Sonic technique for nonvolatile memory 90
Design failures made easy 112
Active filters with nonlinear elements 116

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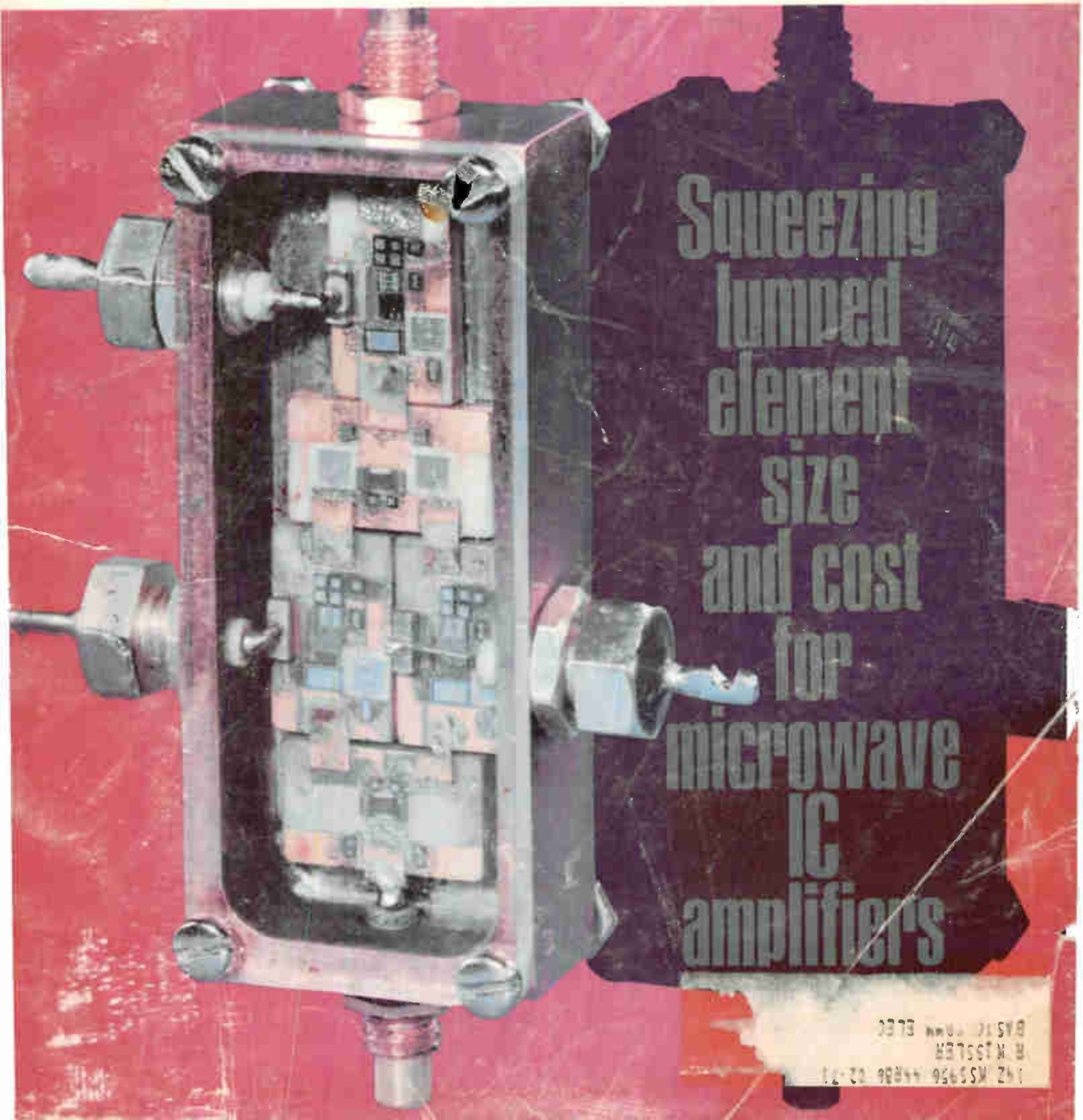
April 14, 1969

Electronics®



New random-noise generator with flat output from 20 Hz to 20 MHz

Wide frequency range, calibrated output, and carefully specified Gaussian amplitude distribution are the key features that distinguish this new random-noise generator from others available. The 1383 generates white noise of uniform spectrum level out to 20 MHz, particularly useful for tests in video- and radio-frequency systems. It is also an ideal broad-band, high-level noise source for use in amplifier testing, noise measurements, tests of signal-detection schemes, distortion measurements, and signal modulation to produce noise sidebands at higher frequencies. The 1383 contains a temperature-limited thermionic diode as a noise source, semiconductor amplifiers, an output meter, an 80-dB attenuator, and power supply, all enclosed in a convenient cabinet for bench use or rack mounting.

Frequency Range. The spectrum is flat (constant energy per hertz of bandwidth) ±1 dB from 20 Hz to 10 MHz, ±1.5 dB from 10 to 20 MHz.

Calibrated Output. The maximum output is one volt, open circuit, from a 50-ohm source impedance.

Carefully Specified Gaussian Distribution. The noise source provides symmetrical Gaussian amplitude distribution, specified to ±3 σ as measured with a "window" of 0.2 σ.

Price: Bench model, $775; rack model, $795.

Prices apply only in the USA. All GR products are subject to a quantity discount ranging from 3% for 2-4 units to 20% for 100 units. For complete information, write General Radio Company, W. Concord, Massachusetts 01781; telephone (617) 369-4400. In Europe: Postfach 124, Ch 8034 Zurich 34, Switzerland.

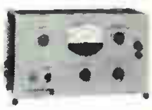
Other true random-noise generators:

1381
- 2 Hz to 2, 5, or 50 kHz
- Gaussian distribution
- adjustable clipping
- 3 V rms output

Price $375, bench model
$398, rack model

1382
- 20 Hz to 50 kHz
- white, pink, or USASI spectra
- Gaussian distribution
- 3-V rms output, balanced, unbalanced, or floating

