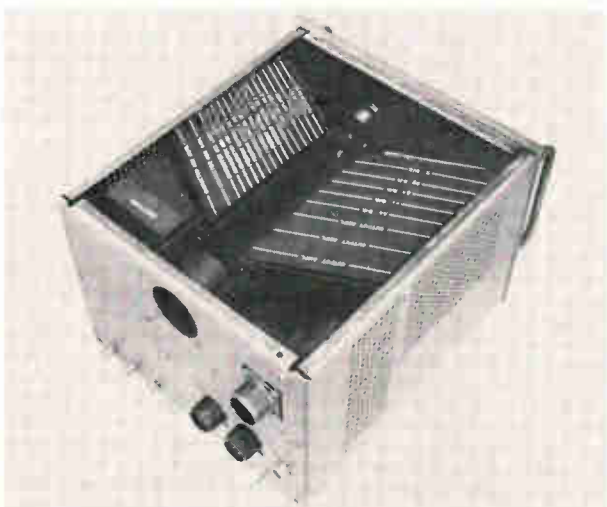
More often, the designer must use thermally inadequate parts because they are the ones readily available. Typically, a decision is made to plug circuit boards into available card files. These



Thermal mockup. Conductive cooling design for multilayer board assembly of IC's can be tested with a mockup like this. The flatpacks contain silicon resistors.

are expected to serve as primary heat paths, although they conduct heat poorly. As a result, the designer must rig up alternate conducting paths or resort to blowers, so system effectiveness suffers.

Another reflex use of stock items is the selection by electrical engineers of power supplies with 10% regulation. In many cases, a system would be more reliable and less expensive if extra money were paid for 5% or 1% power supplies. Components would run cooler and the cooling system would not have to be beefed up to allow for overloads up to 10%.



Chevron. Air stream cools more efficiently when circuit cards are placed at 120° angle rather than the usual 90°.

Components such as power transistors sometimes pump out more heat than the cooling paths can readily handle, creating hot spots. Heat sinks or finned cooling devices can spread the heat.

Thermoelectric coolers should be used only as a last resort. The coefficient of performance of thermoelectric devices decreases exponentially as the temperature difference across the device increases. Since development of a temperature difference is the reason for using the device in the first place, relatively low coefficients must be accepted. In practice, a reasonable upper limit is 0.5—that is, for every watt removed from the hot component, 2 watts must be removed from the thermoelectric cooler. Thus, the hot spot may reappear at another location, which will not be very far from the original spot because thermoelectric coolers are planar devices whose hot and cold sides are close together.

Thermoelectric devices, moreover, are characterized by high currents and low d-c voltages. A single couple has a voltage drop of about 0.1 volt; currents of 10 amps or more are normal. Since the quantity of heat to be pumped governs the number of couples, the d-c supply voltages needed may not be available from the equipment power supply. A special power supply may be required adding to the system weight, size, and power dissipation.

Cold plates are also generally undesirable. They

should be used when they provide the only system interface—for example, when avionics equipment must depend on a central heat exchanger in the aircraft or missile. To save weight and lower component temperatures, the coolant should be in contact with heat dissipating components whenever possible.

A typical cold plate is a hollow metal chamber through which a cooling fluid circulates. It acts as a buffer between the heat dissipating components and the coolant. The heat follows a tortuous path before reaching the final heat sink. This buffer always absorbs a substantial portion of the temperature difference between the components and the coolant—a difference that is usually limited at best in military equipment.

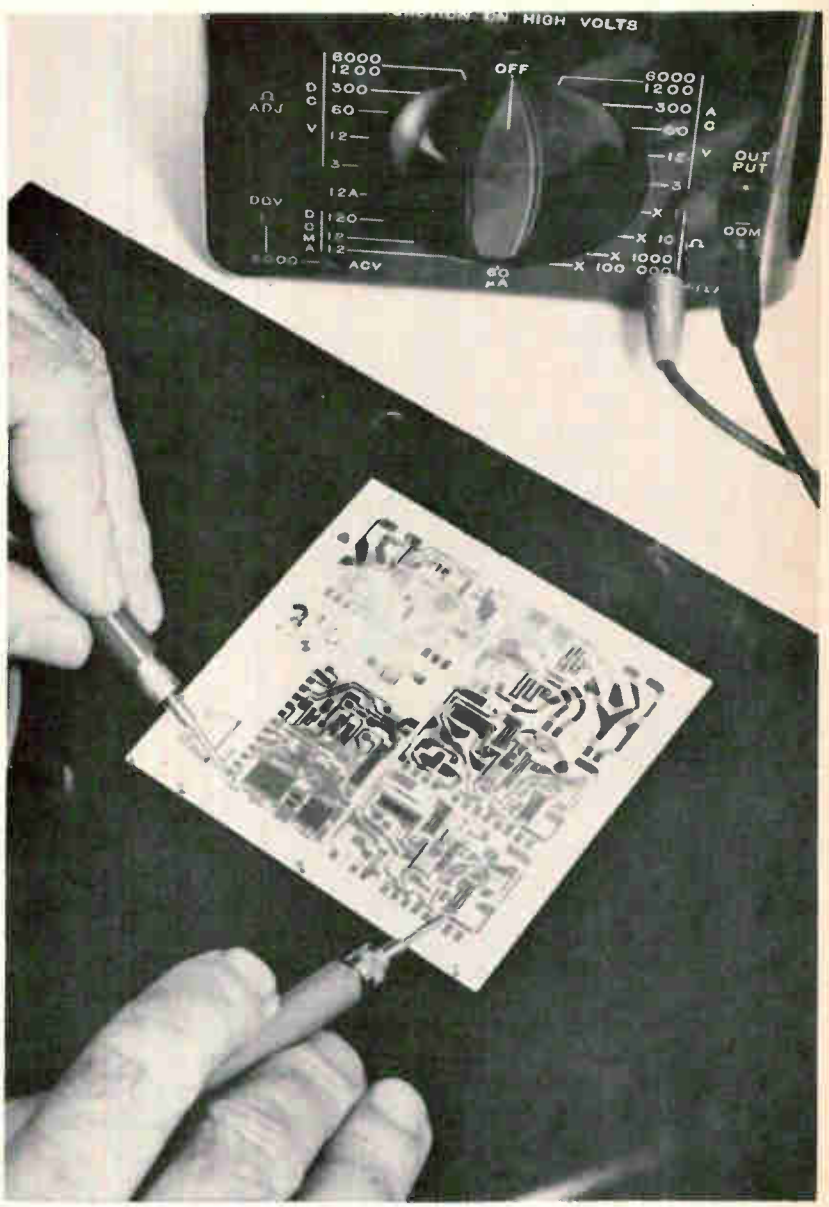
Worst-case design

Thermal designs based on worst-case environments will invariably result in MTBF's being lower than if the design were based on the normal operating environment. The design goal should be the lowest component temperatures in normal use. Backing off from this to minimize the temperature rise in worst-case environments makes the cooling system less efficient in other environments.

While most jet aircraft, for example, operate at altitudes above 30,000 feet, the cockpit is usually pressurized to the equivalent of 10,000 feet. The equipment must be able to operate during a decompression, but that environment will exist for only a small part of the equipment life.

A design based on the high-altitude, decompression condition would use only conduction and radiation, because the air density above 30,000 feet is too low for natural or forced convection cooling. If the designer depends on air cooling during pressurized operation, he can lower component temperatures. Naturally, he'll also make certain that component temperature limits are not exceeded during decompression.

Fin spacing is a good case in point. Fins intended for convective cooling at high altitude are widely separated. Widely spaced fins transfer heat at low



Heaters. Thin-film resistors can be deposited on hybrid circuit substrates to control their temperature by controlling power dissipation. These experimental circuits contain extra heating resistors.

Temperatures in an avionics system

Environment	Worst-case temperatures		Application
	>95% of components	<5% of components	
Sea level $T_a = 95$ °C	120	155	Qualification testing, transient operations
Sea level $T_a = 35$ °C	63	98	Reliability testing, long-duration operations
10,000 ft. $T_a = 35$ °C	68	104	Long-duration operations
70,000 ft. $T_a = 35$ °C	105	140	Qualification testing, transient operations

altitudes—but not as efficiently as a larger number of fins placed closer together.

Another consideration is the relationship between the component population and the maximum component temperature. It may not be necessary to insure that all components remain cooler than the component temperatures required for reliability. Again, the only qualification is that no component be allowed to exceed its temperature limits.

Statistical methods of determining reliability show little difference in MTBF for the following two cases: 100% of the components no hotter than 30°C above ambient; or 95% within 30°C, 3% within 50°C and 2% within 100°C. Designing for the first case instead of the second means paying unnecessary penalties in cost, size, weight, or maintainability.

The table on page 135 represents an actual case—a system designed to operate in a pressurized cockpit. The data represents component temperatures for all pertinent conditions and shows that the equipment will operate satisfactorily in a MIL-E-5400 Class 1 environment. A rise of 35°C above ambient was the temperature limit established by MTBF requirements. The highest temperature allowed for semiconductor devices was 175°C.

The specifications prohibited the use of blowers. Heat was transferred by conduction from all components to the outer surface of the assembly. The rear of the assembly and the rear two thirds of two sides were finned, with fin spacing optimized for an altitude of 10,000 feet. Components with high power dissipation were mounted directly to the finned surfaces. During pressurized operation natural convection transfers the heat from the assembly surfaces to the air, with a negligible assist from radiation. In high-altitude, unpressurized operation, radiation becomes the primary mode of heat transfer.

Putting heat to work

If the temperature of critical circuits must be kept fairly constant, the simplest and most reliable method is to control their power dissipation. Then, the thermal resistance of the cooling system does not have to be made variable to offset fluctuations in ambient temperature—a requirement that might call for moving parts and their controls, such as variable-speed coolant pumps.

Resistors have been added as heating elements to the experimental thin-film circuits on page 135. This is an appropriate method of making IC heaters, since special control circuits requiring temperature stabilization are often made as thin-film hybrid IC's.

The sensing element to be used depends upon the substrate selected for the hybrid IC:

- If the substrate is glass, a thermocouple deposited to contact the most sensitive component is preferred. Because glass conducts heat poorly, the component might overheat before a remote sensor detected the change. However, a thermocouple requires additional circuitry to control power to the heating resistors. Sequential depositions of copper and constantan will form a thermocouple.
- If the substrate is ceramic, a prefabricated thermistor is suitable. Ceramics are generally good heat conductors. One thermistor can control several resistors deposited on either side of the substrate.
- If it isn't practical to put the sensor in the circuit, a thermostat can be placed near it in the heat flow path. Thermostats are economical, but the heat path must be well-defined, which often bars their use in convective cooling systems.

Any of these three methods can control an IC's temperature to ±15°C with less than a watt of power. Consider an IC that dissipates 0.2 watt of power through a normalized thermal resistance of 100°C per watt. At an ambient temperature of 25°C, therefore, the IC temperature will be 45°C. If the ambient drops to —55°C, the temperature can be maintained at 45°C by having the IC dissipate 1 watt—that is, by supplying 0.8 watt to the heating elements.

The higher the thermal resistance of the heat-conducting path, the less heater power is required. A 0.2-watt IC's temperature can be maintained at about 45°C in a —55°C ambient with 0.65 to 0.75 watt when cooling is by convection or conduction, and with 0.4 watt if cooling is by radiation alone. In practice, the value would be somewhere between, because all three modes would be involved.

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The authors

Allen B. Chertoff heads all integrated electronics work at Loral Systems. His group also provides packaging concepts and technical support for the company's antisubmarine warfare and electronic countermeasures groups. His background includes telemetry and digital systems design.

James J. Foti, who is developing a hybrid packaging concept, was formerly consultant to the Navy's ad hoc electronic packaging committee. Before that, he managed packaging and thermal design projects in the Apollo, Polaris, and F-111 programs.

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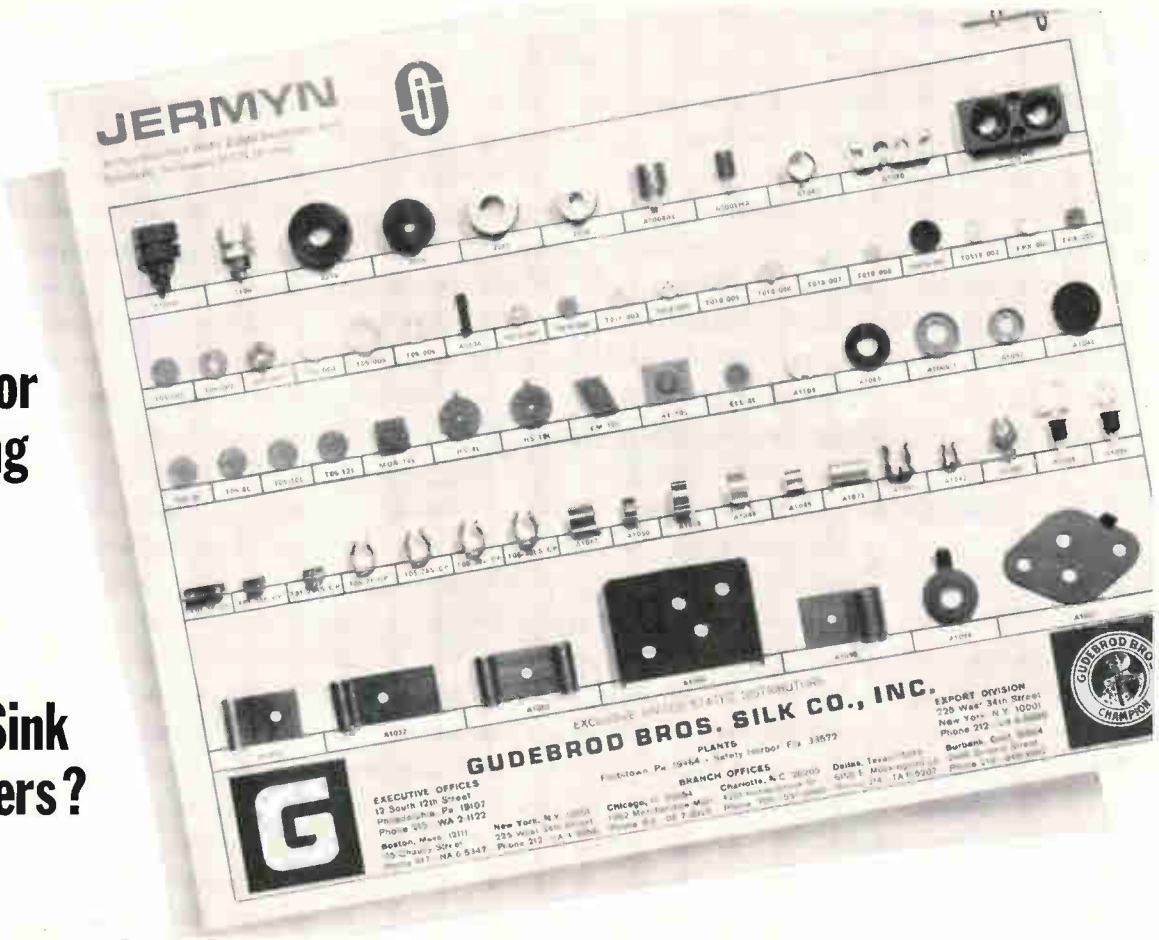

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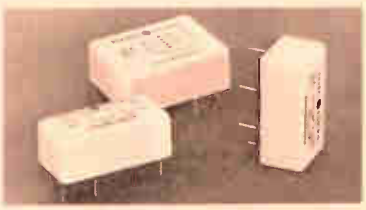

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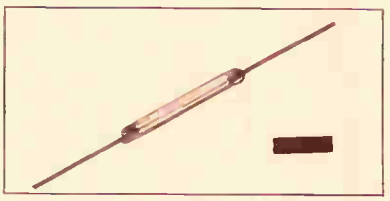

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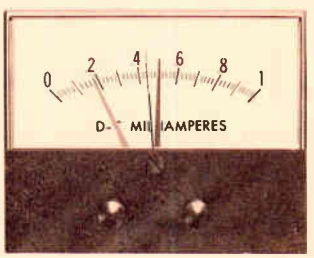

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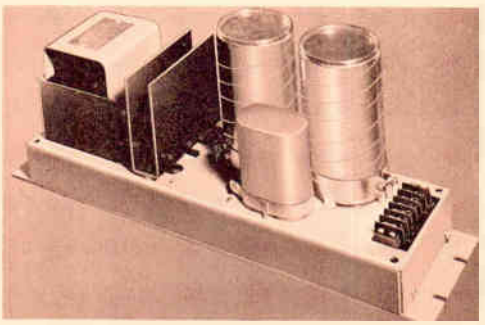

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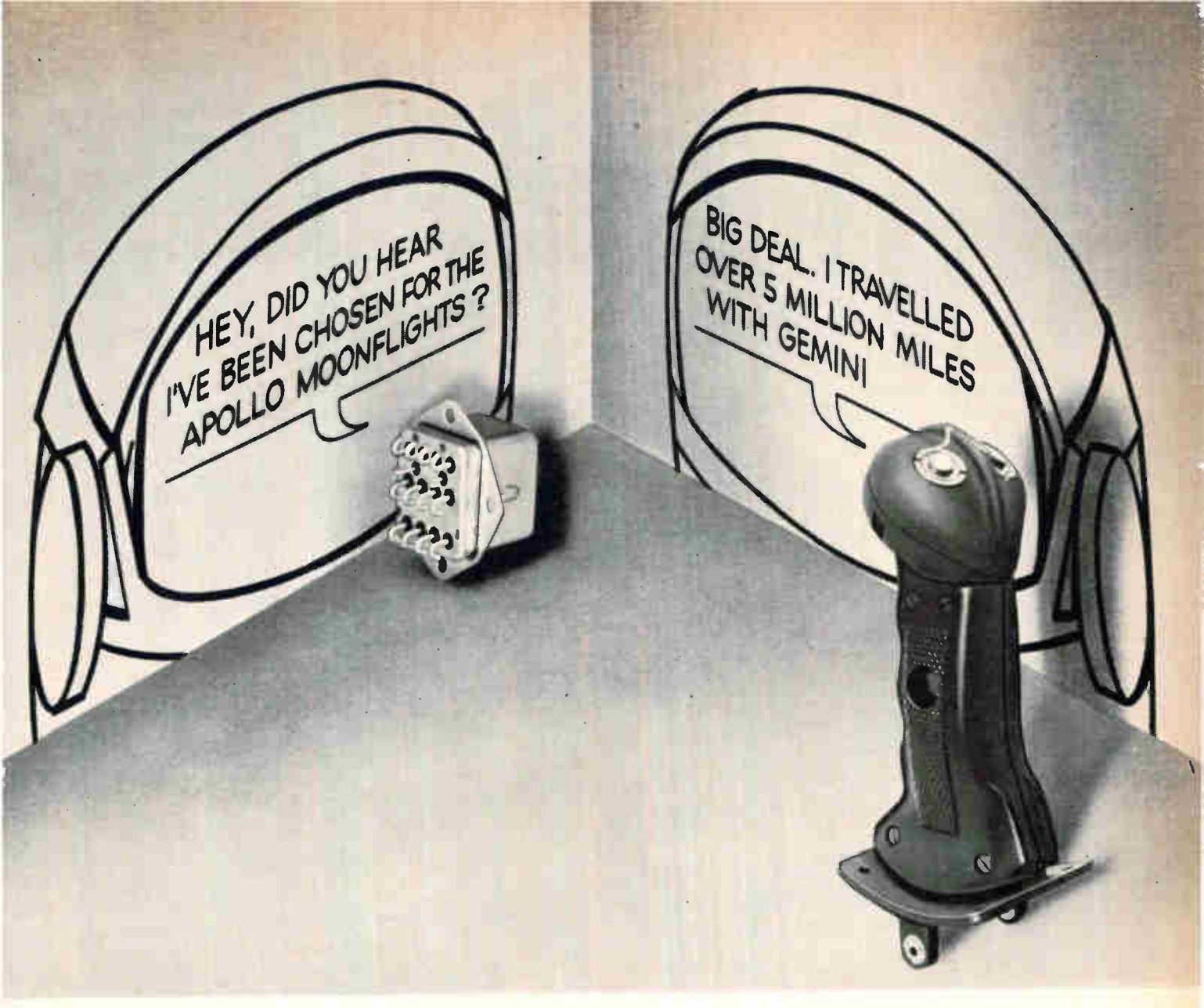

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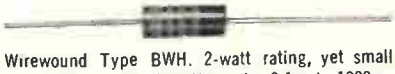

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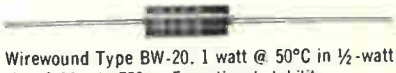

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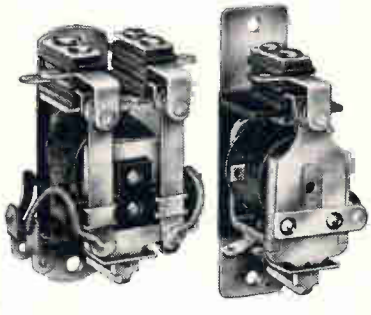

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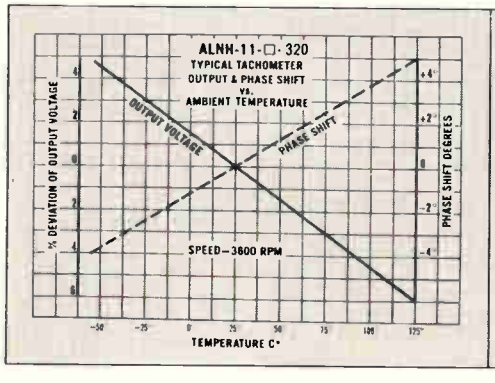

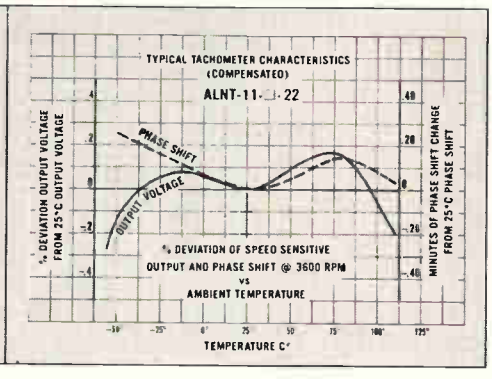

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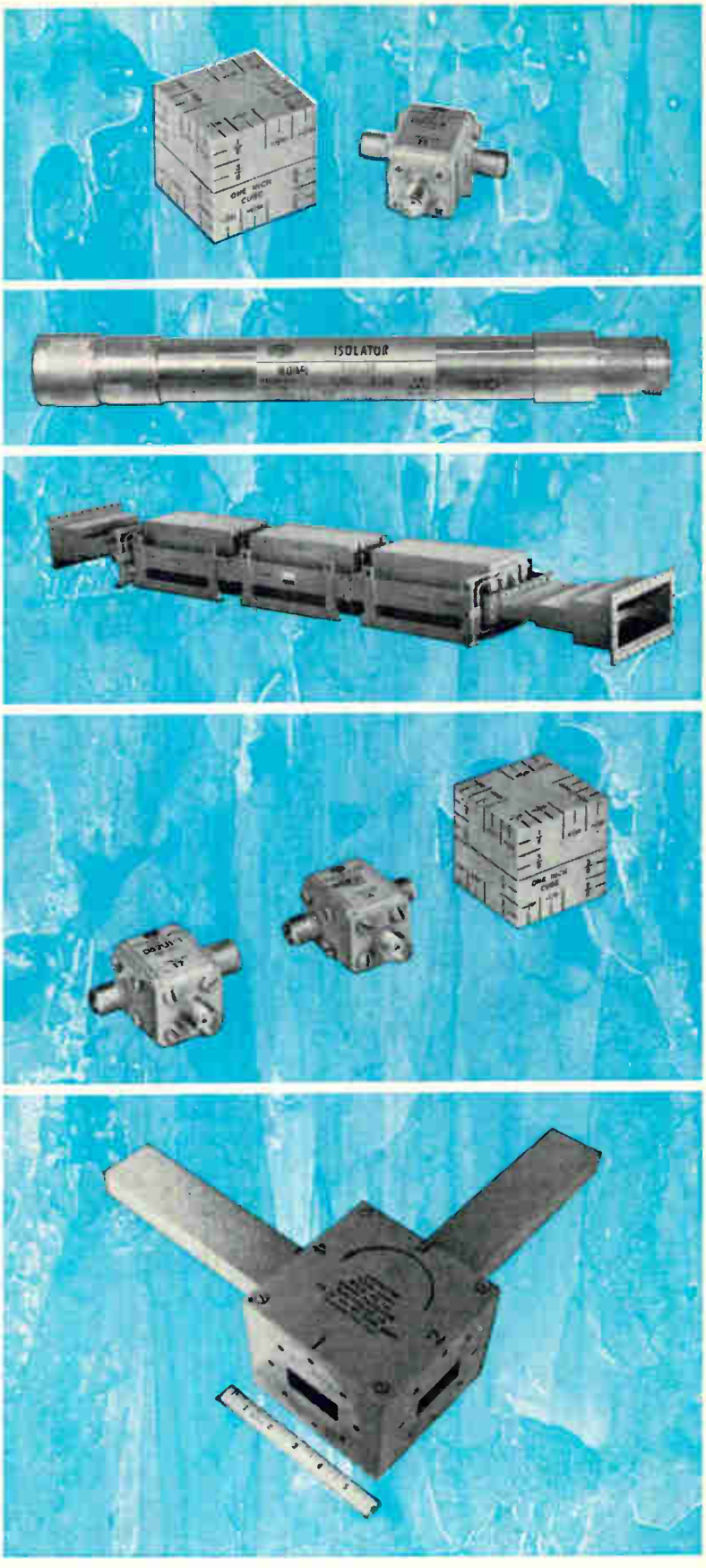

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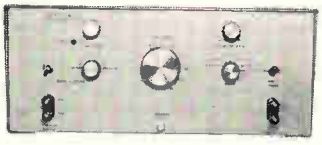

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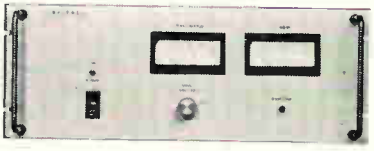

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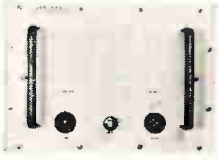

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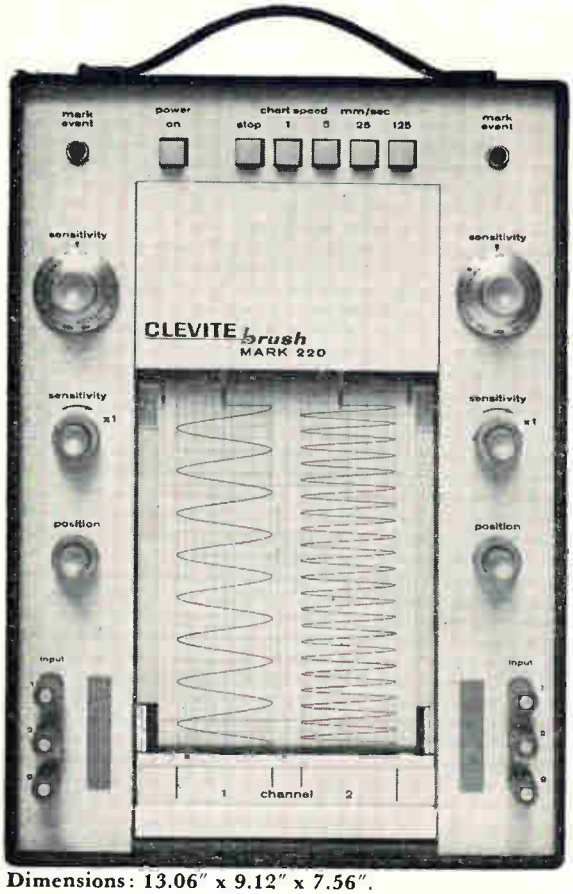

Dimensions: 13.06″ x 9.12″ x 7.56″.

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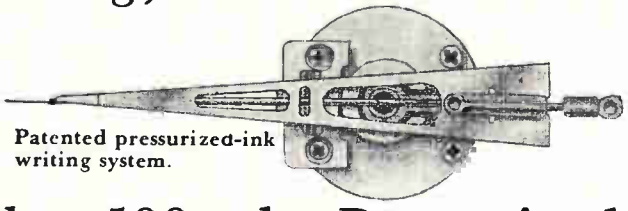
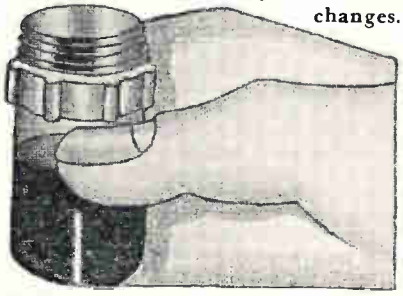

Patented pressurized-ink writing system.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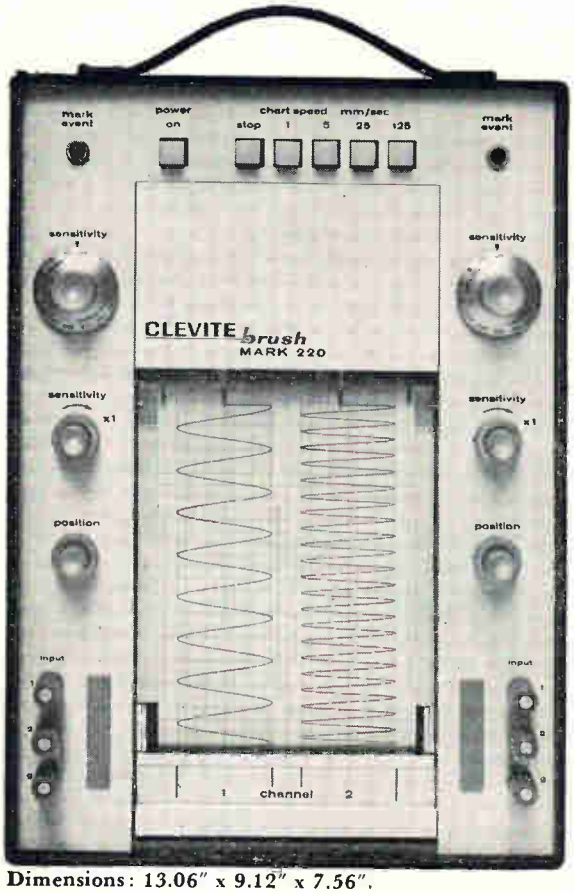

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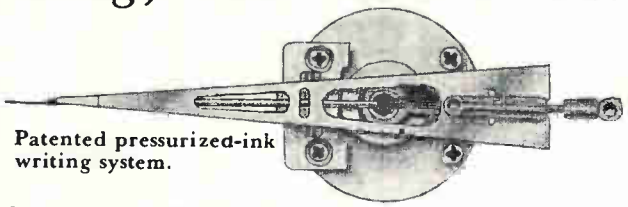
Patented pressurized-ink writing system.

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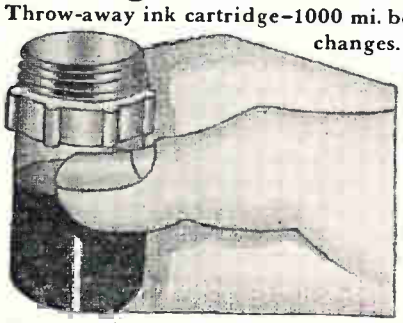
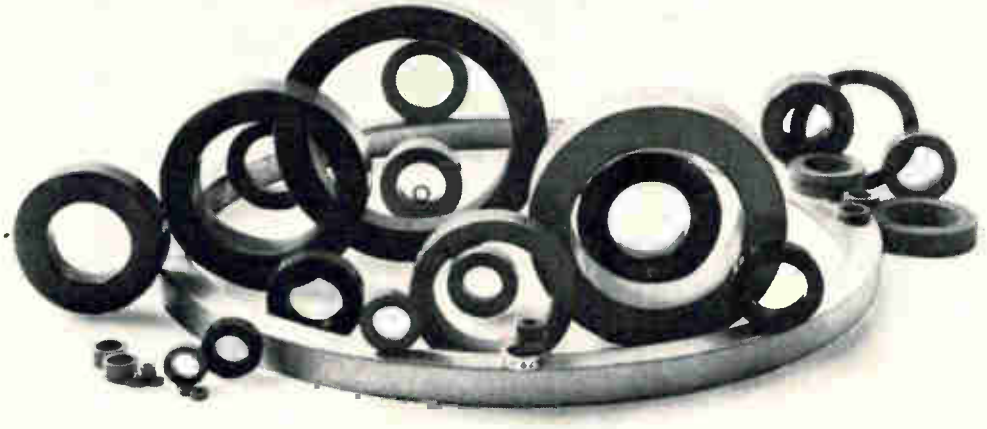


you get a choice,



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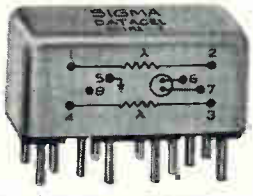

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Option 01 for the 5061A incorporates a built-in digital divider and clock. The divider's 1 pulse per second output is of excellent quality: <20 ns jitter, <50 ns rise time, <1 μs fall time, 10 V into 50Ω. A built-in digital delay generator shifts pulse timing from 1 μs to 1 s by 6 thumbwheel switch decades. Internal and external timing pulses can be synchronized, when desired, simply by pressing the "Auto Sync" button.

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Prices: 5061A Cesium Beam Frequency Standard, $14,800; Option 01, $1500; Option 02, $600.

The 5061A accuracy specifications are backed up by extensive data on HP cesium beam standards: (1) comparison against the U.S. Frequency Standard (USFS, NBS-II and NBS-III) over a two-year span; (2) by three annual "flying clock" experiments in which HP cesium standards were flown around the world and compared to timekeeping standards of many nations; and (3) by comparisons of more than 100 cesium beam standards.

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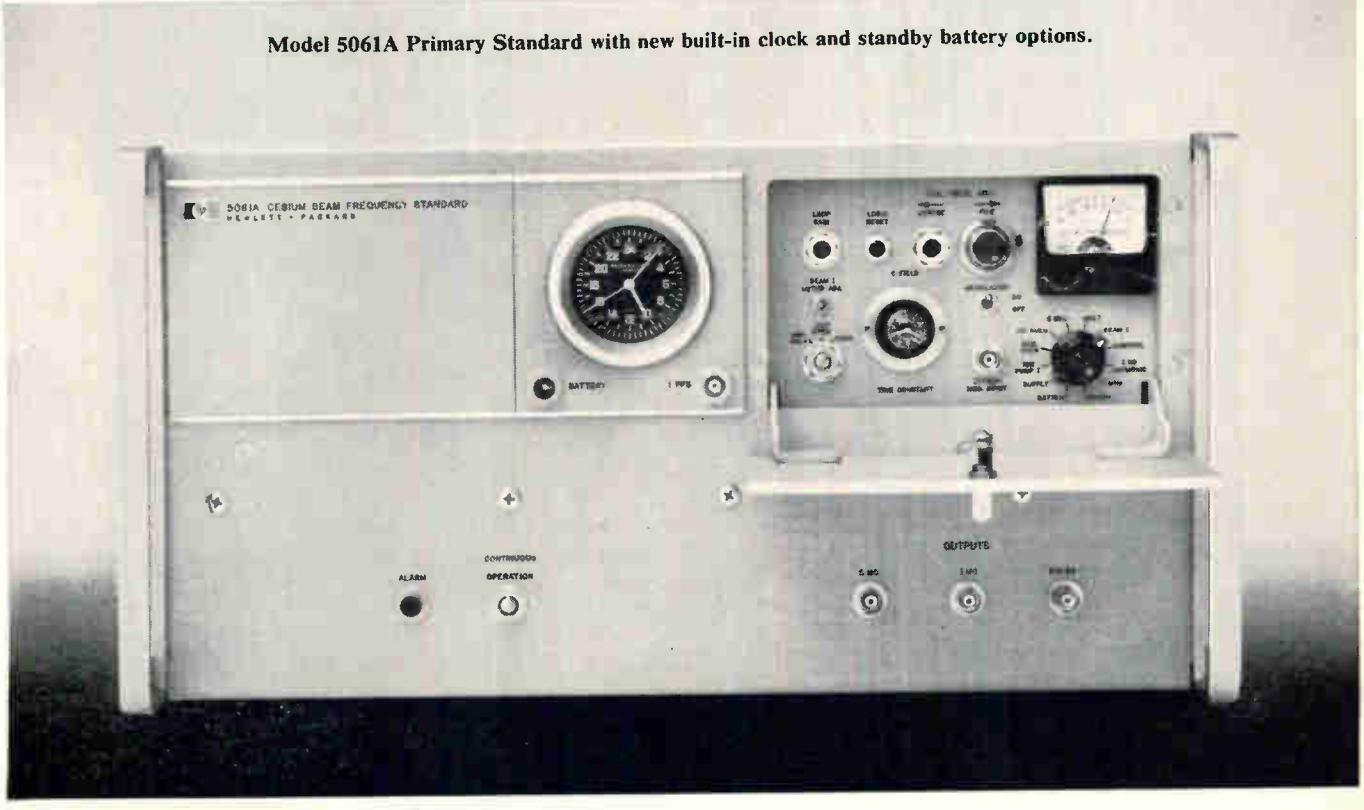

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1.36KΩ to 2.9KΩ	−100 to +300	−0 to +250
3KΩ to 1.35 meg.	−100 to +250	±100
1.36 meg. to 5 meg.	±250	±150
ENR	±2%	±1%
Rotational Life	50,000 cycles ±5% Δ R	100,000 cycles ±10% Δ R
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Probing the News

Patents

Japan's calculated risk

Hayakawa will try to run Texas Instruments' patent blockade of key U.S. market when it exports an IC-equipped calculator this fall; move could bring legal battle

By Charles L. Cohen

Tokyo bureau

Within weeks, Japan will try to neutralize the basic patent on integrated circuits held by Texas Instruments Incorporated, which has effectively, if informally, kept Japanese IC-equipped electronic goods out of the U.S. As a test case, the Hayakawa Electric Co. will export a desk-top calculator built with integrated control circuitry made by the Mitsubishi Electric Corp. Barring an unexpected agreement at the ministerial trade conference in Washington this week, Hayakawa could start shipping its calculators by the end of this month.

The dispute between Japan and Texas Instruments has been simmering since 1964, when the country's powerful Ministry of Trade and Industry rejected the company's bid to establish a wholly owned manufacturing subsidiary there. In addition, the government has wrapped TI's applications for Japanese patents on its semiconductor achievements—particularly bipolar techniques—in miles of red tape, hoping that local firms would have caught up technologically by the time the patents were granted. As a countermove, TI has held off on licensing any Japanese firms to use its U.S. patented techniques. The Japanese fear that selling IC equipment in the U.S., without an agreement with TI, might violate the company's basic patent.

Until now, MITI has persuaded firms under its jurisdiction to avoid a direct confrontation with TI. The Sony Corp. exported a pocket radio with integrated electronics last year, and then withdrew it.

But time is running out. Most Japanese electronics firms have to sell abroad, and the U.S. is their biggest customer. Hayakawa, for example, expects to export 70% of its new calculators to the U.S. and Europe; the company aims to produce IC calculators at a rate of 5,000 a month by next spring.

I. Reluctant dragon

Hayakawa isn't particularly keen on its prospective test-case role. The company simply wants to sell its CS-32 export calculators, which are similar to units introduced in Japan last month.

There are, of course, enormous risks involved in bucking TI—not the least of which is the possibility that the U.S. firm will get a court order to seize all imported IC merchandise at ports of entry.

But Hayakawa, Japan's leading calculator company [Electronics, Aug. 21, p. 189], won't have to go it alone in the U.S. The Japanese government, with the ubiquitous MITI, will back its play with cash and political pressure, as will trade groups and other electronics concerns. As a matter of fact, the government has subsidized the development of the electronic calculator industry in Japan since 1964. Aid, which will continue at least

For openers. Tadashi Sasaki heads Hayakawa division making IC calculators that will be Japan's first assault against Texas Instruments' patent wall.

. . . trade talks are unlikely to provide a solution to the TI-Hayakawa problem . . .

through 1969, now aims at mass production and the use of IC's.

Waiting game. Hayakawa is holding off a formal announcement of its export plans to avoid embarrassing its government before the trade talks between the U.S. and Japan. It's unlikely that the meetings will provide any immediate solution to the impasse. According to a U.S. State Department source, Cabinet members will confer with their Japanese counterparts only on broad topics and avoid specific irritants like the prospective Hayakawa-Texas Instruments hassle. However, a Commerce Department spokesman says that while the patent dispute is not on the agenda, the positions of all interested parties could be discussed.

II. Paper tiger?

In taking up the cudgels, Hayakawa has the strong support of MITI, a sort of superagency that regulates just about every aspect of Japan's economic, commercial, and technological life while setting the ground rules for foreign investment. The trade ministry is openly anxious to see TI's response to exports to the States of equipment with component IC's. Calculators in general and Hayakawa's latest offering in particular offer an immediate and potentially advantageous opportunity to confirm some observers' opinion that TI's bark is worse than its bite.

Deferment. Consumer goods afford a less conclusive testing ground than business machines. Purchasers don't insist on IC's and manufacturers have still to be sold on such devices. An executive at the Matsushita Electric Corp. says divisional managers want high reliability, small size, and low cost in components. Integrated circuitry now satisfies only the first two requirements. Japanese managers are sometimes willing to put perhaps one IC package into a television set even though costs may run as much as 10% higher than those of the replaced components. They figure that prices should go down in the long run and that IC's provide an opportunity for some advertising mileage. However, if any problems crop up, conventional circuitry immediately gets the nod.

Japanese computer makers aren't ready to jump into the U.S. market at all, let alone with IC equipment. They have their hands full producing third-generation machines for their domestic market. The industry has exported a few units to countries new to the computer on the chance that Japanese machines might be made the future standard. But the larger and more mature U.S. market offers no such opportunity. In addition, imports of computers and related items require government approval because the Japanese industry is still weak. If the country were to mount even a token export effort in the U.S., they would be hard put to justify their own restrictions.

III. Competitive edge

However, U.S. demand for electronic calculators is beginning to boom [Electronics, March 6, p. 217], and Hayakawa wants to get into the market while the getting's good. Moreover, integrated circuitry can be employed to advantage in calculators, and customers are vitally interested in such equipment.

Manufacturers have about the same operational goals and work from essentially the same block diagrams. Thus, those skillful enough

The fittest

One observer speculates that natural selection may have had something to do with the emergence of the Hayakawa Electric Co. as Japan's first champion in the impending brawl over integrated-circuit patent rights. Certainly, he says, the company has the required nerve. Hayakawa is now exporting calculators incorporating Nixie-like tubes to the U.S. despite the fact that it has made no royalty arrangements with the Burroughs Corp. Ironically, Hayakawa is one of the Japanese firms approached by Burroughs representatives seeking to buy calculators for resale in the U.S.

to come up with special IC's that save on the package count and cut costs find themselves with a best-selling item.

Short count. The 16-digit calculator Hayakawa intends to export contains only 22 bipolar integrated control circuits paired with ferrite-core registers. The IC packages are the identical quadruple dual-input, transistor-transistor-logic gates used in the memory register of an earlier 14-digit version [Electronics, Feb. 20, p. 295].

In view of the small number of IC's in Hayakawa's machine, which also has 1,200 diodes and 300 transistors, some observers feel the company would be better off buying standard bipolar devices from TI and other U.S. sources. American firms have been hawking their wares in Japan lately on the promise that products using them could be exported to the U.S. with no fuss.

But Mitsubishi modifies the circuits it supplies Hayakawa to provide better noise immunity—a feature which makes the devices easier to use. Mitsubishi also sells its IC's for slightly less than U.S. firms and, of course, is immediately available for consultation should any problems arise. Finally, and perhaps most important, Hayakawa is not about to give up the technical edge it thinks it has because of its virtually proprietary devices.

If Hayakawa thought the CS-32 was an ultimate product, it might readily settle for U.S. devices. But in a year or so when the price of bipolar IC's comes down further, Hayakawa will switch to a completely new calculator in which custom circuitry may well prove competitively decisive. Next month, the company will introduce a smaller machine using metal oxide semiconductor IC's. There are no standard devices for such a product, and Hayakawa worked very closely with its supplier to develop the circuits. It would be difficult, if not impossible, for the company to work with overseas sources to develop a complete family of new circuits. Either Hayakawa uses Japanese semiconductors or it loses much of its design freedom.

IV. Twain meets

Further confusing the issue is the mixed motivation of all the

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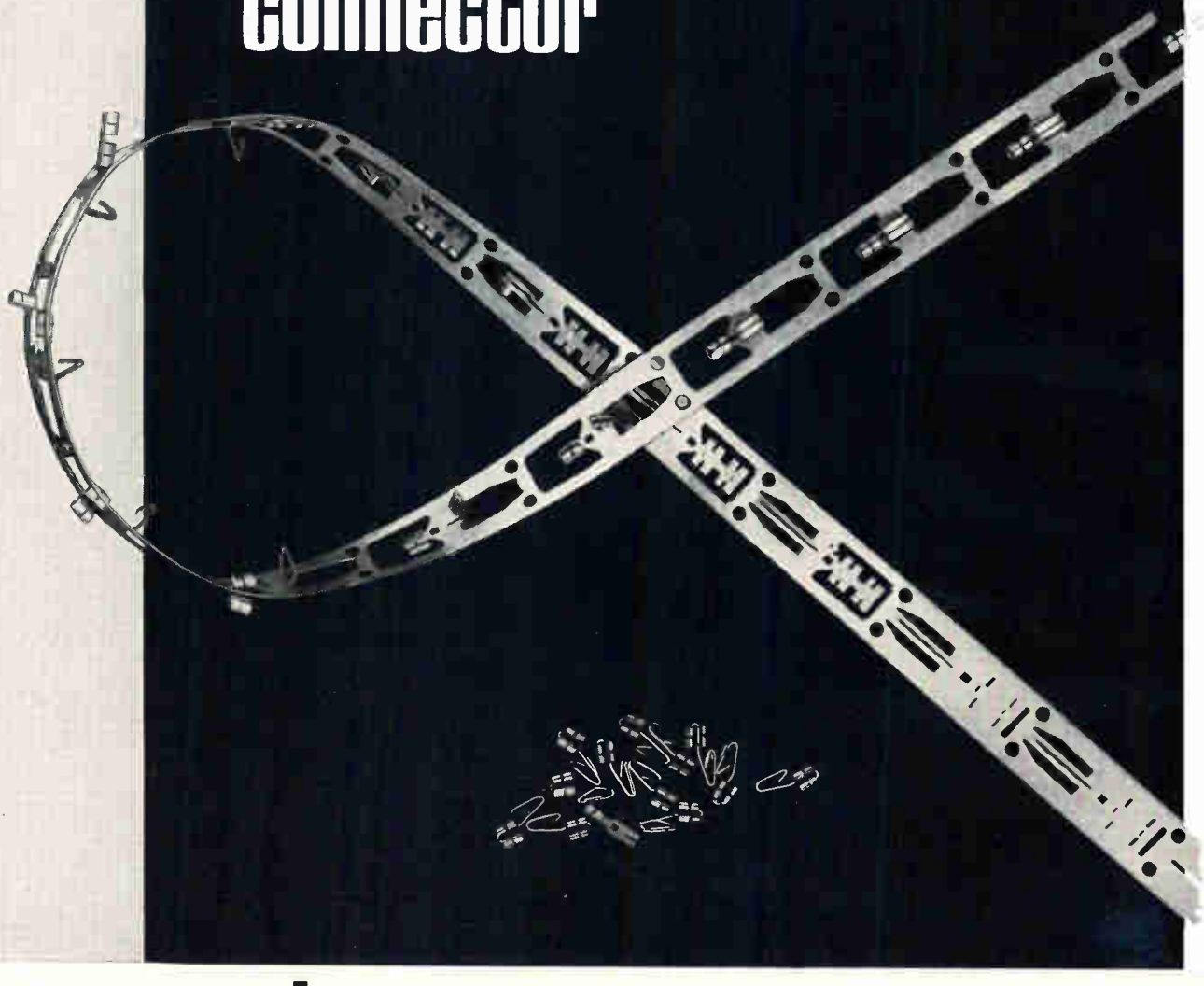

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parties involved in the dispute. Clearly, MITI is intent on advancing Japan's international trade interests. At the same time, however, the agency is anxious to delay TI's local debut until such time as domestic electronic firms have developed a competitive IC capacity. To these ends, the trade ministry has buried TI's application for Japanese IC patents in so much bureaucracy that they may not be granted for five years, and has consistently rebuffed the company's request to establish a wholly owned subsidiary in Japan.

Back at the ranch. Despite the liberalized policies that went into effect this summer, the best terms the U.S. company can get at this point are a 50% joint ownership with Japanese interests. Moreover, TI would have to share its technical knowhow with competitors and limit production until Japanese firms could compete.

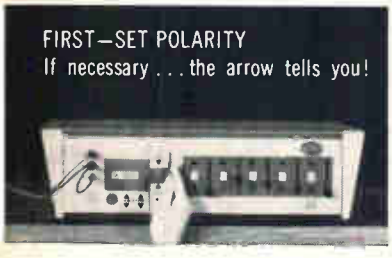
An executive at the Nippon Electric Co. believes that the biggest reason for keeping TI at bay for the time being is the prospect that, once in, the company might go on a price-cutting spree. This would stunt Japanese growth in the IC field, authorities feel, and eventually make the local computer industry dependent upon U.S. devices. In addition, if the trade ministry were to make an exception in the case of Texas Instruments, it would be hard put to rationalize its gradual liberalization of foreign investment in other sectors of the economy.

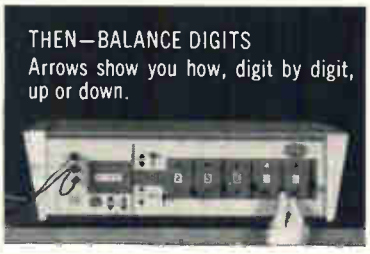
Inscrutable Texans. For its own part, TI obviously wants a piece of what promises to be a lush IC market in Japan. But according to one American authority who has closely followed the company's war of nerves with Japan, there is considerably more to the situation. "The management down there is just too conservative to give up any control, much less go for a joint venture," says this source. "And it's no accident TI didn't follow aggressive outfits like Fairchild into Taiwan, Korea, and Okinawa. These Texans know Japan's still going to be there in 50 years. But they want in only on their own terms."

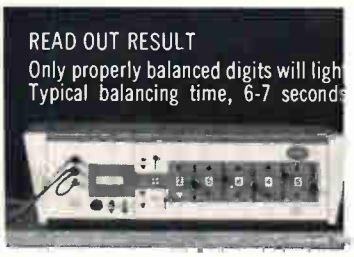
Though Texas Instruments stubbornly refuses to spell out its position, the company has dragged its feet in licensing negotiations with

test foremen are hard to please

...but this one's about to smile







Supervising test operations on a busy production line is rarely a happy job. Too much goes wrong, too often. Cockeyed readings. Instruments that lie. Instruments that shuttle continually from the repair shop to the calibration lab. New testers who take weeks to train, and *still* can't get it right. *Gr-r-r!* But wait—we're about to show him *a Biddle MENTOR™ Logic-Assisted Potentiometer,* the world's first and only *decision-free, error-prohibiting, absolutely fool-proof* differential voltmeter.

We're going to borrow his slowest, sloppiest tester . . . and make her look like a genius. All we'll say is: *"Follow the arrows, and do what they say."* Which arrow? Simple—only one lights at a time!

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Biddle MENTOR instruments will restore your faith in the human eye, hand, and brain . . . save you thousands of dollars per test position per year . . . and return "confidence," "speed" and "efficiency" to your production-test vocabulary. *Call or write for literature . . . or for a completely convincing demonstration.*

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Circle 162 on reader service card

BIDDLE INSTRUMENTS

Japanese firms. In fact, these companies say TI ignores or sidesteps all their inquiries. Mitsubishi, complains that it has yet to receive a reply on a long-standing offer to hammer out a royalty arrangement.

Skirmishing. By the same token, there have been no formal complaints, or threats, against Japanese firms using IC's in the wares they sell at home. On balance, TI's menace seems more implied than substantive. Last fall, for example, the Sony Corp. put a pocket IC radio on the U.S. market [Electronics, Oct. 17, 1966 p. 222]. Shortly afterward, the company's American distribution arm began getting phone calls from TI. After the second, Sony sought advice from the New York office of the Electronic Industries Association of Japan. The company was told to ask TI to put its complaints in writing. There were two more calls but no letter.

Confusion factor. Subsequently, MITI told Japanese manufacturers to hold off on IC-equipped exports until the patent situation was unsnarled. Fairchild Camera & Instrument Corp. holds an uncontested Japanese patent on the planar process. The company and TI have a cross-licensing arrangement covering IC's but the pact specifically excludes Japan. However, a Fairchild license gives planar rights to the Nippon Electric Co., which, with government approval, has made sublicensing agreements.

Sony and Matsushita are the only outfits that haven't made their peace with Nippon Electric and Fairchild. Sony maintains that its devices don't infringe on the patent; it appears, however, to be having second thoughts on this at the moment. Matsushita is depositing amounts equal to potential royalties in a bank account but hopes to avoid a real outlay on the strength of its cross-licensing agreement with NV Philips, the giant Dutch concern. The terms of this accord specify technical assistance from Philips, including patents and licenses. Matsushita has been able to avoid paying royalties to the Radio Corp. of America for semiconductor devices because of a blanket cross-licensing arrangement between RCA and Philips. Meanwhile, Matsushita is going about its business as if there were no outstanding problems.

Now that the planar-process problem is all but cleared up, MITI is ready to lift its export ban on IC goods and test TI's will. Japanese firms desperately need U.S. sales to justify their vast investment in the production of IC-equipped goods. Mitsubishi, for example, has already spent $2.8 million at its main semiconductor plant near Osaka and on a satellite facility where it flies chips for bonding.

V. Day of reckoning

The company's outlays for IC production will eventually top $14 million. Production is now about 80,000 to 90,000 IC packages a month, but Mitsubishi hopes to up the rate to 500,000 by year end. However, some 80% of its output is necessarily for export goods.

Lone arranger. Texas Instruments could hardly let Hayakawa's incursion go unchallenged since other Japanese firms are waiting anxiously in the wings; they figure to follow fast if a beachhead is established. But just what form of action TI might take is still unclear.

Depending on TI's stance in a direct legal confrontation, Japanese interests might opt for any of a number of countergambits. It might be possible, suggests a knowledgeable American source with a stake in the outcome, to attack TI's basic patent position. "What's so big a deal about fabricating metal plates with photographic techniques?" he says. Along these lines, some Japanese observers contend that Hayakawa's MOS calculator might have provided a better basis for a strong test case; they feel that TI's position in this area is more vulnerable than in bipolar IC's. But, warns a Nippon Electric official, patent litigation is a perilous proposition. Nothing is sure until the ruling is made.

Logical contender. On balance, however, the Japanese believe Hayakawa's CS-32 calculator will give a good account of itself. The machine incorporates IC's, but isn't merely a collection of such devices, they reason. Thus, TI might be open to antitrust charges of barring the product of other technologies on the basis of only one patent. Moreover, MITI believes TI would also risk a restraint-of-trade action in the U.S. should it refuse to license its bipolar patents now the Fairchild's planar process has been offered around.

An official with the electronics section of MITI notes that a lot of big U.S. firms, including Motorola Inc., the International Business Machines Corp., and the Signetics Corp., a subsidiary of the Corning Glass Works, have been peddling IC's in the U.S. without TI's blessings. There is, he says, no clear-cut evidence that Japanese outfits could not do likewise.

On another front

Hayakawa's IC calculator isn't the only bone of contention between American and Japanese interests. This summer, the U.S. Customs Bureau won a five-year-old court case centering on the import duties for Japanese receiving tubes. At issue was the U.S. Government's refusal to accept the posted invoice value; authorities insisted—successfully, as it turned out—on basing imposts on what they considered the freely offered wholesale price in Japan. Now, American original-equipment manufacturers and other importers have a potential liability exceeding $12 million.

The Government chose the price of tubes sold for replacement purposes at Akihabara, a crowded Tokyo neighborhood of electronic and electric appliance dealers comparable to New York City's bygone Cortlandt Street. The Japanese electronics industry would consider the successful Customs action ludicrous if the long-range implications weren't so injurious. Local observers contend that using replacement component prices as indexes for original-equipment quotations is probably not valid anywhere; this is particularly true in Japan, where it isn't considered especially ethical for those in service industries to charge high rates for their labor, and radio repairmen make much of their profits selling replacement tubes. Thus, the prices are kept artificially high in Japan. Over the long run, observers fear, the recent ruling may be successfully applied to color picture tubes for television sets and other electronic components.

Radiation issue heats up

Congress moves to grant Federal powers to set standards for emissions from electronic goods; law likely by 1968

With Federal standards for the control of radiation emission from electronic products almost a certainty, all that remains to be answered is when and in what form.

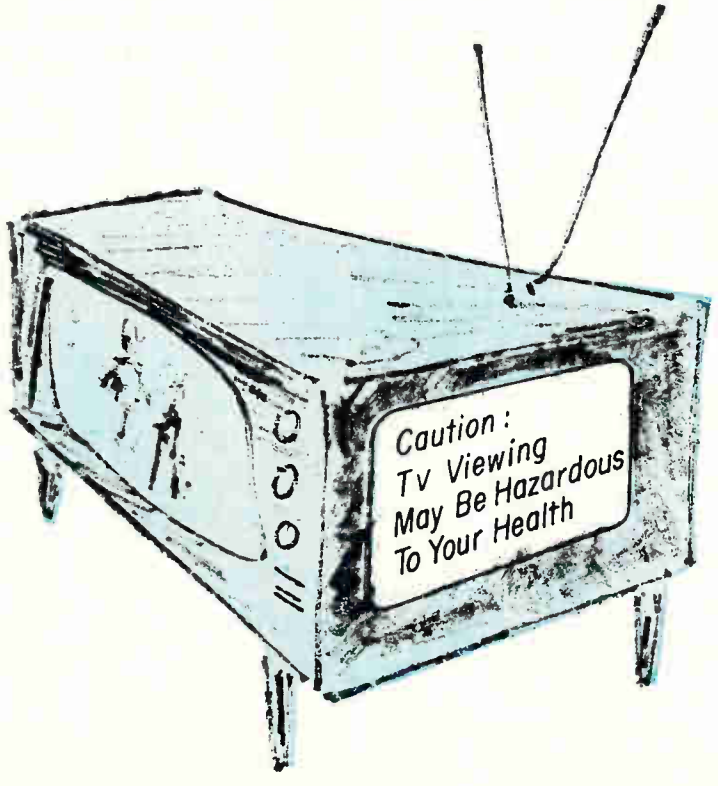
In the wake of the confusion following the disclosure that the General Electric Co. had built 90,000 or so large-screen color-television receivers emitting excessive radiation [Electronics, May 29, p. 52], Congress has come up with two bills, held hearings last month, and scheduled additional sessions this month. With the exception of a few outspoken dissenters, the electronics industry's on-the-record response to Capitol Hill activity can best be described as phlegmatic.

"How can we say we're against the legislation?" asks one Washington-based observer. "It would be like damning motherhood."

At the moment, no one knows quite what to expect, but the industry is hoping for the best. All that is known for sure, is that the Department of Health, Education, and Welfare will be given sweeping regulatory powers over a big segment of the electronics industry.

Legislation. Rep. Paul Rogers (D., Fla.), who with Rep. John Jarman (D., Okla.) coauthored the House bill, is pushing hard to have the measure passed before the end of the present session. Rogers is hopeful hearings will be held before the full House Commerce Committee within a week or so. His sponsorship of the legislation stems, in part, from the runaround he feels he got from the Public Health Service last October. At that time, Rogers was told that there was no evidence of excessive radiation in the GE sets.

Despite the rush in the House, Sen. E.L. Bartlett (D., Alaska), who has submitted an almost iden-



tical bill in the Senate, wants to continue his investigation into next session. He has already indicated that there might be more hearings then. Most observers feel that even if the Rogers bill goes through the House this session, it won't clear the Senate; the measure has to go through Bartlett's commerce subcommittee.

I. New deal

The broad outlines of how HEW regulations for the electronics industry will operate are already visible. Responsibility for setting radiation standards will most likely be handed to the Public Health Service's National Center for Radiological Health. According to James C. Terrill Jr., director of the center, "We [the center] would do most of it ourselves, farm some of it out to other Government agencies, and probably award contracts for certain studies to universities."

Most wanted. Topping Terrill's list of priorities is the establishment of color-tv standards. Other potentially dangerous radiation sources cited by Terrill include: magnetrons; klystrons; regulator tubes; thyratrons; display devices; electron linear accelerators; amateur electronic apparatus; electronic toys; microwave ovens; ultra-high-frequency radar and tv transmitters; infrared lamps and grills; ultraviolet equipment; lasers; and ultrasonic gear.

Do-it-yourself. Concerning tv standards, Terrill says: "With 10 to 20 large companies putting out 20 to 30 models a year, we certainly cannot monitor every set nor every replacement tube going to the 100,000 outlets throughout the country. My idea is to get manufacturers together on these standards and have them do their own checking. In the long run it costs less for firms to check themselves."

Terrill, whose center has come in for criticism because of its less than instantaneous response in the GE case, admits to some sins of omission: "If you'd asked me six months ago if GE was testing, I'd have guessed that it was. We just assumed that testing was going on. We've learned a lesson, however. Now we know that manufacturers have been putting tubes in sets and, if the sets work, they deliver."

Most electronics companies

Timetable for trouble

June 1966:	The General Electric Co. begins production of color-television receivers emitting excessive X rays from shunt regulator tubes.
Oct. 5:	Rep. Paul G. Rogers (D., Fla.) requests Department of Health Education and Welfare to report to him on dangers of radiation in color-tv sets.
Nov. 7:	The acting Surgeon General tells Rogers that evidence suggests industry and the National Council on Radiation Protection and Measurements have studied the problem and kept radiation below the harmful level.
Jan. 1967:	A regional representative of the National Center for Radiological Health is advised by the New York State Department of Labor that a possible radiation problem exists in GE sets.
April 10:	General Electric informs James Terrill, NCRH's director, that receivers with possibly hazardous tubes have been sold.
May 11:	At Terrill's request, GE makes a presentation to NCRH on the problem.
May 18:	The New York Times asks GE for a statement about excessive radiation. GE issues a press release admitting some sets have excessive X-ray emissions. Terrill says there is no evidence to the effect that GE or other tv sets have "excessively exposed viewers."
June 8:	State health officers are asked by NCRH to assist in hunt for GE sets. Terrill reports that GE sets have exceeded recommended radiation limits.
July 21:	The Surgeon General issues a statement telling owners of uncorrected sets to disconnect them.
Sept. 7:	GE reports about 1,400 suspect sets and 6,400 replacement tubes still uncorrected.

are shirking their responsibilities in controlling radiation hazards, says Terrill. "With all the money that is going into electronics and so little going into this problem, we are heading for trouble." Terrill believes that part of the solution will have to come from industry. "I don't believe that most safety officers think in terms of radiation danger because they must worry about immediate things like electrical shock," he says. "The electronics industry must develop a new group of technicians—the equivalent of the atomic industry's health-physicists, who know the biological dangers of radiation."

II. Mouthpieces

When the GE affair surfaced, tv makers quickly retained E. William Henry, former chairman of the Federal Communications Commission and now a Washington attorney, to represent their interests. Most of these manufacturers are members of the Electronic Industries Association. Two nonmembers—Admiral Corp. and Zenith Radio Corp.—also anted up.

Still small voice. The EIA has yet to appear at any hearings. James D. Secrest, executive vice president of the association, attributes the no-show to timing, explaining that it takes a long while to set an EIA policy for such things because of the various committees that must be cleared. "However, at a later date, we may testify," he says.

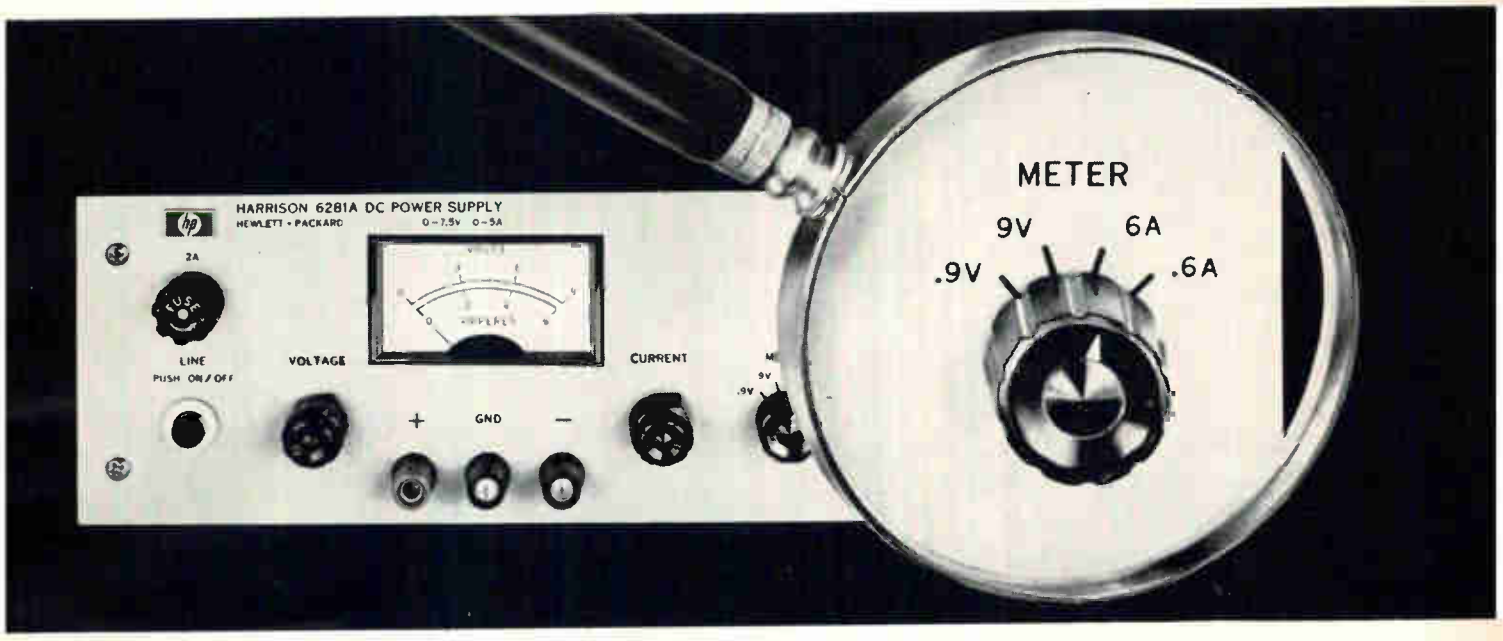
Secrest claims the industry has always been aware of radiation-protection needs, but that the GE case and the ensuing publicity "probably made the field more alert to the problem." He doubts standards will greatly affect the industry, "assuming that they are reasonable."

Henry agrees: "Industry feels that the Government agency that will eventually handle the matter will be reasonable and we feel we'll be able to cooperate." He points out that industry has no argument with the Government's interest. "Obviously, it's a matter for Government concern," he says.

III. Measuring sticks

Until recently, tv makers had a decidedly mixed bag of radiation standards to follow. According to Henry, the industry has been adhering to the Underwriters Lab-

hp new disciplines in DC



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TWIN 0-20V,0-.6A/0-40V,0-.3A DUAL RANGE	3½"HxHRW	6205B	235†
0-20V,0-1.5A	3½"HxHRW	6201B	169
0-20V,0-1.5A/0-40V,0-.75A DUAL RANGE	3½"HxHRW	6200B	189
0-20V,0-3A	3½"HxHRW	6284A	210
TWIN 0-20V,0-3A	3½"HxFRW	6253A	445
0-20V,0-5A	5¼"HxHRW	6285A	350
0-20V,0-10A	5¼"HxHRW	6286A	395
0-24V,0-3A	6¼"Hx⅓RW	6224B	325
0-25V,0-1A/0-50V,0-0.5A DUAL RANGE	6¼"Hx⅓RW	6220B	250
0-40V,0-.75A	3½"HxHRW	6202B	169
0-30V,0-1A/0-60V,0-.5A DUAL RANGE	3½"HxHRW	6206B	169
0-40V,0-1.5A	3½"HxHRW	6289A	210
TWIN 0-40V,0-1.5A	3½"HxFRW	6255A	445
0-40V,0-3A	5¼"HxHRW	6290A	350
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0-100V,0-.75A	3½"HxHRW	6299A	225
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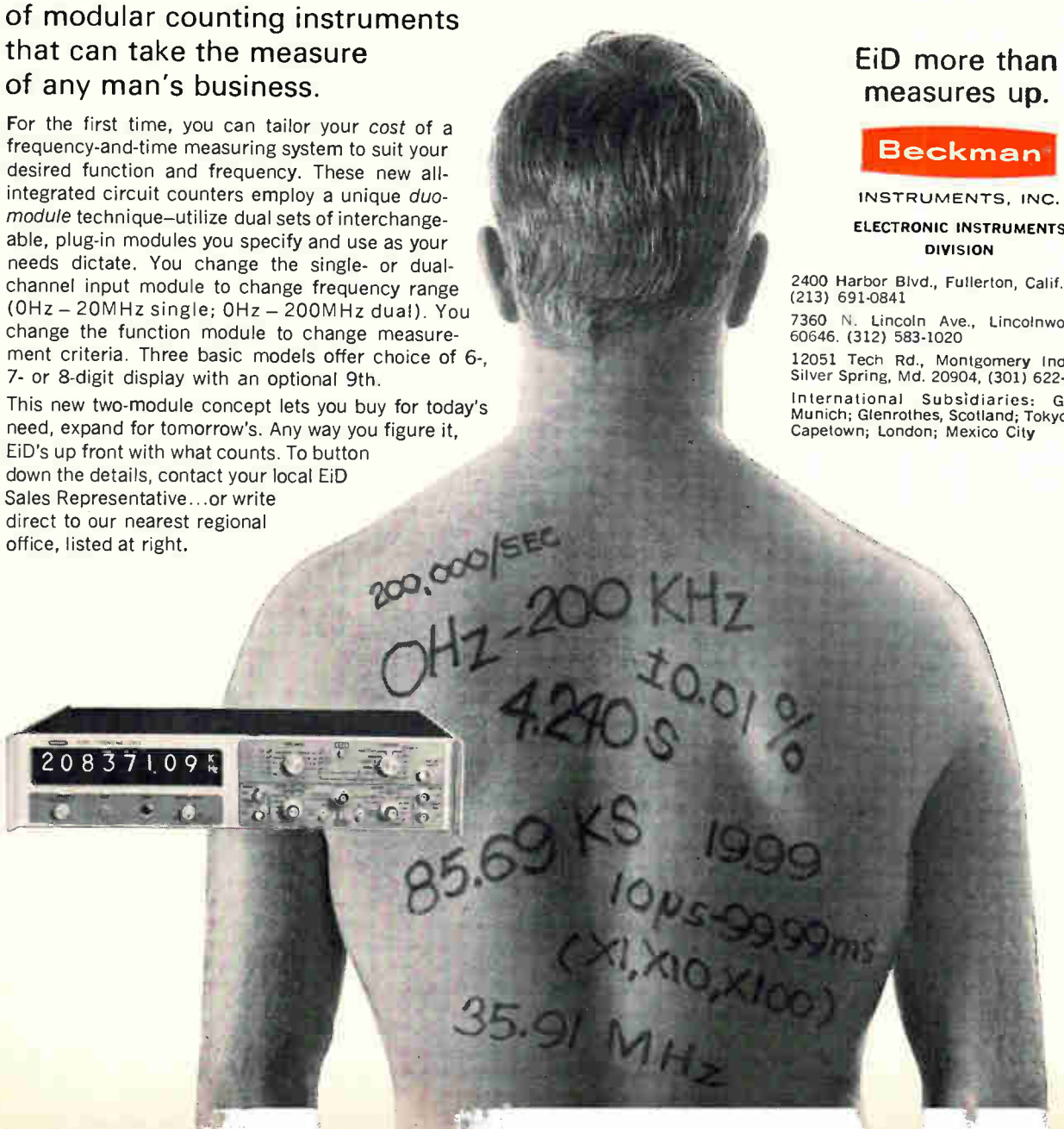

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. . . Congress should check radiation data that's already available says Raytheon . . .

oratories requirements of 2.5 milliroentgens of emission per hour at 5 centimeters from any surface of a receiver. But, in testimony before the House subcommittee, he said the industry has also recognized as an appropriate guideline the recommendations of the nonprofit National Council on Radiation Protection and Measurements: 0.5 mr per hour at 5 cm. Effective Sept. 1, however, Underwriters Labs changed its tolerances to the 0.5 level.

Such wide disparities led a spokesman for the Admiral Corp. to say: "The big thing which the industry is looking to the Government for is an agreement on standards for radiation. We need a guideline, a place to begin and end. This thing is pretty wide open right now, and while it has made all of us more aware, there's nothing we can do until we have more specific information as to what is expected of us."

For the record. Confusion abounds, some observers fear, about just what's at issue. The Raytheon Co., which makes a variety of radiation-producing items including X-ray tubes, magnetrons, and microwave ovens, cautions lawmakers against going over old ground. In preparing a single codifying document, says Charles H. Resnick, Raytheon's general counsel, "it would be our hope that Congress would take full advantage of the massive investigative work that has already been done."

Contradicting some assertions that "nothing has been done" to determine the potential hazards of microwave emissions, Raytheon safety director George Luedke points out that the Air Force in the late 1950's conducted a five-year, $13-million tri-service study of the biological effects of microwave radiation, particularly around large radars. There were three basic findings, says Luedke: that the biological effects are thermal only; that they are noncumulative; and that man has a built-in alarm system and pain threshold that protects him.

The problem of ionization, or X radiation, is another story, says Luedke. X rays are cumulative and have penetrating and lasting effects. Massachusetts, he points out, has pioneered in drafting safety measures in guarding against harmful X radiation. State laws require badges to be worn wherever X rays are used.

IV. A little knowledge

Terrill believes the military should be consulted on radiation standards because of its experience in this area. But he, too, believes not enough is known about the biological effects of radiation. Says Terrill: "The military only wants to know how much radiation a man can take before he is no longer fit for combat."

Lauriston S. Taylor, president of the National Council on Radiation Protection and Measurements, which sets some radiation standards for industry but is financed by Government grants, urges that there be no "approach by fear" to the setting of standards. He backs the Bartlett bill, but cautions against standards based on inadequate research.

At the bottom. Testifying about GE's experience before Bartlett's subcommittee, James F. Young, vice president for engineering services, said: "The regulator tubes used were no different than regulator tubes that we have made for many years and used in earlier sets, or that other manufacturers have made and used in their sets. The error was in the shielding. This was the defect. The tubes themselves were not defective."

Overseer James G. Terrill directs the Public Health Service unit that will set radiation standards for electronics.

Before the problem was discovered, GE tested tv sets for dangerous radiation emissions on only five sides, but not the bottom of the set. Now they check the bottom, since that's where the leakage was coming from.

At the Radio Corp. of America, a spokesman says, "I don't think we need to be concerned about the prospect of legislated radiation standards. What really matters is how the law is worded. If the Rogers bill is passed as is, it will prevent substandard imports from getting into the country and will augment research on the short- and long-term biological effects of radiation."

Gamesmanship. Officials at Packard-Bell Electronics Corp. have sent a letter to distributors and dealers handling the firm's line of color and black-and-white tv receivers informing them that the design of the company's sets differs from that of the GE sets that started the consumer and Congressional furor. The letter also states that Packard-Bell sets meet the recommended standards of both Underwriters Laboratories and the National Council on Radiation Protection Measurements.

V. Change in the scene

Leonard Horn, engineer-nucleonics at Underwriters Labs says: "We never see much of the equipment to be covered by the bill since we concentrate on consumer goods like tv sets, radios, phonographs, X-ray equipment, diathermy machines, and radar ranges. We test about 95% of the various types of tv sets produced in this country, which gives us a good idea of what is going on in the plants. But right now we're in the process of revamping all our programs to make our standards more stringent and our test more comprehensive."

Horn doesn't anticipate another GE-type affair. "The issue," he says, "brought home the fact that companies, particularly large producers, were getting a little too relaxed in their attitude towards their products and safety standards. Periodically we need something to point up the fact that you must maintain continual vigilance."

All u. device checks have been run at the labs; there has been no quality control program, per se. "In

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. . . laser researchers have been slow in responding to safety suggestions . . .

view of pending legislation however, it is evident to us that we will have to become more involved in a quality-control program," says Horn. "We must change our standards, too."

VI. Less than radiant

Among the more outspoken critics of the proposed Federal legislation is George Borg, manager of radiation and safety at Electro-Optical Systems Inc., a division of the Xerox Corp. Borg, a health-physicist licensed by the state of California, administers a safety program patterned after that of the nuclear industry—a field which he maintains has compiled about the best safety record of any industry during the 21 years of its existence.

Borg fears restrictions inhibiting technology could follow Federal laws if those drafting the legislation aren't technically oriented. He doesn't think the X rays emitted by television sets are much of a problem, and when legislation results from an emotional reaction "it usually fouls up the works somewhere down the road."

Eos makes such radiation-producing devices as electron-beam welders, electron microscopes, and lasers. Except for the lasers, these are state-licensed products for which Borg believes present standards are "very realistic." The rules dictate that persons not normally working with radiation-producing devices may not receive more than 2 mr per hour, or more than 300 mr in a calendar quarter.

Exception. Borg does believe, however, that at least one segment of the electronics industry will have itself to blame if restrictive legislation is passed. He has been pushing laser researchers to establish standards. They have been slow to respond, and both state and Federal agencies are now investigating standards for lasers.

Fred P. Burns, manager of operations at the Korad Corp., a laser-making Union Carbide Corp. subsidiary, doesn't think Federal legislation would significantly affect his operation—"if the legislation is sensible."

Robert L. Mortensen, sales manager for Spectra-Physics Inc., a laser manufacturer, says: "Naturally we're interested in people's safety." But he doesn't see any big problems with lower power lasers. Mortensen doesn't expect any serious changes in manufacturing from Government-imposed standards, but "it depends on what the standards are. If they're reasonable, they won't have a strong impact. Low standards would be worse," he says. However, Mortensen does express concern over a new Illinois law that requires the registration of all lasers in that state.

Tolerable. John Olander, general manager of the Cryodry Corp., a subsidiary of Armour & Co. that makes microwave ovens, says, "As far as we're concerned, we meet the law on the amount of tolerable radiation." The law he is referring to is an FCC regulation; the commission is concerned lest microwave ovens, which operate at 915 and 2,450 megahertz, interfere with other microwave signals. The FCC approves designs, but it does not police the regulations.

In any case, Olander says, the ovens are designed so that excess radiation is trapped. The Congressional hearings, he feels, are likely to have nuisance value only; they won't affect oven design. The stray radio-frequency signals that would bother the FCC are not nearly so strong as the signals that would be hazardous to health.

But microwave devices remain a prime Terrill target. He points to a recent study purporting to prove that the risk of siring Mongoloid children is greater among men who have been radar technicians. He suggests that there is a crying need for research in this area. Microwave ovens are being used by people who don't realize the potential dangers they face, he says.

Burton Silver, marketing manager of the Electron Tube division of Litton Industries Inc., says the hearings would definitely affect both his division and the Atherton division, which makes microwave ovens. "The hearings couldn't have come at a worse time. Microwave oven sales were just beginning to grow," Silver says.

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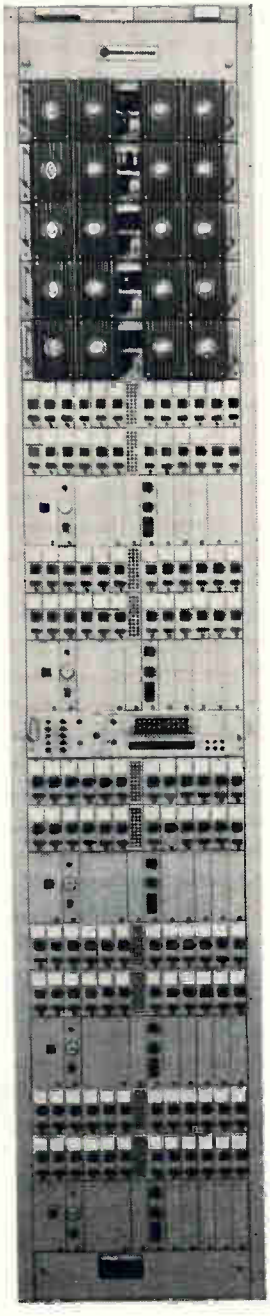

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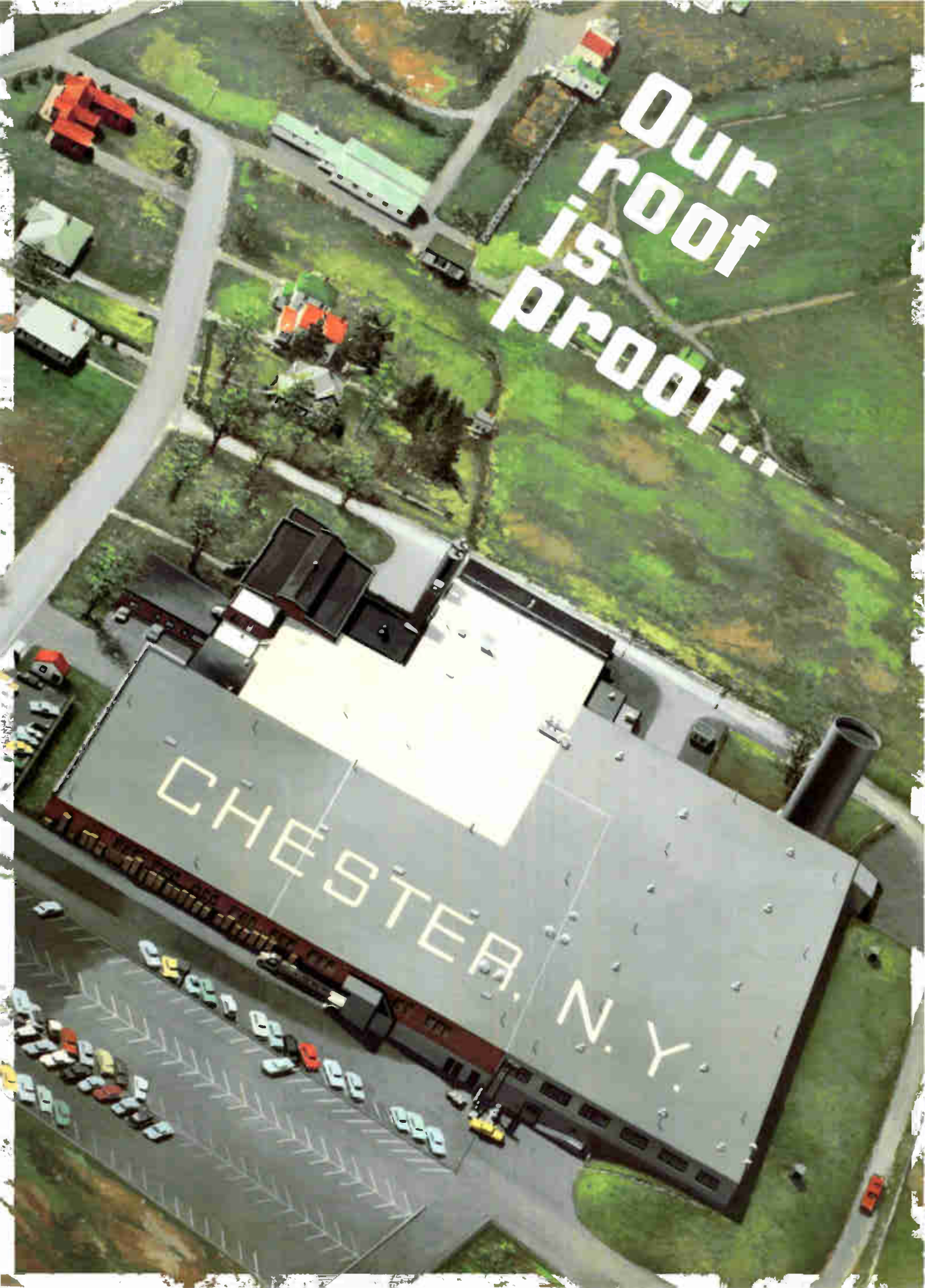
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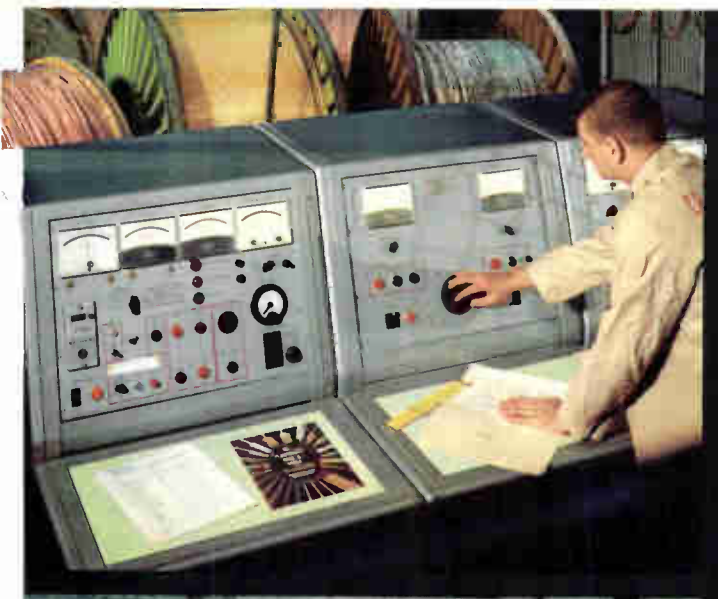

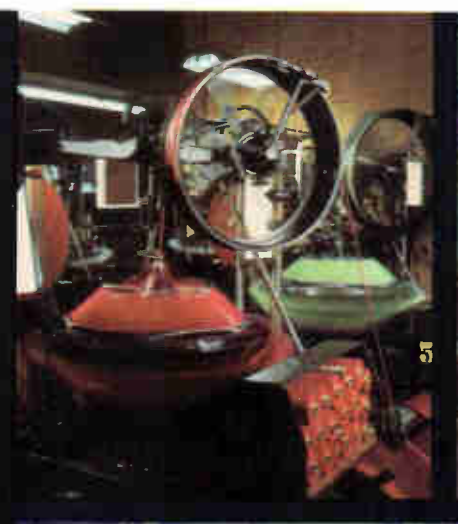

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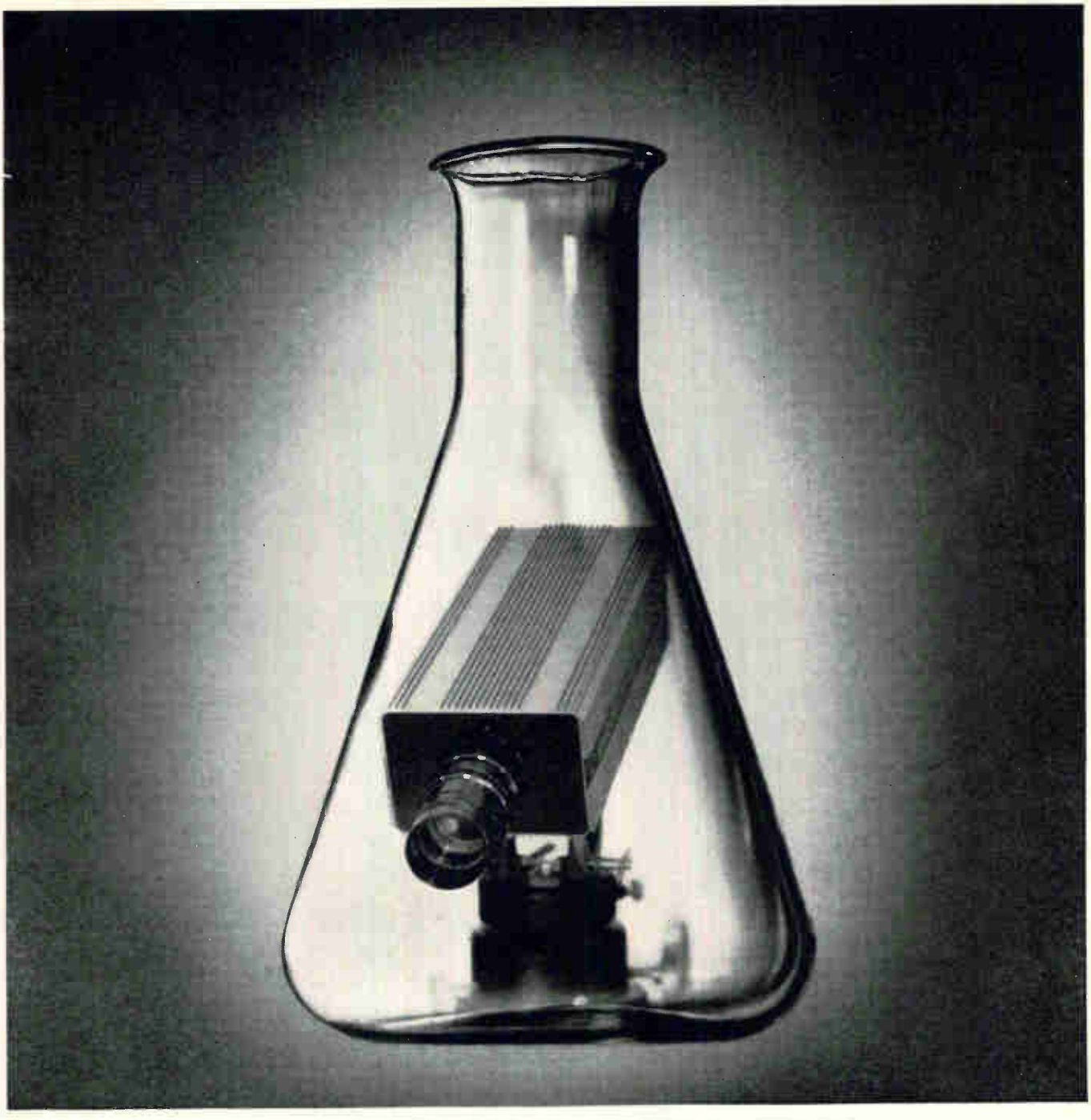

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Circle 175 on reader service card

MILGRAY SHELVES NEW ENGLAND!