Price: $375, bench model
$398, rack model

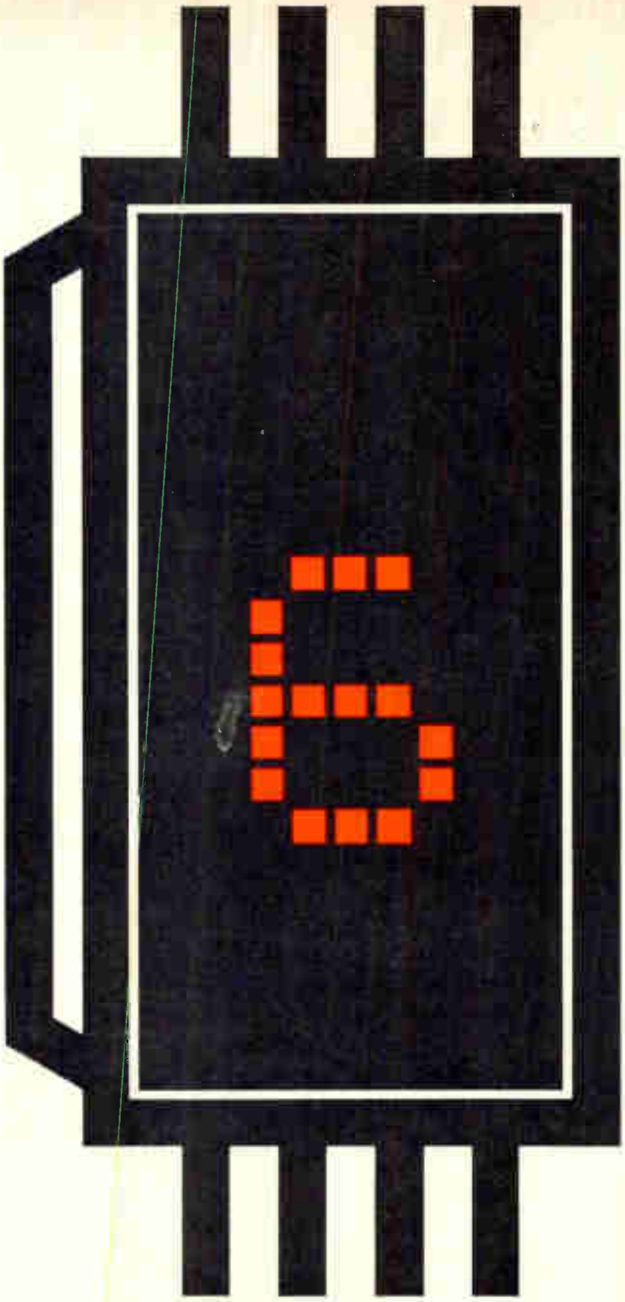


1390-B
- 5 Hz to 5 MHz
- 30-μV to 3-V output
- ±1-dB audio-spectrum-level uniformity
- white spectra, and pink (with filter)

Price $375; $50 for pink-noise filter

GENERAL RADIO

Circle 900 on reader service card



Surprise package
(1" x ½" x 1⁄10")

It's a completely new way to display digital information. The Hewlett-Packard solid state numeric display packs everything in one, small unit only 1"x 0.5"x 0.16". Gallium arsenide phosphide diodes and an IC driver/decoder chip deliver bright red numerals—bigger than life, visible for yards.

This new "total package" also gives you the edge on cost. You don't have to buy driver elements, or anything else. No special interfacing is needed. Only four line 8-4-2-1 BCD input and less than five volts to drive it. The modules are available in three-character packages, too.

The Hewlett-Packard solid state numeric display is ideal for instruments requiring smaller, tighter display panels. Or any application demanding either low power or resistance to shock and vibration, without catastrophic failures.

Get more information about the new technology for numeric indicators. Call your local HP field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

SOLID STATE DEVICES

01902

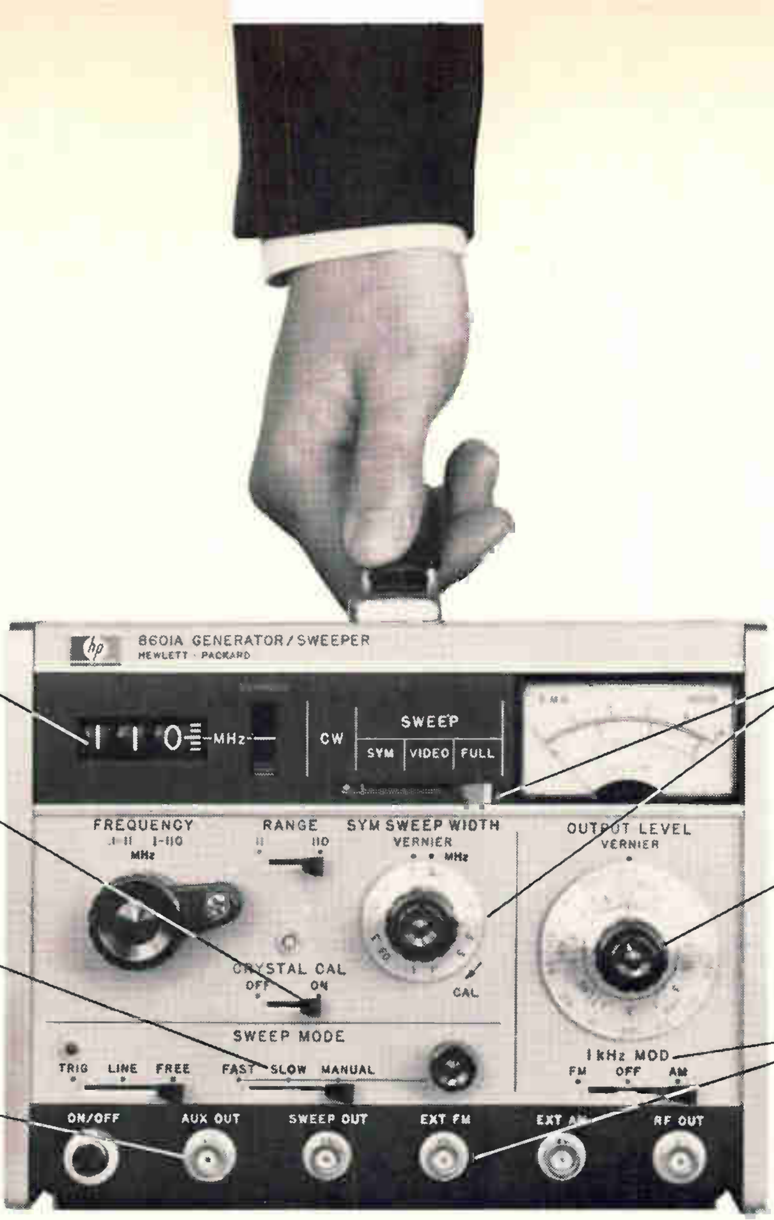
Circle 1 on reader service card

Digital frequency dialing accurate to 1% of frequency.

0.01% calibration check at 5 MHz intervals.

Sweep speeds and triggering versatility for all applications.

Monitor frequency to 110 MHz with low-cost 10 MHz counter—HP 5321.



3 sweep functions, each with 0.5% linearity. Go from broad to narrow sweep with the flick of a switch.

±1 dB output accuracy from 10 dBm to −110 dBm; flatness is ±0.25 dB from 0.1 to 110 MHz.

Modulation: AM or FM, internal or external. (Internal: 30% AM and 75 kHz deviation FM.)

This 110 MHz sweeper is so accurate you can forget about markers

...and it doubles as a signal generator

Covering 100 kHz to 110 MHz, this all-solid-state 21 lb. instrument is a natural for both lab and production use. Price is $1975. Call your HP field engineer for complete details on the 8601A Generator/Sweeper. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

Circle 2 on reader service card

HEWLETT hp PACKARD

SWEEP SIGNAL GENERATORS

04903

Electronics

Volume No. 42 Number 8 April 14, 1969

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U.S. Reports

Electronics International

New Products

Technical Articles

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Readers Comment

Domestication

To the Editor:

In your international edition, you published a story on a new Telefunken optical mask aligner (with optics from Carl Zeiss) for projecting precise patterns on silicon wafers [Feb. 17, p. 13E].

The article describes a second-generation machine that offers a 1:1 reproduction ratio and also provides faster exposure times than the first-generation machine. Of the earlier machines, 90% were sold in the U.S., and I feel you would do your U.S. readers a favor by telling them about this new mask aligner.

Bernd K. Knoerr
AEG-Telefunken
Schenectady, N.Y.

▪ Readers who want to know more about the machine can write to *Electronics* for a free reprint of the article. Kulicke & Soffa, Fort Washington, Pa., is the U.S. sales agent.

One spelling lesson

To the Editor:

As a manufacturer's rep for the Semtech Corp., I was not too flattered to see the company listed with other suppliers of voltage triplers as "Sempeck" [Jan. 6, p. 137].

Jack E. Sweet
Scott Electronics
Fort Wayne, Ind.

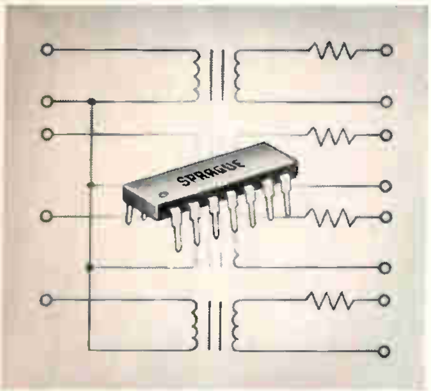
. . . and another

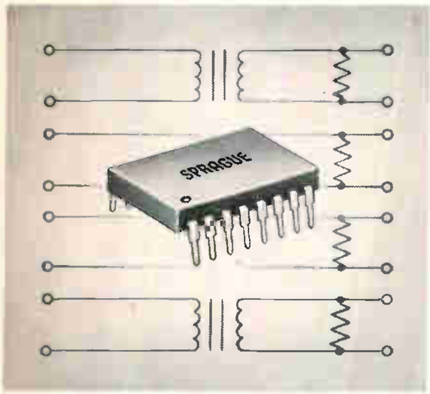
To the Editor:

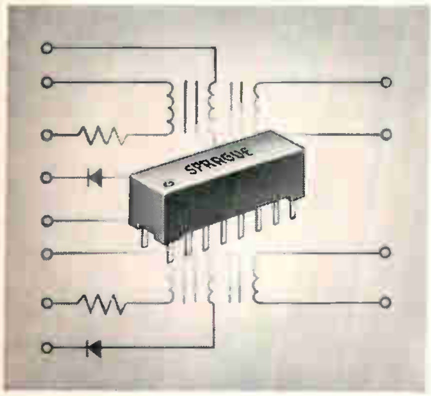
Regarding your story "Phased-array statellite antenna pops up when orbit is reached" [Feb. 17, p. 53], the correct spelling of Radiation Inc.'s dish antenna feed system is "dielguide"—a contraction of "dielectric waveguide"—and not "Dialguide."

Also, the maximum efficiency of such a system approaches 80% for main reflector diameters in the vicinity of 200 wavelengths. Effi-

MODULINE® Memory-drive Hybrid Circuit Modules combine miniaturized inductive elements with thick-film ceramic-based technology.







You get pulse transformers and resistors (diodes and capacitors can also be included) in a circuit tailored to your specifications.

A single module may contain up to four identical circuits. They're particularly useful in memory systems where a similar repetitive pattern exists.

Flexibility offered by modular concept simplifies specific designs.

3 package styles: standard dual in-line, jumbo dual in-line, molded case with pin leads. They're all compatible with conventional in-line circuit layout.

High component density permits substantial size and cost reduction.

For complete technical data, write for Engineering Bulletin 22210 to: Technical Literature Service, Sprague Electric Co., 35 Marshall St., North Adams, Mass. 01247.

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ciencies greater than 75% have been achieved on at least one production system. The 70% figure you give is for a reflector diameter of about 20 wavelengths, which is, admittedly, more in line with satellite design.

R.J. Fratello
Sperry Gyroscope Division
Sperry Rand Corp.
Great Neck, N.Y.

. . . and yet another

To the Editor:

Please note that in your coverage of our tunable transmission reference cavity [Feb. 3, p. 157], the text loses much of its significance because the word "setability" is rendered as "stability." Also note that the stability is called out earlier in that sentence as being ±250 Ghz over the temperature range from −15° to +65°C. The significant part of the specification is that frequency can be set with great accuracy.

George E. Tirone
Frequency Engineering Laboratories
Farmingdale, N.J.

Color mixup

To the Editor:

I want to call your attention to some technical discrepancies in your article "Logic circuits improve tv color mix" [Feb. 17, p. 169].

One can almost overlook your placement of the article in the new subassemblies section instead of under new instruments; or your headline, in view of the fact that the logic circuits' primary advantage is the pattern stability they provide, not their control over color mix; or your misplaced emphasis on tv production applications when the instrument was designed for color tv servicing. But the statement "use of logic circuitry to improve reproduction of the National Television System Committee color standards" cannot remain unchallenged.

The Heath IG-28 color-bar and dot generator produces the service standard offset carrier rainbow display, not the NTSC color television standards.

Also, it's understandable that the block diagram of the instrument required reduction for convenient publication, but errors occurred in the process. The most harmful of these was your designation of the 3.56-Mhz oscillator as a 3.58-Mhz unit. This error lends credence to the earlier NTSC misstatement. Further, the IG-28 produces 12 patterns, not 13, and only the dot, cross-hatch, and gray-scale patterns can be operated in nine-by-nine and three-by-three modes. The color-bar vertical lines and horizontal lines, on the other hand, are either nine or three.