(with almost a mile of shelves... and a million-plus components...now ready for immediate delivery from our new Facility in Greater Boston!)

On Monday, August 28, we cut the tape on MILGRAY/NEW ENGLAND, INC....and, in the process, cut some "red tape" for electronics Buyers and Purchasing Agents in Massachusetts, Rhode Island, Vermont, New Hampshire, Maine and northern Connecticut.

Our New England location is a full-service facility, stocked in depth with a comprehensive array of the active and passive electronic components most urgently and frequently required by our customers and prospects in the area.

Milgray Red Tag delivery is available on all items.

In addition, Milgray/New England is "plugged-in" to the complete circuit of all other facilities (New York, Cleveland, Philadelphia, Washington) via open telephone lines, teletype and continuous inventory and reporting procedures that enable us to locate any difficult-to-find components within moments.

We've appointed Mr. Andrew Donahue, Manager of Milgray/New England, Inc. Throw him the next really difficult problem that comes up.

After all, the chances for immediate off-the-shelf delivery are bound to be a lot better when you've got more shelves to deliver from.

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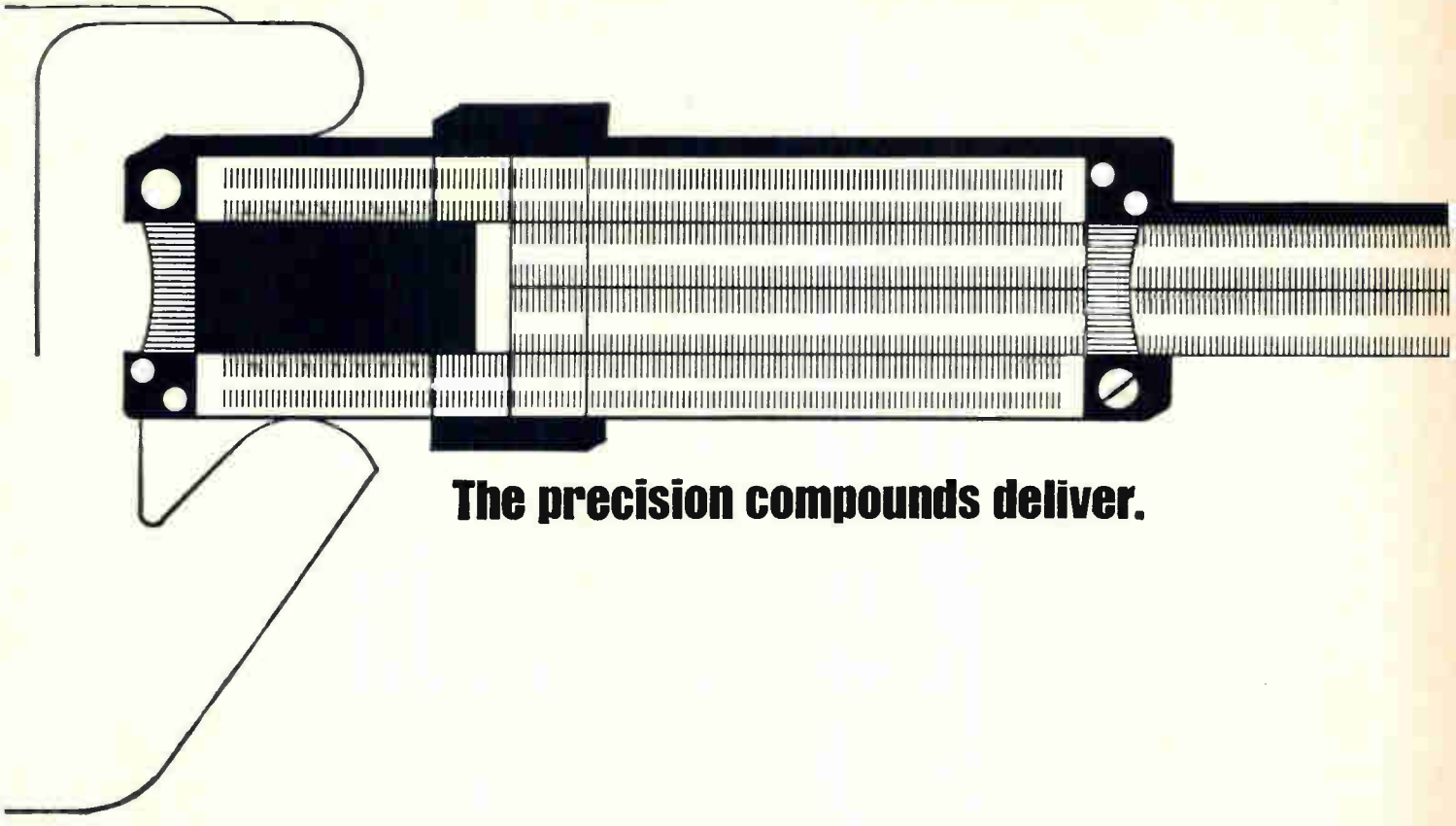
Milgray/New England, Inc.,
79 Terrace Hall Avenue, Burlington, Massachusetts (617) 272-6800.



The precision compounds deliver.

Durez® phenolic, diallyl phthalate, and alkyd molding compounds

Whether your specs call for moldability that can give you walls as thin as .050 inch, or superior heat and chemical resistance on the job, the precision molding compounds from Durez deliver.

Durez' broad line of phenolic, diallyl phthalate, and alkyd molding compounds offer the balance you want from among these key design requirements: good electrical and thermal properties, impact strength, durability, relatively low cost; heat, corrosion, and chemical resistance; flame retardance, dimensional stability, and retention of electrical properties after long periods at high humidity.

The precision compounds are now playing a major role in electrical component design. Ask our sales engineers and technical service men to check your specific application or materials selection problem.

Specify the precision compounds from Durez.

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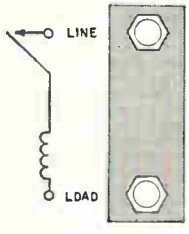
ANY OF FIVE PROTECTIVE CIRCUITS IN ONE EASILY OPERATED SWITCH

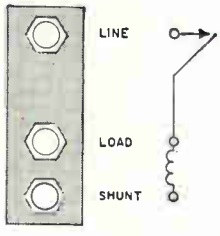
APL CIRCUIT PROTECTORS

SERIES TRIP



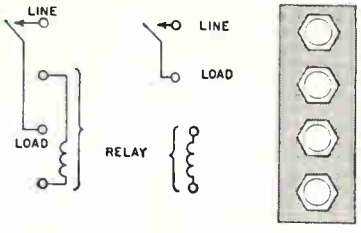
Airpax APL circuit protectors are manufactured in five circuit configurations. Each is available in any of 10 time delays, in any of 16 standard trip levels, and rated for a maximum of either 50 vdc, 250 vrms at 60 Hz, or 250 vrms at 400 Hz.

SHUNT TRIP



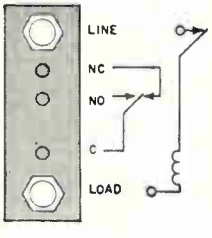
Shunt trip provides you with several possibilities. You can program an external shunt across the coil to change trip level for different operating modes of your equipment.

RELAY TRIP



In protector Types APL-4 and -5, coil and contacts terminate at separate pairs of terminals. With this configuration, you can control current in one circuit by a different current in a separate circuit.

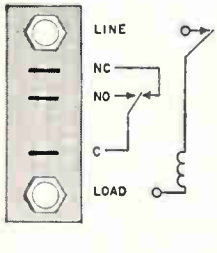
REMOTE INDICATION



A switch built into Type APL-RE protector transfers up to 5 amperes in a separate signalling circuit.

To the operator it's an ON-OFF switch. To you it's a design simplifier.

REMOTE OPERATE



Auxiliary contacts built into Types-RO and -RO1 handle up to 10 amperes. This spdt switch operates simultaneously with the main contacts. Used to switch a remote load, this feature provides means for interlocking and protecting related loads.

AIRPAX ELECTRONICS

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New Products

New integrated electronics

The swing to TTL becomes a stampede

Use is growing so fast that customers have trouble getting the circuits; the rush of new lines may satisfy the demand

Among engineers who design high-speed logic systems with integrated circuits, the current darling is transistor-transistor logic, better known as TTL. The biggest advantage of TTL is speed: 15-nanosecond propagation delays in the earlier products, as fast as 5 nsec in the newer ones. Buying interest is so great that customers have trouble getting TTL circuits these days.

Transistor-transistor logic is a direct fallout of a military program. Designed for the Phoenix missile, early circuits were built on a pilot line in 1963 by Sylvania Semiconductors, a division of Sylvania Electric Products Inc. Now the company has two lines—SUHL-1 (Sylvania Universal High-Level Logic), with an 11-nsec propagation time, and SUHL-2, with a 6-nsec propagation time. With 380 circuits in both lines, including gates, expanders, flip-flops, and functional arrays, Sylvania has probably the largest TTL line in the semiconductor industry.

Today, business is growing so fast that Sylvania has to allocate both SUHL-1 and SUHL-2 despite opening an IC-assembly plant in Bangor, Maine, last April, and a wafer facility in Woburn, Mass., a month later. But the short supply of TTL has prompted a flock of rumors that Sylvania cannot produce the faster SUHL-2 line.

Alvin B. Phillips, general manager of integrated circuits for Sylvania, pooh-poohs such talk. "The problem is the tremendous demand for such circuits and inability to expand fast enough to meet it. It's been a painful few months we've been going through."

Exploding demand. At Texas Instruments Incorporated, marketing men second Phillips talk of exploding demand. One application engineer estimates that 80% of new computer designs now call for TTL instead of the older diode-transistor logic (DTL), resistor-transistor logic (RTL), or direct-coupled transistor logic (DCTL).

I. Others follow suit

During the past 12 months, TTL has clearly been the fastest growing form of integrated circuits. Just a year ago, TTL represented 12% of total IC production. Now its share has doubled while total IC production has also mushroomed.

Sylvania's difficulties with deliveries have prompted most other semiconductor companies to rush out new lines of TTL, many of which closely resemble SUHL-1 or -2. Motorola Semiconductor Products, which has its own form of high-speed logic, called Motorola Emitter Coupled Logic, now supplies SUHL under a Sylvania license.

Two months ago, the Raytheon Co. started producing Sylvania's 50-megahertz dual J-K flip-flop and now offers it commercially.

Westinghouse's Molecular Electronics Division has put nine circuits of the SUHL-2 line in its catalog, including two J-K flip-flops, an expander, and gates of various input configurations.

Philco-Ford Microelectronics will put from eight to 10 circuits of the SUHL-2 line into commercial production in late autumn.

Although all of these second sources admit to copying SUHL products, each claims that its circuits are a little better than the original. Westinghouse, for example, boasts its TTL circuits use less power—4 to 5 milliwatts less per gate function—than the SUHL circuits it has copied. Raytheon believes it has improved the manufacturing process by easing the tight tolerances that SUHL circuits demand.

Eyeing LSI. A different approach to TTL has been taken by Texas Instruments with its 54/74 series. At Sylvania, high-speed was obtained by improved components. Texas Instruments, on the other hand, improved speed by increasing the complexity, putting more components into each circuit. With this circuit-development experience now behind it, TI believes that its approach to TTL is a workable way to move into large-scale integration (LSI) later.

At the same time, TI recognizes that Sylvania's approach has won the popularity contest among customers so far. This autumn, TI will launch an extensive marketing program to sell its kind of TTL after introducing new products gradually for most of the year.

Signetics Corp., a subsidiary of Corning Glass Works, also has a form of TTL that is part of its Designers' Choice Logic so that it is compatable with Signetics DTL circuits. It competes with SUHL-1 in speed, though its design approach is akin to that of TI. Because of a technical agreement with Signetics, the Sprague Electric Co. also fers Designers' Choice Logic.

. . . some people wonder if everybody using TTL really needs it . . .

Sprague's 8200 series, there are two TTL circuits; in the 8800 series there are 12 TTL circuits—all 15-nsec circuits.

At Wescon last month, Sprague started off on its own by introducing three circuits that didn't stem from Signetics development. Called Sprague Super-Speed Logic, they are: a flip-flop with a 60-Mhz binary toggle rate, a dual four-input gate, and a quad two-input gate. Each has a 5-nsec propagation delay. More circuits will be added to this line after the first of the year. Next month, Motorola, too, will introduce its own .5-nsec TTL.

Transitron Electronic Corp. participated in the original development of TTL and has specialized in that kind of logic ever since.

On the move. Fairchild Semiconductor, a division of Fairchild Instrument & Camera Co., was in on the original development of TTL for the Phoenix missile and did, in fact, build a few circuits in 1964 for that project. The company owns the patent on the multiple-emitter transistor that is central to TTL. But Fairchild never brought out a commercial TTL line until nine months ago, when it introduced the 9000 series having 10 circuits. This autumn, Fairchild will start unveiling additional circuits as part of a plan to catch up to Sylvania.

The reasons behind Fairchild's slow start in TTL were worries about production, the kind of thinking that has caused so many rumors about nondelivery of TTL circuits. Says Ben Anixter, Fairchild's marketing manager of integrated circuits: "From our work on Phoenix, we were convinced that you needed tolerances of 0.0001 inch, too hard to make commercially. So we sent the project back to R&D which found that 0.15- or 0.2-mil tolerances were perfectly good."

II. Gaining experience

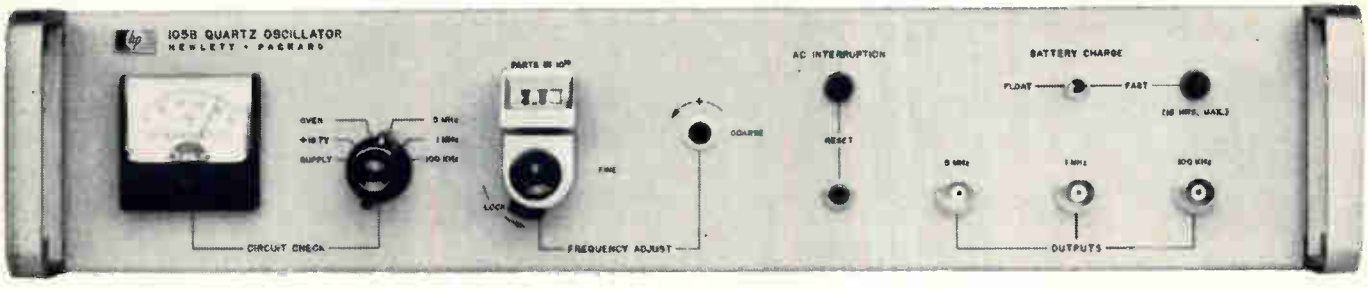
Although Sylvania's Phillips stoutly maintains that demand has been the main problem—he says, "Despite rumors, we have in no way underestimated the complexities of these circuits"—others in the industry are willing to admit that yields of TTL circuits are still far under DTL, for example, so production is not running as fast as a lot of people would like. Admittedly, the companies have not yet built up as much production experience as they have with DTL. Transistor-transistor logic circuits require small geometries, thin lines, and shallow diffusions—all of which can cause trouble in production.

Off and running. Makers believe they are solving production problems by developing better masking techniques and better furnace control. Fairchild's Anixter insists that "we'll be making TTL until it comes out of our ears" this fall. And Sylvania's Phillips sees his allocations ending before the first of the year.

The big question to a lot of people, however, is where are all these circuits going? Phillips says SUHL circuits have been specified for most advanced military programs, sophisticated systems such as Ihaas (Integrated Helicopter Attack Avionics System), the Mark II avionics system for the controversial F-111 aircraft, the avionics of the giant C-5A military transport aircraft, the computer for a tactical air-control system, and in the Navy Tactical Data System. At least half of the military and commercial applications use SUHL-2, Phillips adds.

What has made TTL so attractive to so many people has been its faster switching speeds, better noise immunity, a higher fanout, and lower power requirement than DTL. But still some people wonder if everybody who is using TTL needs it. At Philco-Ford, J. Philip Ferguson, head of the microelectronics division, thinks that the great demand is somewhat irrational. "How much equipment operates at 10 Mhz?" he asks. "People go to high-speed circuits without knowing what the problems are. Although TTL has high d-c noise immunity, it is very sensitive to voltage transients. Because TTL is so fast, a voltage spike could trigger a TTL circuit under circumstances that wouldn't give a DTL circuit enough time to change states. Then, too, there are some impedance-match-

In quartz oscillators, what more could you ask for than high stability, great spectral purity and fast warm-up?



How about phase-locking, small size and lowest price?

That's right. The new Hewlett-Packard 105A/B Quartz Oscillators combine all these features to create the best buy for your precision quartz oscillator requirement. Short-term stability is better than one part in 10^{11} rms for 1-sec averaging time. Output typically reaches 1×10^{-7} of final frequency in 30 minutes; aging rate of $5 \times 10^{-10}/24$ hours after full warm-up.

S/N exceeds 90 dB. Rated output is 1 V rms into 50Ω. Outputs are 5 MHz, 1 MHz, 100 kHz sine wave and 1 MHz or 100 kHz clock drive. Height is only 3½"; 105A weighs only 16 lbs.

Price: 105A, $1500; 105B (8-hour standby battery supply), $1800.

Call your local HP field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

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FREQUENCY STANDARDS

Circle 181 on reader service card

. . . even more new products in the works for next year . . .

ing problems that can give designers trouble."

Costs hold key. Just how big an inroad TTL makes in the DTL business will depend ultimately on cost and application considerations. DTL has a three-year lead in design. It usually costs less because DTL yields average about twice as high as those for TTL circuits.

Still, the higher costs of TTL don't always show up on the bills. Fairchild now charges the same price for DTL and TTL, even though it costs the company more to make TTL. For example, Fairchild sells a dual four-input gate in lots of 100 or more for $4.40 when built to military specifications whether it be DTL or TTL. Explaining this strange behavior, Fairchild's Anixter says, "If DTL is already designed in, and you want to sell TTL, the only way is to offer it at the same price." Fairchild is also betting that TTL yields will improve enough to match DTL yields by the spring of 1968. There's no reason why TTL should cost more than DTL he says.

As if all this burgeoning activity in TTL wasn't enough, most semiconductor producers have even more new products in the works for next year. Sylvania, which is still far ahead in number of TTL products, plans to introduce additional functional arrays such as a four-bit shift register, a binary counter, a decade counter, and a parity counter. In addition, Sylvania has already designed a low-power series of SUHL for avionics systems that do not require the highest speed but can dissipate only 1 or 2 milliwatts. Production is scheduled for early in 1968.

Planning a family. Fairchild, too, plans to introduce a line of low-power TTL in 1968. But one of the most attractive prospects for TTL at Fairchild is as a forerunner of large-scale integration. In a medium-density approach, 40 to 50 gates per chip, Fairchild talks of using TTL devices—characterized by multiple-emitter inputs and active pull-up outputs—for external contact, and DTL or even RTL devices internally. Thus the company will have a TTL family of circuits each with different internal logic.

When it comes to custom assemblies, we can solve millions of problems.

Like taking millions of plastic and/or metal parts made to the most exacting tolerances, fitting them into an assembly, sub-assembly or finished product, wrapping them, sealing them and shipping them.

Complex components like computer circuit boards, telephone switching equipment, memory core frames, computer control connectors, switches, contacts for plug assemblies, practically anything you specify, we can make and put together.

That means your designers need not be inhibited by the limitations of your own facilities and machinery.

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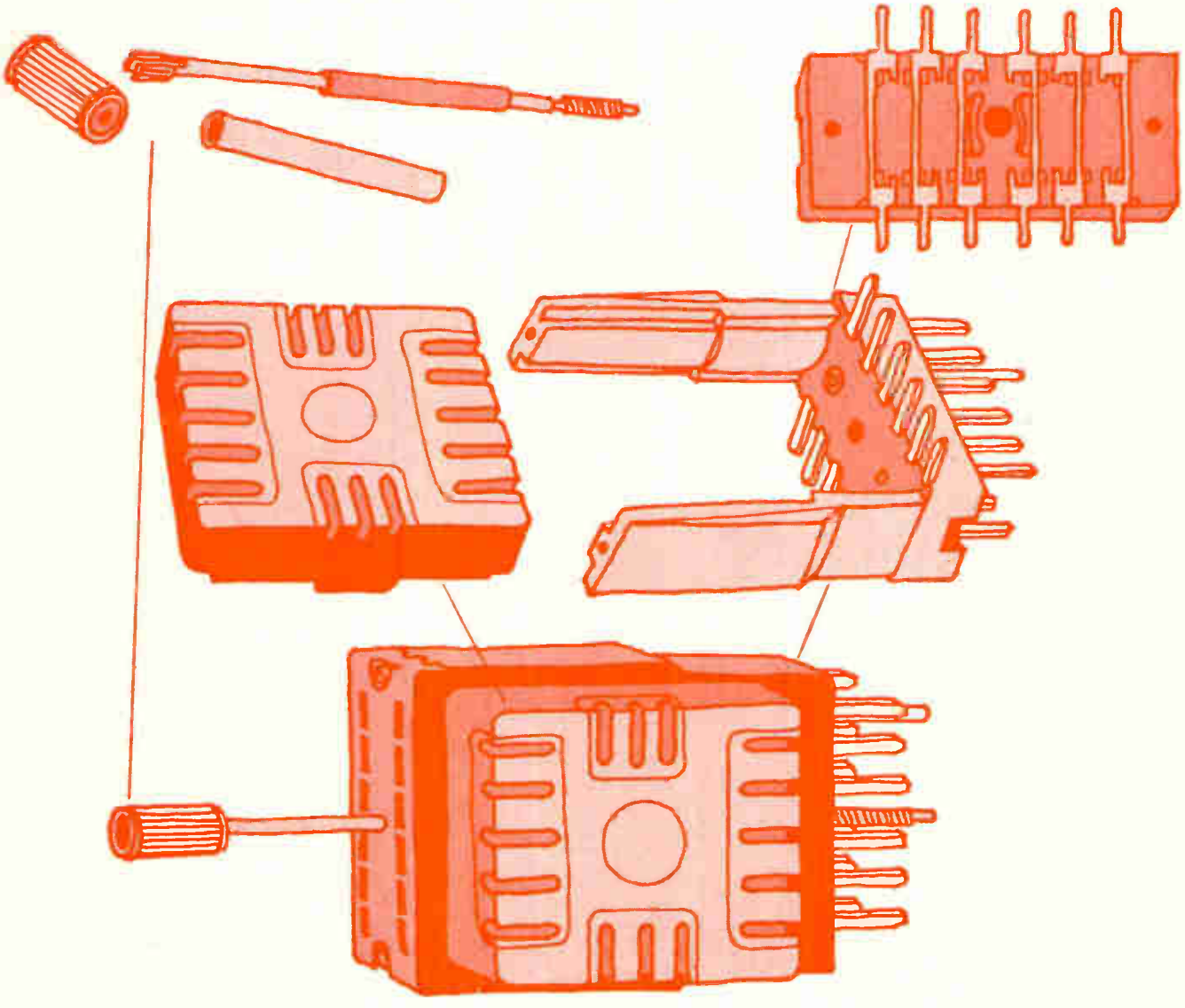
Let us put our men, machines and plants to work for you. Give us your specifications, we'll do the rest. We've done it for a lot of others.

Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania 16365.



SYLVANIA

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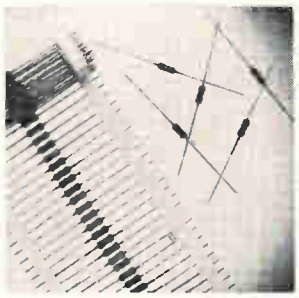
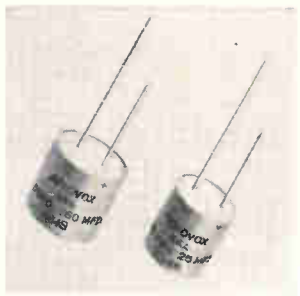
Circle 183 on reader service card

Designed for fast computer circuits, switches are moisture-proof and have less than 1 μs contact bounce after transfer. B5200 and BW5200 series are rated at 3 amps resistive, 1 amp inductive, and 1 amp lamp-load at 28 v dc or 120v a-c. They are available in 3 circuit arrangements with 18 mounting styles. Controls Co. of America, 1420 Delmar Drive, Folcroft, Penn. [341]

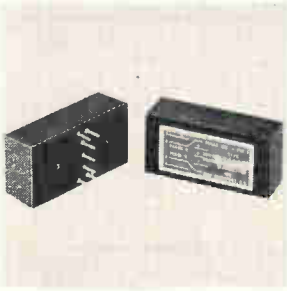
A semiassembled feed-through terminal is for installation in a 0.040-in. ±0.02-in.-thick chassis, mounting in a 0.136-in. hole. Designated FT-2-SM-1200, the terminal's 0.040-in. diameter gold-plated brass lug extends 0.100 in. above and below the Teflon bushing. The unit handles 5.5 amps and can be used from 65° to 200°C. Sealectro Corp., 225 Hoyt St., Mamaroneck, N.Y. [342]



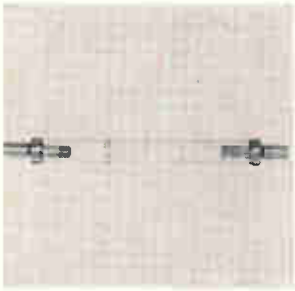
Metal alloy film resistor MAL-20 is a ½ watt (70°C) semiprecision device for use in color-tv, computers, and industrial instrumentation. It has temperature coefficients of 100 and 150 ppm/°C, and resistance tolerances of 2 and 5%. The unit meets or exceeds requirements of MIL-R-22684. It is epoxy coated and stamped and color-coded. Mallory Controls Co., Frankfort, Ind. [343]



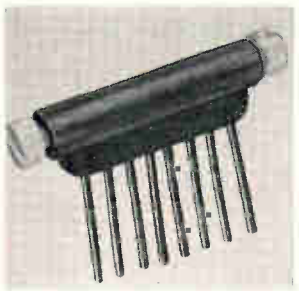
Plastic-cased electrolytic tubular capacitors with epoxy end sealing are designed for p-c transistor circuitry and miniature electronic assemblies. Type EKA units come in 11 different models with capacitance values from 5 to 250 μf; and in 3 sizes, the largest being 15/32 x 31/64 in. D-c voltage ratings include 3, 6, 10, 15, 25, 35, and 70. Aerovox Corp., New Bedford, Mass. [344]



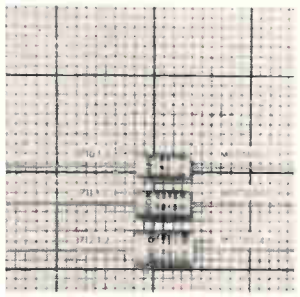
Arc accuracy of 30 seconds is attainable with a series of Scott-T transformers. The miniature toroidal devices convert 3-phase synchro inputs to 2-phase resolver outputs. Line-to-line input voltage is 11.8 v, rms output voltage 5 v. Operating frequency is 400 hz; temperature range is −55° to 125°C. Price is $70 for single units. Magnetico Inc., 6 Richter Court, East Northport, N.Y. [345]



Linear xenon flashtube model FX 81-4 has a 4-in. arc length. The 10 x 12 mm quartz device handles an energy input of 3,000 joules per flash with a pulse duration of 1.4 msec. Units can be used in environments ranging from ocean depths to outer space. Applications include laser stimulation, medical research, and satellite flashers. EG&G Inc., 160 Brookline Ave., Boston, Mass. [346]



Double tuned i-f transformers, with average dimensions of 0.097 x 0.75 in., can be mounted between hybrid amplifier cans. Operating frequency is 1 to 100 Mhz. Typical temperature coefficient is ±65 ppm °C from −55° to +125°C. The transformers can contain up to 4 windings, and are suited for r-f and i-f strips. Piconics Inc., North Billerica, Mass. 01862. [347]



Molded chokes come in 3 types. Models 3710-1 through -7 cover inductances from 47 to 150 μh in a 0.250 x 0.560-in. package. Q values range from 18 to 75. Models 3711-1 through -5 cover 180 to 390 μh, are 0.310 x 0.560-in. with 80 to 75 Q's. The 3712-1 through -5 cover 470 to 1,000 μh and are 0.375 x 0.625 in. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. [348]

New components

Plating sets gap in stereo heads

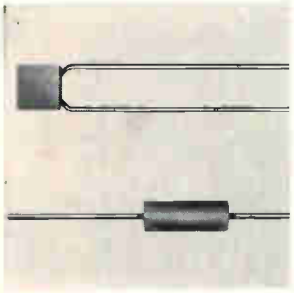
Process that cuts reject rate to 15% could trigger price reductions in home tape recorders and players

A Japanese firm's technique of plating metal on ferrite may bring about the long-awaited break in prices of home tape recorders. Despite the steady decline in the prices of other home-entertainment products, quality tape recorder prices have been difficult to budge. One of the major reasons has been the cost of record and playback heads, which is high compared with other components.

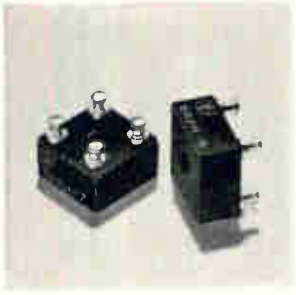
Foster Electric Co. says its plating technique cuts head reject rate by nearly two-thirds and eliminates a lot of manual assembly work. The company claims a reject rate of 15% or less for stereo cartridges, compared with the industry average of 40%. With less scrap to write off, selling prices can be shaved.

No shims. The main reason for rejecting a conventional ferrite head is that the air gap between the metal pole pieces is askew. These pieces are usually made from stacks of laminated material, such as Permalloy. The gap is set by inserting a shim of copper between the pole pieces, after which the assembly is encapsulated in plastic and ground to shape.

Because the surfaces of the individual pole pieces aren't always



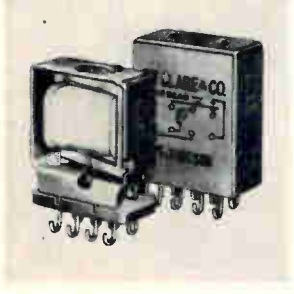
Series TT ceramic capacitors in encapsulated radial and axial configurations, have tolerances of ±0.25%, ±0.5%, and 1%; and a capacitance range from 1 pf to 200,000 pf as standard. Applications include delay lines, a-d conversion, precision filtering, timing circuits, and ratio matching. Electro Materials Corp., 11620 Sorrento Valley Rd., San Diego, Calif. 92121. [349]



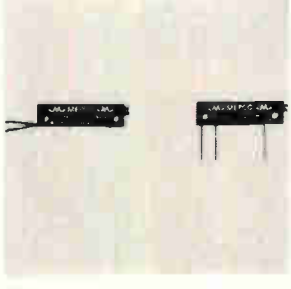
Miniature single-phase bridge rectifier assemblies with ratings up to 2,500 piv mount to p-c boards with one screw; terminals are silver-plated brass for easy soldering. Devices offer piv's of 1,500, 2,000, or 2,500 at current ratings of 1.2, 0.8, or 0.6 amps respectively. Price is $3.27 each in lots of 1,000. Sarkes Tarzian Inc., 415 N. College Ave., Bloomington, Ind. [350]

An ultralinear variable magnetostrictive delay line provides continuously variable delays from 2 to 35 μsec at frequencies up to 2 Mhz. Unit operates in temperatures from −40° to 85°C and survives shocks of 600 g. Delay is varied by a shaft; normal performance is 167 ns/turn with linearity to better than 0.25%. Digital Devices Inc., 200 Michael Dr., Syosset, N.Y. [351]

An interstage pulse transformer—1 cu in. in volume and weighing 75 grams—operates up to 50,000 ft, withstands thermal shock and h-f vibration to 50 g, and environmental temperature from −54° to +110°C. With a working voltage of 10 kv d-c, it has a 1:1 turns ratio, a 0.05-μsec rise time, and meets MIL specs. PCA Electronics Inc., 16799 Schoenborn St., Sepulveda, Calif. [352]



Military relay type PF has contact ratings up to 10 amps, with operate and release time of 7 msec max. Initial circuit resistance is 10 milliohms max., 20 milliohms max. after more than 100,000 operations at 10 amps, 28 v d-c. Unit operates from −65° to +125°C, withstands vibration of 20 g at 10 to 2,000 cps. C.P. Clare & Co., 3101 Pratt Blvd., Chicago. [353]



Fired-film trimming pots for the industrial market, designated Accutrim, have all-welded construction, with a stainless steel 1-piece lead screw and a slider that insures long resistance element life. They have infinite resolution, a range from 100 ohms to 1 megohm, and exceed requirements of MIL-R-22097, Characteristic B, Type RJ12B. Mepco Inc., Columbia Rd., Morristown, N.J. 07960. [354]

A resistor 0.040 in. in diameter and 0.130 in. long operates from 1×10^8 to 1×10^{12} ohms with a tolerance of ±25%. It handles temperatures to 100°C and with a compatible epoxy can be readily encapsulated. The ends of the resistor serve as terminals for direct soldering to terminal board and circuit component connections. Pyrofilm Resistor Co., 3 Saddle Rd., Cedar Knolls, N.J. [355]

Reed relay series 325-12-1A measures 1.4 x 0.25 in. sq. with 0.1-in. pin spacing for standard p-c layout techniques. Direct p-c mounting eliminates changes in reed characteristics caused by cutting and bending of axial-lead types. The spst contacts switch in less than 1 msec, and are rated at 4 v-a into a resistive load. Self-Organizing Systems Inc., Box 9918, Dallas. [356]

smooth, the gap formed by the shim can vary. Monaural recorders can tolerate a slight variation in air gap, but frequency response and amplitude linearity can suffer badly in stereo systems.

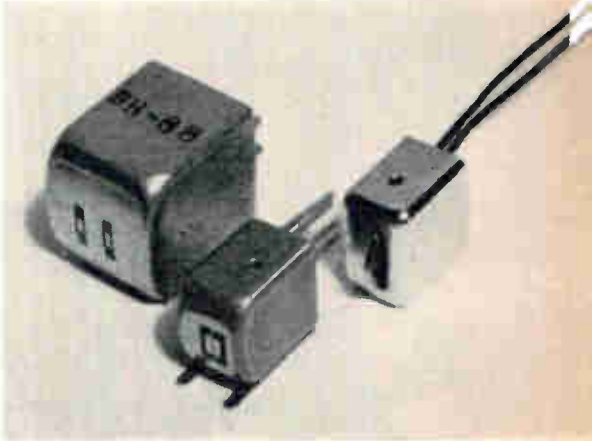
Instead of using stamped laminations, Foster plates the pole pieces directly onto ferrite, and then plates the heads with copper to provide the gaps. This is achieved in a three-step process that assures dimensional uniformity.

To make a stereo head, two pieces of ferrite and two coils are first clamped together, with the ferrite heads at the exact spacing required in the finished head. The clamp becomes a permanent part of the assembly, retaining the spacing through the next steps. Then the pole pieces and the copper spacer are plated. Finally, the heads are encapsulated and ground to shape.

Bonus. Foster says it can make the platings as thick as 2 millimeters, while controlling composition of the nickel-iron alloy.

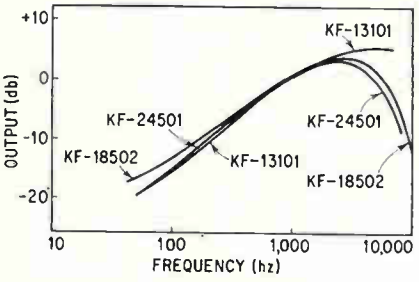
As a byproduct of the plating approach, the company claims its heads will last three or four times longer than laminated heads. The reason: plated-pole pieces are harder—about Vickers 600 hardness contrasted with 120 to 150 for laminated heads.

Although Foster isn't ready to



Japanese heads. Standard stereo, Cassette stereo, and film projector heads (from left to right) are being made with the new plating process.

. . . new heads are cheaper, but no prices yet . . .



Frequency response. Output versus frequency for three types of heads.

disclose prices for its heads, it says they will be competitive with conventional heads. Production on three heads started this summer, but hasn't reached the point where the company will quote off-the-shelf prices. Foster prefers to negotiate prices with volume buyers. The three types are the KF-13101, an eight-track stereo head for playback only, the KF-18502, for Philips Cassette stereo record and playback machines, and the KF-24501, a single-channel record-playback head for 8-mm sound movie projectors.

Specifications

Model KF-18502

Function	Cassette record and playback
Gap	1.5 microns
Impedance	400 ohms at 1 hz
Bias frequency	60 khz
Bias current	0.7 ma
Record current	100 μa
Playback level	−72 dbm at 1 khz
Crosstalk rejection	45 db min. at 1 khz
Track width	0.023 in.
Track spacing	0.0345 in

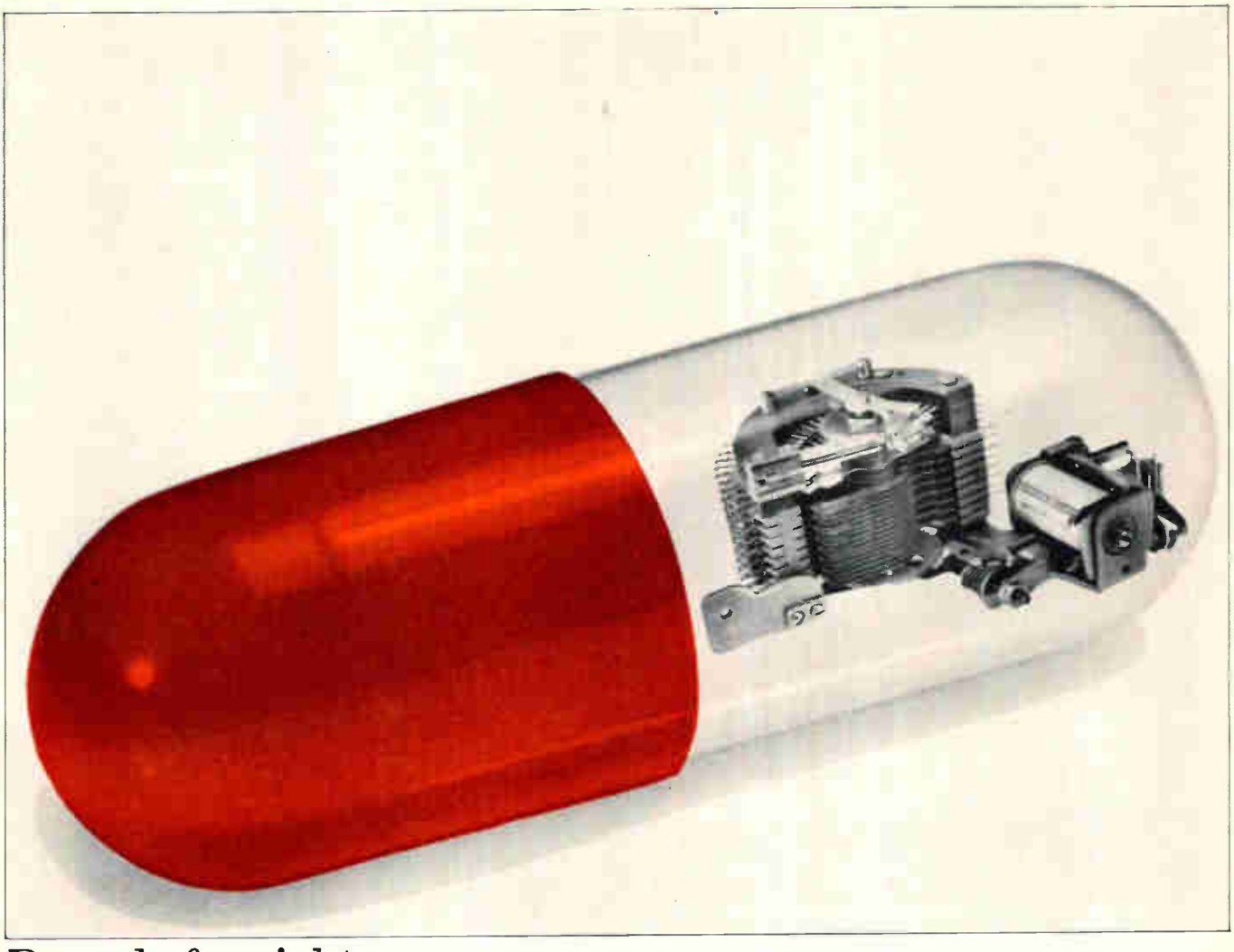
Model KF-13101

Function	8-track, 2-channel playback only
Gap	3 microns
Impedance	2.5 kilohms at 1 khz
D-c resistance	550 ohms
Playback level	−60 dbm at 1 khz
Crosstalk rejection	60 db min. at 1 khz
Track width	0.02 in.
Track spacing	0.127 in.