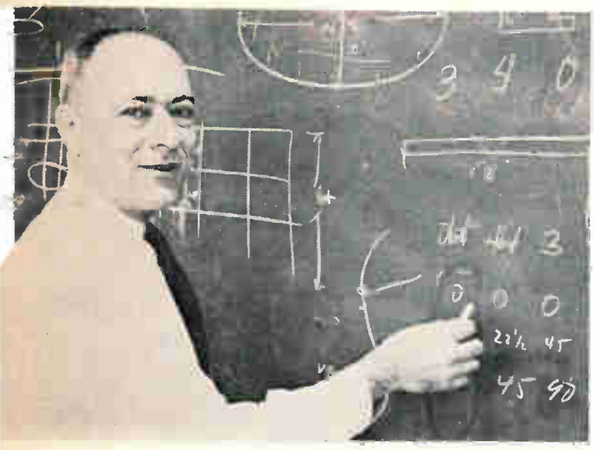
E.C. Fiebich
Heath Co.
Benton Harbor, Mich.

Who's Who in this issue

Caulton Poole

Physicist Martin Caulton, coauthor of the cover story on lumped elements that starts on page 100, has both academic and practical credentials. The holder of a doctorate from Rensselaer Polytechnic Institute, he was a 1954-55 Fulbright scholar at the Imperial College of Science and Technology in London. Following his return to the U.S. he was a member of the technical staff at Bell Labs, researching low-noise microwave tubes. Caulton left Bell to become assistant professor of physics at Union College in 1958. Two years later he joined RCA Labs where he's been doing extensive research in the microwave field. Caulton has not, however, turned his back on the educational world; he's written a textbook on physical electronics, and is adjunct professor of electrical engineering at Drexel Institute.

Caulton's collaborator on the cover article, Walter E. Poole, has also moved in two worlds. Before signing on with RCA, he was for two years an instructor in the physics department at Drexel, where in 1964 he had earned his bachelor's degree. At RCA, Poole has been responsible for the design and fabrication of various uhf and microwave integrated amplifiers, as well as thin-film passive elements for different applications.



Slate

Experience, bitter and otherwise, may well be the key to Matthew W. Slate's grasp of how to facilitate design failures—a subject he discusses with wryness and relish in the article beginning on page 112. Recently named manager of electronics development at Sedco Systems, he has held responsible executive posts at such firms as Blass Antenna, Loral, Maxson, Dumont Labs, and Hazeltine. Slate earned a bachelor's degree (cum laude) from the City College of New York and a master's at Columbia.

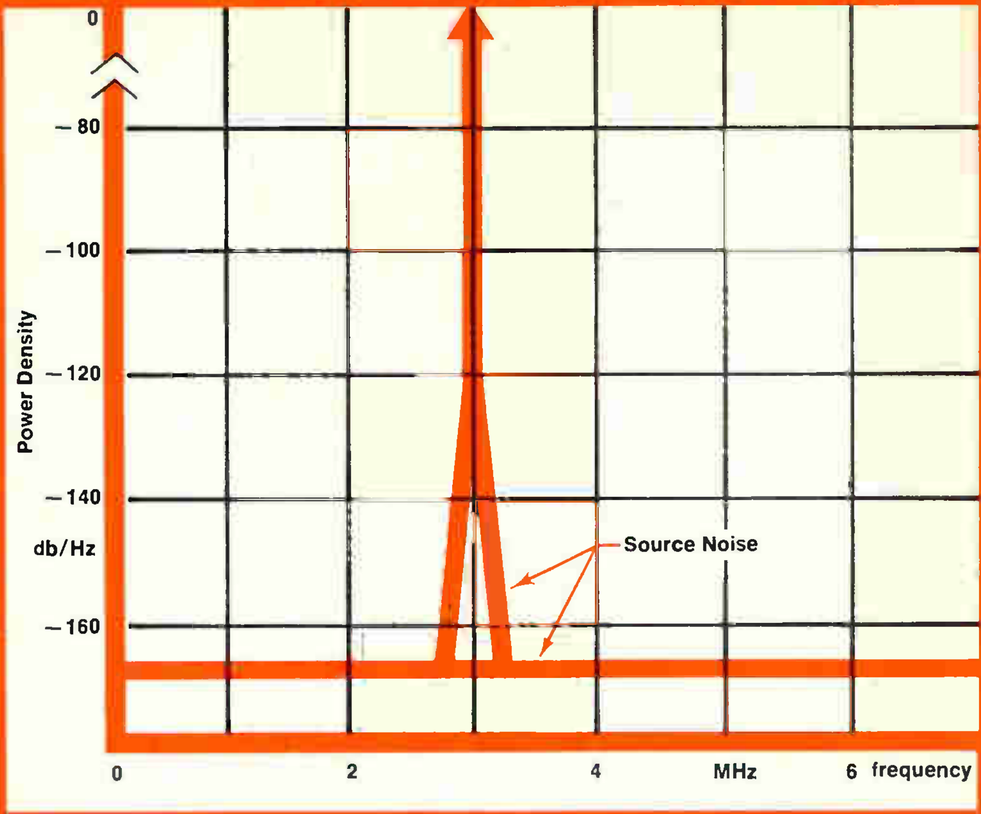
Marsocci

Cairo-born Rabah Shahbender, author of the article on sonic film memories on page 90, began his career doing seismic exploration in Middle-East oil fields. He later switched to electrical engineering and earned a Ph.D. at Illinois in 1951. Following a stint at Honeywell, he joined RCA in 1955.

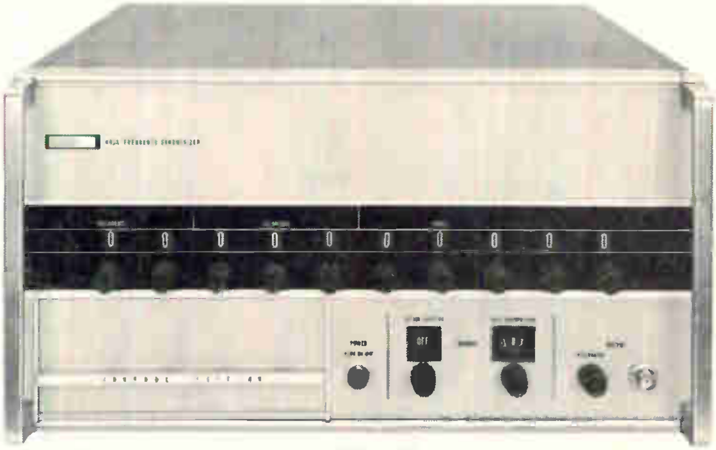
Dividing his time between a classroom and a research lab at New York State University's Stony Brook campus, Velio A. Marsocci somehow finds time to write articles like the rundown on nonlinear elements in active filters beginning on page 116. Marsocci holds a doctorate from New York University.

Shahbender

Here's the RF spectrum of an "ideal" synthesizer



and the closest thing to it!



The new Fluke 645A!

The Fluke 645A features symmetrical search oscillator and built-in sweep-marker generator for filter and resonator testing. Automatic remote output leveling for systems applications. Twenty microsecond switching from remote decimal, or BCD program source. Modular design simplifies special configurations to meet your particular needs.

Key Specifications

FREQUENCY: DC to 50 MHz
INCREMENTS: 0.01 Hz
SPURIOUS CONTENT: <100 db
HARMONIC CONTENT: <30 db
NOISE FLOOR: <135 db/Hz at 5 KHz
CLOSE-IN NOISE: <100 db/Hz at 10 Hz offset
PRICE: $13,500.

Fluke, Box 7428, Seattle, Washington 98133. Phone: (206) 774-2211, TWX: 910-449-2850. In Europe, address Fluke Nederland (N.V.), P.O. Box 5053, Tilburg, Holland. Phone: (04250) 70130. Telex: 884-50237. In the U.K., address Fluke International Corp., Garnett Close, Watford, WD2 4TT. Phone: Watford, 27769. Telex: 934583.

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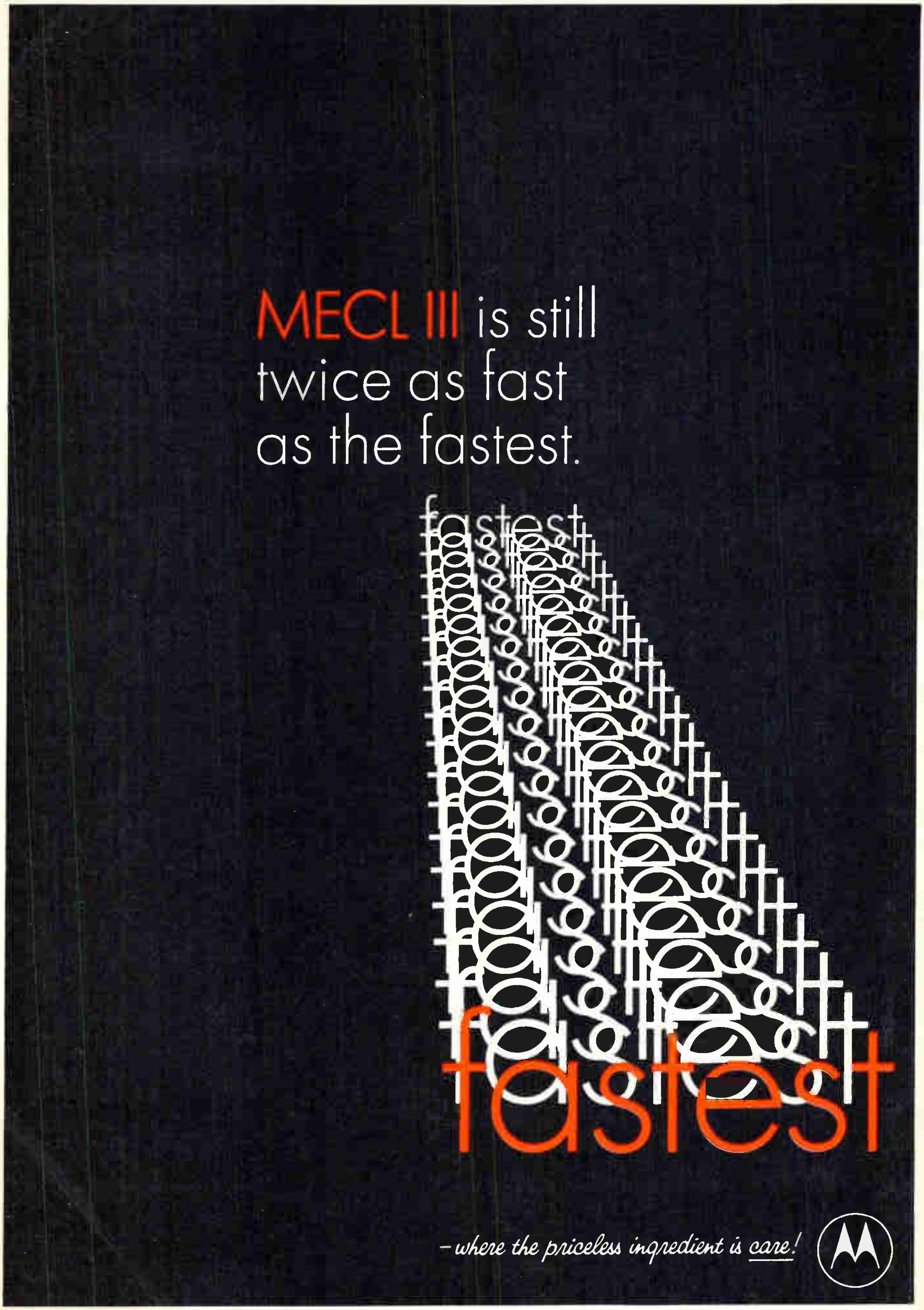
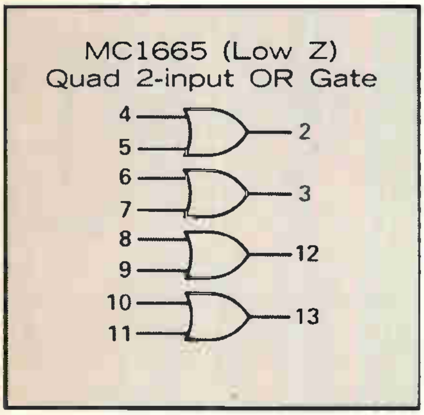
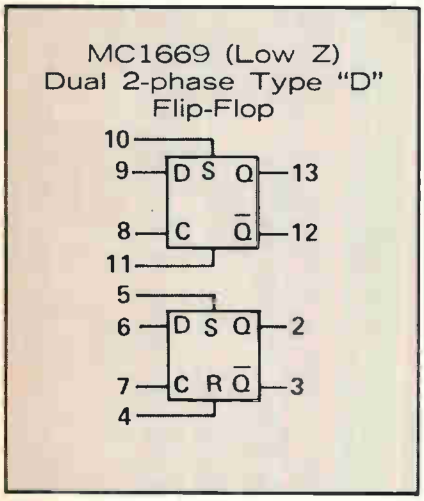
Circle 9 on reader service card


MECL III is still
twice as fast
as the fastest.
fastest
– where the priceless ingredient is care!