Model KF-24501

Function	8-mm film record and playback
Gap	2 microns
Impedance	100 ohms at 1 khz
Inductance	14 mh
D-c resistance	25 ohms
Bias frequency	50 khz
Bias current	1.5 ma
Record current	200 μa at 1 khz
Playback level	−75 dbm at 1 khz
Track width	0.023 in.

Foster Electric Co., 512 Miyazawacho, Akishima, Tokyo **[357]**



Remedy for nightmares: AE's Type 45NC stepping switch with "shorting" levels.

Many of today's complex switching circuits look like an engineer's nightmare. Why not simplify them? You can replace whole groups of components with an AE Type 45NC "stepper."

This switch has normally closed ("shorting") levels. It's designed so that pairs of contacts *open* successively when the rotor is stepped.

The Type 45NC can solve almost any circuit-transfer or testing problem.

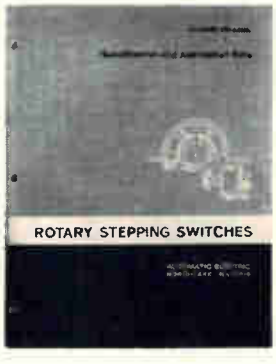
It's ideal for self-interrupted hunting, and you don't need auxiliary relays.

You get one or two electrical levels of either 26 or 52 point normally-closed contacts. For extra versatility, you can specify additional levels of *normally-open* contacts—on the same switch.

Contacts are gold-plated phosphor bronze. Contact resistance: a maximum of 50 to 100 milliohms, measured at 6 volts 100 milliamperes.

When you specify AE rotary stepping switches, you get the benefit of our continuous research—in design, in metals and insulating materials. All this plus *positive positioning* – a unique AE design feature that locks the rotor and makes overthrow impossible.

Find out more about AE rotary stepping switches—an economical, rugged and reliable way to simplify switching circuits. There's a lot of helpful application information in our new reference circular 1698-L. To get your copy, just ask your AE representative. Or write to the Director, Relay Control Equipment Sales, Automatic Electric, Northlake, Illinois 60164.



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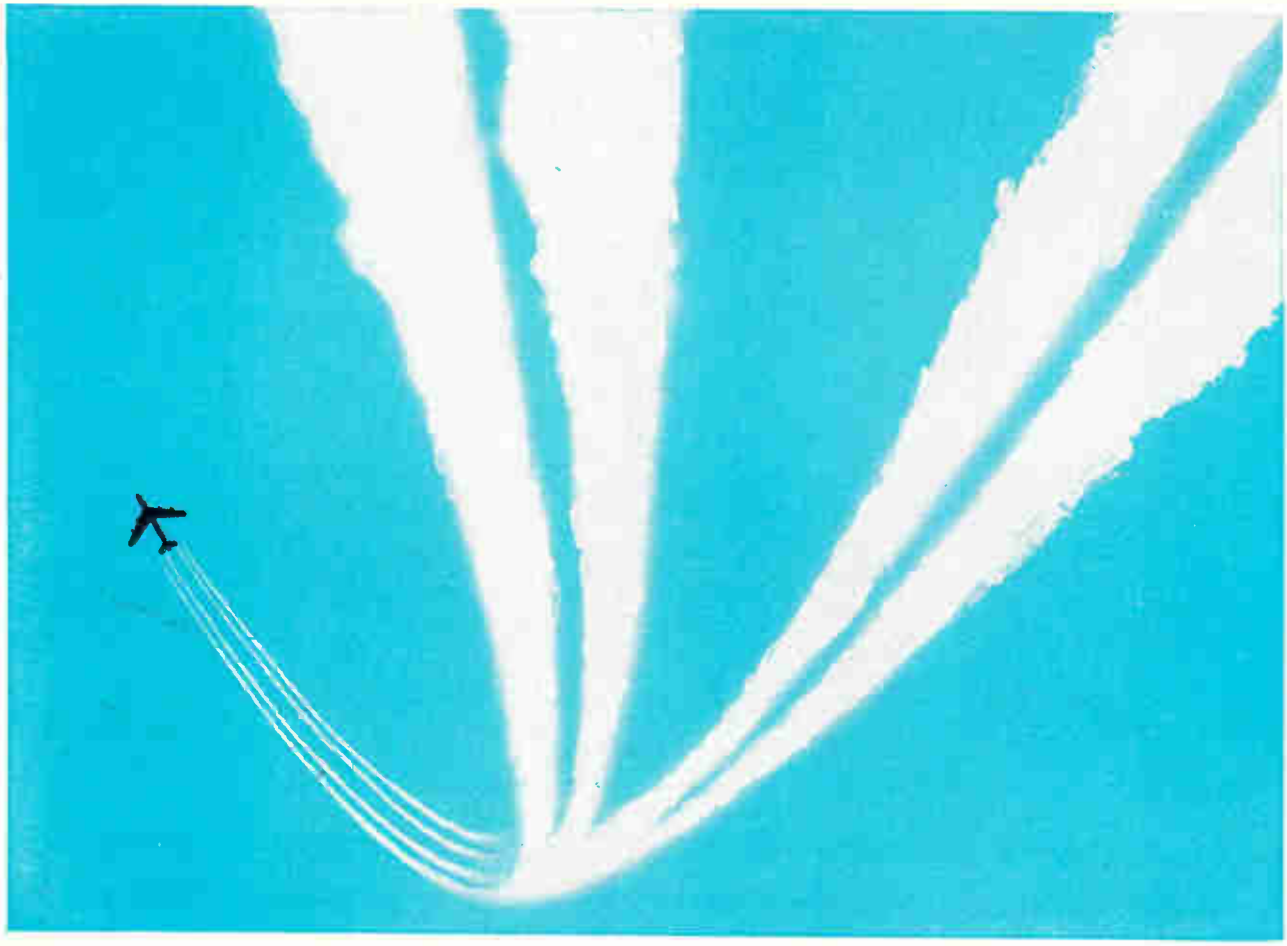
Circle 187 on reader service card



Our abrasion-resistant TFE wire keeps on flying after others call it quits.

Keeps flying up to 12 times longer, as proved in use on six leading types of commercial and military jets. Reason? It's 100% more abrasion resistant than other airframe wires. Because it has a tough insulation core of mineral-reinforced TFE bonded between pure TFE layers.

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Right now, it's reducing wire replacements in aviation, mining, refining, ground transportation and railroad equipment manufacturing. It can do the same for your application. For a free test sample and further data, write: ITT Wire and Cable Division, International Telephone and Telegraph Corporation, Clinton, Mass. 01510.

WIRE AND CABLE ITT

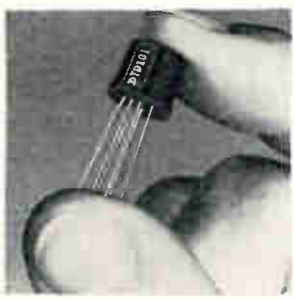
New Semiconductor Review

Series NL-C180 are silicon controlled rectifiers with voltage ratings from 100 to 1,300 v. Devices are all-diffused, shorted-emitter types with 235 amp rating. Minimum dv/dt rating is 200 v/μsec; maximum di/dt ratings, up to 100 amps/μsec. Peak on-voltage is 1.8 v. Hard solder construction yields low thermal fatigue. National Electronics Inc., Geneva, Ill. [436]

"Doorbell" rectifier module series UG has ratings up to 8.25 amps in air and 10 amps in oil, and from 2.5 kv to 10 kv. Modules are vacuum encapsulated with high-thermal-conductivity filled epoxy for voidless construction and corona-free operation. Each module has threaded connectors for stacking up to 600 kv. Delivery takes 2 weeks. Unitrode Corp., 580 Pleasant St., Watertown, Mass. [437]

Photocontrolled resistor type 5082-4510 uses a cadmium-sulfoselenide photocell for stability in a changing temperature environment. Photocell resistance, when illuminated, changes typically by a factor of 1.5 with a variation in temperature from 25° to 65°C. Units cost $8 each in small quantities, and $6.80 for 10 to 99. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. [438]

Current-regulating diodes with working currents from 0.22 to 4.7 ma come in a 32-device series. The 1N5283 through 1N5314 are field effect diodes that provide constant currents independent of voltage. Devices offer a peak operating voltage of 100 v, 600 mw power dissipation. Prices are from $4.90 for 100 units. Motorola Semiconductor Products Inc. Phoenix, Ariz [439]



Plastic complementary silicon transistors rated at 360 mw with a maximum operating junction temperature of 150°C can be used to replace the standard 2N2222 series. The TD100 meets MIL-S-19500/255E, with a noise figure of 0.5 db and a minimum gain of 100 at 10 μa. Base-to-emitter voltage is matched within 2.5 mv. Sprague Electric Co., North Adams, Mass. [440]

Sensitive gate scr's 2N5060-2N5063 are rated at 800 ma (forward current rms) with voltage ranges from 30 to 150 v in a TO-92 Unibloc plastic package. Gate current requirement is 200 μa. Uses are in fractional h-p motor controls, sensing and detection circuits. Prices range from 51 to 85 cents (100 and up). Motorola Semiconductor Products Inc., Box 13408, Phoenix, Ariz. [441]

Fast recovery 12-amp silicon rectifiers designated JAN 1N3889 through 1N3893 meet MIL-S-19500/304(EL) specs. The series is for high-reliability military equipment using high-frequency sine wave, square wave or pulsed inputs. Applications include inverters, modulators, converters, and accelerators. Electronic Devices Inc., 21 Gray Oaks Av., Yonkers, N.Y. 10710. [442]

Hybrid IC, d-c wideband amplifier HX610 is offered in a 10-lead TO-5 can. It has built in by-pass capacitors and needs no external components when used as an amplifier with a voltage gain of 26 db. Maximum output voltage swing with no load is 20 v peak-to-peak to 8 Mhz, derating to 2.5 v p-p at 100 Mhz. Halex Inc., 139 Maryland St., El Segundo, Calif. [443]

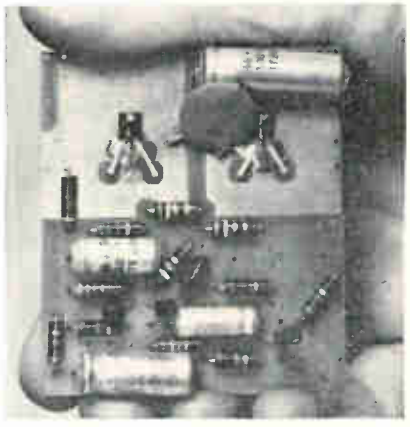
New semiconductors

Plastic transistor dissipates 1.6 watts

By changing lead material, transistor passes heat out to circuit board

When it comes to transistors, encapsulating them with plastic isn't the only thing Texas Instruments Incorporated is doing these days—it's increasing the power-handling capability at the same time. With a new process to get heat away from the transistor [Electronics, Sept. 4, p. 26], TI can now dissipate 1.6 watts at 25°C case temperature in a TO-92 package.

The first units in which the new process is used are silicon audio transistors for consumer electronics applications. Designated the TIS90, 91, 92, and 93 series, the small-



Hand made. Collector lead is connected to area of copper in a circuit developed to test the power dissipation of the TIS90.

. . . try, try again to dissipate heat . . .

signal units are for applications formerly restricted to metal-case, medium-power devices or where heat sinks had been used.

Many tries. When TI engineers started the project, they tried attaching a metal heat sink to a regular plastic unit. But this didn't prove too effective. The engineers found that most of the heat went out through the leads. Next they tried changing the plastic's formula, but this failed, too—all it did was change the electrical characteristics by lowering the volume resistivity. The third attempt, using an area of copper on the face of the etched circuit board as a heat sink, proved successful. And this process had a built-in bonus: no additional cost.

The selected area is connected to a high-conductivity collector lead that directs the heat away from the transistor. Continuous device dissipation of the series is typically 625 milliwatts at 25°C free air—double that of previously available plastic packages of the same size.

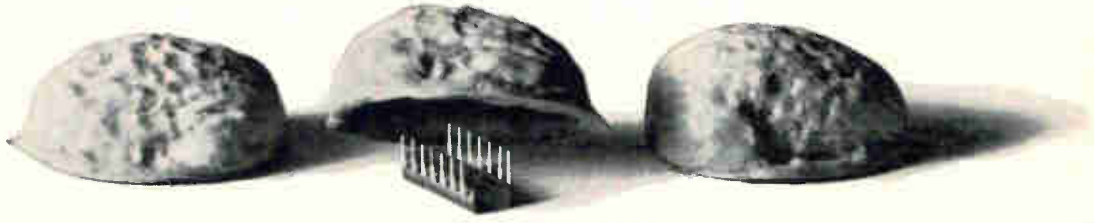
Silicon planar epitaxial transistors are available as npn types TIS90 and 92, and as pnp types TIS91 and 93. They are also available in matched complementary pairs—TIS90M/91M and TIS92M/93M—for low-cost audio driver and output circuits with up to 2 watts for phonograph and stereo applications.

Electrical characteristics include a minimum 40-volt breakdown voltage (collector-base and collector-emitter), and a maximum 400-milliamp continuous collector current. The maximum collector-emitter saturation voltage is 0.25 v, and the maximum junction temperature is 150°C. The package is TI's solid, transfer-molded TO-92 with in-line pin configuration or a 100-mil pin-circle arrangement. Prices range from 39 to 50 cents each in quantity.

More plastic. A series of 18 transistors for radio, television, and audio applications was also announced. These transistors are also encapsulated in the transfer-molded plastic package, but without the new heat-sinking design.

Eleven of these units—TIS83 to

THE CONFIDENCE GAME



If you're going to spend hard cash for integrated circuits, you don't want to play guessing games. You want a company you can have confidence in. A company like Signetics. Our integrated circuits go through one of the toughest quality assurance programs in the business. Signetics SURE program meets all the requirements specified by the military for TX (testing extra) device testing. Reliability documentation? It couldn't be more thorough. Send for the SURE Bulletin #5001 and our latest reliability report. They give you good reason for confidence in Signetics, the world's largest maker of integrated circuits exclusively. Write Signetics, 811 E. Arques, Sunnyvale, California 94086.

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87, and 94 to 99— are silicon transistors ranging in price from 36 to 70 cents. The highest priced is the TIS83, which is a high-performance oscillator transistor designed for use in uhf tuners. It features a high-injection current—I_{osc} is 2.5 ma at 930 megahertz—and a high transconductance at uhf frequencies—Y_{FE} is 70 micromohs at 200 Mhz—enabling the device to be used with Schottky-barrier or automatic-frequency-control diodes. Other devices in the series include: r-f amplifiers, video i-f stages, and audio preamplifiers.

The seven other new transistors are the germanium planar plastic type. These units—TIXM13 to 19—have an operating temperature range of −60 to +125°C and are priced from 26 cents to $1 in quantity. They include audio amplifiers, a-m and f-m amplifiers, mixers, oscillators, and transistors for automatic-gain control applications.

Texas Instruments Incorporated, Dallas **[444]**

New semiconductors

Diodes brighten way to IC displays

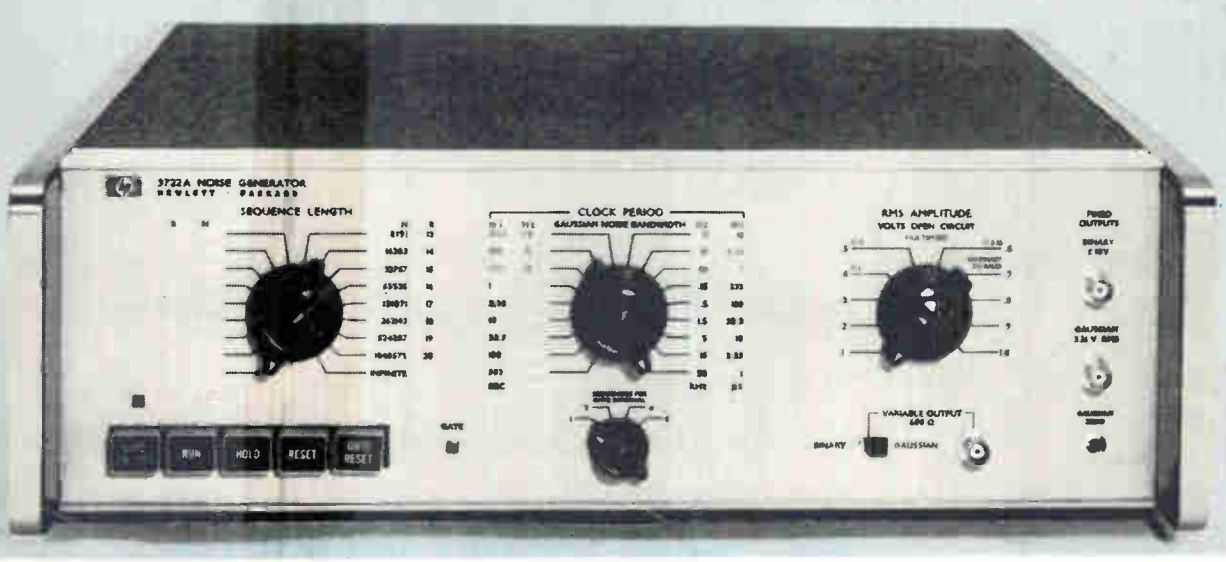
Improved efficiency cuts forward current, makes diodes IC-compatible

Diodes that emit 500 foot-lamberts of visible red light—a tenfold improvement in brightness—are being made by the Monsanto Co. Extra brightness isn't the only reason company engineers are beaming.

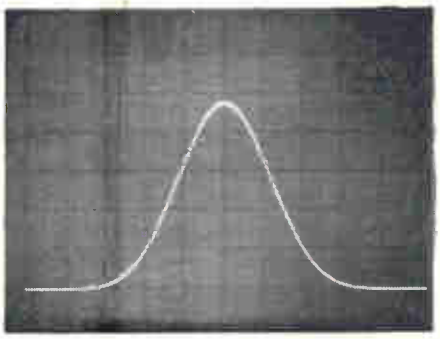
The new diodes require no more forward current than the 50-ft-l diodes, also made of gallium-arsenide-phosphide semiconductor material, which the company was selling for 18 months. Both reach maximum brightness at a forward current of 50 milliamperes. In addition, Monsanto has upgraded the original diodes so that they are now produced at half the previous cost —about $4 instead of $8—and emit 120 ft-l at 50 ma.

The greater efficiency stems

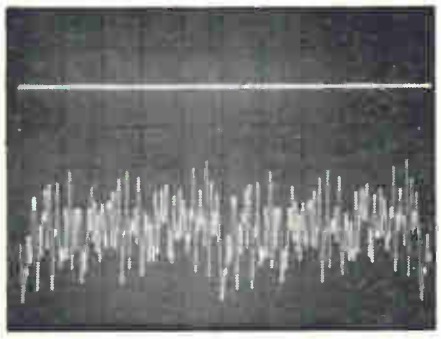
Put noise to work



DC to 50 kHz, HP now offers calibrated, repeatable noise patterns, random or pseudo-random, constant power and excellent Gaussian distribution.



EXCELLENT GAUSSIAN DISTRIBUTION
Using HP 5400A Multi-Channel Pulse Height Analyzer, ±250 mv; 1024 channels; Noise Generator: sequence length, 1,048,575; clock period, 3.33 μsec.



REPEATABLE
Sweep time of oscilloscope, 0.2 millisec/cm; Noise Generator: sequence length, 1023; clock period, 1 μsec.

The Hewlett-Packard 3722A Noise Generator now lets you harness noise so that it becomes a defined and calibrated input to your system. It allows you to synthesize and reproduce at will noise signals of constant noise power with a probability density function (pdf) in the classical Gaussian construction. This unique new instrument uses computer techniques to synthesize noise patterns of selectable length that are thoroughly defined and repeatable.

Because the 3722A employs a unique combination of digital and analog filtering, it is able to produce usable controllable power at low frequencies not previously possible. And, too, the digital nature of noise generation enables exact repetition of noise patterns of selectable length. This can save you hours of testing time, and you can test circuits, components or systems with confidence. System responses can be completely defined.

Ideal for such applications as control system response measurements, communications testing, acoustic measurements, temperature and flow fluctuations, study of air, water and earth turbulence—and other real-time analog simulation. HP 3722A, $2650.

For more information call your local HP field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva. 18703

HEWLETT hp PACKARD

SIGNAL SOURCES

Array. Developmental array of light-emitting diodes is a step toward solid state alphanumeric displays.

from accumulated process and design improvements. Monsanto expects additional bonuses in performance and price from its program, which is partially supported by the Air Force Materials Laboratory at Wright-Patterson Air Force Base, Ohio.

Arrays the goal. The higher efficiency puts the company within striking distance of a major goal—a solid state alphanumeric display that can be driven directly by integrated circuits. A current requirement of 50 ma would put considerable strain on the IC drivers, but IC's can easily deliver 10 ma. At that forward current, the new diodes will still emit 50 ft-l, which is ample for many applications. The diodes are also in the IC voltage ball park, requiring only 1.6 volts d-c.

For now, Monsanto is offering the diodes only as individually packaged components, and in developmental assembled arrays. One such array contains 35 diodes in a 5 x 7 arrangement. At the going price for the brightest diodes—about $15 in quantities of 1,000—these arrays are too costly for routine display applications. They are aimed for applications such as recording encoded data on film.

However, the lower current requirements and process improvements raise the likelihood of monolithic arrays, able to display characters and numbers, being produced in the future.

Variety. Although the new diodes emit 500 or more ft-l of light, Mon-

If you make a product that needs control, and you are still using relays, the facts are, some of your competitors are using cheaper, more reliable, more versatile solid state circuits.

If you make equipment to control, or measure, or analyze, the facts are, some of your competitors are building small computers inside. You hard wire for one task, one purpose. They write programs for the computer that permit typed-in instructions for many tasks, many purposes.

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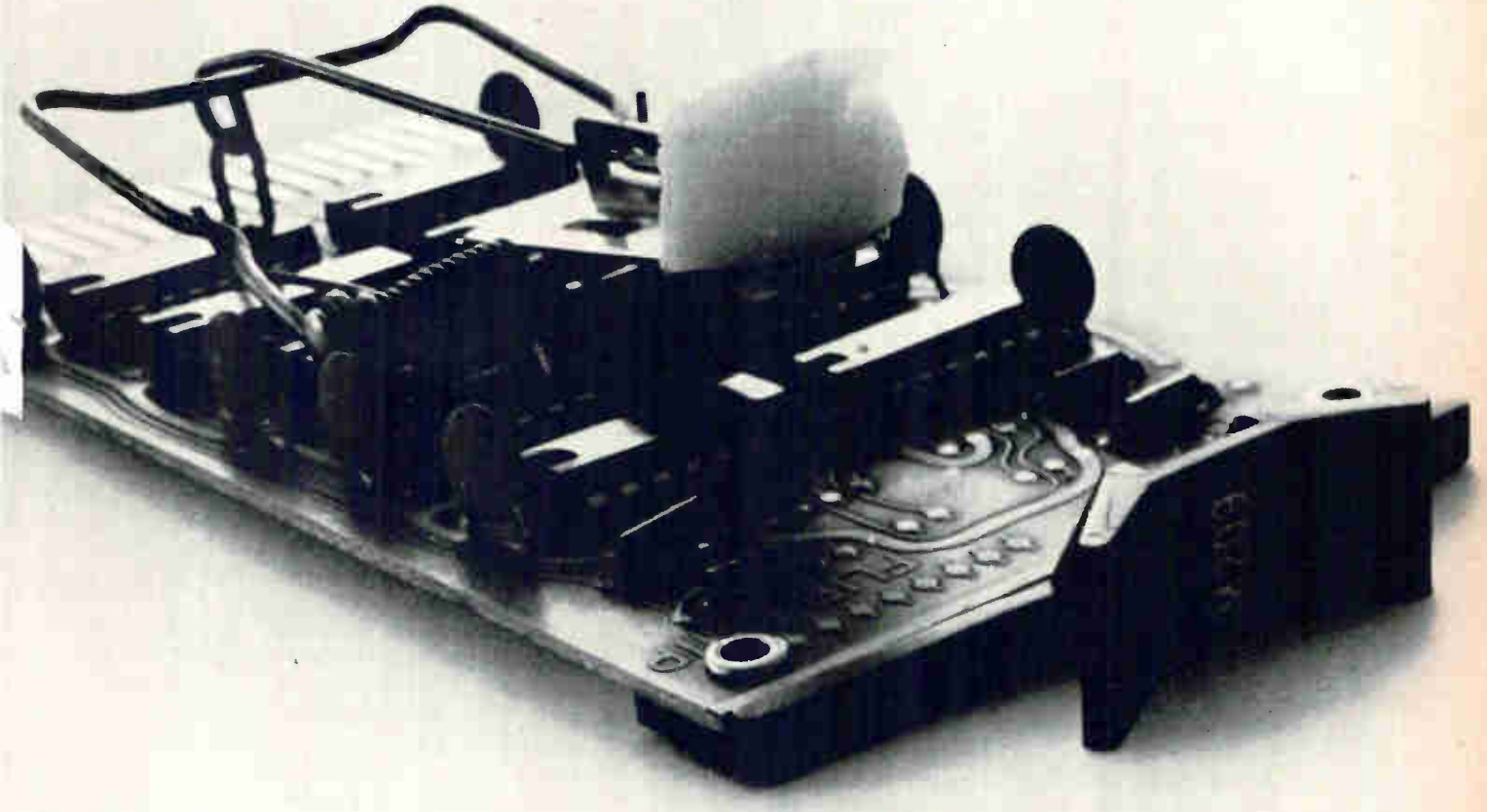
Digital Equipment's product line includes noise-immune solid state circuits for industrial controls, computer speed modules for interfacing and simpler instruments, analog to digital converters now no bigger than a circuit card. And the computers themselves. Digital Equipment is the leading manufacturer of small computers in the world. PDP-8/S, which sells for $10,000 before OEM discounts. PDP-8 at $18,000. PDP-9 and the time-sharing PDP-10 for bigger tasks.

We have literature on the products and the applications. Free for the asking.

How to automate A Better Mousetrap



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santo specifies them in two nominal brightness categories: 300 and 450 ft-l at 50 ma. The first will emit 50 ft-l at 20 ma, and the second provides 50 ft-l at 10 ma.

Among the recommended applications, besides data encoding on film, are graticule illumination, long-life indicator lights, and light sources for light-sensitive semiconductor detectors. At the lower current, they are suitable for IC diagnostic indicators—a diode can be connected to an IC assembly to indicate malfunctions and is driven directly by the IC power supply without a buffer amplifier.

Unlike semiconductor lasers—which Monsanto also makes—the diodes emit incoherent light. Output wavelength varies between 6,000 and 7,000 angstroms and spectral bandwidth is 400 angstroms. The diodes can be selected to provide a requested peak output at a wavelength within the nominal range.

The diodes are mounted in TO-18 headers, or in a smaller, coaxial package that allows them to be put closer together. The TO-18 can's diameter is 0.230 inch and the coaxial package's is 0.1 inch. In the first, the anode and cathode are pins; in the other, the cathode extends through the anode. The top of each package is an epoxy lens that protects the semiconductor chip, serves as a window, and concentrates the emission into a narrow cone.

Monsanto Co. 800 N. Lindbergh Blvd., St. Louis, Mo. 63166 **[445]**

New semiconductors

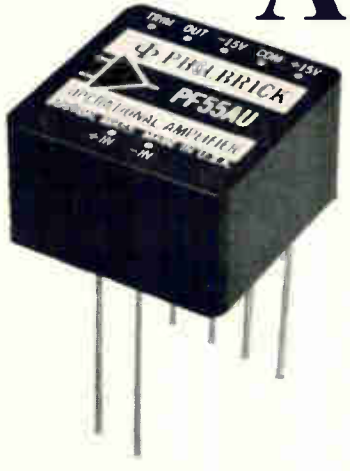
Square solar cells convert for less

Ceramic solar cells cost 1/10th as much as silicon for the same power output

Inexpensive ceramic solar cells developed at Japan's Matsusita Electric Industrial Co. wireless research laboratory may lead to many applications not practical with sili-

Buy this ten dollar Philbrick Operational Amplifier

...and let everyone think you paid twenty. They'll believe it, when they see its performance.



Plain language—our low prices come from volume-production savings and new packaging efficiencies. Others achieve them by cutting corners—thereby making your design job more expensive, more difficult, and more restricted.

Here's what we mean—Economy-Grade Philbricks give you *design resilience* the others don't have. Things like:

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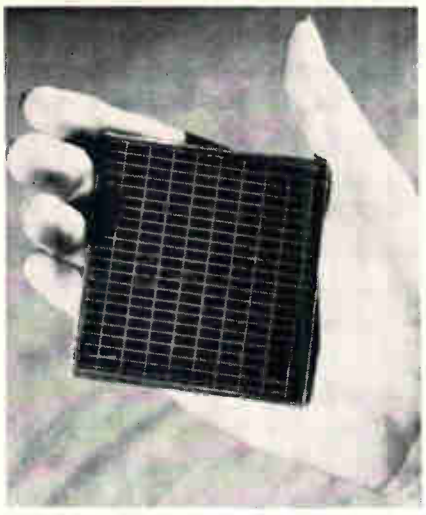

Substitute. Ceramic solar cells replace silicon at lower cost.

con cells. When solar cells first became commercially available it was thought that they could be used to heat homes, power cars and remote radio stations, and, in general, be a free source of power. But even after the development of the silicon cells, these goals were not achieved because of the high cost. Matsushita engineers say the cost-per-watt generating capacity of the new cells is about 1/10th that of standard silicon solar cells.

The base for the new cell is a sintered wafer of cadmium sulfide, which is a ceramic-like material. It can be made in almost any size or shape, unlike silicon which is limited to small wafers. The basic material costs only about $7 a pound.

Conversion. Sintered wafers are n-type semiconductors. The front surface is converted to a p-type semiconductor by immersion in a copper-sulfate solution. The reaction between wafer and solution converts the front surface to copper sulfide, which has p-type properties. The junction is between the copper sulphide and the cadmium sulphide, and is heterojunction rather than homojunction as in silicon and germanium solar cells. The back of the wafer is masked to prevent its conversion.

The converted layer is from 10 to 100 microns thick, depending on treatment time. This is much thicker than the layer above the junction in a silicon solar cell. One reason for the thickness is the granular nature of the material. Only the surface of individual

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Reliably trouble-free readouts. All Datavue characters are fully formed—not segmented. The fully formed characters are brightly displayed and easy to read—at distances up to 30 feet.

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They're readily available—in sample and production quantities. For samples, prices, or technical information, call your Raytheon regional sales office or distributor. Or write: *Raytheon Company, Industrial Components Operation, Quincy, Mass. 02169.*

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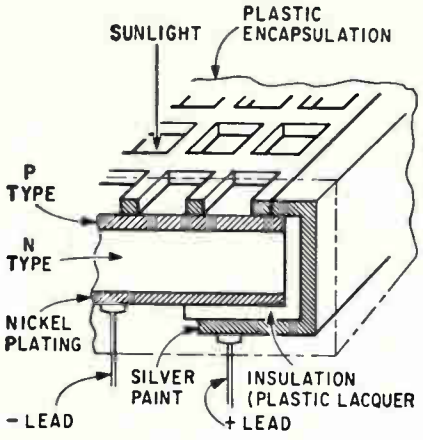


grains of cadmium sulfide are converted to copper sulphide, while the inner portion remains unconverted.

Positive stripes. A grid made of stripes of silver conductive paint on the front surface of the cell forms the positive electrode. Closer spacing and increased width of stripes lower the cell resistance and increase maximum current available, but decrease efficiency because part of the active region of the cell is shaded. Nickel plating on the cell's rear surface forms its negative electrode.

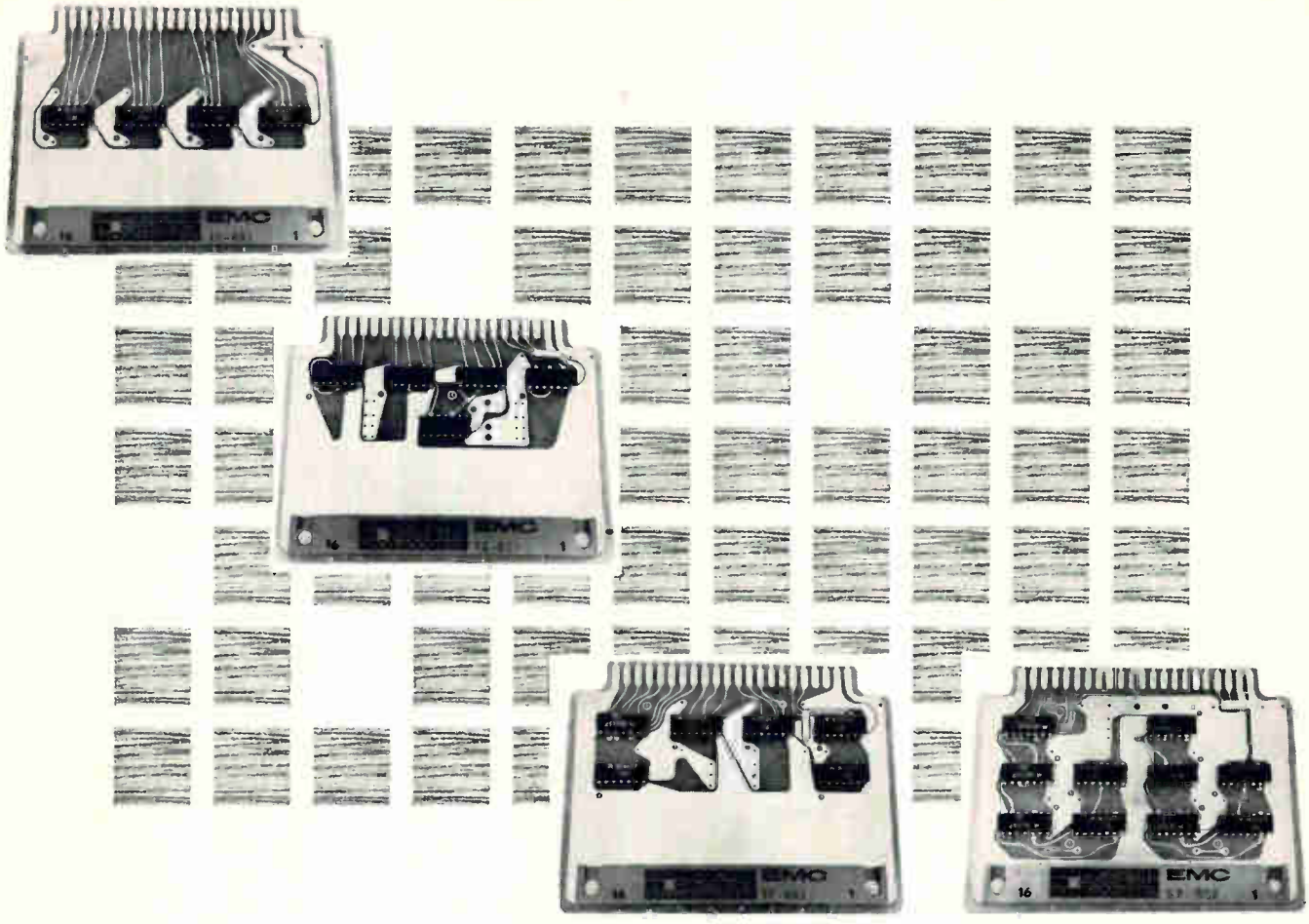
While the conversion efficiency of the cells is lower than that of silicon solar cells, Matsushita engineers calculate that in some applications the efficiencies of the two types may be almost equal on an area basis.

The cadmium-sulfide cells can be made square, while silicon cells have to be trimmed into rectangles to obtain the maximum output from a solar panel. If the silicon cells were used in their natural form, as circular or semicircular slices, the gaps between the cells would make the area efficiency about the same as for ceramic cells.

Ceramic and silicon cells

Characteristic	Silicon cell	Ceramic cell
Conversion efficiency (Incident radiation to electricity)	10-15%	5-8%
Open-circuit voltage	0.6v	0.45v
Short-circuit current	30 ma/sq.cm	30 ma/sq.cm
Temperature coefficient	–0.5%/°C	–0.5%/°C
Cost per watt	$54 to $67	$5.40
Resistance to radiation	Poor	Good to excellent

Matsushita Electric Industrial Co., Tokyo [340]



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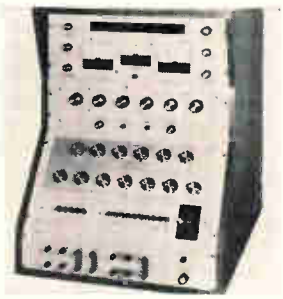
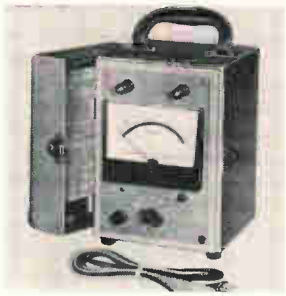
New Instruments Review

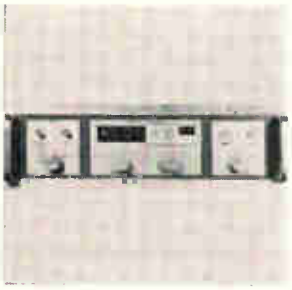


Guildline 9930 d-c current comparator potentiometer features a 7-figure readout without critical resistors. Linearity is 0.05 ppm over full range, and long term drift less than 0.1 ppm per year. The unit's resolution is only 1 part in 2 x 10^7 of full scale, and standard cell dial resolution is 0.1 ppm. Cost is $7,890. Hallmark Standards Inc., 145 Library Lane, Mamaroneck, N.Y. [361]

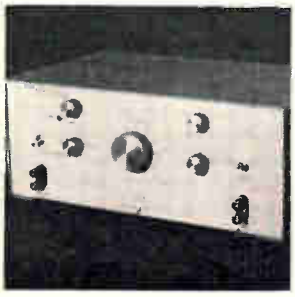
The Centurion line of electrical meters has easy-to-read scales, recessed glass window to minimize marring, and glare-free scale illumination. D-c current sensitivities are available from 5 μa through 50 amps with self-contained shunts. D-c voltage sensitivities are from 3 mv through 500 v with self-contained multipliers. Beede Electrical Instrument Co., Penacook, N.H. [362]



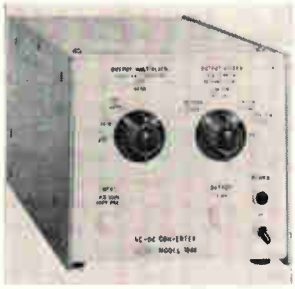
Portable ohmmeter 244 has 0.5% accuracy at center scale. It makes direct readings of resistances from 0.05 to 50,000 ohms. It is calibrated in 4 ranges: 0 to 50, 0 to 500, 0 to 5,000, and 0 to 50,000 ohms. Accuracy is assured by a built-in standard that compensates for battery condition and lead resistance. Associated Research Inc., 3777 W. Belmont Ave., Chicago. [363]



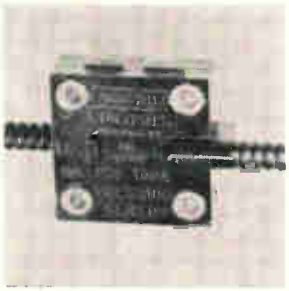
Digital frequency difference meter model 9403 provides a rapid, digital intercomparison of 2 frequency standards. It measures frequency offset from 1 Mhz reference to one part in 10^{13}. The unit is useful in the setting or calibration of secondary standards and in short- and long-term frequency stability measurements. RMS Engineering Inc., 486 Fourteenth St., N.W., Atlanta, Ga. [364]



Portable transient generator model 4881 determines the ability of equipment and systems to withstand sudden changes in a-c or d-c power supply sources. Pulse amplitude is variable from 0.1 to 300 v; peak pulse power is 43 kw, 0.5-ohm load; and synchronous pulse positioning, 0° to 360° on power line waveform. Honeywell Inc., P.O. Box 391, Annapolis, Md. 21404. [365]



Suited for swept frequency measurements, model 1008 a-c/d-c converter has a 70-db dynamic range, a frequency response from 5 hz to 5 Mhz, and a 300-μv sensitivity. It is applicable for audio and video measurements such as those encountered by telephone companies and filter manufacturers. Pacific Measurements Inc., 940 Industrial Ave., Palo Alto, Calif. [366]



Pressure sensor PSF100A senses level changes in liquids, granular powder semisolids, equivalent to ½ in. or less of water column or pressure/vacuum and differential in the same range. It is virtually insensitive to shock, vibration, and acceleration. It is 1 x 1 x 11/32 in., and weighs less than 10 grams. Fairchild Camera & Instrument Corp., 225 Park Ave., Hicksville, N.Y. [367]

Lock-in voltmeter 131 measures very weak radiant energy. It operates with any detector over the spectrum from ultraviolet to far infrared. It is suited for general measurements of absorption, fluorescence, emission, reflectivity, and transmission. Frequency range is 1 hz to 10 khz; gain stability, 0.25%. Price is $2,150. Brower Laboratories Inc., Turnpike Rd., (Route 9), Westboro, Mass. [368]

New instruments

A-c tests weed out defective chips

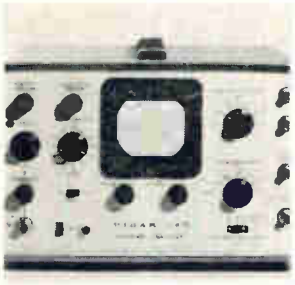
System tests IC's before wafers are separated and packaged, eliminating faulty circuits that pass the usual d-c tests

Functional tests of integrated circuits are normally made after packaging. Inductance and capacitance contributed by the probes used to make d-c tests on the wafer can cause propagation delays greater than those the tester is trying to measure. From necessity, manufacturers have learned to get along with d-c tests; yields after this stage—before scribing, bonding, and encapsulation—can run as high as 90%.

The faster and more complex IC's become, the less likely it is that d-c tests will weed out all the defective chips, and the manufacturer will have to go through the expensive packaging process before knowing which circuits are good.

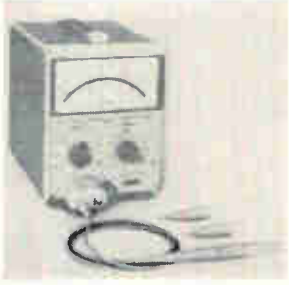
Last fall, Sylvania Electric Products reported a pilot process for a-c testing on the wafer [Electronics, Oct. 17, 1966, p. 94.] And last month at Wescon, E-H Research Laboratories Inc. of Oakland, Calif., demonstrated the first commercial system for such testing.