Now, 12 MECL III circuits are available in production quantities

350 MHz Flip-Flops head list of devices in three systems-oriented MECL families





Your counter or logic system is still only half as fast at is could be — if you're not using MECL III — the World's fastest, most advanced form of integrated circuit. Now you have nine new functions including one-nanosecond gates and a variety of flip-flops with toggle/shift frequencies of 350 MHz — with either high or low impedance inputs. And, they're all available in production quantities, with still many other types in the development stages. Here are the 9 new types:

- MC1661S (Low Z) Dual 4-input OR/NOR Gate
- MC1663S (Low Z) Quad 2-input NOR Gate
- MC1664S (High Z) Quad 2-input OR Gate
- MC1665S (Low Z) Quad 2-input OR Gate
- MC1666S (High Z) Dual, 2-phase R-S Flip-Flop
- MC1667S (Low Z) Dual, 2-phase R-S Flip-Flop
- MC1668S (High Z) Dual, 2-phase, Type "D" Flip-Flop
- MC1669S (Low Z) Dual, 2-phase, Type "D" Flip-Flop
- MC1671S (Low Z) Dual, Single-phase, Type "D" Flip-Flop

A new "Advance Information" brochure is now available to assist you with your MECL III designs. Send for it.

Circle 508 on reader service card

Compatible MECL II . . . still faster than saturated logic!

You may not need or want quite as much speed for other sections of your digital system. So, there's a MECL series that offers 4 nS propagation delay and approximately 100 MHz toggle/shift frequencies. That's MECL II. And, now there are more than 65 devices in this unique series, counting the four new ones below:

- MC1028L Dual 4 nS, 4-Channel Data Selector. (The first low-cost multi-layer metal circuit that is commercially-available.)
- MC1039L Quad Level Translator.
- MC1040L Quad Latch.
- MC1043L 3-Bit Binary to One-Of-Eight Line Decoder.

Circle 509 on reader service card

Watch for the introduction of these additional 2 nS MECL II Circuits!

- MC1062 Quad 2-Input NOR Gate
- MC1064 Quad 2-Input OR Gate
- MC1061 Quad Twisted Pair Line Receiver.
- MC1063 Quad Twisted Pair Line Driver. (OR/NOR outputs)
- MC1066 Triple 2-Input Gate With OR/NOR outputs.

All MECL III types (MC1600 series) are currently available from distributor stock in the 14-pin flat pack with stud (for heat sinking).

The MECL II types (MC1000 series) are in the 14 and 16 pin dual in-line ceramic packages. For complete specification data and applications information, circle the reader service number or write to the address below.

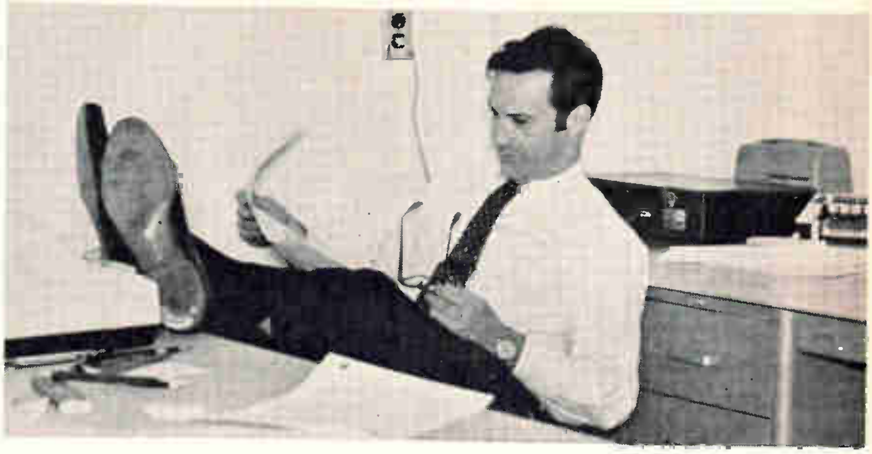
Circle 510 on reader service card

MOTOROLA Integrated Circuits

Motorola Semiconductor Products Inc./P. O. Box 20912/Phoenix, Arizona 85036

Codex introduces a modem that transmits 9600 bps over one voice grade line!

Who's Who in electronics


Kass

A continental commuter, Hal Kass has been making regular trips between Hillside, N.J., and Sydney, Australia—not to watch tennis matches but, rather, to get to the post office. As newly appointed manager for automated postal systems at the Plessey Airborne Corp., at Hillside, Kass has been studying the operation of the Redsern Mail Exchange, Sydney's completely automated post office.

Although postal automation is a new line for Plessey Airborne, a subsidiary of Britain's Plessey Co., it shouldn't be surprising; the Redsern installation was built by Plessey's Australian subsidiary.

Import. Plessey Airborne, which before its acquisition last year was known as the Airborne Accessories Corp., initially intends to import from Australia and sell the Plessey Letter Mail Sorting System. In operation, says Kass, the system automatically sorts each piece of mail according to a destination number encoded on the back of the envelope. The number is determined when clerks, sitting at remote consoles, interrogate a computer for the destination code. The code is then printed in a special ink on the back of the envelope. Once the letter or package is encoded, the system, via a series of conveyors, sends the material to the appropriate carrier.

Although competition for postal automation contracts in the U.S. becomes stiffer as more and more firms enter the field, Kass is confident that Plessey Airborne is assured of success because it already has a proven product. In fact, Kass hints, several contracts already are being negotiated.

Another sign of Plessey Airborne's confidence is a new manufacturing facility recently opened in Hillside to eventually produce the letter-sorting systems.

Kass, who came to Plessey Airborne from the Intertype Co., where he was involved with automated typesetting equipment, feels another advantage to the Plessey system is that it's modular in design. Thus it can accommodate even the largest mail volumes simply with the addition of more modules.

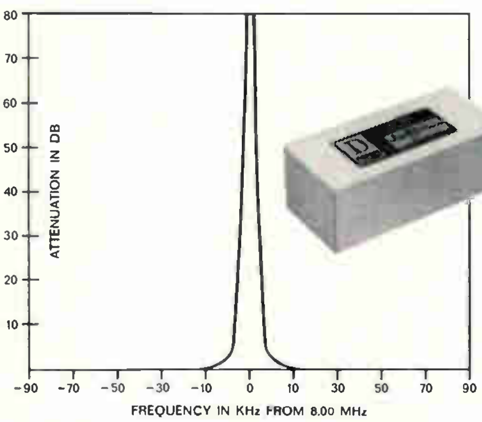
Everyone who's been in the Army can recall at least one supply or administrative snafu, whether it was getting tomatoes when tent pegs were ordered or finally receiving tires after five tries only to discover they were the wrong size. The Army has long been conscious of the problem, but it wasn't until the recent refinement of automated data processing that it felt it could do anything about it.

Now the service has created a Computer Systems Command to oversee the design and development of systems for its various administrative and support operations. Commanding is Brig. Gen. Wilson R. Reed, formerly in charge of the Automatic Data Field Systems Command, which forms the nucleus of his new command.