The E-H Series 4001 and 4002, based on two instruments that E-H introduced at the IEEE show last March—a switching-time converter for making nanosecond time-interval measurements and a strobing



Dynamic flutter analyzer 720 provides precise analysis and measurement of tape recorder flutter. The built-in oscilloscope identifies and measures all flutter-contributing components from 0.2 hz to 10 khz. The analyzer includes a crystal-controlled reference-frequency oscillator. Both sine- and square-wave outputs are provided. Vidar Corp., 77 Ortega Ave., Mountain View, Calif. [369]

Automatic transfer standard model ATS is a true rms to d-c converter that makes a measurement in 10 seconds for frequencies from 2 hz to 10 Mhz. Accuracies are: 0.1% for a-c signals up to 1,000 v and to 20 khz; 0.02% up to 500 v and to 50 khz; 0.05% up to 16 v and to 1 Mhz; 0.5% up to 8 v and 10 Mhz. Singer Co., 915 Pembroke St., Bridgeport, Conn. [370]



H-f probe 11096A converts d-c voltmeters into a-c instruments that measure signals from 100 khz to 500 Mhz. Accuracy in this range is better than 1 db. Input impedance is 4 megohms shunted by 2 pf. The probe works with analog or digital voltmeters that have input resistances of 10 megohms ±10%. Price is $45. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. [371]

Frequency converter CRS-150A converts 50 or 60 hz single-phase input power to precision, low-distortion 400 hz single-phase output. It delivers 150 v-a, with continuous duty in ambients of −20° to + 60°C. Its sine-wave output has less than 1% total harmonic distortion. Frequency regulation is ±0.25%. CML Inc., 350 Leland Ave., Plainfield, N.J. 07062. [372]

Model 0S2000 oscilloscope, made by Xetex Electronics, England, has 20-Mhz bandwidth with sensitivity of 10 mv/cm. There is a choice of single- or dual-trace and high-gain differential amplifiers, and standard or delayed-sweep time bases. Signal delay of 200 nsec ensures that the leading edge of an acceptable waveform is clearly visible. Alban Electronics, 111 Cedar Lane, Englewood, N.J. [373]

Frequency counter 5247M counts directly from 10 hz up through the communications bands to 135 Mhz. With frequency converter plug-ins, the range can be extended to 18 Ghz. The instrument has a time-base oscillator with short-term stability of better than 5×10^{-11} rms for a 1-sec averaging period. Price is $3,000. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. [374]

Impedance bridge 1606-B, adaptable to coaxial connectors, measures in the 400-khz to 60-Mhz range. Resistance range of the bridge is 0 to 1,000 ohms, and reactance range is ± 5,000 ohms at 1 Mhz. At other frequencies the reactance reading must be divided by the frequency in megahertz. Price is $1,050. General Radio Co., West Concord, Mass. 01781. [375]

Programable, digital volt-ratio meters series 6600 handle 1,000 samples per sec. Accuracy is within ±0.01% of full scale ±0.017% of reading for 6 months over a temperature range of 10° to 40°C. With the optional millivolt preamp accessory, the 6600 automatically ranges from +10.999 mv to ±1099.9 v d-c full scale. Lear Siegler Inc., 1152 Morena Blvd., San Diego, Calif. [376]

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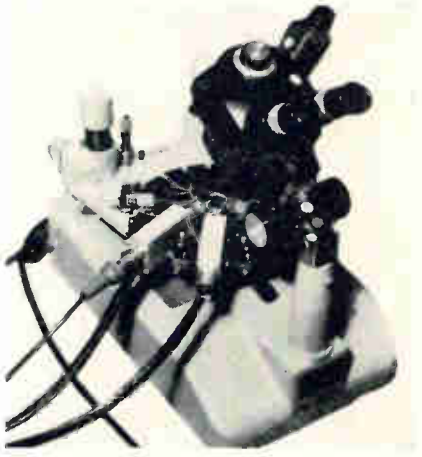
voltmeter for fast waveform measurements—can be used with standard commercial-wafer probes.

Hurling a challenge. The system got a mixed reaction from semiconductor makers, some of whom seemed to have given up on the idea of making a-c wafer tests and were reluctant to change their minds. There were a number of a-c testers on display at Wescon, but all except E-H's were designed to accept finished packages. Such testers would be used as an adjunct to d-c wafer probes: circuits that survived the wafer tests and were packaged would be given final a-c tests before shipment. The company is, in effect, challenging the whole concept of d-c testing. "Except for leakage, we don't see any reason to make d-c tests at all," says applications engineer James E. Fisher.

Motorola Inc., for one, is reportedly interested in the E-H concept. Texas Instruments Incorporated assisted in the development stage of the system by providing data on required tolerances and parameters. The company has its own a-c tester for packages. Sylvania is still very interested in a-c wafer testing, but its system is still in pilot use for complex circuits.

The E-H system measures propa-



Wafer probe. Tester's discriminator heads are attached directly to a standard semiconductor-wafer probe.

... single shot for all parameters ...

gation delay, turn-on and turn-off delays, and rise and fall times on a single pulse. Two pulse-height discriminators at the probe itself enable the switching time converter to make accurate timing measurements. A sinusoid from the circuit under test will generate start-stop pulses at programed levels. The start pulse turns on a current that is fed into an integrator, which generates a voltage that rises linearly with time; the stop pulse turns off the current.

The strobing voltmeter behaves as a sample-and-hold meter with an aperture time (for data acquisition) of 4 nanoseconds. It provides a stretched and amplified version of the input signal at the output. The circuit is similar to that of a sampling oscilloscope, according to product line manager Doug Curé. But the design compromises are such that it can make single-point measurements on a single-shot basis, while keeping a d-c reference with the input.

"The single-shot measurements are not a synthesis, like a sampling scope's," Curé says. "A single-event—one logic cycle—can give all the parameters." That capability is important, he says, because it cuts down the time per test (the system can make 700 measurements a second), and because it tests the logic in the same way that a computer would use it. Circuits perform differently under a train of pulses and under a single pulse, he says.

Careful calculation. The inductance problems that plagued previous attempts to perform a-c tests on the wafer were critical, but posed no theoretical barrier, Curé and Fisher say. If physical and mutual inductance and capacitance are measured, the entire system may be treated as a transmission line and the characteristic impedance calculated from the relationship Z equals the square root of L over C. This "line" will have a transit time that can be taken into account in the measurements.

Prices of the E-H systems will range from $28,775 for the simplest version, to more than $100,000, for the fully automated ver-

sions having core-memory elements. Despite this sizable price tag, the company is convinced that the system can pay its way in cost savings, particularly for IC's that are fast and complex.

Sylvania's Richard Sirrine provides a succinct reason for a-c testing at the wafer. "When you take a complex circuit like a frequency divider, which has four flip-flops, you can't just test for input and output levels." But Sirrine, who worked on Sylvania's a-c system, doesn't believe a-c testing will completely replace d-c. There are some circuits, he says, that will perform functionally yet won't meet the manufacturer's specifications.

In any case, a-c testing performed on the wafer will save the packaging of defective circuits. The circuits on a wafer, Curé says, are worth only a few cents; in the package they may be worth several dollars.

Instrument hookup. The basic components of the E-H system are the model 153 strobing voltmeter, the model 142 switching time converter, the model 1420 timing unit, and the model 1139 pulse driver, all E-H catalogue items. The voltmeter's rise time is less than 3 nanoseconds, which is equivalent to a bandwidth of 100 megahertz, and its dynamic range is ±1 volt a-c or d-c. The strobe delay's range is from 100 nanoseconds to 100 microseconds, with an accuracy within 0.35% of full scale. Ranges of the time converter span from 1 nsec to 1,000 nsec in four decades.

E-H Research Labs Inc., 163 Adaline St., Oakland, Calif. 94607 [377]

New instruments

Small, economy set does big job on IC's

Stripped-down system makes most of the d-c tests needed to evaluate IC's

Some integrated circuit engineers who goggled at the computerized and automated—and expensive—IC

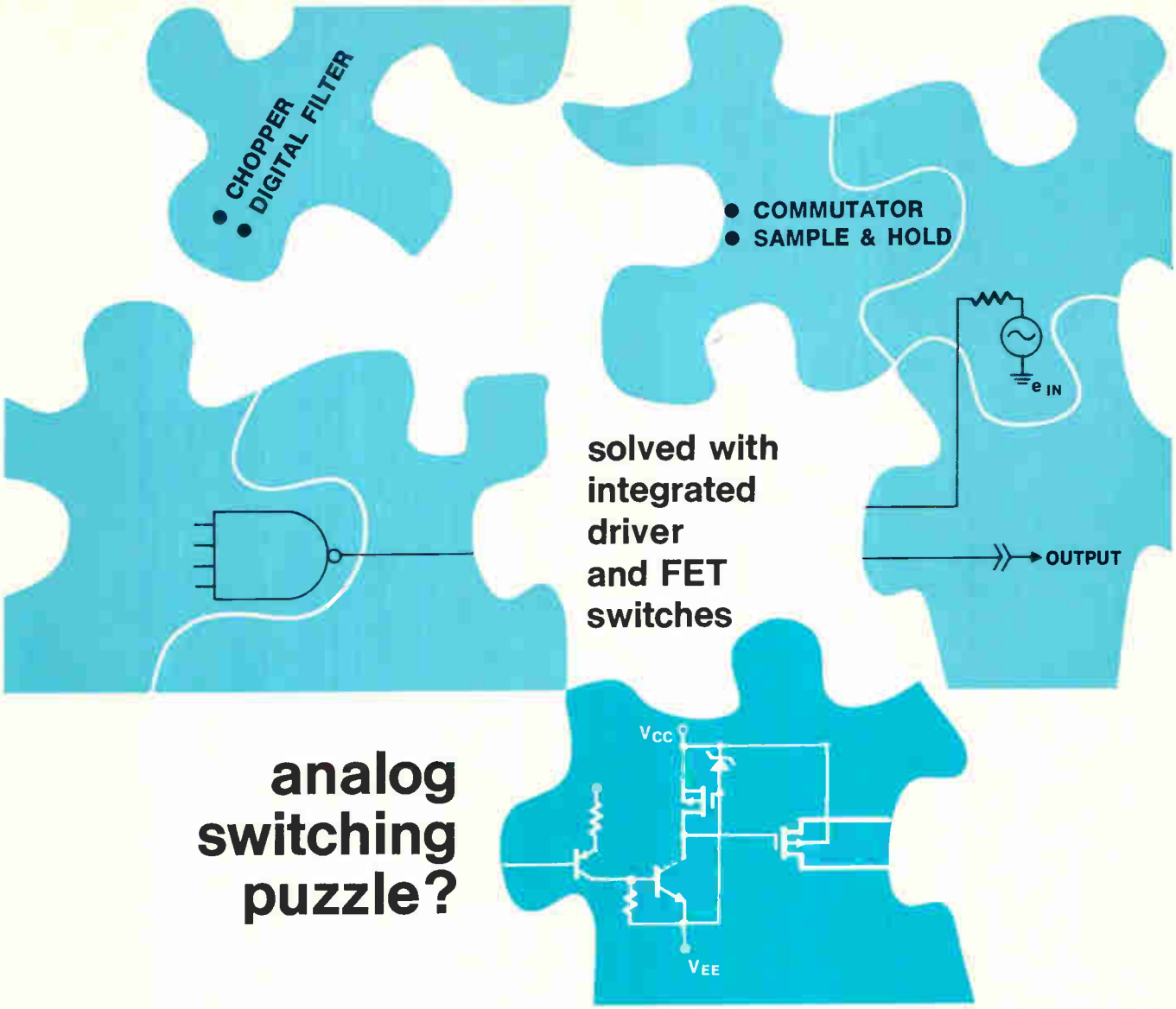
In production. Off-the-shelf models are more attractive than the original instruments Beckman designed for use in its own plants.

testers on display at Wescon last month made side trips to a suite in San Francisco's Fairmont Hotel, where the Electronic Instruments division of Beckman Instruments Inc., a nonexhibitor at Wescon, was showing a stripped-down model priced at only $495. Beckman's "Volkswagen" makes d-c tests only, and is intended for the low-volume user of digital IC's. But Beckman expects it to compete with products costing five to 10 times as much.

"It's an instrument born of desperation," says Neal W. Vinson, chief of the laboratory instruments group at Beckman's Richmond, Calif., operation.

Beckman, which has been using more and more IC's in its growing line of instruments, could not find test equipment at a price that seemed reasonable for its still-modest IC purchases. The company therefore designed its own instrument, found that production and quality control departments in at least two divisions could use it, and decided to test the open market.

Vinson says that an operator can completely test about one circuit



analog switching puzzle?

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DG103F	2	1	Jct
DG104F	2	0	Jct
DG110F	2	1	MOS
DG111F	2	0	MOS
DG112F	2	1	MOS
DG126F	2*	1	Jct
DG116F	4	1	MOS
DG118F	4	0	MOS
DG123F	5	1	MOS
DG125F	5	0	MOS
DG122F	2*	1	MOS
DG132F	2*	1	MOS
DG120F	3*	1	MOS
DG121F	3*	0	MOS

* Differential — two common gate switches with common output.

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1140 W. Evelyn Avenue, Sunnyvale, California 94086
Telephone (408) 245-1000 TWX: 910-339-9216

Circle 207 on reader service card

. . . sliding contacts for fast setup . . .

a minute with the instrument. For this reason, Beckman says that the 999 is suitable for both laboratory use and low-volume testing of incoming IC's.

Sliding setup. Beckman's model 999 provides exact d-c parameters, accurate to ±2%, on an analog meter. It is "programed" by moving gold-plated sliding contacts (one for each IC package pin up to 16) over a printed circuit board that determines input voltages, ground, clock, and logic level voltages. Two bus lines on the p-c board also make it possible to connect pins on the IC package. Actually, supply, noise immunity, and truth tables are used to test input threshold levels, high and low output current, short-circuit output current, input forward current, fan out, power dissipation, and current drain.

Since Beckman's aim was economy, the 999 has few extras. "Still," says Vinson, "we've taken gate and flip-flop measurements right off Fairchild data sheets, and checked everything except propagation delay." In a typical setup, he adds, the operator might first determine logic levels by taking high and low values of V_{IN} from the data sheet, setting the matrix so that the input voltage V_{CC} and ground are on the correct pins, and monitoring the output pin while the corresponding input pins are being switched between the high and low values of V_{IN}. This operation verifies V_{IN}, determines the logic operation, and gives high and low output swings. Two other operations are required for input and output current.

Since the 999 gives actual values, the user can determine when a circuit might be of marginal use, or determine trends in a given batch.

Swinging clock. The 999 does not provide a frequency generator to sweep voltages. Instead, its 100-kilohertz clock swings between the actual logic limits of the package. For another $495, a buyer can have Beckman's 9010 frequency generator, which does provide the voltage sweeping function. The 999 also has a plug for more precise

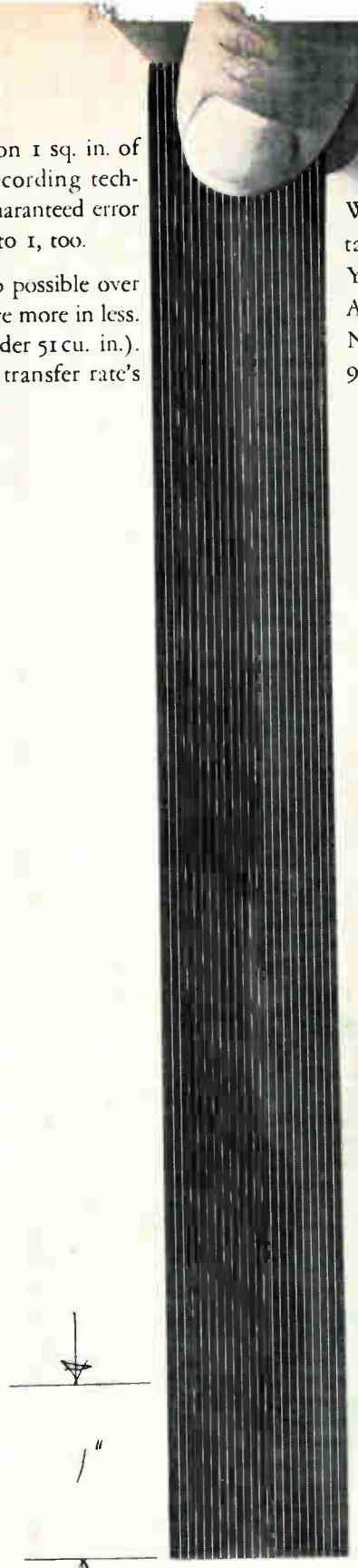
You can record up to 1 million bits on 1 sq. in. of magnetic tape with our exclusive recording techniques and still get that same high guaranteed error rate. Tape speeds are reduced over 10 to 1, too.

In space you get the fastest data dump possible over a telemetry window. Airborne you store more in less. (For example 200 million bits in under 51 cu. in.). And on the ground "on line", your transfer rate's so much faster you get closer to your computer's real-time capability.

We call the whole thing HDDR* high density digital recording.

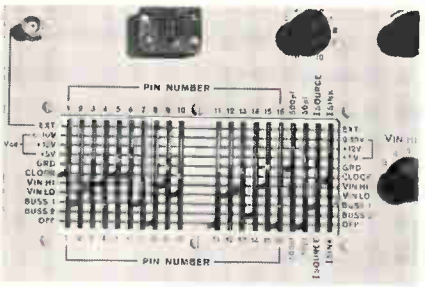
You'll call it a necessity.

Ask us at Leach Corporation—Controls Division, 717 North Coney Avenue, Azusa, Calif. 91702 Telephone (213) 334-8211 **LEACH**



10 to 20k bits/in./track and errors less than 1 in 10^8 This is a high density recording.

. . . cheaper to use discretes in IC-tester circuits . . .



Programer. Operator sets up test conditions with contacts that are pushed by hand over printed circuit program boards.

external monitoring by an oscilloscope or a digital voltmeter.

The inside of the Beckman box is, as one might suspect, simple to the point of bareness. The 10-pound instrument contains four power supplies, control logic for the matrix, current sources and sink circuitry, the 100-khz clock (with 20-nanosecond rise and fall time), and metering circuitry. Only the clock contains integrated circuits; elsewhere, Beckman found it cheaper to use discrete components. All power supplies are current-limited, so that is is not possible to burn out a circuit under test without really trying.

The cost of IC's depends on how many and what kinds of tests the manufacturer runs, so it's to the advantage of users to make some, if not all, of the tests themselves. The 999, with its fast programing method, should find wide acceptance, especially with smaller companies.

Specifications

V_{cc}	+5 v ±2%, 0-200 ma +12 v ±2%, 0-200 ma 1 to 10 v, 0-200 ma
Current source and sink	50 μa to 100 ma, adjustable in 3 ranges
Clock	100 khz (internal)
V_{in}	High, d-c to 1 Mhz (external), 0 to 10 v adjustable; 0 to 50 ma; low, 0 to 10 v adjustable, 0 to 50 ma
Meter ranges	0 to 10 v ±2%; 0 to 2.5 v ±2%; 1, 10, and, 100 ma full scale
Power	114/23 v a-c, 50 to 1,000 hz, 10 w
Operating temperature	0 to 50°C
Dimensions	16½ x 7 x 12¼ in.
Price	$495
Delivery	4 weeks

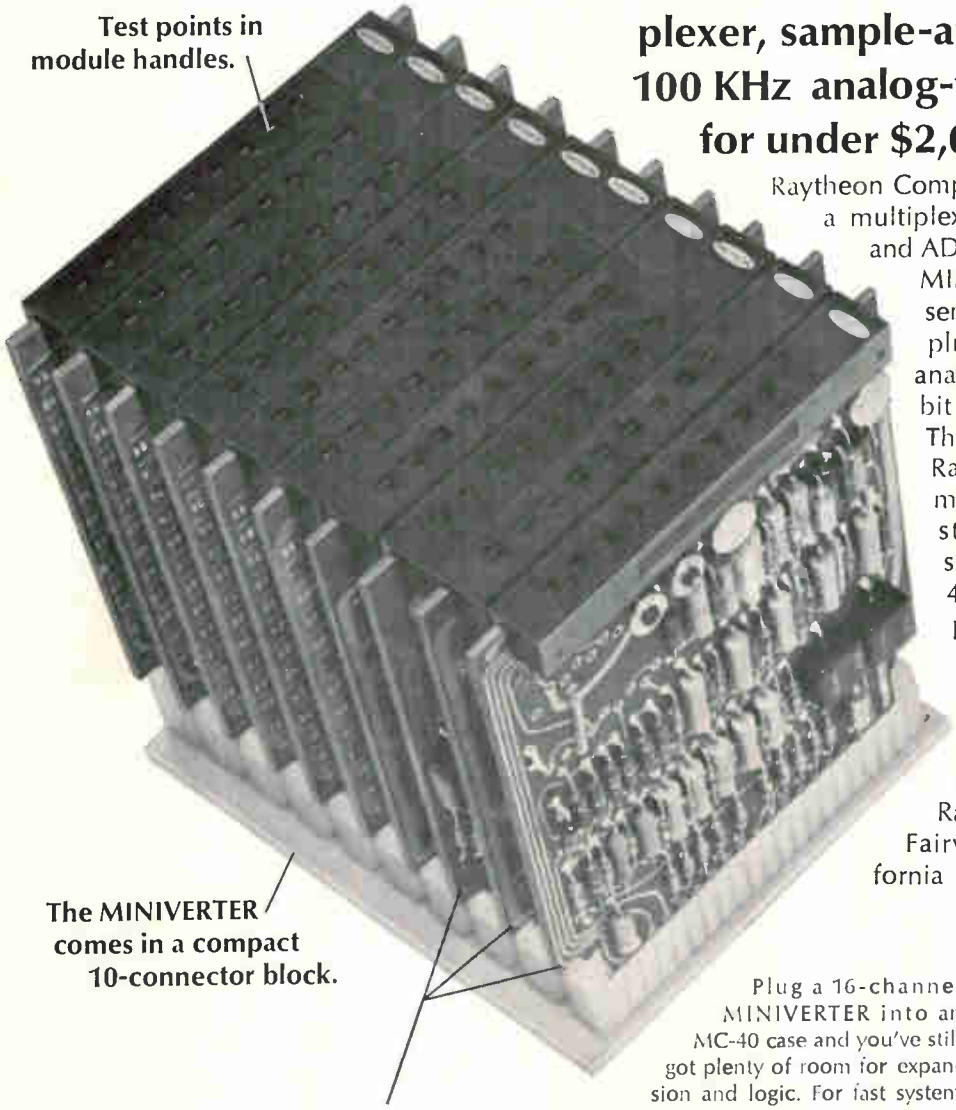
Beckman Instruments Inc., Instruments Division, 220 Wright Ave., Richmond, Calif. [378]

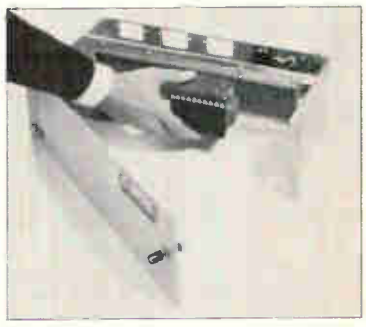
When you hold a MINIVERTER™ in your hand

. . . You'll have a 16-channel multiplexer, sample-and-hold and 10-bit, 100 KHz analog-to-digital converter for under $2,000.

Raytheon Computer's new MINIVERTER packs a multiplexer, sample-and-hold amplifier and ADC into just ten IC modules. The MINIVERTER (or the ADC) is assembled and pre-wired, ready to plug in and use. ■ Two more new analog IC modules make up a 10-bit digital-to-analog converter. ■ These instruments are built from Raytheon's standard M-Series IC modules and there's a whole stockroom full of compatible systems hardware. More than 40 analog and digital modules, power supplies, three different chassis—all so thoroughly engineered all you do is design your logic. ■ Our literature is almost as exciting as our products. Write or call today. Raytheon Computer, 2700 South Fairview Street, Santa Ana, California 92704. Phone: (714) 546-7160.

RAYTHEON





Plug a 16-channel MINIVERTER into an MC-40 case and you've still got plenty of room for expansion and logic. For fast system assembly, module connectors come in blocks of 10, 30 and 40. Power and analog and digital ground are available in module cases via laminated bus bars. And you can have automatic wire wrap if you want it.

Circle 211 on reader service card 211

New instruments

Half an rfi receiver is better than one

Meter probes receiver's i-f or video output to measure offending signals

What's really the best indicator of radio-frequency interference—a receiver whose operation is not up to snuff, right?

Honeywell Inc. is asking and answering the question with an unusual voltmeter that, in effect, helps a receiver diagnose its own rfi or other electromagnetic interference problem. As long as the receiver's video or intermediate frequency falls between 10 kilohertz and 65 megahertz, the instrument can act as an rfi stethoscope. It is connected to the receiver video or i-f output.

According to St. John Martin, one of the engineers who designed it, the model 7870 metering panel is the first ever built with such capability. It is called a panel, rather than an rfi measuring system, since it can't do the measuring job alone. While the meter determines the intensity of interfering continuous-wave signals, an oscilloscope or other external display finds the peak amplitude of pulsed signals, and the receiver itself is tuned to determine interference frequencies.

Incorporation. One advantage of making the receiver part of the rfi-measuring system is that it keeps the receiver part of the analysis loop. In some cases, this could lead to more accurate corrective measures for a specific receiver at a specific site. The customary technique of probing the electro-

Add a receiver. Metering panel makes receiver into an rfi instrument.

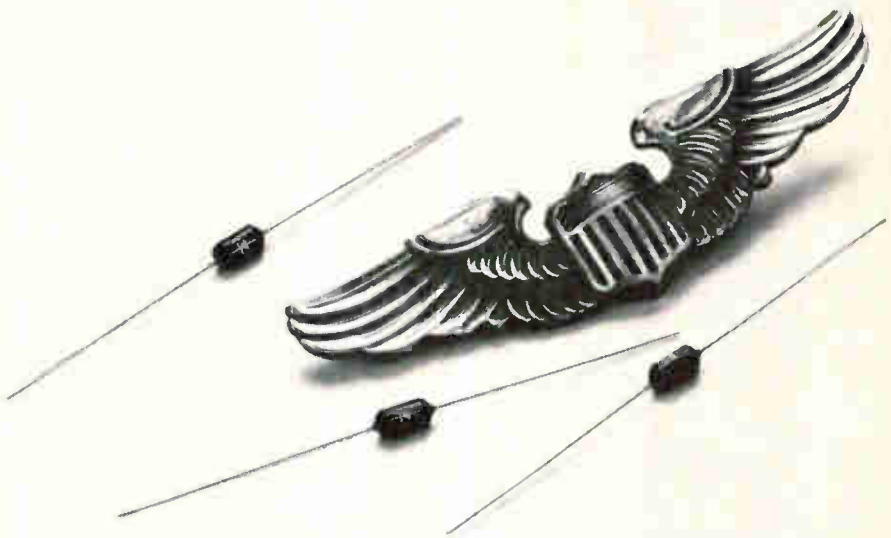
Circle 212 on reader service card
Circle 213 on reader service card→

WE'VE GOT OUR WINGS! Types IN4942, IN4944, IN4946, IN4947 and IN4948 are . . . ideal for use in high reliability airborne and missile power supplies. Semtech Fast Recovery High Current Silicon Rectifiers offer maximum rectification efficiency with high frequency power sources. Offering reverse recovery (typically) of 100 nanoseconds up to 600 volts and 250 nanoseconds, up to 1000 volts PIV. Rated to handle an average rectified current of one amp at 55°C offering extremely low leakage current of 0.1 micro-amp at rated PIV, 25°C.

TX and MIL Types

Fast Recovery Rectifiers

Meets MIL-S-19500/359 (USAF)



Semtech hermetically seals the rectifiers in rugged Alumina filled glass body (.275" long by .135" diameter). Internally, equal area heat sinking is provided on both sides of the silicon junction with tungstaloid pins that match the thermal expansion characteristics of the silicon. The junction tungstaloid pins and solid silver (.030") leads are bonded above 900°C. Immediate delivery.

SEMTECH CORPORATION

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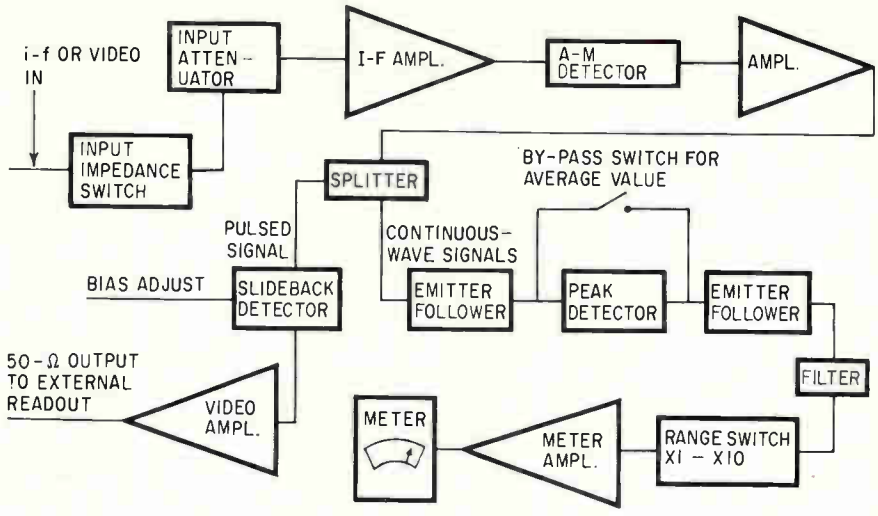


Two detection paths. Pulsed input signals are measured with slide-back detector. Either the peak or average value of continuous-wave signals can be measured in second detection circuit.

magnetic environment with independent instruments takes the receiver out of the loop. Also, the field engineer would have less to lug, since the metering panel weighs only 9 pounds.

Honeywell, however, expects to find the widest acceptance among operators of rfi testing laboratories and receiver manufacturers who want to stretch the usefulness of existing general-purpose units. They'll be able to convert standard receivers to tuned voltmeters and signal-strength meters, and measure the susceptibility of receivers to electromagnetic interference.

Field or lab, the main attraction is being able to put together a wideband instrumentation system for a small fraction of the price of conventional rfi measuring equipment. Honeywell plans to charge only $600 for the metering panel.

Signal splitter. Signals enter through a switch adjusted to match the meter's input impedance and the output impedance of the receiver's video or i-f stage. The operator sets an input attenuator so that high-level signals will not overload the measuring circuitry. Input levels can be as low as 20 microvolts, and gain can be varied as much as 25 decibels. One more step completes signal conditioning —removal of the carrier frequency added to the unknown signal by the receiver. This is done with an amplitude-modulation detector.

The input signal then passes through a wideband amplifier to a signal splitter. If the input is pulsed, it goes to a slide-back impulse detector; if it is continuous, it goes through an r-f voltmeter.

Forward and reverse. The slide-back detector is essentially a reverse-biased diode. The operator adjusts the bias voltage until it just cancels the input signal. The cancelling voltage is thus a measure of the input signal's threshold voltage. If the operator wants to determine peak amplitudes, he nulls the signal as usual and substitutes a calibrated signal source for the unknow input. Then he increases the signal level from the generator until the bias voltage is overcome and an output appears on the external display, such as an oscilloscope.

A continuous-wave input goes from the splitter through an impedance matching emitter-follower circuit, a peak detector, another emitter follower, and a low-pass filter on its way to the indicating meter. A front-panel switch bypasses the peak detector if the operator wants to measure the average value of the signal. Another switch changes the meter's sensitivity by a factor of 10.

Specifications

Frequency range	10 khz to 65 Mhz
Input level	20 microvolts
Input impedance	50, 93, 300, and 600 ohms
Gain adjust	25 db
Video output	2 v rms, into 50-ohm load
Weight	9 lb
Size	3½ x 19 x 8 inches
Price	$600

Honeywell Inc., Test Instruments Division, P.O. Box 391, Annapolis, Md. 21404 **[379]**

The new series 1000 from AAI tests integrated circuits at a rate of about 180 tests per second. At this speed, crisp, clear readout is imperative. That's one of the reasons AAI specified IEE rear projection readouts. It's the World's most readable readout, because of the exceptionally bright, single-plane display.

AAI also wanted a readout as attractive as their circuit tester. In addition, they needed displays in various sizes, colors, symbols, characters and words. This they could only get with rear projection readouts. And this they got with the IEE Series 340, 120 and 10.

If you design, manufacture or market a product requiring visual display, specify IEE readouts. They can't be matched for readability, aesthetics or versatility. That's what AAI discovered.

The Rear Projection Readout: When a lamp at the rear of the readout is lighted, it illuminates one of 12 film messages, focuses it through a lens system, and projects it onto the front viewing screen. The displayed message is clearly projected on a single plane, with no obstruction from unlighted filaments. It is extremely versatile, since anything that can be put on film can be displayed on an IEE readout.

"I-Double-E," the world's largest manufacturer of rear projection readouts. Industrial Electronic Engineers, Inc., 7720 Lemona Avenue, Van Nuys, California 91405. Represented in principal cities around the world.

IEE

"When you're testing 6,000 circuits an hour, readout makes the difference."

Raymond W. Wells, V.P. & General Manager, AAI Pacific Division

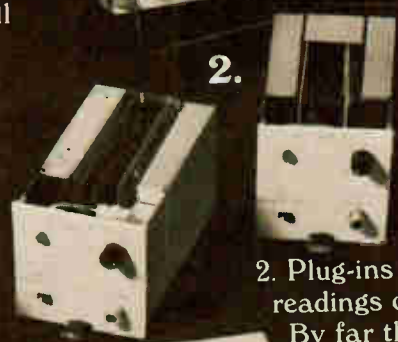
Circle 215 on reader service card

If you buy HP counters, we have news for you.

Systron-Donner makes advanced counter instrumentation that has no equivalent in the HP catalog. That's why it pays to check with Systron-Donner before you buy. You'll find equipment with unique capability like:

1. A plug-in that will extend your counter's frequency range to 15 GHz – measuring FM and pulsed RF as well as CW and AM. The only way to get the full dc to 15 GHz range in one cabinet. No calculations. Displays final answer.

1.



2.

2. Plug-ins that produce automatic readings of microwave frequencies. By far the most compact and economical equipment for producing automatic readings in the 0.3 to 3 GHz band or the 3 to 12.4 GHz band.

3.

3. "Thin Line" counters that take only 1¾" of rack space. Built with ultra-reliable integrated circuits to give you automatic frequency measurements – dc to 100 MHz or 0.3 to 12.4 GHz.

These are the highlights of expandable systems that will make just about any measurement possible with counters. The accuracy of our basic 50 MHz and 100 MHz counters is unsurpassed. (Time base aging rate is only 5 parts in 10^{10} per 24 hrs.) All devices to extend the range or add functions are convenient plug-ins – not rack mounts. The newest are a prescaler to extend counter range to 350 MHz and a heterodyne converter to measure noisy signals in the 0.2 to 3 GHz range.

Are you surprised that Systron-Donner is a step ahead of HP in counter technology? How else could we stay in business?

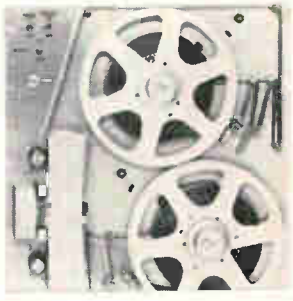
Systron-Donner Corporation, 888 Galindo Street, Concord, California 94520

Send for catalog.

SYSTRON DONNER

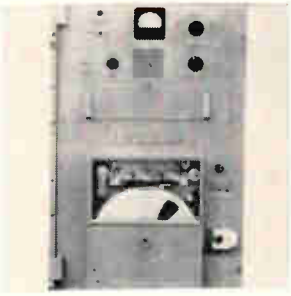
New Subassemblies Review

Frequencies from below 200 khz to above 220 Mhz are amplified linearly more than 50 db to power levels up to 400 watts by the M404A laboratory amplifier. No tuning is needed. Applications include communications systems, rfi tests, antenna research programs, and nuclear magnetic resonance work. Instruments for Industry Inc., 151 Toledo St., Farmingdale, N.Y. 11735. [381]



Bidirectional reader/spooler model RRS-502B features a 500-characters/sec reader and a 50-in./sec spooler equipped with 10½-in. diameter reels. Panel height is 21 in. Price is $3,580 in small quantities, with discounts for higher quantities. Delivery is 10 weeks. Remex Electronics Division, Ex-Cell-O Corp., 5250 W. El Segundo Blvd., Hawthorne, Calif. 90250. [382]

Stabil-ac is a 14-oz d-c/a-c inverter that provides 400-hz output with ripple-free, low-noise characteristics. It is used with airborne, synchronous servo equipment. Frequency stability is ±0.25%. Adjustable output (±1%) compensates for mechanical tolerances in users' equipment. Price is $375 in quantities of 1 to 9. MIL Associates Inc., Dracut Rd., Hudson, N.H. [383]



Ten-channel monitoring-recorder system PI-8010 meets MIL-E-16400 and will operate for 24 hours on a 10½-in. reel of ½-in.-wide tape. Audible monitoring of any recorded channel is achieved by switch selection. Bandwidth capability is 2.7 khz; a cueing system has forward and rewind modes. Precision Instrument Co., 3170 Porter Dr., Palo Alto, Calif. [384]

Battery - operated preamplifier series PA uses a noise-canceling circuit and features an rms-integrated broadband noise level below 10 μv. Input impedance is 1,000 megohms; frequency range, 0.2 hz to 100 khz. Models are available in fixed gains of 0, 10, 20, 40, and 60 db, and variable gains of 0 to 20 and 20 to 40 db. Agac-Derritron Inc., 600 N. Henry St., Alexandria, Va. [385]

Analog multipliers 610T(A) and 610T are for use in high-speed data-reduction systems. The 610T(A) accepts 2 signals in the range of 0 to ±5 v and its output is 1/5th the algebraic product; the 610T accepts signals of 0 to ±10 v and its output is 1/10th the algebriac product. Bandwidth is 500 khz minimum. GPS Instrument Co., 188 Needham St., Newton, Mass. [386]

Parallel entry data from a wide variety of devices is converted to serial presentation for teleprinters and card or tape punches by digital-data scanners called model 1300 Data Interfaces. Storage can be included in the modular designed units for automatic presentation of coded or informational data along with input data. Humphrey Electronics Inc., Box 9143, Raleigh, N.C. [387]

Heavy-duty, solid state supplies series PSR-500 deliver continuously variable 500-w outputs with regulation of line or load to less than 1%, no load to full load. Ripple is less than 1% at max. rated current. Three models are available: 2-32 v d-c, 0-15 amps; 2-55 v d-c, 0-10 amps; and 2-125 v d-c, 0-5 amps. Electro Products Laboratories Inc., 6125 Howard St., Chicago. [388]

New subassemblies

Strain-gage readouts go all-electronic

Tumbling prices of integrated circuits enable digital system to compete with electromechanical devices in process control

Time—in the guise of integrated circuits—has finally caught up with the strain-gage readout equipment that is a basic building block in numerous kinds of industrial control systems. For decades, the readouts have had electromechanical innards. Now the readout is done with digital voltmeters.

To protect its position as a major supplier of strain gage equipment, and to improve readout speed and resolution, BLH Electronics Inc. has come up with an all-electronic system. The company, a division of Baldwin-Lima-Hamilton Corp., considers it the first off-the-shelf electronic readout.

A year ago, explains Jack Joyce, instrumentation product manager at BLH, digital voltmeters costing less than $1,000 started appearing. "And now, one company is talking about a three-digit unit for $289—that's cheaper than a good panel meter." In the new system a dvm replaces the customary analog meter.

Do-it-yourself. Users have been putting together their own electronic systems, but until now the off-the-shelf market consisted of null-balance devices, Joyce points out. Null-balance readouts are set

←Circle 216 on reader service card

"... servosystems will be obsolete by 1968 ..."

manually, or by a servomotor, amplifier, gear train, and counter, to provide an odometer-type readout.

At $1,800, the new all-electronic model is priced competitively with the electromechanical system and has better resolution and higher readout speed. "Our servo-type systems will be obsolete by 1968," Joyce predicts. Two years ago, he says, an electronic system would have cost $5,000 to $6,000.

"We are now able to build d-c amplifiers that operate in the microvolt region with excellent stability and temperature coefficients." Load cells using strain gages as sensors operate on the Wheatstone-bridge principle, and the signal conditioning of the millivolt outputs from the sensors must be stable and linear to produce an accurate reading.

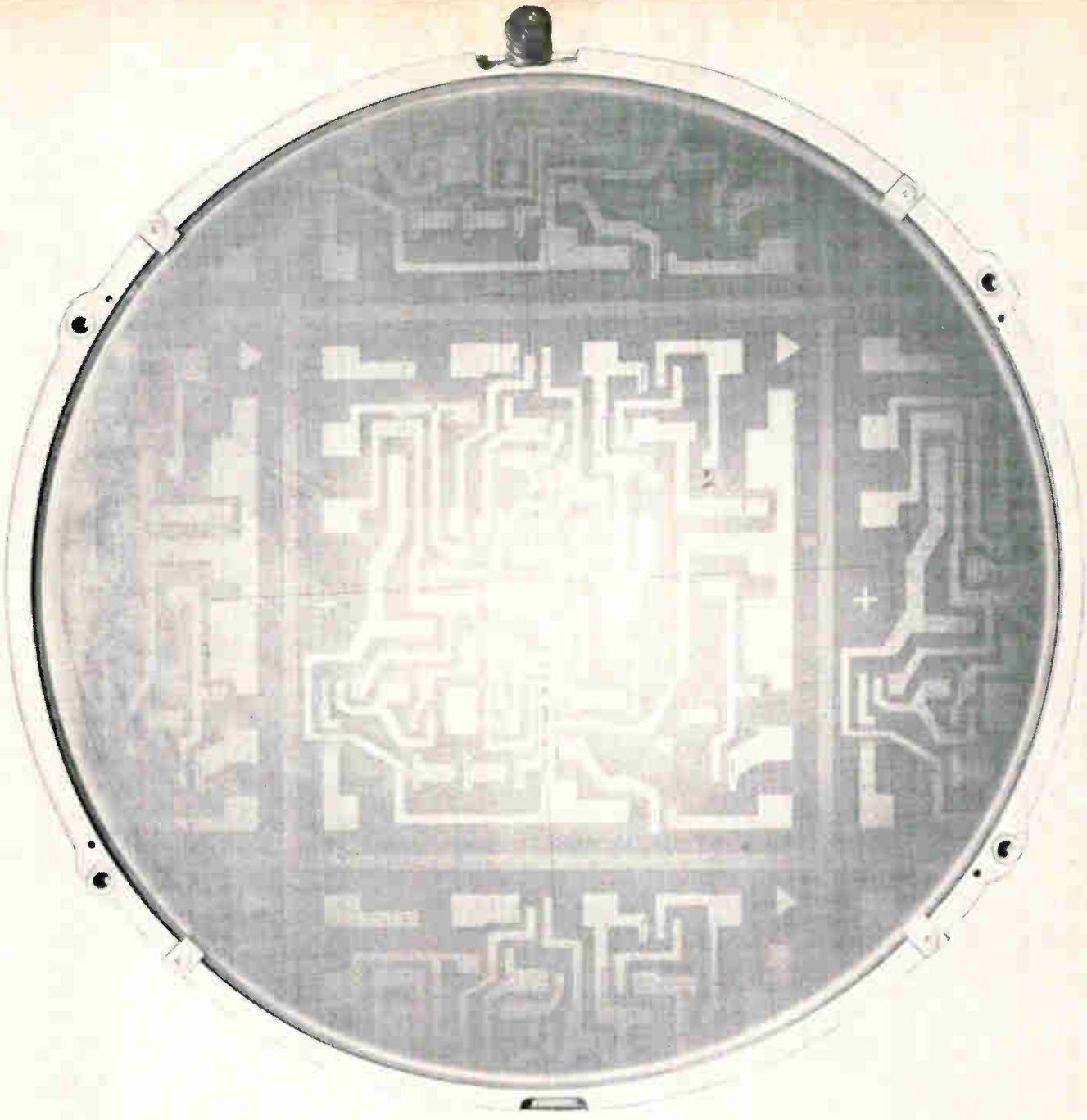
The 800-system design stresses versatility. Plug-ins will be available so the basic system can handle outputs of wire, foil or semiconductor strain gages, and special transducers. In each case, the sensor output will be read directly on a digital display.

Others in the works. By the time the series is complete, says Joyce, the company will have developed a strain-gage data acquisition system. The system will use switching and balancing units, and a scanner drive, so that it can feed 200 time-shared data channels. The user can attach a printer or a card-punching machine to the system, or feed the data directly to a computer. The binary-coded decimal output of the system is a natural input to computers, Joyce points out. Loop-closing low- and high-power analog outputs are also available to drive valves and other control equipment.

Specifications

Input impedance	1 meg min.
Gage factor	0 to 10
Gage resistance	60, 120, 350, 500, and 1,000 ohms
Gage excitation	5 ± 1 v d-c 2 ± 0.5 v d-c
Output signal	0 to ±10 v at 2 ma
Bandwidth	10 khz
Readout	4-digit and bcd output
Size	5¾ x 17 x 19 5/16
Power requirements	115/230 v, 60 hz

BLH Electronics Inc., 42 Fourth Ave., Waltham, Mass. [389]



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MARK OF EXCELLENCE

New subassemblies

IC's are disguised as relay logic

Sophistication avoided so technicians can design own systems

"Stone-age electronics" is how one engineer describes a series of digital-logic modules designed as building blocks of industrial control systems. "Electronics for technicians," says a more charitable engineer.

Raven Industries Inc., doesn't seem to care what people are going to say about its Wedge Logic modules. In fact, the company indicates that the module format is a great way of selling solid state logic assemblies in large quantities to customers who care little about sophisticated circuit design.

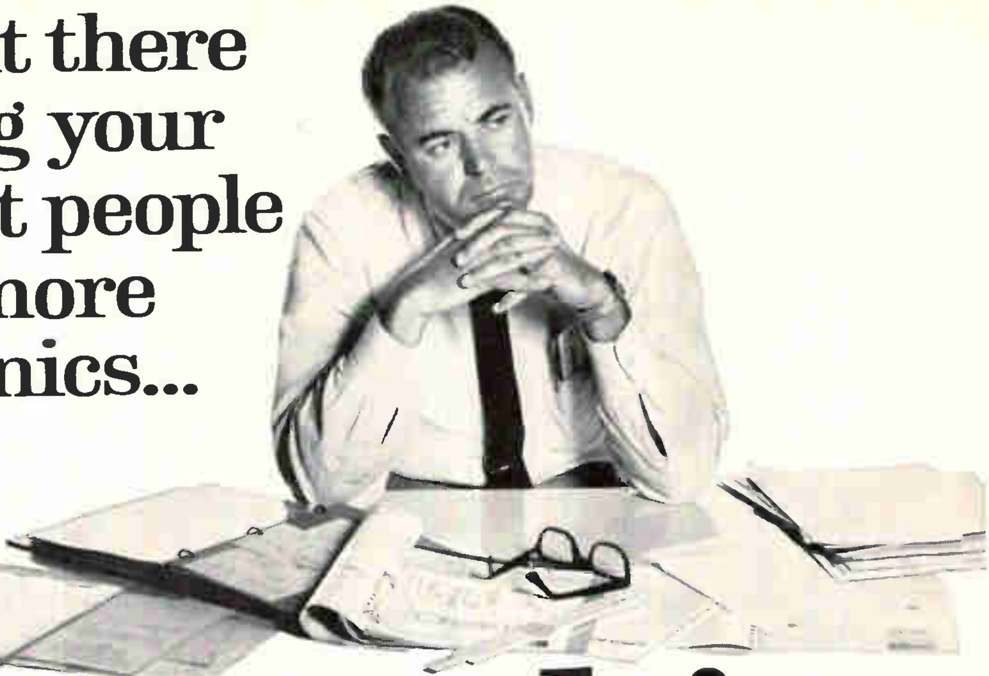
Although they are built with integrated circuits and other semiconductor devices, the modules are a replacement for the old-fashioned relay-tree design. They are slow, bulky, and cost about the same as relay logic assemblies.

Call the electrician. A plant manager who wants something like a small computer to control the operation of a bank of machines needn't call in a consulting engineer. Instead, he can call in the company's electronics technician to design the system, and the plant electrician to wire up and install the equipment in much the same way as in the days before sophisticated systems.

To make it easier for the technician-turned-designer, Raven Industries avoided the use of NAND or NOR gates. The modules are based upon AND and OR functions that are comparable to relay logic. This should, the company says, allow "the painless development" of special-purpose computers for plant-wide control and monitoring systems.

The fist-sized modules are keyed to plug into standardized mounting rails that accept 5, 10, or 20 modules. The rails are equipped with

Don't sit there <u>wishing</u> your support people knew more electronics...



<u>do</u> something

Look over your men. Pick out a few who are intelligent enough to profit from more education in electronics, ambitious enough to work hard to get it. Send us their names and addresses. We'll send them complete information about CREI Home Study Programs in Electronics, tell them how these programs have helped thousands of young men increase their value to their employers. We'll explain how they can study at home, at their own pace, on their own schedule without traveling to classes. We'll give them the names of the more than 80 leading scientists and engineers who help us develop and update programs related directly to the needs of industry.

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Gentlemen: The men listed at right are high school graduates working in some phase of electronics. Please send them your FREE book, "How to Prepare Today for Tomorrow's Jobs" and complete information about CREI Home Study Programs.

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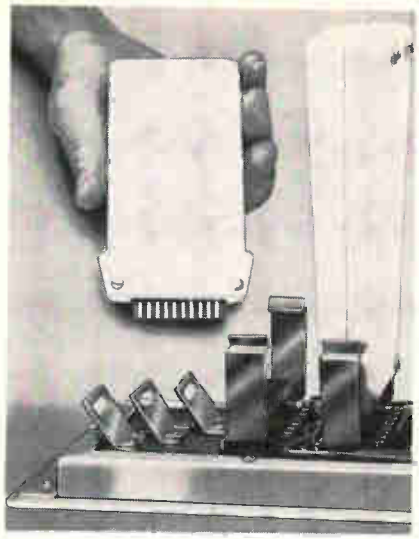
*City*____ *State*____ *Zip Code*____

(Not enough room? Attach sheet of paper with additional names and addresses)

Circle 221 on reader service card



No mistake. Modules and the rails they plug into are engineered to prevent installation mistakes.

printed circuits for power distribution, spring-clip module retainers, and cam clamps or wiring posts so extra wiring can be added up front. Any number of mounting rails can be interconnected to form a large-system panel.

Each module has a lamp that indicates the logic state and, in effect, acts as a hedge against installation errors. The lamp also serves as a maintenance aid. Trouble-shooting can be accomplished without test instruments. All module connections are labeled on both sides of the unit to avoid confusion.

What's available. At present, 16 modules are available, including AND, OR, and OR-NOT gates with several input arrangements, time delays adjustable in three ranges between 0.04 to 25 seconds, memory, five-bit counter, amplifier, reset, input, and output. Special modules, such as set-point inputs and specialized input and output functions, are expected to be made available soon.

The IC's are diode-transistor logic (DTL), chosen in preference to resistor-transistor logic because it has higher noise immunity. A noise immunity of 1 volt is needed in an industrial environment, the company says. Transistor-transistor logic was rejected because DTL costs less and is available from more suppliers. The main virtue of TTL—which is high speed—wasn't an attraction.

Raven Industries, P.O. Box 1007, Sioux Falls, S.D. 57101 **[390]**

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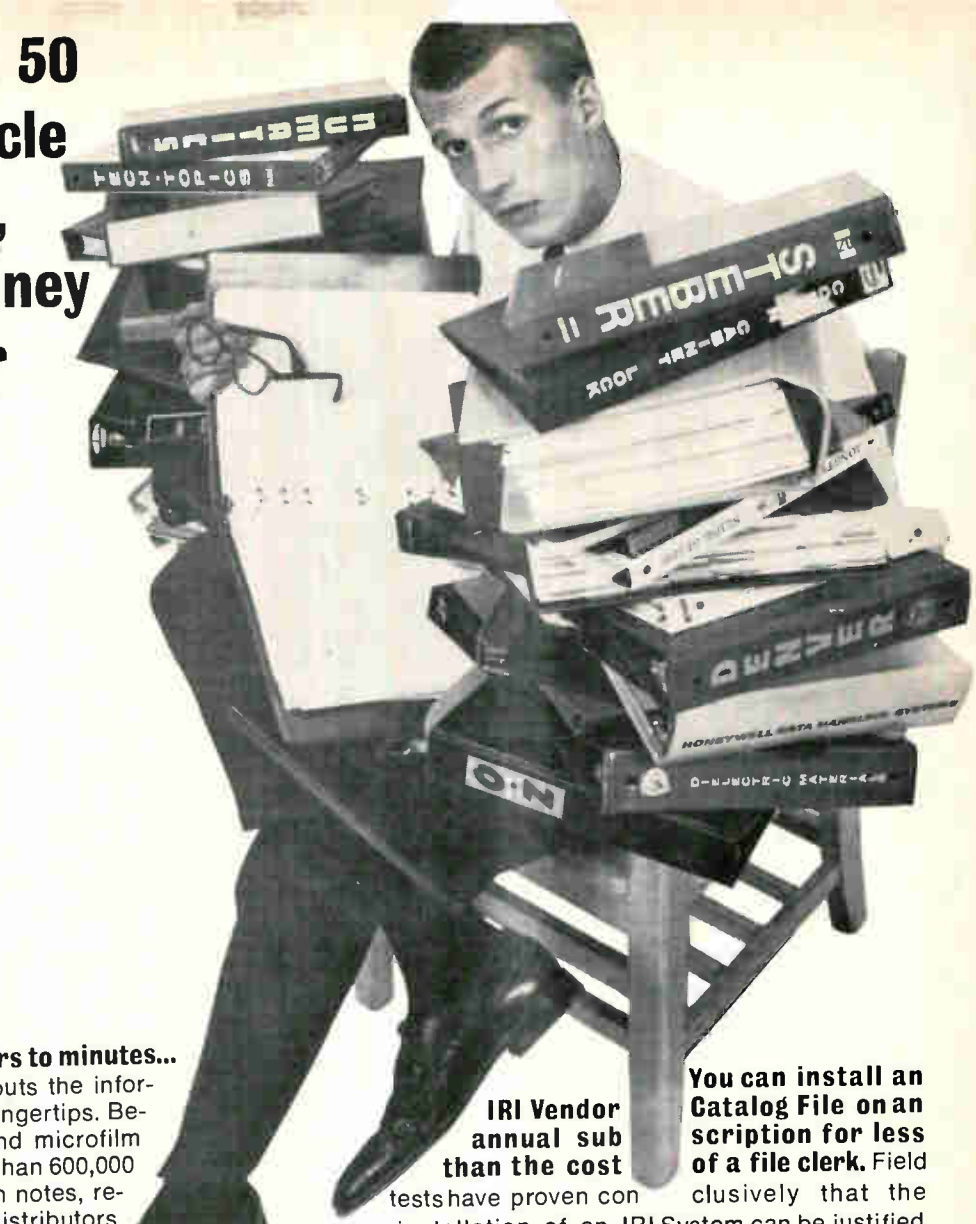

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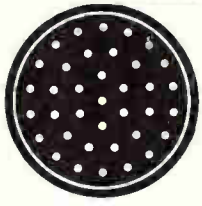

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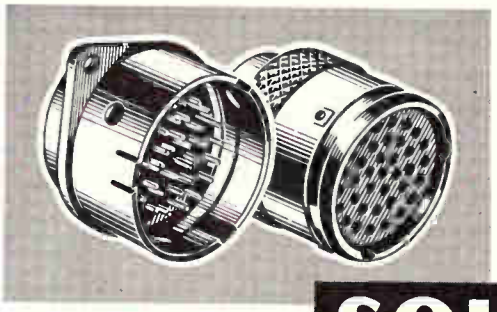

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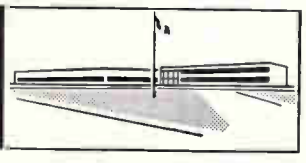

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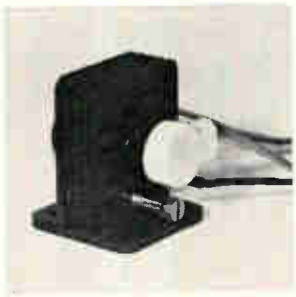
New Microwave Review

A uhf/f-m transmitter for aerospace telemetry applications delivers 20 w minimum at S-band frequencies in the 2.2- to 2.3-Ghz range. The 3620-01 withstands 55 g shock, 20 g sine-wave vibration, and 30 g acceleration environments. Center frequency stability is within ±0.003% under all environmental conditions. Electro-Mechanical Research Inc., Box 3041, Sarasota, Fla. [401]

A line of waveguide isolators is based on a patented design that eliminates the external magnet. Series covers 5,925-7,125 Mhz frequency range. Units have 20, 30, or 40 db isolations with maximum losses of 0.5 to 0.8 db. Bilateral vswr is 1.15 maximum. Devices can be furnished with magnetic shielding. E&M Laboratories, 7419 Greenbush Ave., North Hollywood, Calif. [402]



Reflex klystron oscillators series EM-1149 are useful as pump tubes for parametric amplifiers. The 5,000-hr warranty tubes, operating from 12 to 18 Ghz, are available in 2 versions. One offers an output of 1 w over a 500-Mhz tuning range; the other, 1.5 w over a 100-Mhz range. The 7-oz tube mounts in any position. Varian Associates, 611 Hansen Way, Palo Alto, Calif. [403]

A remote coaxial switch, with 10^6 cycles minimum lifetime, is a spdt unit with a range of d-c to 12.4 Ghz. Isolation is 60 db minimum over entire range. Insertion losses as low as 0.3 db from d-c to 7 Ghz and 0.6 db from 7 to 12.4 Ghz are claimed. SR-2 series switches are available with N, TNC, BNC, or RSM connectors. RLC Electronics Inc., 25 Martin Pl., Port Chester, N.Y. [404]

A rising sun magnetron that delivers 5-nsec pulses of 95-Ghz energy at 10 kw has a 3.2-mm wavelength output. Output figure of the DX287 lies in the center of an atmospheric window where the attenuation is much lower than that at other frequencies in the mm region. Duty cycle of 0.0002 allows repetition rates to 40 khz. Amperex Electronic Corp., Hicksville, N.Y. [405]

Miniature d-c block, model 754, has a capacitance in series with both the center and outer conductors preventing a flow of d-c current while permitting an uninterrupted flow of r-f power. Typical specifications at 6 Ghz include a vswr of 1.20 max; insertion loss, 0.25 db max; impedance, 50 ohms; and d-c voltage, 100 v. Kevlin Manufacturing Co., 24 Conn St., Woburn, Mass. [406]

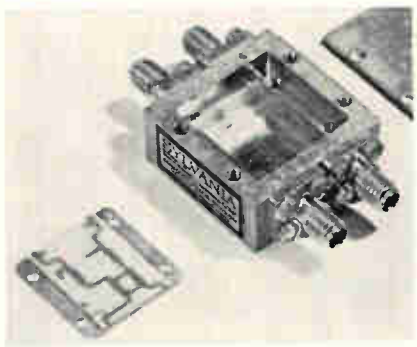
L-band signal generator model 1105 covers the 0.95 to 2.4 Ghz range. The manufacturer's Unidial control system provides single-band continuous tuning with digital frequency indication accurate to ±0.5%. Frequency stability is 0.0008% per volt change in line voltage and 0.005% per°C change in ambient temperature. Polarad Electronic Instruments Inc., 34-02 Queens Blvd., L.I.C., N.Y. [407]

Shutter switch model S050T operates from 2.4 to 11 Ghz with a vswr of less than 1.30. Insertion loss is under 0.4 db, and isolation exceeds 30 db in the normally open position at 11 Ghz. Switching time is 0.01 sec, operating life greater than 100,000 cycles. The switch weighs 3 oz, is 1⅝ x ¾ x 1⅞ in. Bendix Microwave Devices Inc., Farmington, Conn. 06032. [408]

New microwave

Hybrid IC's win new support

X-band mixer is forerunner of commercial integrated circuit line that will feature beam-lead devices on ceramic substrates



Dropout. IC can be replaced in the field.

For openers in its play to become a major force in the microwave integrated circuit market, a chip smaller than its model number—SYM8-OOB—has been introduced by Sylvania Electric Products Inc. The circuit, an X-band balanced mixer, is the forerunner of a broad line of mixers and other microwave IC's that will be appearing during the next year or so.

The construction of the mixer underlines the dominance of hybrid IC's in microwave applications. Its elements consist of beam-lead semiconductor devices connected to microstrip conductors and photoengraved passive components on an alumina substrate. The substrate

. . . replaceable chip eases repair . . .

measures 0.7 by 0.5 inch and is 0.02-inch thick. The coaxial package is only about an inch square.

The beam-lead devices in the initial circuit are matched Schottky-barrier diodes. The leads are welded to the conductors on the substrate. Other beam-leaded semiconductors, for other circuits, are being developed. Unless another company steals a march on Sylvania, the mixers will be the first commercially available microwave IC's with beam-lead components. Engineering samples of the mixer will be available in about two to three months and production will begin late this year.

Throwaway chip. The IC chip is designed to be thrown away to reduce receiver maintenance cost. Mixer burnout sometimes plagues receivers, so rather than substituting an entire mixer, the user would merely replace the circuit, diodes and all, and reassemble the coaxial package.

This feature exacts its price in performance, however. Voltage standing wave ratio (vswr) is high—about 2 to 1. Sylvania engineers aim to lower it to perhaps below 1.3:1 by redesigning the circuit board and improving IC-coaxial connector interfacing.

Noise is also higher than desired at 8 decibels over-all between 9 and 10 gigahertz. This also is to be reduced; 6-db noise figures have already been achieved in the lab.

What's new? After the first X-band mixer is delivered, units for lower and higher frequencies should follow quickly. Sylvania's aim is a mixer line extending from the uhf (below 1 Ghz) to Ku-band (15.3 to 17.2 Ghz).

Problems to be overcome lie in microwave-frequency filter design. Alumina substrates make high Q's hard to attain and thus, filters with sharp bandpass characteristics are difficult to come by. Microstrip IC construction also makes couplers (power dividers) difficult to build. Even though Sylvania can achieve line-edge tolerances below 1 mil, a 3-db coupler that couples at exactly 3 db is a rare thing.

Beyond Sylvania's mixers loom more complex subassemblies. Work

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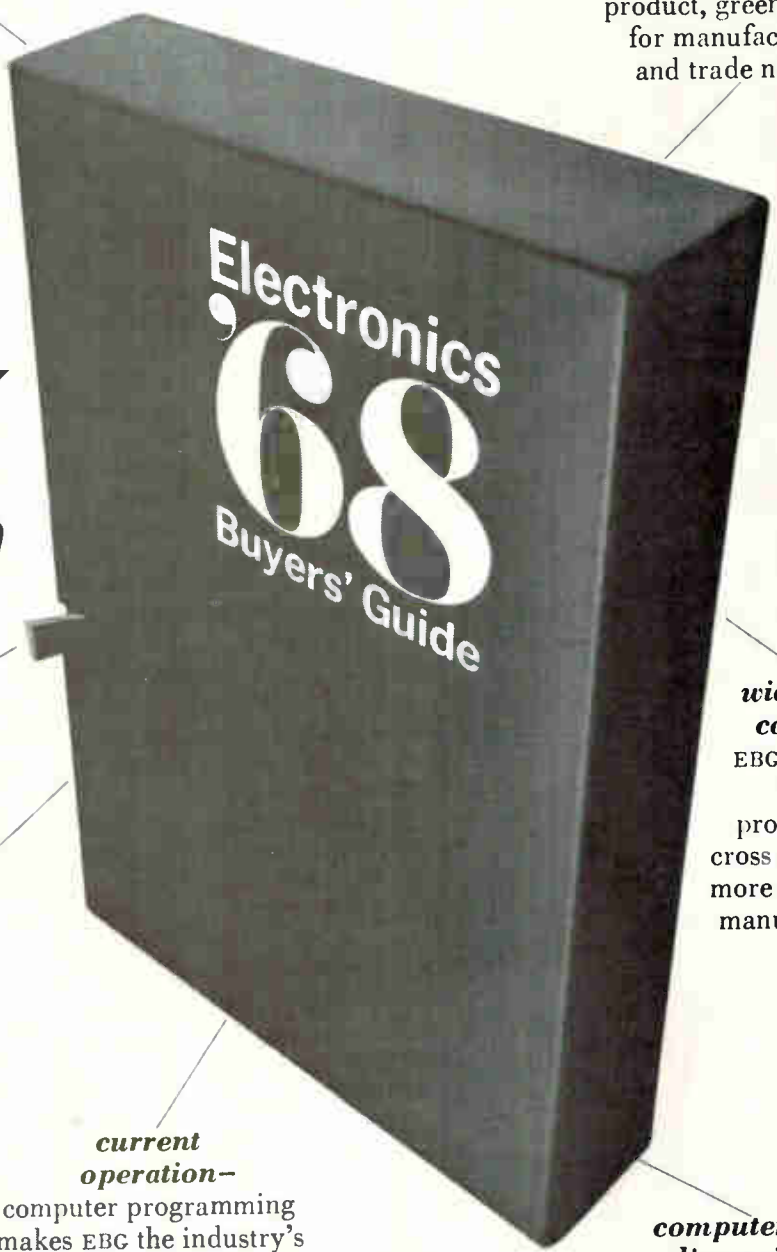

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. . . I-o will be added and combined with mixer . . .

has already begun on a combination of a mixer and intermediate-frequency amplifier. Marvin Groll, marketing manager for microwave devices, also predicts a mixer will soon be combined with a local oscillator.

Certainly the groundwork is being laid. Brian Dale, chief engineer at Sylvania's semiconductor products facility has men working on transistors, p-i-n diodes, and varactor diodes—all in beam-lead configurations and suitable for receiver, local oscillator, or frequency multiplication applications. Meanwhile, Arthur Solomon heads an effort at the same plant that will take advantage of Dale's semiconductors and develop such components as sputter-deposited loads and terminations for microstrip circuits.

Specifications

Frequency range	9-10 Ghz
Noise figure, including 1.5 db IF noise	8 db
Mixer type	double balanced
VSWR	about 2:1 max.

Sylvania Electric Products Inc., Semiconductor Division, 100 Sylvan Rd., Woburn, Mass. 01801 **[409]**

New microwave

Tiny switch couples IFF antenna pairs

IC's that can handle 3-kw peaks to replace mechanical switches

Work that proved too arduous for mechanical switches—shuttling kilowatts of power between aircraft antennas—doesn't faze a hybrid integrated circuit. The circuit, developed under an Air Force contract, was designed for use in IFF (identification friend or foe) transponders.

Microwave Associates Inc. plans to offer such IC's to companies designing microwave systems with IFF capability. It will also sell them off

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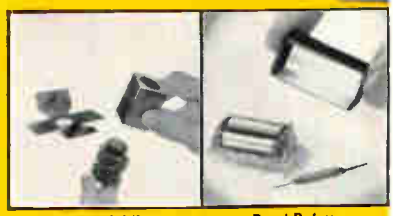

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Mfd. under Tabet U. S. Patents 2,841,660, 2,971,066, 3,015,000, 2,956,131, 2,988,607.

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PRECISION PRODUCTS DIVISION 1725 Diversey Blvd., Chicago, Illinois 60614 Phone: WEllington 5-4600

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the shelf. The application the Air Force had in mind when it gave the company the development contract was radar-beacon assemblies for the military portion of the national air traffic control system planned for the 1970's [Electronics, July 24, p. 141].

The circuit acts as a single-pole, double-throw switch between a transponder and two antennas. Some aircraft equipped with IFF have antennas on each side so the planes do not screen themselves from interrogating ground stations.

Replacements. When the Air Force decided that IC's were the way to better reliability in microwave equipment, the natural starting place was switching circuits. There was a great deal of dissatisfaction with mechanical switches. In some aircraft, solid state circuits are already replacing mechanical switches. And, plans call for the eventual use of IC's.

"A building block toward total integration" is how William J. Moroney, semiconductor development manager at Microwave Associates, views the switch. Circuits that are more difficult to design as IC's can be built around it later, he says.

Beating the heat. At the power handled, heating can be troublesome. To minimize thermal effects on performance, organic materials were ruled out of the circuit because of their characteristics.

The thick-film hybrid is built on an aluminum-oxide substrate. After the circuit pattern has been photographically defined, including main transmission line and bias terminations, silver is sprayed on the transmission-mode microstrip. Thick-film capacitors are then deposited for biasing purposes. These consist of high-dielectric-constant glass coated on metalized pads and fired. Metal is deposited on top, and a coating of glass is added to protect the capacitors. The p-i-n diode elements, which are then inserted, consist of glass-coated silicon sandwiched between two metal pieces.

Specifications

Frequency	L band (390 to 1,550 Mmz)
Power switched	250 w average, 3 kw peak
Duty cycle	0.001
Breakdown voltage	600 v minimum

Microwave Associates Inc., Burlington, Mass. **[410]**

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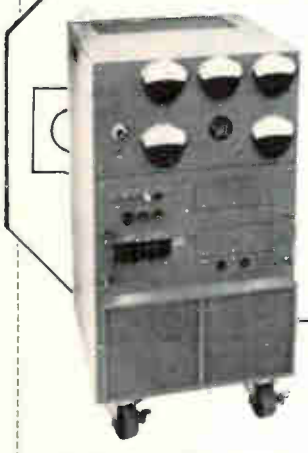

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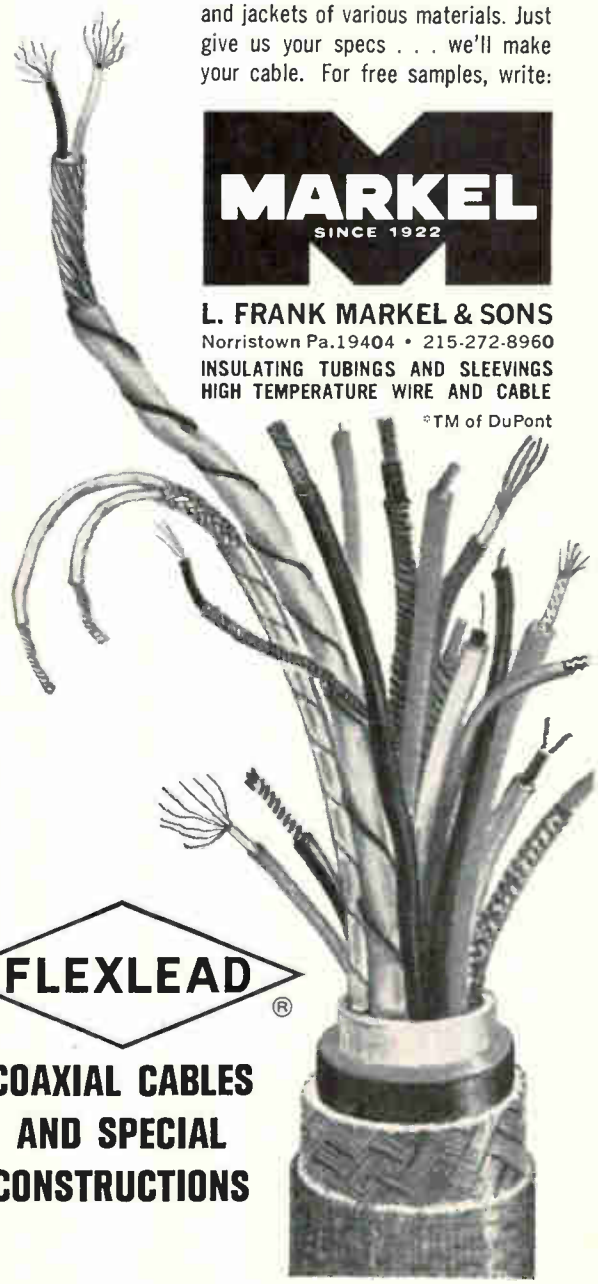

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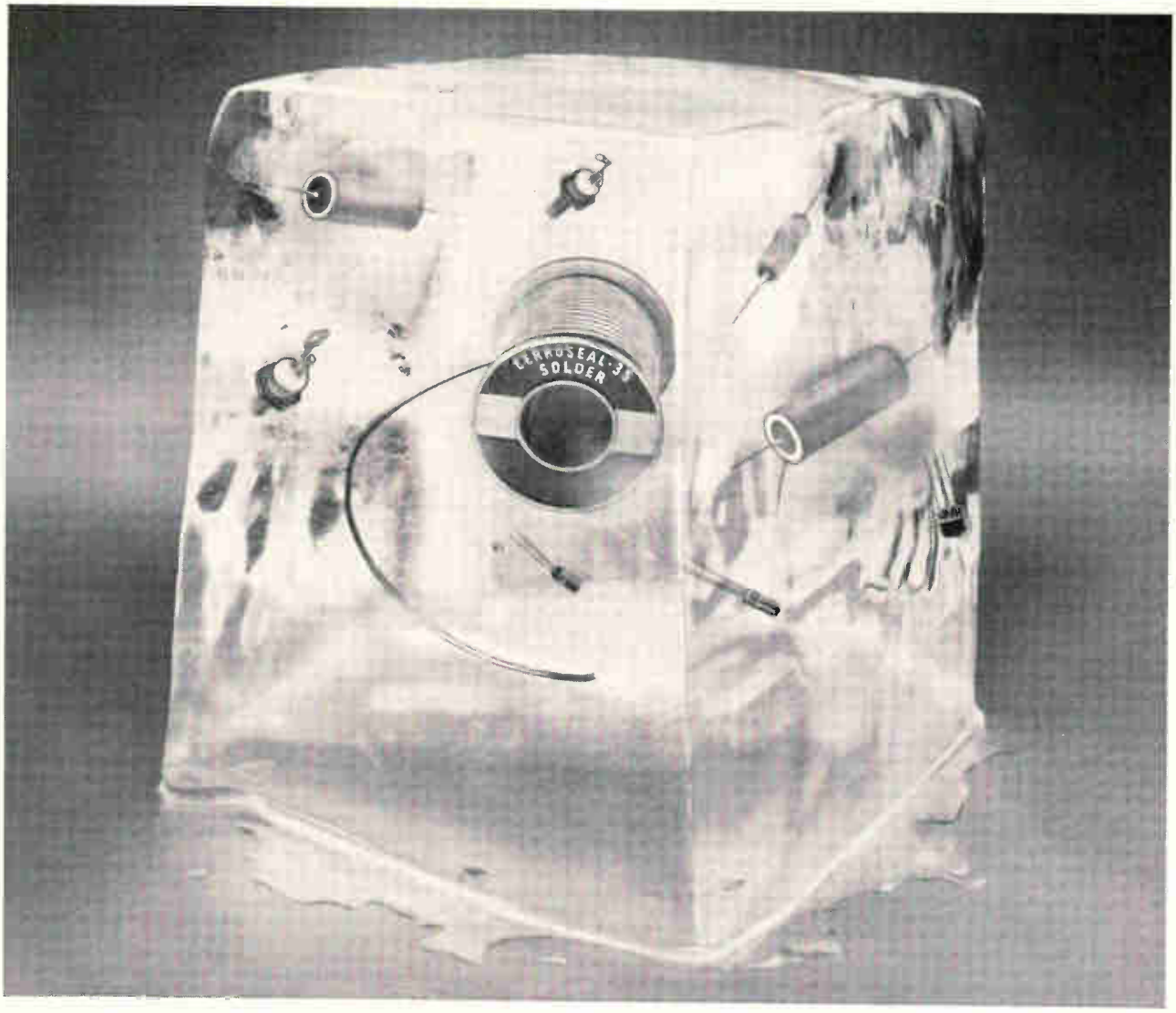

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New Production Equipment Review

Pulsemeter soldering system features pencil-type holder and miniature parallel-gap electrodes. Both time and current can be preset to control heat delivered. Time settings range from 0.1 to 1.0 sec; current settings, from 10 to 35 amps. Uses include IC flatpack soldering, and thin- and thick-film soldering. Development Associates Controls, 725 Reddick Ave., Santa Barbara, Calif. [421]

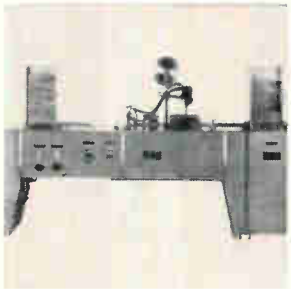
Pantograph reflow-soldering system RS-334 consists of a power supply, 2 reflow-soldering heads, a pantograph p-c board positioning mechanism, and an IC loading/placement fixture. It positions an IC on its mounting board and solders as many as 14 leads at once. Each soldering head has interchangeable electrode-tip configurations and sizes. Sippican Corp., Mattapoisett, Mass. [422]

Test chamber ZOHP-3 is designed to provide stable life-test temperature conditions for in-chamber parameter measurements of semiconductor and axial-lead components mounted to p-c boards. It provides for life-test temperature environments from 100° to 400°F with a stability of ±0.25°F, utilizing a laminar air flow. Associated Testing Laboratories Inc., 200 Rt. 46, Wayne, N.J. [423]

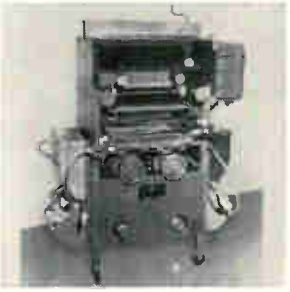
Model **1400** console enables the welding of insulated tape cable to itself or to connector terminals without prestripping the insulation. It includes 2 a-c power supplies, 1 d-c supply, an a-c/d-c controller, and a weld head with 4 electrodes (2 above and 2 below the items being welded). Copper-to-copper welds take ½ sec. Wells Electronics Inc., 1701 S. Main St., South Bend, Ind. [424]

Temperature heating rate of −100°F to 200°F in 2 hours and cooling rate of 200°F to −100°F in 1 hour are featured in an environmental Thermaline vibration chamber that is insulated with nonsetting, nonhygroscopic Fiberglas/Foamglas. Control is maintained to within ±3°F. Environmental Engineering Division, Bethlehem Corp., 225 W. 2 St., Bethlehem, Pa. [425]

Valve assembly V4-198 provides control of gas flow into a vacuum system or other chamber for thin-film sputtering, electronic-tube filling, test-chamber pressure regulation, arc melting, zone refining, and crystal growing. A replaceable, baffled, hot filament assembly removes impurities. Price is $425. Deliveries are from stock. Materials Research Corp., Orangeburg, N.Y. [426]



HD-3 remote masking-spray coater, TL-1 automatic tray-loading machine, and ML-1 magazine loader are for continous automatic wet or powder application to axial-lead components. They handle from 3,000 to 10,000 components per hour, depending on sizes. After spray coating, the ML-1 stacks 40 loaded trays for baking or storage. Conforming Matrix Corp., Toledo, Ohio. [427]



Roller coater for applying thin-film photoresist materials to p-c boards has a double-pumping system for automatic cleanup, ground rolls, dial indicators for thickness adjustment, and separate drive systems for doctor roll and coating roll. Coater operates at any speed from 3 to 9 ft oer minute. The unit will accept boards up to 1 in. thick. Union Tool Corp., Warsaw, Ind. [428]

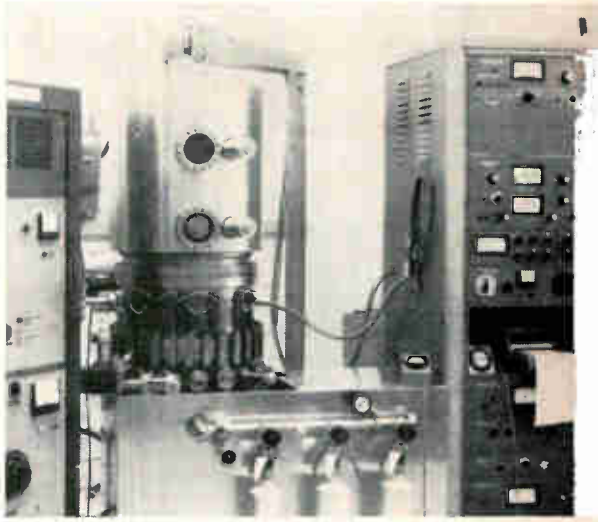
New production equipment

Purer metals are worth the wait

Zone refining system takes a long time to clear impurities from thin-film materials, but it helps improve IC yields

Unkind words are often voiced by production managers saddled with vacuum-processing systems that must be pumped down for more than a few hours. Yet a ponderous system that chugs away for a couple of shifts before it goes to work is expected to find a welcome at plants producing electronic components.

The machine's job is purifying metals with an electron beam—a job it does better than anything anybody else has devised, according to Materials Research Corp. It will refine tantalum, for example,



Refinery. Power supply and control cabinets flank the vacuum chamber.

. . . impurities swept to end and then cut off . . .

to the point where the resistivity ratio—an electrical measure of purity—is 2,100. That, says MRC, is almost 10 times better than the best tantalum from other refiners.

Besides, the day or so spent in refining a metal rod can step up production. Suppose linear integrated circuits are being made. Scrap rates can quickly rise if IC characteristics start straying because of minor differences in composition of the materials deposited as thin-film elements. A half-pound rod shaped into a deposition source can keep a thin-film sputtering system fed for a year.

Two to make ready. The EBZ-95 system refines as well as it does because it is the first to add ultra-high-vacuum distillation to float-zone refining, the company says.

Zone refining is a method of sweeping impurities out of a rod. In the electron-beam version of the technique, the beam scans the rod slowly, causing a small, molten zone to traverse the rod. Soluble impurities collect in the zone, so they can be concentrated at one end, which is cut off.

While the beam is clearing away impurities having high melting points, impurities with relatively low melting points boil off in the vacuum. The higher a vacuum, the more impurities will boil off. The EBZ-95 attains a vacuum of 1×10^{-11} torr in less than 24 hours.

One to go. Ceramics can be refined in the EBZ-95 with the aid of custom-grid assemblies. But MRC prefers a new cathodic system that prevents constituents like oxygen from coming out of the compound.

With a hollow cathode heating the material during the zone refining process, the chamber doesn't have to be evacuated (an electron beam can only function in a vacuum). Oxygen can then be bled into the chamber to prevent dissociation of oxides. Conversely, hydrogen can be supplied if oxides must be reduced.

The price of the EBZ-95 is about $42,000, and delivery takes eight weeks.

Materials Research Corp., Orangeburg, N.Y. 10962 [429]

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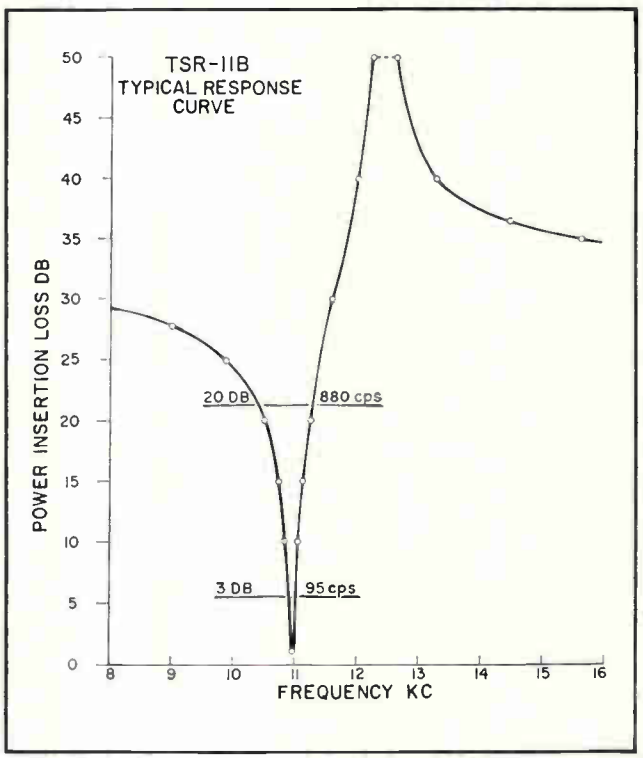

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CLEVITE

Circle 235 on reader service card

New production equipment

Bonder reduces purple plague

Preheating of devices is no longer needed in bonding gold wires

Pulse heating the tip of a thermocompression bonder isn't new, but attempts to overcome some of the technique's major problems—premature tip wearout, wobbly tip support, and ball-size inconsistency—have, for the most part, proved unsuccessful. But now, the Hughes Aircraft Co.'s Vacuum Tube Products division believes it has whipped these problems. It has come up with the MCW/BB (for microcircuit welder/ball bonder), which the company believes will enable it to grab a share of the $4 million-a-year wire-bonder market.

The Hughes bonder handles gold-wire diameters ranging from 0.0007 to 0.005 inch without any preheating of the devices. Moreover, it can bond at any heat without requiring setup changes. These features, says Gary D. Wrench, manager of the division's display and equipment operations, should make the bonder particularly attractive to makers of hybrid thin-film and thick-film devices.

By coupling a direct current nickel-cadmium battery power supply to a comparator circuit that compares the voltage across the tip with a preset value, Hughes is able to control the duration of maximum heat. When the voltage exceeds the preset limit, the comparator circuitry signals a bank of control transistors that reduces the power output. The sensing signal feeds back to the power supply every 25 microseconds. The significance of tip-temperature control, Wrench says, is that it "turns the tungsten-carbide tip down just before it goes to the red condition, thus lengthening tip life."

In the work. Wrench says Hughes had been experimenting "off and on" for four years to develop the bonder. A concerted effort was made during the last

. . . less heat transfer reduces resistor drift . . .

10 months to make the tool a standard product.

Although life tests haven't been conducted yet, the company believes users will be able to get 30,000 to 40,000 bonds per tip—about the same tip life of conventional bonders. Actual bonding requires between 250 and 500 milliseconds, compared with a full second of heating required by pulse-heated bonders using a-c power supplies. Thus, there is much less heat transfer to thin- or thick-film resistors on the substrate adjacent to the bond, minimizing resistor degradation. This reason, if for no other, is why the company believes hybrid-device makers will buy the bonder, which will sell for $4,290. Hybrid devices use a considerable amount of thin- and thick-film resistors, which are susceptible to thermal damage.

Tip wobble usually results when the tip is clamped to its conductive supports—the tip expands at a different rate than the clamp material. To avoid this, Hughes welds the tip to its conductive supports, eliminating the interface resistance of the clamp and allowing uniform expansion of tip and support.

Gold wire-ball size is also uniform, says Wrench, because wire tension is kept consistent by a "novel wire support" that depends on zero-clearance bearings in the wire-spool support.

Bugaboo's gone. The company is counting on interest from buyers who have previously avoided gold-to-aluminum bonds because of the purple-plague bugaboo often encountered in bonding the two materials at high temperatures. Although tip temperature may reach a maximum of 600°C, no substrate preheating is required with the MCW/BB, thus reducing both purple plague and resistor drift.