"We're basically a management information shop," says the veteran

winning form

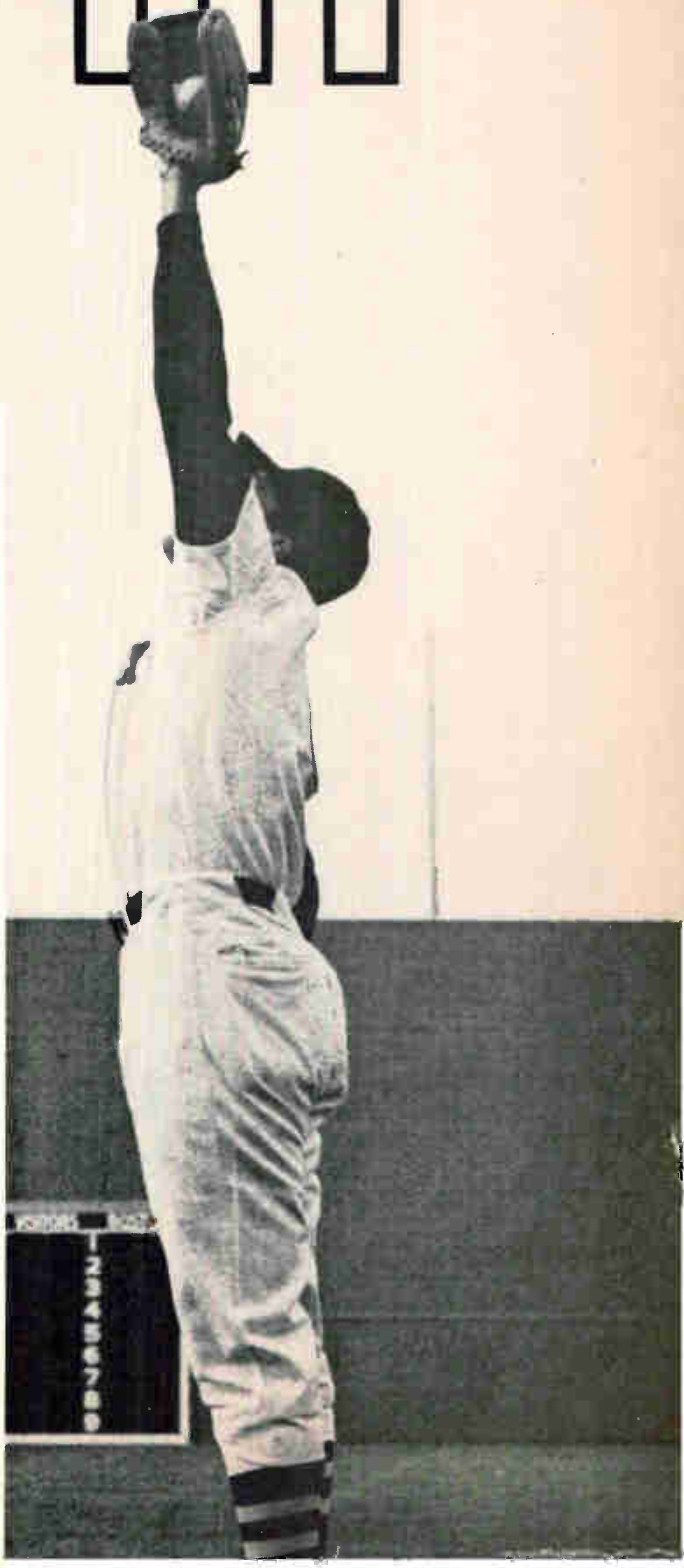
from the form-factor specialists at Damon



When your system calls for an ultra-sharp attenuation "spike" . . . specify a **Damon Model 6108A Band-Reject Crystal Filter.** Operating from a known source into a low-noise amplifier, the Damon Model 6108A filter rejects local oscillator and related feed-through — but preserves the system noise figure. With unwanted signals rejected before amplification, it also improves the system's dynamic range and reduces intermodulation from vibration and shock.

The Model 6108A has a center frequency of 8.00 MHz. Attenuation: not less than 75 db ±240 Hz from f_R, and 11 db ±4 db at −3 kHz and +3 kHz from f_R. Operates over −40°C to +85°C range with vacuum tube, transistor, or MOSFET amplifiers.

Whatever your signal-shaping need — from a narrow band-reject "spike" to a broad band-pass — you can rely on the form-factor specialists at Damon. Write: Electronics Division, Damon Engineering, Inc., 115 Fourth Avenue, Needham, Mass. 02194, or call (617) 449-0800.



DAMON

Circle 15 on reader service card

Who's Who in electronics

of 32 years' service. "We'll be managing contracts and guiding contractors right away. We hope to be able someday to develop programs in-house, but it's a long way off."

Under way is a program to develop unified data processing systems for the 40-odd Army posts in the U.S. Up to now, Reed explains, there's been little uniformity in the way these posts have been run. Under the new program, such administrative functions as finance, personnel, and supply have been broken into "packages" and developed separately for data processing. Half of the 10 packages planned are now ready to go, Reed says.

What this program means is that the Army will be able to cross-check its inventories and spot irregularities. It may discover that one stateside tank batallion is using more sparkplugs than another, and may trace the discrepancy to a local maintenance regulation requiring changes every four months.

Progress. And, says Reed, "Whereas before you may have ordered five times to get Jeep tires, you do that with the new system and you'll get five sets of tires."

Other projects under his command include Tacfire (an automated artillery information system made by Litton), the tactical operations system, an intelligence collator, and the combat service support system (a transportable bookkeeping system undergoing extensive tests at Fort Hood, Texas.)

Besides the post-level systems, the new command will take over an experimental system for field armies called centralization of Supply Management Operations (Cosmos) and now being tested at the Sixth Army headquarters at the Presidio in San Francisco. One future problem will be to interface the Army-level and post systems, Reed notes.

Reed stresses that even though the systems at Fort Hood and the Presidio are developmental, they can't be taken out when the trials are over. For one thing, commanders get used to them. "As one general told me the other day," Reed says, "'you can't take it out. If you do, I'm dead.'"