Specifications

Energy source	constant voltage d-c
Energy range	to 800 amps
Response time	approx. 25 μsec
Pulse duration	from 1 to 9,900 msec in 3 ranges
Wire diameters	0.007-0.005 in.
Force range	10 to 1,000 grams
Micropositioner	10:1 reduction
Microscope	Bausch & Lomb Stereozoom

Hughes Aircraft Co., 2020 Oceanside Blvd., Oceanside, Calif., 92054 **[430]**

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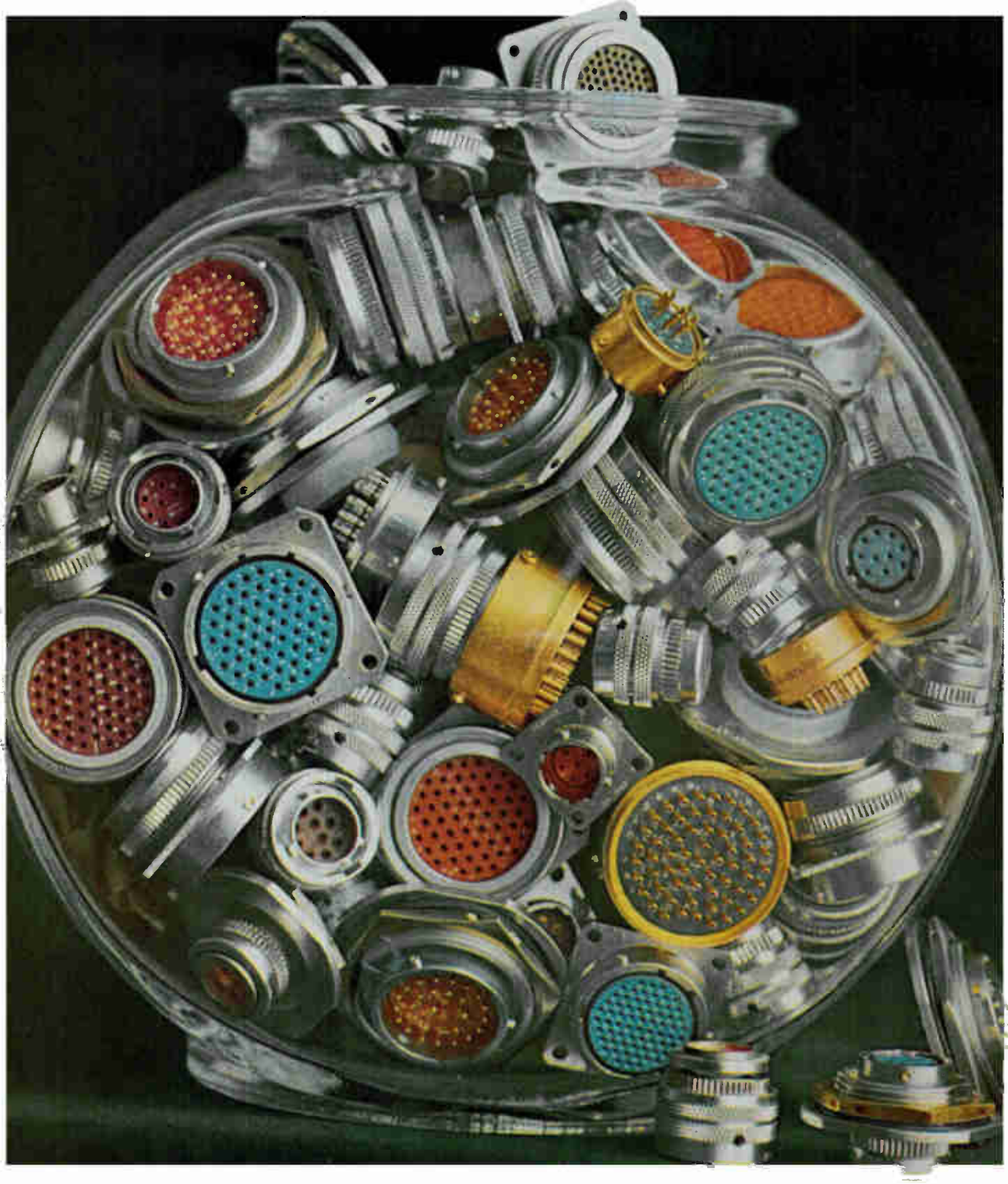
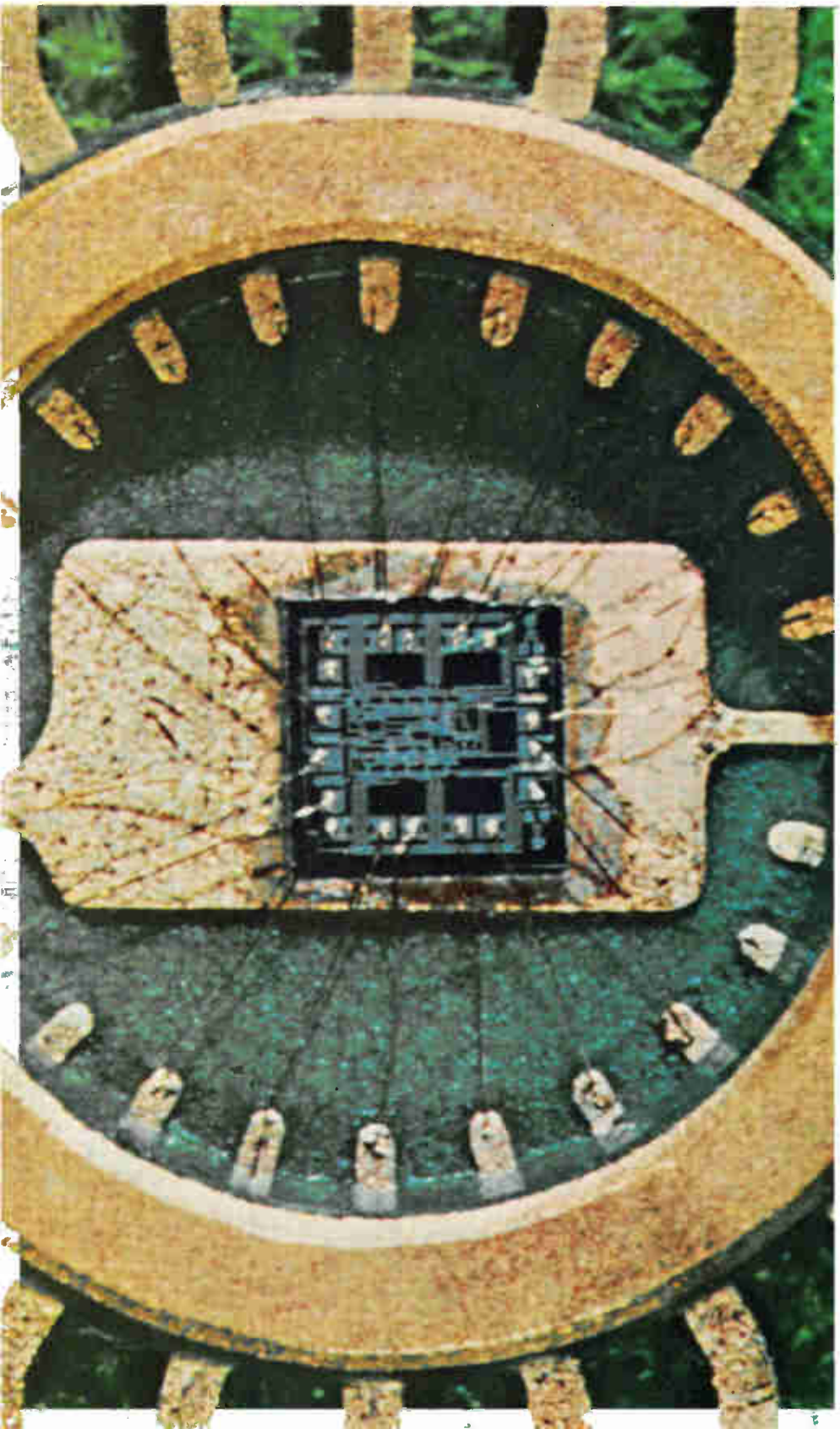


You sure act big for such a little guy.



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New Books

From pipelines to space

Handbook of Telemetry and Remote Control
Elliott L. Gruenberg, editor
McGraw-Hill Book Co., 1300 pp., $35

Many engineers forget that telemetry developed as wired systems for remote instrumentation in the gas, electric, and chemical industries. This book does not. Though space telemetry now gets far more publicity, these first applications have grown in importance and therefore are not neglected by the author. Coverage is from a modern point of view of the unusual problems posed by industrial telemetry and remote control. The coverage of remote control as an extended version of feedback-control principles is authoritative and expertly done.

Since telemetry includes not only the measurement but also the transmission of data, the handbook also devotes much attention to the particular methods of communication that lend themselves to accurate, high-capacity transmission of data. It covers methods of modulating and multiplexing, such as fm-fm frequency-division systems, pulse-amplitude modulation, pulse-duration modulation, pulse-code modulation time-division systems, high-efficiency systems and phase-locked loop systems.

The chapter on sampling and handling of information is done with great care and skill and, all in all, is the best short treatment of the subject so far published. However, little coverage is given to digital information processing, now a fast moving field with the upswing in the use of digital integrated circuits.

With a specialized subject and a high price, this book probably will find its way to the bookshelf of only a relatively few electronics engineers. It is, nonetheless, a useful reference work for those concerned with telemetry as well as people in all the other fields that have borrowed the techniques developed by workers in telemetry. The topics for each section cover the field well.

But, as often happens with books that are written by a large group

New Books

of authors—30 in this case—the quality of coverage is spotty; some portions are excellent while others are disconcertingly obscure. For example, the treatment of transistor telemetering circuits is well done, but the treatment of general design considerations for transistor circuits is inadequate. Typographical errors also mar a few of the chapters.

Walter C. Johnson
Princeton University
Princeton, N. J.

Recently published

Digital Computer User's Handbook, edited by Melvin Klerer and Granino A. Korn, McGraw-Hill Book Co., 922 pp., $27.50

This handbook is aimed at the user with professional training in a field other than programing. It provides a reference to current methods of programing and numerical analysis, and computer applications.

Integrated Circuit Technology, edited by Seymour Schwartz, McGraw-Hill Book Co., 331 pp., $15.00

A handbook on the processing and instrumentation techniques for the fabrication, test, and failure analysis of IC's. The book will be valuable to engineers in IC production and evaluation.

Adaptive Control and Optimization and Techniques, Virgil W. Eveleigh, McGraw-Hill Book Co., 434 pp., $14.75

Static optimization procedures, adaptive control, and dynamic optimization are covered in this graduate-level text. Necessary mathematical background is included with emphasis on the time-domain methods and steady-state vector representations.

Electronic Devices and Circuits, J. Millman and C.C. Halkias, McGraw-Hill Book Co., 752 pp., $12.50

FET's and monolithic IC's are included in this text for college juniors. Thevenin's and Miller's theorems are used extensively in analysis of transistor and tube circuits. Elementary concepts in electronic quantum theory are also discussed.

Introduction to Dynamic Systems, J.B. Reswick and C.K. Taft, Prentice-Hall Inc., 294 pp., $8.95

This undergraduate text concentrates on developing simplified models of physical systems. Laplace transform techniques have been avoided, so that the student can better understand the algebraic basis of classical transient and steady state analysis. Complex frequency functions are discussed and a heuristic treatment of Fourier series is given.

Electrical Characteristics of Transistors, R.L. Pritchard, McGraw-Hill Book Co., 715 pp., $19.50

Basic transistor physics is presented on an elementary level. This is followed by a discussion of the properties of transistors, covering the discrepancies between the physical devices and common simplified models, d-c and a-c characteristics, switching response, temperature sensitivity, and gain, distortion, and noise characteristics. Material is geared to the average graduate engineer.

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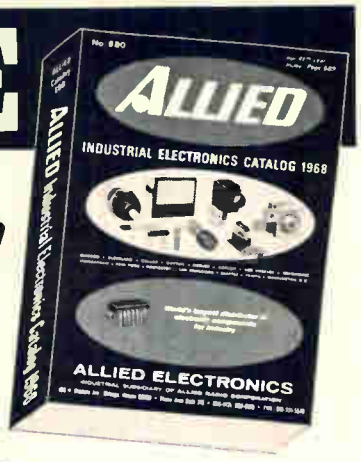

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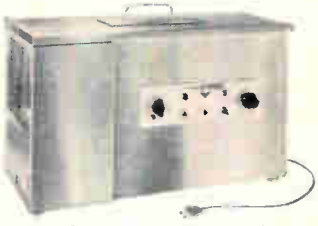

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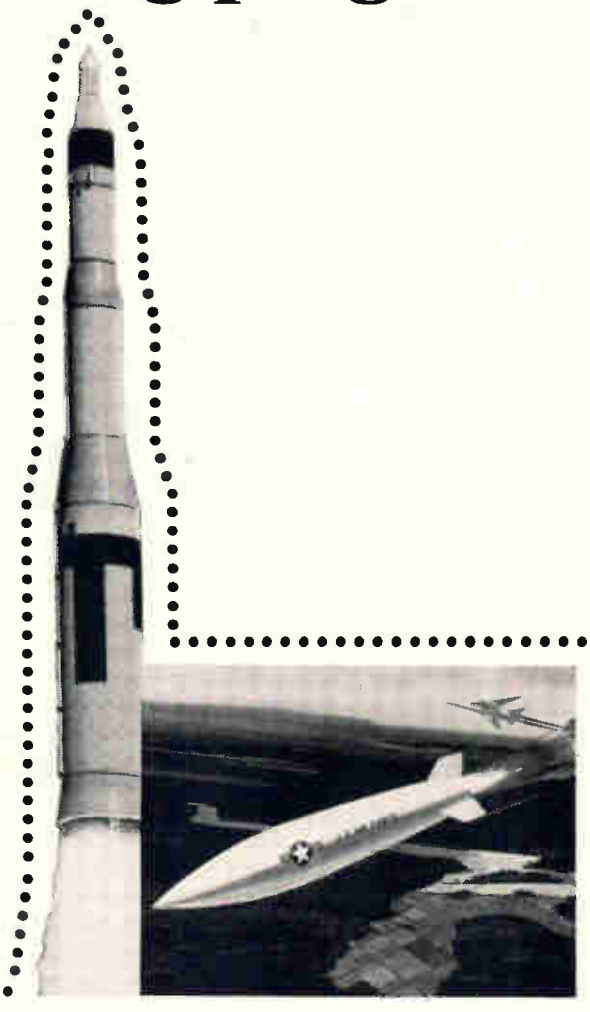

Boeing's deep involvement with the nation's major missile and space programs provides immediate career opportunities for electrical/electronic engineers at Seattle, Huntsville, and Kennedy Space Center.

Boeing is system integration contractor for SRAM, the U.S. Air Force's new Short-Range Attack Missile. The company also is weapon system integrator for the USAF advanced Minuteman II ICBM. In space, Boeing is prime contractor for the National Aeronautics and Space Administration's Lunar Orbiter, the moon-circling spacecraft which is helping NASA scientists select the best landing sites for Apollo astronauts. In addition, Boeing is a major mission-support contractor to NASA on the Apollo/Saturn V program, and is building the first stage of the Saturn V launch vehicle.

Immediate openings exist at Seattle on the SRAM, Minuteman and Lunar Orbiter programs. Assignments in test technology include data systems and instrumentation and test data handling and processing. Qualifications include a B.S. or M.S. in electrical engineering and two to five years applicable experience. Flight technology positions are available in flight control and flight mechanics. Qualifications include a B.S. or M.S. in electrical engineering with two to five years experience.

Additional Seattle openings exist in developmental design and electronic packaging. Design assignments are in airborne control systems, ground system electrical power systems, and environmental control, and require a B.S. degree in an applicable discipline plus related experience. Electronic packaging qualifications include a B.S. in electrical engineering plus applicable experience.

A number of openings also exist on the Apollo/Saturn V program. At Huntsville, assignments in flight mechanics and flight evaluation include operational trajectories, mission analysis, trajectory analysis, post-flight trajectories, flight simulation development, and flight dynamics. Qualifications include a B.S., M.S. or Ph.D. in electrical engineering. Openings also exist for electrical/electronic engineers at Kennedy Space Center.

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Technical Abstracts

Handle with care

Evaluation of bulk and epitaxial GaAs by means of X-ray topography
Eugene Meieran
Fairchild Semiconductor Research and Development Laboratory, Palo Alto, Calif.

Even routine handling of a gallium arsenide wafer can damage its surface. The slightest touch with tweezers causes deep scratches, rarely less than 4 or 5 microns. Table tops and, surprisingly, filter papers also can cause scratches. Such scratches are invisible with a microscope, but a new method of X-ray topography brings them out, and allows study of other defects caused by crystal growing, sawing, mechanical polishing, and diffusion.

Saw damage usually is fairly shallow, about 10 microns, and consists of a skin of cracked GaAs which is somewhat polycrystalline. Mechanical polishing also leaves a polycrystalline surface, though a microscope will show no signs of damage. X-rays, however, reveal scratches about 10 or 20 microns deep.

An X-ray comparison of boat-grown GaAs with Czochralski crystals shows that the boat-grown crystals are superior. The Czochralski crystals have heavy segregation of dopants and large numbers of dislocations—effects which are not observed in boat-grown crystals.

Presented at the Technical Conference on Preparation and Properties of Electronic Materials, Compound Semiconductors, and Materials for Integrated Circuits, New York, Aug. 28-30.

Try phastor storage

The phastor, a simple analog storage element
D. Aspinall, University of Manchester, England
W.J. Poppelbaum, University of Illinois

An analog storage element was built with a simple voltage comparator circuit, a clock-pulse generator, a monostable multivibrator, and some gating circuits. The circuit, called the phastor, uses a time interval to represent the voltage and lends itself well to integrated circuit format. Its accuracy depends primarily on how high the clock frequency can be made.

One way to store some value of an analog voltage indefinitely is to compare it with a sawtooth waveform, produce a narrow pulse when the two are equal, and feed the pulse into a delay line whose delay is equal to the period of the sawtooth waveform: Thus, when a pulse leaves the delay line, the sawtooth is again at the voltage equal to the analog voltage. If the sawtooth is sampled at that instant, the analog voltage can be recovered.

The delay line, however, stores only one piece of information—it can be replaced with a simpler astable multivibrator whose period is equal to that of the sawtooth. The astable multi is held off until the analog voltage is equal to the sawtooth, and then the multi is

allowed to oscillate freely. From then on, whenever the multi completes a cycle, the sawtooth waveform at that instant will again be at a voltage equal to the analog voltage.

Whether the sawtooth is perfectly linear or not is not important, so long as each cycle always repeats itself exactly. What is important is that the timing between sawtooth and multi remain coordinated.

The phastor eases the restriction on equality of the two periods by using a clocked system and a monostable multi instead of the astable. The monostable is triggered by the time coincidence of a clock pulse and the comparator output. The period of the monostable must nearly equal the period of the sawtooth. Specifically, it must be less than but within one clock pulse of the sawtooth waveform's period.

Once the original coincidence between sawtooth and analog voltage is sensed, and the multi switched, the clock pulses will, from then on, take over the timing and switch the multi at points in the cycle corresponding to the proper sawtooth voltage. Thus, the multi must switch over to its unstable state when hit by the first coincidence pulse, remain there, oblivious to the steady stream of clock pulses, and then switch back to its original state in time to be switched again by a clock pulse which is coming exactly one sawtooth waveform period later.

A breadboard model of the circuit was constructed using a 3-millisecond ramp. The circuit was able to store analog voltages to an accuracy of better than one part in 32 for several minutes. Work now is proceeding on using a higher clock rate, which would provide the analog memory with better accuracy.

Presented at the Conference on Computer Technology, Manchester, England, July 18-20.

Making microwave IC's

Fabrication of monolithic microwave integrated circuits: materials and process considerations
Robert C. Hooper, Charles A. Wheeler, Texas Instruments Incorporated, Dallas

A marriage of compatible techniques is the secret to fabricating microwave integrated circuits. Monolithic circuits for operation at microwave frequencies can be built by growing epitaxial silicon on a semi-insulating silicon substrate, fabricating high-frequency transistors in the epitaxial material, and then depositing thin-film resistors and capacitors. Amplifiers operating at 500 megahertz were made with this process.

The semi-insulating silicon substrate, which provides isolation between devices, is high-resistivity (300 ohm-cm) p-type silicon, which is masked with silicon dioxide and then selectively etched to form pockets about 10 microns deep. The pockets are refilled with epitaxially grown silicon.

Next, an npn transistor is diffused into the refill area, and a molybdenum-gold contact is deposited to

produce low-resistance ohmic contacts to the transistors and to help form better thin-film capacitors. Finally, a film of SiO_2 is deposited over the surface. Typical transistors built like this had an f_t of 2.5 gigahertz and a 500-Mhz noise figure of 3.5 decibels.

Resistors are formed by vacuum-evaporated nichrome films. Thin-film capacitors are formed in windows cut in the protective SiO_2 down to the transistor expanded contacts. Such capacitors are the most difficult thin-film component to build successfully.

Thin-film capacitors fail because of rough substrates, contamination in the atmosphere and pinholes in the photoresist, but the most serious defects are related to the interaction of dielectric film and metal electrodes. If aluminum were used for the contacts, processing temperatures in the range of only 250°C would cause the SiO_2 film to rupture, because of the thermal mismatch of coefficients of expansion of aluminum and the film. In addition, the aluminum tends to recrystallize during deposition of the film and produces a rough surface which can cause capacitor breakdown.

Making the bottom electrodes with molybdenum avoids the problems with aluminum, and produces capacitors with excellent characteristics. A minimum breakdown voltage of 60 volts was observed for 100-picofarad capacitors and the capacitors can be heated to 350°C without failure.

Presented at the Technical Conference on Preparation and Properties of Electronic Materials, Compound Semiconductors, and Materials for Integrated Circuits, New York, Aug. 28-30.

Fast turnaround

Thick-film techniques and design criteria for space vehicle application
A.V. Ottaviano and J.J. Thomas
General Electric Co.
King of Prussia, Pa.

The General Electric Co.'s reentry systems department, in an operation about a year old, is fabricating prototype thick-film hybrid integrated circuits in three days. The department, concentrating on linear circuits not available as stock items, has produced 50 different circuits for use in reentry vehicles in the past six months.

Interface circuits like signal conditioners, secondary power supplies, and analog programmers are often the last in the system to be defined, demanding a fast turnaround time in the design-to-fabrication process. Typical circuits operating up to 400 megahertz have been processed from engineering layout to finished assembly in 24 man-hours.

One of the major problems was screen printing resistors. Depositing resistors to within ±10% of nominal value requires that the distance and parallelism between the bottom of the screen and the substrate surface be closely controlled, along with the squeegee angle and pressure. Adjusting squeegee pressure from 4 pounds to 7 pounds produced a resistance change of about 25%, and a 0.010-inch modification in screen-to-substrate distance introduced a change of about 10%.

Presented at Wescon, San Francisco, Aug. 22-25.

New Literature

Precision meter terms. Precision Meter Division, Honeywell Inc., Grenier Field, Manchester, N.H., 03105. Definitions of terms for electrical indicating instruments are spelled out in a six-page brochure.
Circle **446** on reader service card.

Microwave relay equipment. RHG Electronics Laboratory Inc., 94 Milbar Blvd., Farmingdale, N.Y. 11735. Solid state, f-m microwave relay equipment is discussed in catalog 67b. **[447]**

A-c generators. Kato Engineering Co., 1415 First Ave., Mankato, Minn. 56001. An eight-page brochure covers the company's line of a-c generators with controls from 1 to 1,500 kw. **[448]**

Ultrasonic detection. Delcon Division, Hewlett-Packard Co., 333 Logue Ave., Mountain View, Calif. 94040. A 10-page brochure presents the growing uses of ultrasonic detection in 11 major industrial applications. **[449]**

Photomultiplier tube housings. Pacific Photometric Instruments, 3024 Ashby Ave., Berkeley, Calif. 94705. Bulletin 207B gives electrical and mechanical details on a variety of housings for photomultiplier tubes. **[450]**

Current sensors. American Aerospace Controls Inc., 129 Verdi St., Farmingdale, N.Y. Technical bulletin 109 describes the series 4008 clamp-on current sensors for measurement of d-c currents in the range of 150 to 5,000 amps. **[451]**

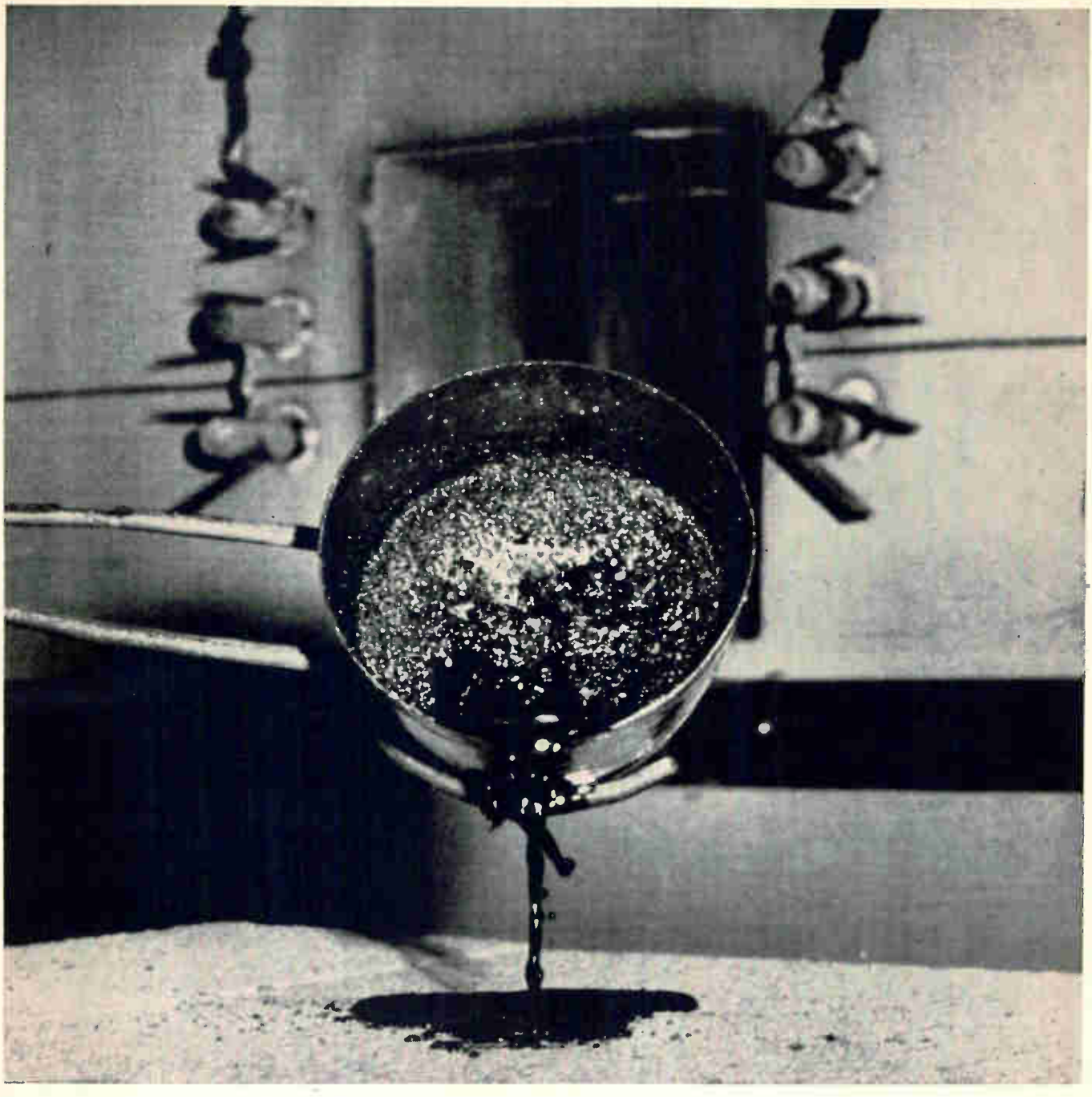
Plastic-encapsulated rectifiers. Semiconductor Division, Westinghouse Electric Corp., Youngwood, Pa. Important electrical and mechanical characteristics of a family of low-priced, plastic-encapsulated rectifiers are presented in a 12-page booklet. **[452]**

Scalar feed. TRG-Boston Division, Control Data Corp., 400 Border St., East Boston, Mass., has issued a four-page illustrated brochure on its model LS871/881 scalar feed horn. **[453]**

Connector assembly machine. Edward Segal Inc., 132 Lafayette St., New York, has a catalog sheet describing a machine with automatic feed for the assembly of interlock connectors for tv sets and similar uses. **[454]**

D-c measurements. Julie Research Laboratories Inc., 211 W. 61st St., New York 10023. A 12-page brochure covers Ratiometrics, the company's fully instrumented concept for measuring d-c resistance, voltage, current, and ratio with accuracies of the order of a few parts-per-million. **[455]**

Aerospace digital computers. Kearfott Group, General Precision Systems Inc.,



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New Literature

1150 McBride Ave., Little Falls, N.J. 07424, has issued a 24-page catalog describing nine aerospace digital computers and their variations. **[456]**

Adjustable crimping tools. Buchanan Electrical Products Corp., 1065 Floral Ave., Union, N.J. 07083. An illustrated, six-page bulletin (TA 100) describes and gives specifications for a line of eight-indent, cycle-controlled crimping tools. **[457]**

Thyratrons. Amperex Electronic Corp., 230 Duffy Ave., Hicksville, N.Y. 11802. An application report on thyratron tubes contains 19 pages of useful information and data for the design and application engineer. **[458]**

Digital products. Digital Products Division, Vernitron Corp., 59 Central Ave., Farmingdale, N.Y., offers a digital products catalog listing its brush-type shaft encoders, as well as solid state digital-to-synchro and digital-to resolver converters. **[459]**

Cooling fan assemblies. General Electric Co., 1635 Broadway, Fort Wayne, Ind. 46804. Publication GEA-8258 describes a line of blower units for computer and electronic equipment cabinets. **[460]**

Semiconductor cooling. Wakefield Engineering Inc., Wakefield, Mass. 01880. Twenty-page catalog No. 1967 covers semiconductor heat sinks and other thermal products. **[461]**

Silicon rectifiers. Edal Industries Inc., 4 Short Beach Rd., East Haven, Conn. 06512. Bulletin 119 offers details on a line of subminiature, high-voltage silicon rectifiers. **[462]**

Current drivers. Computer Test Corp., 3 Computer Dr., Cherry Hill, N.J. 08034, has published a technical data sheet (bulletin 66-R) on a complete line of 20-nsec current drivers. **[463]**

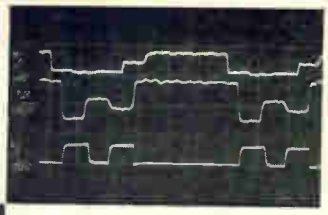
Elapsed time indicators. A.W. Haydon Co., 232 N. Elm St., Waterbury, Conn. 06720. Bulletin MI603 describes microminiature elapsed time indicators for operation on 400 hz, 60 hz, and d-c. **[464]**

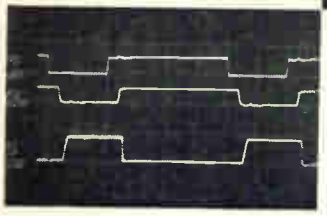
Synchro simulator. North Atlantic Industries Inc., Terminal Drive, Plainview, N.Y. 11803, offers a data sheet describing model 532 synchro simulator that features 30-second accuracy. **[465]**

Flatpacks. Veritron West Inc., Chatsworth, Calif. A catalog details a wide spectrum of basic sizes of flatpacks for IC, hybrid, and thin-film packaging. **[466]**

Antennas. RF Systems Inc., 155 King St., Cohasset, Mass. A brochure sum-

Signal distortion between racks*





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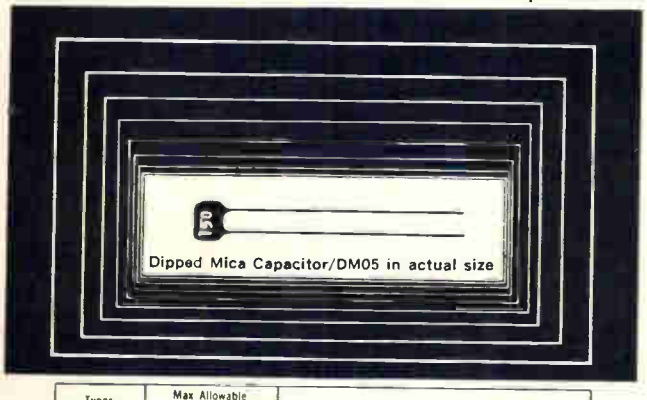

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DM 05	200	130	–	7.0	5.0	3.5	7.0	5.0	3.5	–	–	–
DM 10	440	390	330	8.5	5.5	3.5	8.5	5.5	3.5	8.5	5.5	3.5
DM 15 (CM05)	2090	1200	510	13.0	11.0	6.5	12.5	10.5	6.0	12.0	10.0	5.5
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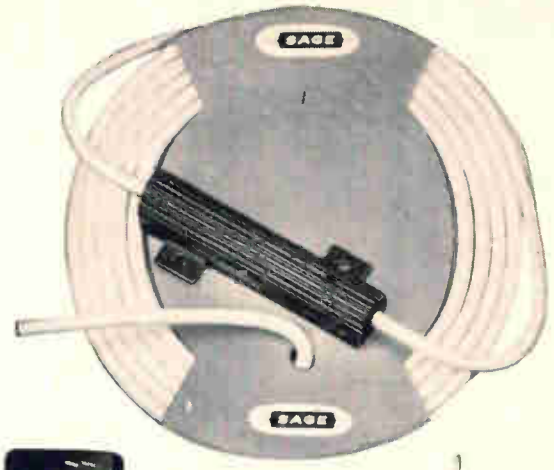

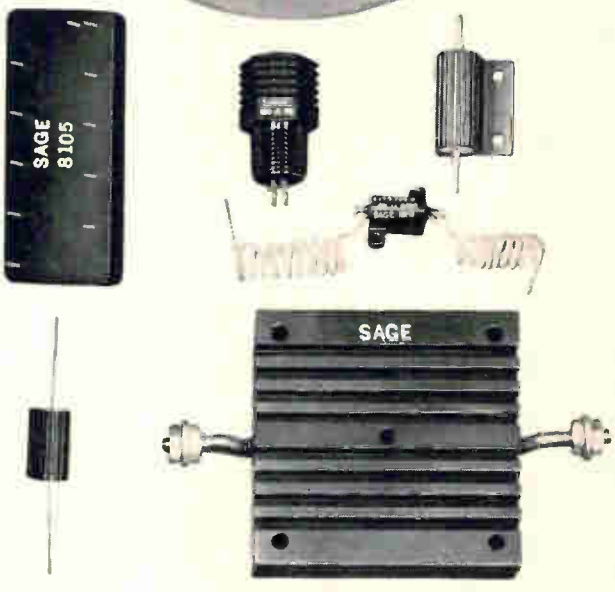

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Circle 253 on reader service card

New Literature

marizes and pictures military and commercial antennas and tower structures manufactured by the company. **[467]**

Microwave components. Bendix Microwave Devices Inc., Farmington Industrial Park, Farmington, Conn. 06032. A 44-page catalog (No. 14) contains over 1,000 models of directional couplers, circulators and isolators, r-f loads and terminations, power and vswr meters, switches, filters, and integrated devices. **[468]**

Shift register. Microelectronics Division, Philco-Ford Corp., 2920 San Ysidro Way, Santa Clara, Calif. 95051. Application Note 401 describes the pL5R100 MOS monolithic 100-bit shift register. **[469]**

Balanced mixers. Microwave Associates Inc., Burlington, Mass., has released a four-page technical bulletin on the Orthotee series hybrid balanced mixers with characterized diodes. **[470]**

Rotary stepping switches. A.W. Haydon Co., 232 N. Elm St., Waterbury, Conn. 06720. Bulletin CS902 describes series 42700 rotary stepping switches for operation on 12 or 28 v d-c, or rectified 115 v a-c, 60 hz. **[471]**

Linear integrated circuit. Fairchild Semiconductor Division, Fairchild Camera & Instrument Corp., 313 Fairchild Dr., Mountain View, Calif. Two technical publications examine consumer, industrial, and military applications for the μA703 linear integrated circuit. **[472]**

General purpose relays. General Electric Co., Schenectady, N.Y. Eight-page bulletin GEA-7882 describes features of the CR120 type H general-purpose relays for multipole switching applications. **[473]**

Digital printers. Franklin Electronics Inc., E. Fourth St., Bridgeport, Pa. 19405. A 36-page technical manual 2041B is a complete treatise on the theory and application of digital printers. **[474]**

Ferrite core wires. Electronic Memories Inc., 12621 Chadron Ave., Hawthorne, Calif. A two-page application note describes how optimum wire sizes for a given ferrite core can be readily determined. **[475]**

Digital voltmeter. Dana Laboratories Inc., 2401 Campus Drive, Irvine, Calif., has published a brochure on the model 5700 digital voltmeter, which carries a one-year calibration guarantee. **[476]**

D-c/a-c inverters. Natel Engineering Co., 7129 Gerald Ave., Van Nuys, Calif. 91406, has issued a two-page data sheet covering a line of miniature d-c/a-c inverters. **[477]**

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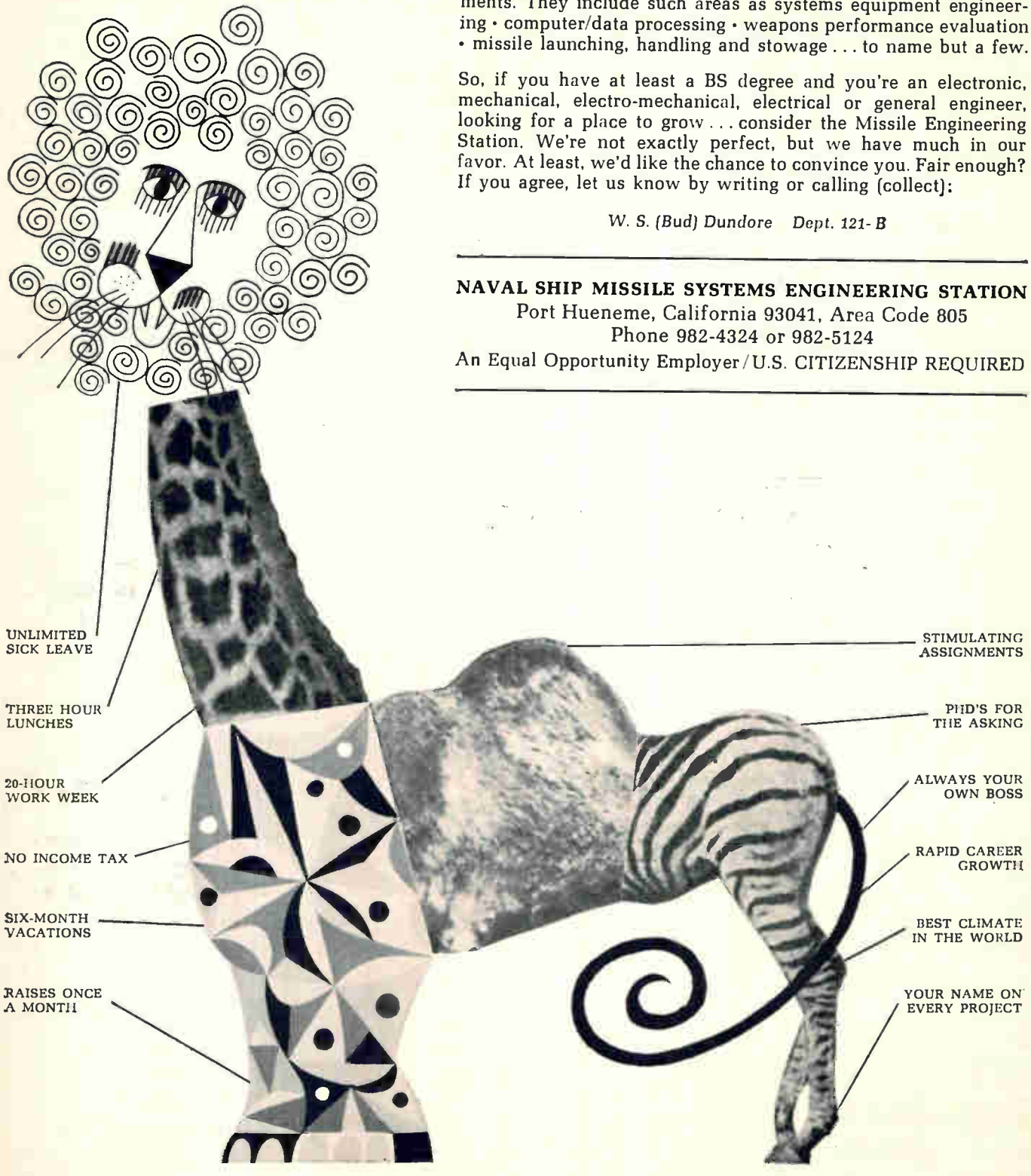

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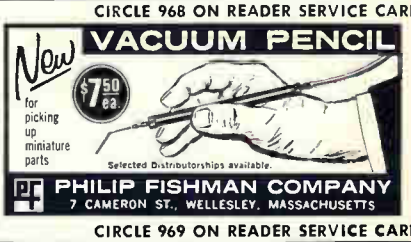

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HUMAN FACTORS SPECIALISTS Degree plus 2 to 8 years experience. Positions will involve system analysis, optimizing man-machine relationships, design inputs, maximizing maintainability, task analysis and specifying qualitative and quantitative personnel requirements.

MAINTAINABILITY ENGINEERS BSEE plus two or more years experience in Maintainability Engineering—the concept, maintenance flow, throwaway vs. repair criteria, etc. Positions involve design input, analysis (MEARS), documenting, reporting, auditing and demonstration testing.

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ELECTRONIC COMPONENTS ENGINEERS BSEE with 3 to 5 years experience in the application and specification of electronic parts for advanced military products. Speciality may be in computer peripherals, major electronic devices, magnetic devices, solid state components or general electronic components.

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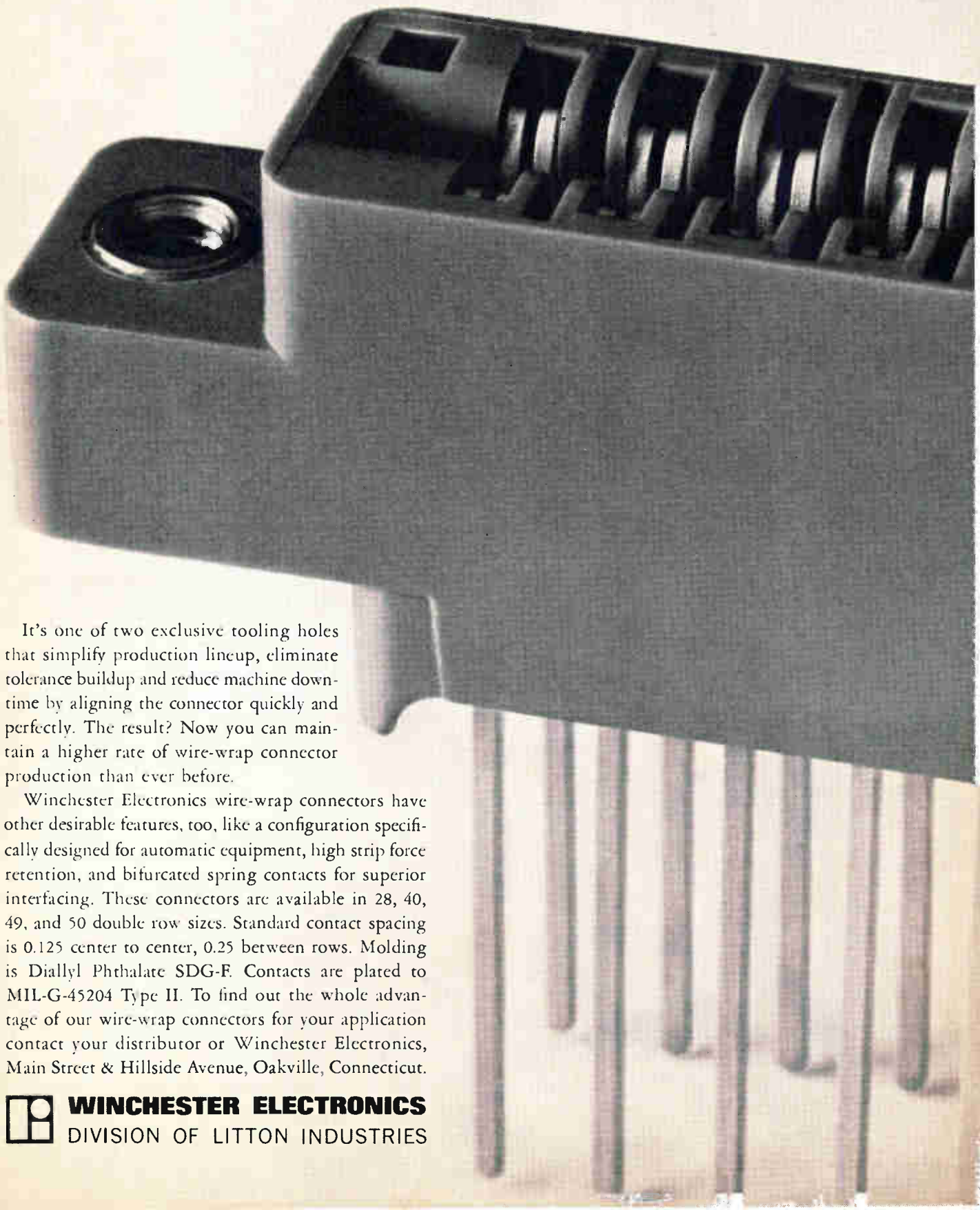

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September 18, 1967

Black box controls gasoline injection in '68 Volkswagens

West Germany's largest auto maker, Volkswagenwerk AG, will start selling in the U.S. next week the first mass-produced car with a fully electronic fuel-injection control system. The black box is standard equipment on VW's top-of-the-line models for 1968—the 1600 fastback and the 1600 station wagon.

About the size of a cigar-box and mounted in the engine compartment at the rear of the car, the control unit makes use of 25 transistors, 35 diodes, 140 resistors, and 20 capacitors. Sensors on the motor feed in such data as intake-manifold pressure, cylinder temperature, crankcase temperature, throttle-valve position, and engine speed. From this data, the unit develops opening and closing pulses for the fuel-injection valves.

VW developed the electronic control with Robert Bosch GmbH of Germany primarily to meet U.S. standards on exhaust gases. With the electronic control, the 1600 engine exhaust has a carbon monoxide content of 1% or less, much lower than the 2.3% limit set by U.S. antipollution laws. In addition, Bosch claims, the black box cuts fuel consumption.

Russian color tv at bargain price

Soviet officials now claim they'll have a color-television set on the market early next year for about $300—a price that would make the set a loss leader elsewhere in Europe. **Y.B. Soloviev, head of the institute that designed the receiver, says the model is put together mainly from components used in black-and-white sets;** hence the hard-to-believe low price.

Although the Russians insist they've started producing color sets in quantity, few will be in evidence when colorcasts start on Nov. 7. The first color programs will be seen on only some 100 receivers set up in public places.

German order likely for Phantom jets

The West German Defense Ministry and the McDonnell Douglas Corp. very likely will close a deal around year's end for at least 150 Phantom 2 jet fighters. The planes would cost up to $3.5 million apiece and would go to accident-depleted squadrons now flying F-104G Starfighters.

The deal should be good news for the German electronics industry. **Bonn will probably specify that much of the avionics gear in the planes be made domestically.** That's what the British did when they placed their large Phantom order [Electronics, Dec. 26, 1966, p. 93].

Britain rejoins Mallard Project

British communications equipment makers now stand to pick up a piece of the action in Project Mallard, a massive tactical communications system that will take almost a decade to build and will cost upwards of $500 million [Electronics, May 15, p. 153].

The British, who initiated the project and then pulled out last Spring after a squabble over contract allocations, rejoined the U.S., Canada, and Australia last week. Britain will contribute 30% of the $126 million it will cost to develop the system; the U.S. will handle 62% of the tab, Canada 5%, and Australia 3%.

Originally, Britain insisted that her share of Mallard contracts match her contribution. The Pentagon, however, wanted contracts awarded to low bidders—meaning U.S. companies in most cases. What brought

Newsletter from Abroad

Britain back in was apparently a compromise that assures British electronics firms of contracts, but not necessarily in strict proportion to the U.K. contribution.

Fujitsu may crack U.S. computer field

Fujitsu Ltd. now has high hopes of breaking into the U. S. computer market. The Japanese company says it's well along in negotiations with the Control Data Corp. for the export of a large number of Facom 230/10 computers.

Control Data most likely will offer the small Fujitsu computers as satellite equipment for its own large machines. The 230/10 has a 4,000-word basic internal store with a cycle time of 2.2 microseconds. To swing the deal, Fujitsu may buy tape and disk memory units from the U.S. firm.

U.K. silicon maker asks tariff boost

British semiconductor-materials makers should get an idea next month of how much to expect in the way of government protection against price-cutting foreign competitors. The reading will come from a Board of Trade ruling on a request for a higher duty on one size of silicon wafer imported from Belgium.

Britain's largest producer of silicon slices, Monsanto Chemicals Ltd., filed for an anti-dumping duty on a wafer produced by Metallurgie Hoboken. The added duty would bring prices of Hoboken's wafers to the same levels as British-made wafers. Monsanto asked that the tariff be raised on a specific wafer (1.283 to 1.287 inches in diameter and 0.0095 to 0.015 thick) but almost certainly will file for action on other sizes. **Hoboken says it has the same price scale in Britain as in many other countries.**

Spain restores investment curbs

The Franco government has suddenly tightened its controls on the establishment of consumer-electronics plants. Up to this month, foreign or domestic companies proposing new production facilities in the country were assured of approval if the planned output came to 100,000 receivers or more annually. **Now the government has switched to a policy of considering plant investment plans case by case.**

Industry ministry officials describe the move as part of an effort to restructure Spain's highly fragmented consumer-electronics industry. With at least 45 receiver makers now competing in the market, the government wants no new small operators. At the same time, it's encouraging mergers by offering tax incentives.

Marconi group gets Eurocontrol award

A consortium headed by Britain's Marconi Co. has won the $2.8 million order for air traffic control equipment for Eurocontrol's experimental control center at Bretigny, France. **The contract, which will probably be signed this week by the companies and the seven-nation air-space-control organization, covers software and hardware, plus an experimental data processor.**

Marconi's partners are Standard Elektrik Lorenz, a West German ITT affiliate, and SAIT Electronics of Belgium. Among the losing bidders were the Eurosystem consortium [Electronics, Sept. 4, p. 202] and a group that included Philips' Gloeilampenfabrieken.

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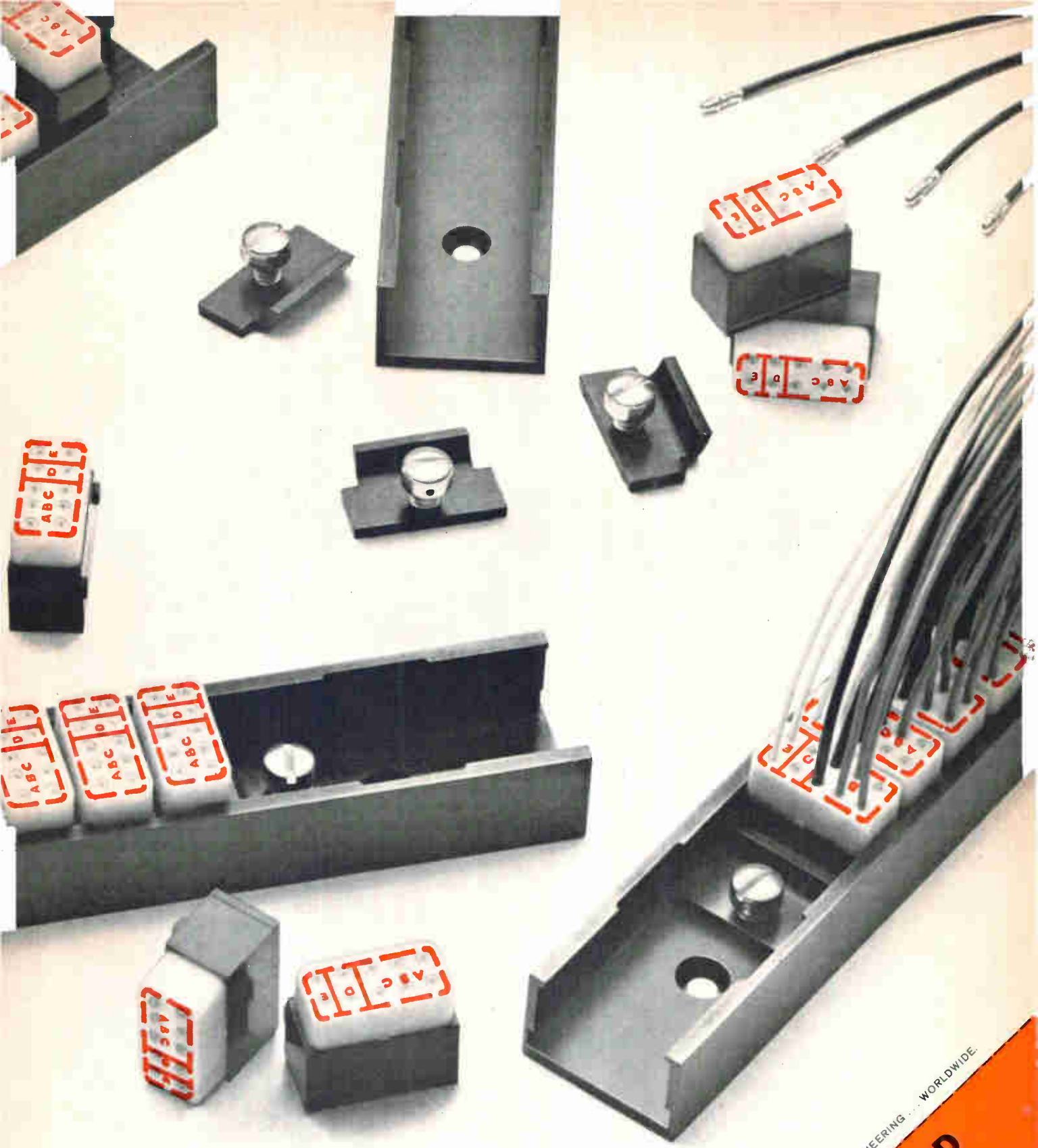

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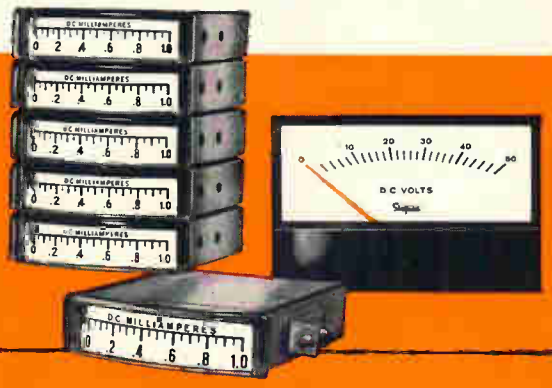

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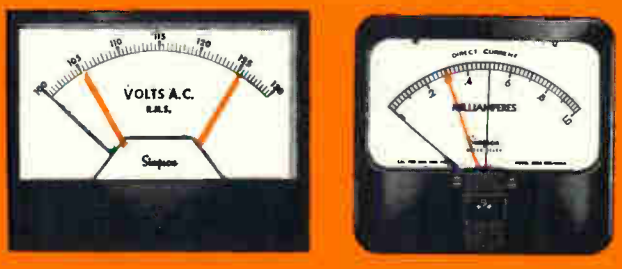

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AGM DIVISION

September 18, 1967

Electronics Abroad

Volume 40
Number 19

Great Britain

Double standard

By and large, broadcast networks have taken the easy way out for intercontinental relays of television programs. Instead of trying for sophisticated electronic conversion from one standard to another, most telecasters have simply aimed a tv-camera onto an image storage tube linked to receiving circuits for the incoming standard.

This electro-optical scheme, however, makes for poor picture quality even for black-and-white. And it won't do at all for color tv. Realizing this, the engineering division of the British Broadcasting Corp. has been working on a fully electronic conversion technique. So has the Japan Broadcasting Co. [Electronics, Feb. 6, p. 108]. But BBC figures to be the first to put electronic conversion into service for colorcasts. At the International Broadcasting Convention in London this week, BBC engineers will tell of an interim system ready for use now and an advanced system that should be in service within a year.

Playing the field. Both systems rely heavily on quartz delay lines to convert from the U.S. standard of 525 lines per frame and 60 fields per second to the European color standard of 625 lines and 50 fields. In both standards, two interlaced fields make up a frame. And in both BBC systems, the basis of the conversion is dropping one out of every six incoming fields.

In the interim system, though, the compensation for the lost field is much the simpler. Where the advanced system stretches the retained fields from 16⅔ milliseconds to 20 ms by adding 50 lines to each field, the interim system simply shortens the line length in a line-store converter to match the shorter field period. This keeps images proportional, but makes them about 17% smaller.

Cascade. Fields are knocked out by running the 525/60 video input through a five-position switch and a cascade of four quartz delay lines. The first incoming field passes directly through the switch to the following stage, the line-store converter. The second field is passed through the first 3⅓ ms delay line and then is switched onto the line-store unit. The third field passes through two delay lines, the fourth field three delay lines, and the fifth field four delay lines before they are switched. As a result, the fifth field is switched onto the line-store exactly when the sixth field of the raw input appears. This field never reaches the line-store; by the time the switch returns to the first position the first field of the next group of six is at the input.

Lineup. Although the interim system produces a good-quality color image by knocking out fields and shortening line lengths, BBC plans to do considerably better with its follow-on system. It uses 3⅓ ms delay lines in cascade but couples them with a second cascade where each delay lasts twice as long as the preceding one. A logic circuit switches in the binary delay units so that 50 averaged lines can be inserted into each field, stretching its duration from 16⅔ ms to 20 ms.

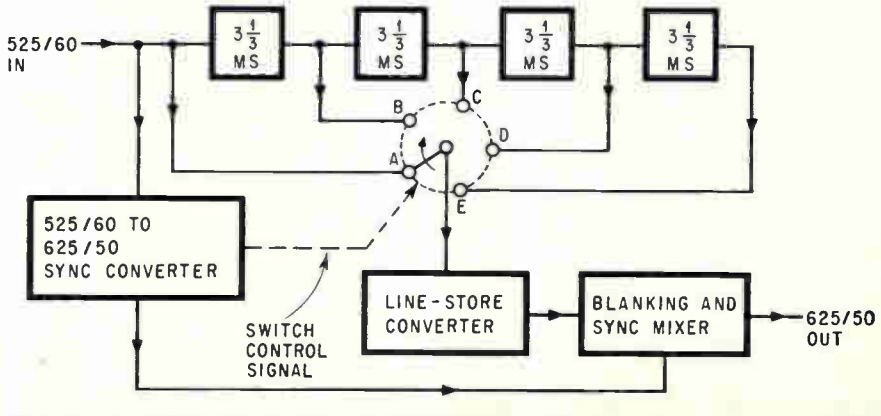
West Germany

Hue and cry

It was a premiere worthy of Hollywood in its heyday. The West German post office and broadcasting networks spent $25 million getting ready for the occasion. And when, after weeks of ballyhoo, the great day arrived, droves of stage and screen stars shared the spotlights with government officials.

But the glitter and the fanfare that marked the start of color television in West Germany late last month did little to allay the worries of set producers. Their concern is the price war that began early this summer. Gone are the producers' plans to hold set prices at fairly high levels at the outset and then trim them gradually as the market grew. Gone, too, are retailers' hopes of high profit margins on color receivers.

Snowball. The first shot in the price war was fired in June, when Neckermann Versand KGaA, the



Slight delay. Five-position switch and four delay lines in cascade are key to BBC's television-standard converter.

country's largest mail-order house shattered the industry's $600 minimum price level by offering 25-inch color sets for $460 [Electronics, July 10, p. 189]. Since then, all the major set makers, plus retailers, discount houses, and even the federal cartel office have been drawn into the fray.

The set makers first countered by dropping their retail prices by about $50. But when the retailers' association balked, the set makers restored part of the cut, settling on a level of about $575. But discounters and big department stores broke the new price barrier, selling 25-inch sets for just under $500.

The industry reacted fast to this second assault on its price line. Three producers—Siemens AG, the General Electric Co.'s Kuba-Imperial subsidiary, and Graetz KG, an affiliate of the International Telephone & Telegraph Corp.—took the problem to the federal government's cartel office, the agency that oversees marketing practices. The department stores fell back into line, but the discounters claimed the sets they were selling weren't subject to price fixing. To sidestep price-fixing regulations, the discounters set up export-reimport deals so that their receivers would be legally classed as coming from Israel even though they had been made in Germany.

Plane spotter. Ring of monopole antenna elements picks up small aircraft's radio transmission and from it determines plane's bearing.

Falling out. After a flurry of charges and countercharges, the cartel office ruled that the producers had no case. As a result, the alliance of the producers seems about to collapse. Kuba, for example, is now giving its color-set retailers free rein on prices. Says a Kuba official, "We are not in the business to fight in courts all the time but to produce television sets."

Kuba's new stance could well trigger a chain reaction throughout the industry, with each producer going his own way. One likely result is a spate of smaller, lower-cost sets. Some producers are considering 22-inch models that would sell for $535 and 19-inch models with price tags in the neighborhood of $420. Kuba will soon put out an 11-inch portable priced below $375. Neckermann, presumably, will hold to its $460 price for the 25-inch set supplied to it by Koerting Radio Werke GmbH. When Neckermann started the price war, it planned to bounce its "introductory" price up to just under $500 after color-casts started in West Germany.

For all the woes it has caused set makers, the price war has helped get West Germany's infant color-receiver market off to a bounding start. Some 40,000 sets have been sold in the past two and a half months. Optimists predict 100,000 color-set sales by year end, and volume of between 200,000 and 250,000 in 1968.

Bargain beacon

By and large, the Sunday pilot is limited to flying on days when he can see where he's going, when he can use landmarks to determine where he is and how to return home. Not for him are the sophisticated navigational aids such as very high frequency omnidirectional range installations, localizer equipment, and instrument landing systems essential for commercial aircraft. Such aids require sophisticated electronic gear well beyond the means of small-plane owners. Moreover, the instruments would take up too much space in small aircraft and use too much power.

Now, West Germany's Rohde & Schwarz has developed a system that brings direction-finding into the cockpits of most small planes at no cost to their owners. From the signals broadcast by the two-way radio sets carried on small planes, the system's ground equipment determines bearings. When a pilot has lost his bearings, he calls the airport for a reading and the airport control tower radios it back to him. The operation takes about three seconds and the indication is accurate to within 1°.

The ground equipment, called NP8, sells for $11,250 and several small West German airports have it on order.

Circle. The antenna system consists of 16 vertically installed monopole elements arranged uniformly around a 10-foot diameter circle. Monopole elements are used because they cut out interference caused by the antenna supporting pole and other equipment that may be under the base of the antenna array. These monopole elements probably also account for an antenna pattern in which the so-called cone of silence (a region directly over the antenna of a transmitter, in which no signal is heard by the pilot), is greatly reduced. Because of these factors, selecting the site for an NP8 antenna is less critical than it is for conventional direction-finding equipment such as Adcock systems based on dipole antennas.

Merry-go-round. To pick up the signal broadcast by an aircraft radio, the individual monopole elements are electronically scanned in a clockwise direction by a 170-hertz signal fed to each element via diodes.

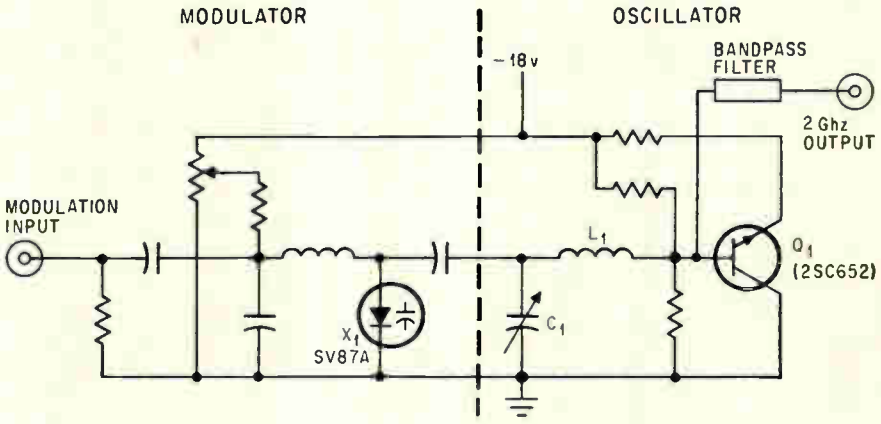
To stabilize the bearing indication, the phase differences obtained during 180 simulated rotations are averaged out in 1.05 seconds. For plus or minus 1 degree bearing determination, the carrier frequency has to be present at the antenna for at least 1.2 seconds.

Depending on altitude of the aircraft and transmitting power of its equipment, the range of the direction finder is between 30 and several hundred miles. Modular construction techniques allow separate

installation of the direction-finding transmitter and the indicator.

The system has a 1-megahertz bandwidth and operates in a 117.5- to 136.5-megahertz frequency range.

Hands-off. Once the operating frequency has been set, the system is fully automatic. Three digital indicator tubes indicate the true bearing and the direction is shown by one of 36 glow lamps arranged around the indicator field. A built-in loudspeaker permits monitoring the tuned-in airborne transmitter.



Do-it-yourself doubler. Nonlinear collector-to-base capacitance of transistor multiplies basic frequency to 2 Ghz in simplified oscillator for microwave repeater transmitter.

Japan

Self-booster

Long strong in high-capacity microwave links, the Nippon Electric Co. seems ready to make its mark with equipment designed for relatively few channels.

Last week, the concern shipped to Morocco $200,000 worth of hardware for a 60-channel, three-hop, 2-gigahertz system. Later this year, a 4-Ghz system will go to Mexico. And Nippon Electric has on its order books low-capacity, 6-Ghz links for Mexico and Brazil.

More than anything else, the combination of a low price and telephone-system reliability has brought this business to Nippon. Largely because of a simplified transmitter designed for baseband operation, Nippon's microwave repeater units cost considerably less —half in some cases—than comparable heterodyne types, according to the company.

Kingpin. The paramount component in the transmitter is a high-frequency transistor developed by Nippon for microwave use. The transistor (2SC652) has a maximum frequency of about 1.6 Ghz, but the circuit is arranged so that the nonlinear collector-to-base capacitance boosts the frequency to 2 Ghz at the output, eliminating the need for a varactor multiplier. A low-power varactor, (SV87A), however is used to frequency-modulate the self-multiplying transistor oscillator.

The circuit is essentially a variation on an old standby, the Colpitts oscillator. A series resonant circuit (L_1 and C_1) sets the oscillation frequency. The input signal is applied to the varactor (X_1)—in parallel with C_1—and its variation in capacitance modulates the oscillator. The transistor's emitter-to-base and base-to-collector capacitances take care of the voltage division needed for feedback.

Efficient. Input to the oscillator is normally 900 milliwatts and output at the fundamental frequency of the transistor is 400 mw, for a conversion efficiency of 44%. With the circuit tuned for 2-Ghz operation, the maximum oscillator output is 160 mw. Because the transmitter works in a baseband system with the modulation recovered at each repeater, the oscillator is set for optimum modulation characteristics rather than maximum power output. This slightly cuts the modulated power fed to the antenna to 100 mw for 2-Ghz operation, for example. For 4- and 6-Ghz systems, varactor doublers or triplers are added on to the basic 2-Ghz oscillator, lowering the power fed to the antenna even further.

Colorful. Repeaters using the simplified transmitter are intended mainly for telephone links. With 4-foot antenna dishes, the repeaters can be spaced at 30-mile intervals and still easily meet CCIR international standards for 120-channel operation. For 300-channel operation, the output power is a little low for 4-foot antennas and 30-mile spacing, but it suffices for larger antennas or shorter hops between repeaters.

Nippon says the modulation characteristic of the simplified transmitter is highly linear over a wide frequency band, good enough for one color-television channel. One potential customer, in fact, may buy the microwave system as a backup for a telephone-cable link and use the standby equipment for tv transmission.

Soviet Union

People's patents

There was a time when Soviet officialdom could turn up a "Comrade Inventor" for just about any important technological advance anyone cared to name.

But since the Soviet Union joined the Paris Union—the international patent agreement—two years ago, it's become clear that the Soviets are piling up a serious deficit in their "balance of patents." In a move aimed at wiping out the deficit, the all-powerful Soviet Council of Ministers last month put into force some sweeping revisions in the country's patent policy.

High on the list is a new patent service that will be run by the State Committee on Inventions and Discoveries. The committee also has been ordered to set up a special panel to oversee filing of patents abroad and selling licenses outside the Soviet bloc. All government agencies involved in research and development have been ordered to

send on to the committee detailed reports on inventions that look like candidates for licensing abroad.

Factories with strong design staffs, too, have been instructed to set up patent bureaus. And a network of patent libraries will cover the country starting next year. All will have access to a master file of patent information in Moscow.

Incentives. To spur patent production, the Soviet Council from now on will channel half the foreign currency earned from sales of licenses or patented machinery to the government of the republic where the invention originated. The research institute that developed the innovation, in turn, will get 30% of the republic's share.

Also from here on out, technological institutes will be judged partly on the number of licenses they sell. Other important criteria will be the number of patents received and the benefits to the economy from an institute's new machines or techniques.

Individual inventors, however, will reap the same rewards as before. Rather than file for patents, Soviet citizens apply for inventor certificates that name them as innovators but make the inventions the property of the state. Based on the invention's value to the national economy, an inventor can get a cash award as high as 20,000 rubles —$22,200 at the official, but inflated, exchange rate.

Although the revisions are primarily intended to foster Russian invention, they also figure to step up the inflow of technology from the West. One of the new regulations stipulates that before an agency assigns a development project to an institute it must "examine the technical and economic expediency of buying licenses for similar machines or processes."

Backsliders. On paper, at least, the Soviet Union has had a formidable patent organization ever since it joined the international patent union. Theoretically, 5,000 patent agencies are operating at plants, research institutes, and design offices. But two-thirds of them have never applied for a patent.

"Many design offices do not know the road to the Invention and Discovery Institute," complains Yuri Maksarev, chairman of the institute's governing committee. "To put up any longer with such a situation," he says, "would mean great losses for us both at home and in foreign markets."

The Netherlands

A first of sorts

News of yet another radio with integrated circuits no longer creates much excitement—as long as the set maker is American or Japanese.

But NV Philips' Gloeilampenfabrieken figures to cause a considerable stir with an upcoming pocketable portable that will be Europe's first IC-equipped production set. The Dutch company will market the radio this fall at a price of about $30.

Philips has packed much of the set's circuitry onto two IC's. One includes the entire intermediate-frequency strip—13 transistors, 13 resistors and a diode capacitor. The other, part of the audio circuit, has 3 transistors and 3 resistors.

Because the loudspeaker is by far the largest working component in the set, Philips has packaged the radio in a round case roughly 3 inches in diameter and 1 3/16 inches thick. The circuit elements, mounted around the perimeter of the back plate, are tucked around the loudspeaker's magnet when the plate is in place. The set operates off rechargeable cells instead of dry cells.

Australia

Out of step

The Australian electronics industry, which thought it was advancing toward a larger share of military orders, was told by its government this month that it's tripping over its own feet.

According to the Auditor-General's annual report, only 20% of a wide variety of electronic parts and components made locally during the year ending June 30 met Australian military specs. The report squelched the industry's hopes that the government was sympathetic to demands that more defense electronics be purchased Down Under [Electronics, Aug. 7, p. 180].

Handful. Philips portable boasts a pair of integrated circuits and snug packaging.

Who, us? Reaction was quick, angry, and mostly predictable. It ranged from refusals to comment —the usual thing in an industry known for its secrecy and suspicion of competitors—to a statement from Bert Leckie, managing director of Sonic Electronics of Melbourne, that "an increasingly higher proportion of qualification approval certificates is being issued." And M.H. Hicks, president of the National Electrical Manufacturers Association, called on the industry to share production statistics as a step towards higher standards.

In the most pessimistic reaction to the Auditor-General's report, one manufacturer maintained that the government leaked stories about the high rejection rate to support continued buying of components abroad.

Budget woes. The cloud has a silver lining—the fiscal 1968 budget message calls for a 9.5% increase in over-all expenditures, and

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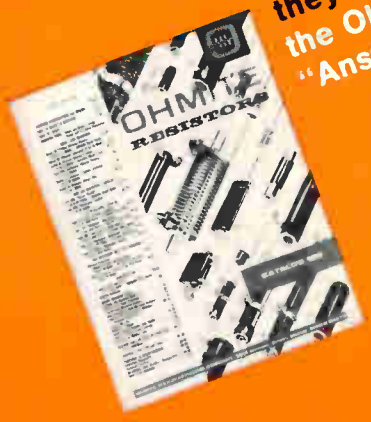

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Electronics Abroad

an 18% boost in defense outlays to $1.2 billion, a good part of which could go toward made-in-Australia electronics. But the budget would require an increase in postal rates, and the opposition party, joined by independents, is preparing to fight the measure. If the bill were defeated by the legislators, Prime Minister Henry E. Holt might dissolve the House of Representatives and schedule elections for November, delaying budget passage and possibly even resulting in sharply reduced defense expenditures.

Around the world

Pakistan. A satellite link between East and West Pakistan, separated by 1,000 miles of unfriendly Indian territory, now seems certain. The U.S. Import-Export Bank has agreed to loan the divided country $10 million to cover the cost of designing the system and building two ground stations. The Communications Satellite Corp. has received a letter of intent for the design and preparation of bid specifications. The Pakistanis hope to have the system operating by 1969, most likely using an Intelsat-3 satellite with ground stations.

Japan. Tokyo Shibaura Electric Co. has developed an electric auto with a cruising range of about 50 miles and a top speed of 62 miles an hour. The car is powered by a 27-horsepower, 20,000 rpm motor that has a six-thyristor bridge rather than the conventional segment-and-brush commutator.

Switzerland. The Federal Council has cleared the way for the start of color television in Switzerland by adopting Telefunken's phase-alternation-line (PAL) system as the country's standard. Broadcast officials plan to begin televising special events and color movies next year. First studio programs, however, won't be aired until 1970 or 1971. Sets equipped to pick up both Swiss colorcasts and the Secam transmission from neighboring France will be on the market by mid-1968.

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GATE LEAKAGE CURRENT: I_{GSS} = 10 pA max. @ 25°C T_A

DRAIN-TO-SOURCE "OFF" RESISTANCE: R_{DS} (off) = 2 X 10^8 ohms min.

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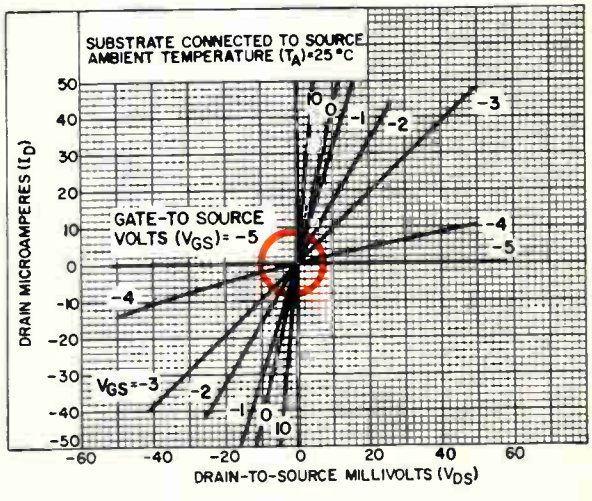

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Standard Coil Resistance	Nominal Operating Voltage	VOLTAGE ADJUSTED Maximum Pull-In Voltage at +25°C	Maximum Pull-In Voltage at +125°C	Drop-out Voltage Min.
70	6.0	3.0	3.9	0.3
280	12.0	6.0	7.8	0.6
1500	26.5	14.0	18.0	1.4

Coil characteristics applicable at +25°C unless otherwise specified.

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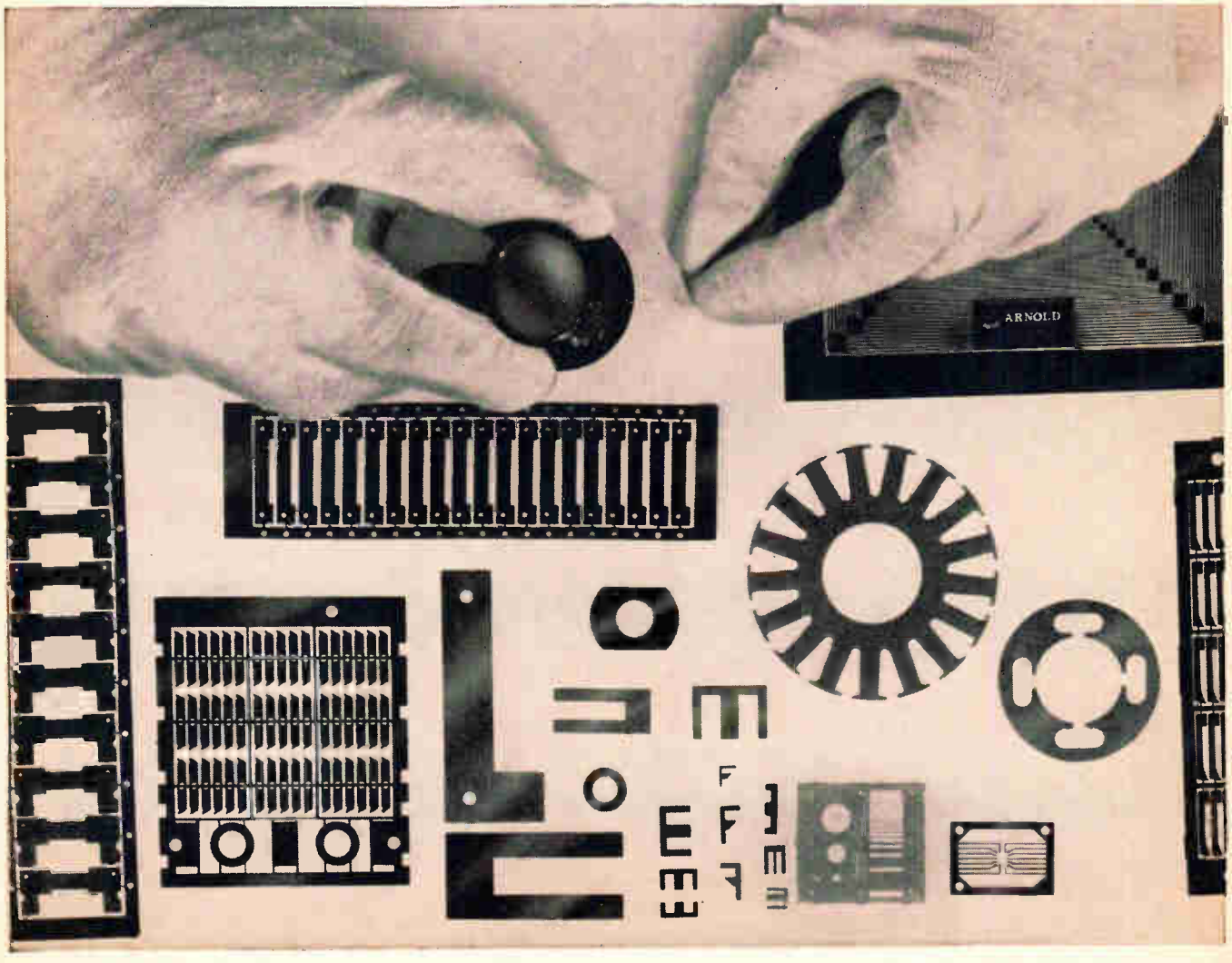

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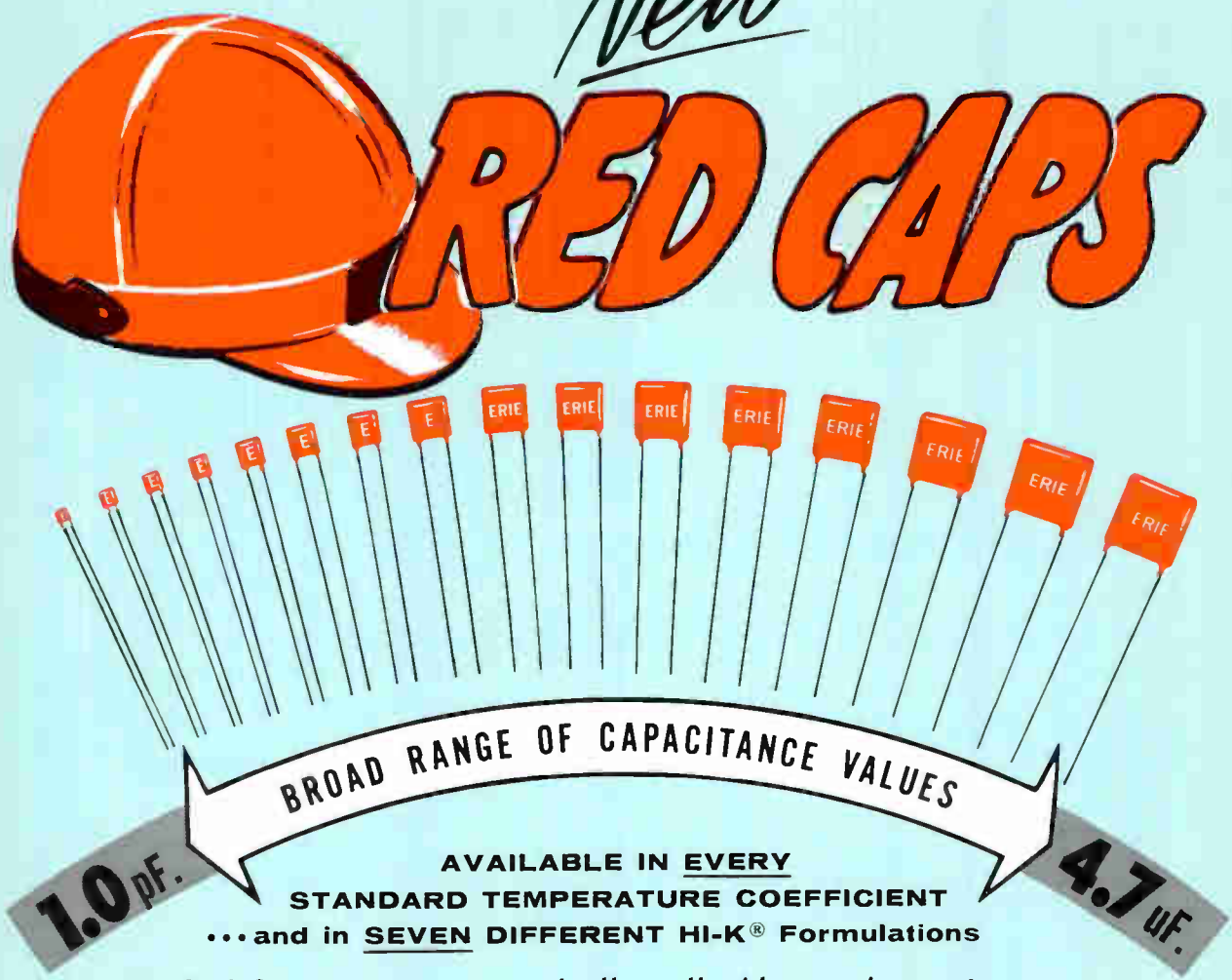

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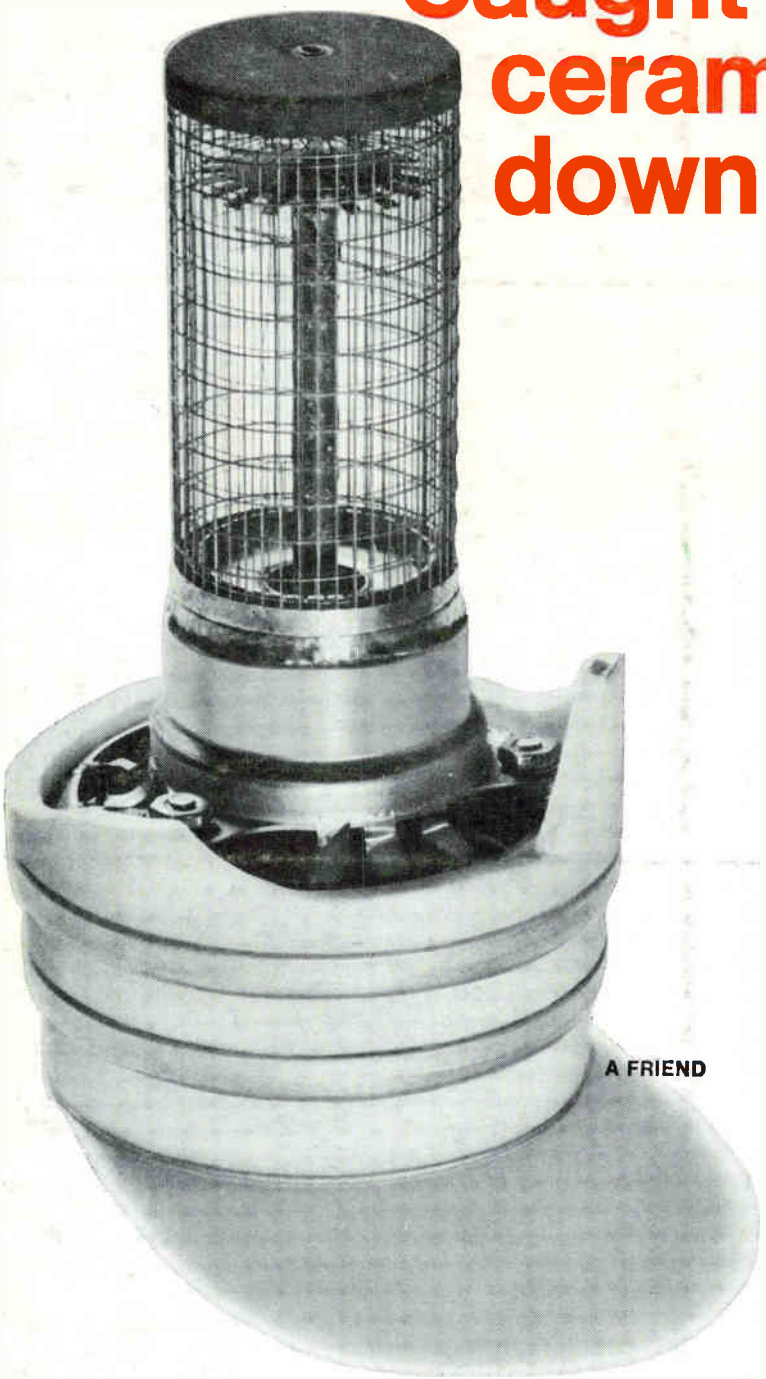

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For more information on this and other RCA Cermolox® tubes, see your RCA Representative. For technical data on specific tube types, write: RCA Commercial Engineering, Section I-19 Q-3, Harrison, N. J.

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