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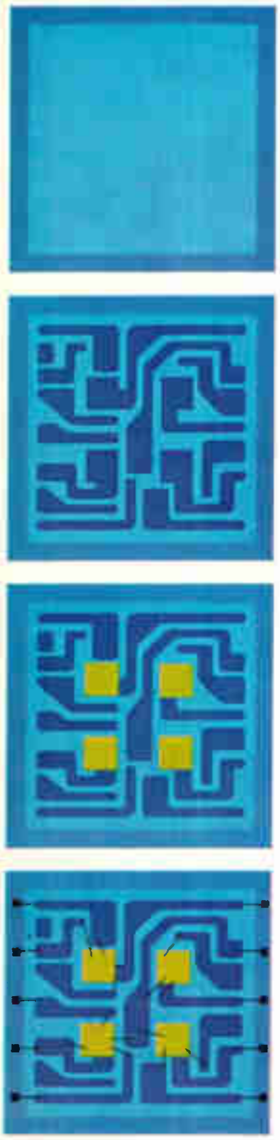

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Meetings

Diversity marks International Microwave Symposium

If quantity is any indication, this year's International Microwave Symposium should be almost twice as good as last year's. The 1969 edition will offer 83 technical papers in 12 sessions, against 49 papers in 1968. Topics will range from the emerging technology of microsound to the established disciplines of precision measurements and components. The meeting, to be held in Dallas, May 5 to 7, will present seven papers from overseas—including two from Russia—and two from Canada, plus several invited papers.

There will be two sessions on microwave integrated circuits, one covering multistage transistor amplifiers, digital phase shifters, low-noise microwave mixers, interdigitated strip-line quadrature hybrids, and wave propagation in microstrip; the other will concentrate on amplifiers and oscillators. Papers will describe a 200-watt uhf amplifier, parametric amplifiers with impatt-diode pumping, yig-tuned transistor oscillators with amplifier buffering, a hybrid integrated transistor amplifier for high-volume production, and a hybrid microwave integrated circuit telemetry transmitter and command receiver.

Sound of the waves. The session on microwave acoustics features two invited papers: Ernest Stern of MIT's Lincoln Laboratory, a pioneer in microsound technology, will review the state of the art, while B.A. Auld of Stanford University will give a tutorial paper on acoustic-wave analysis using microwave concepts. Other papers will touch on the more advanced aspects of this technology.

Millimeter-wave systems and components will be discussed at two sessions, one of which will feature an invited paper on planar ferrite devices by G.P. Rodrique of the Georgia Institute of Technology. Other subjects include yig filters, vhf and uhf junction circulators, a low-cost latching ferrite phaser fabrication technique, a thin-film lumped-element circulator, slot-line techniques, and coplanar waveguide for nonreciprocal gyromagnetic devices. And there'll be a paper from the Soviet Union on six-port phase-type circulators and switches.

The single session on solid state circuits and devices will take up the design of highly stable and efficient varactor multiplier chains, broadband frequency doublers using charge-storage diodes, and all-transistor, 1-kilowatt, high-gain uhf power amplifier, radar duplexers, and high-power pulse limited space charge accumulation gallium arsenide devices.

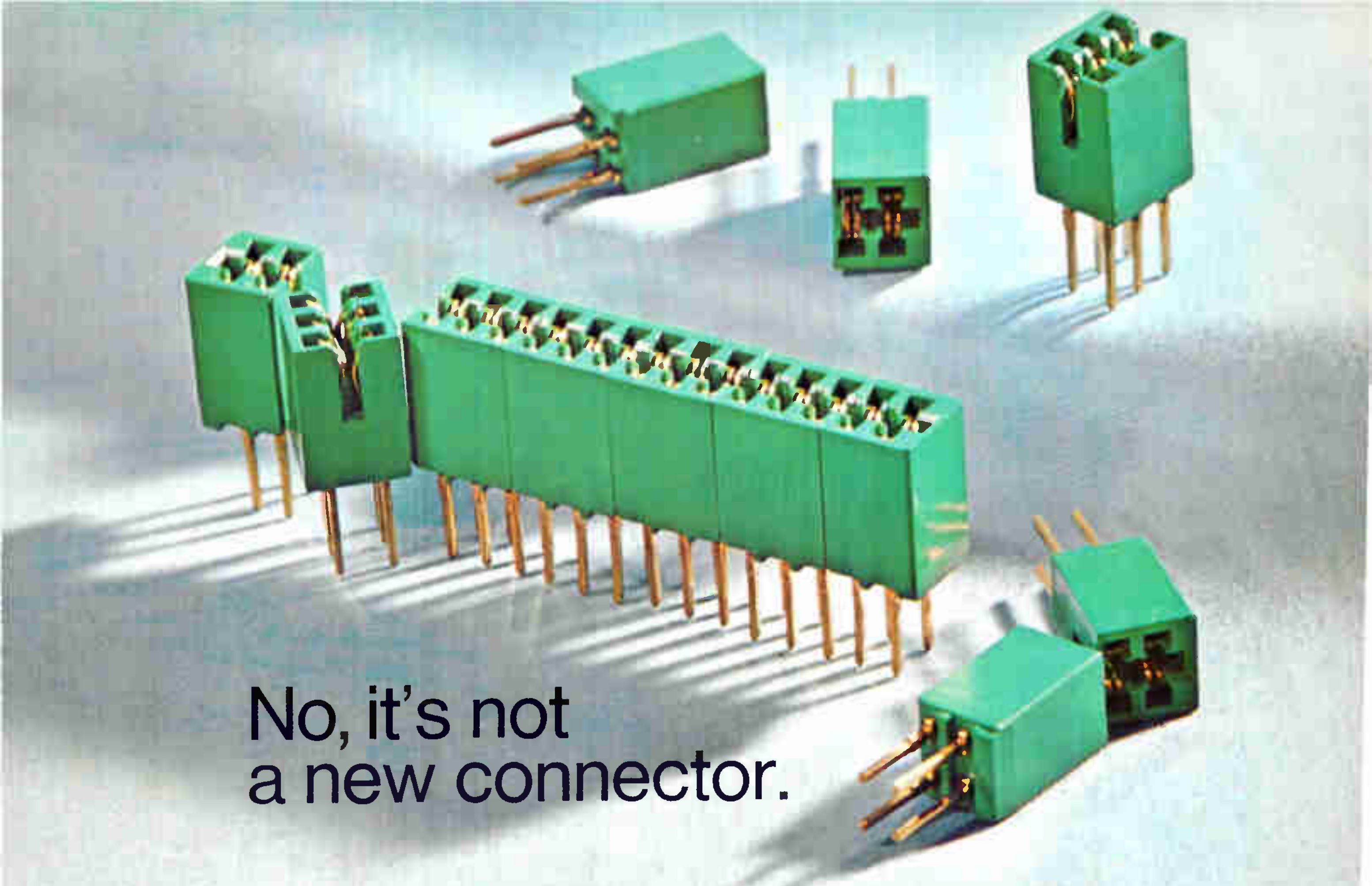
Confrontation. Concerning diodes, the symposium will give equal time to two opposing camps. One session will be devoted to Gunn-effect devices, another to avalanche types. Among the Gunners, L.F. Eastman of Cornell University will review the state of the art, a Japanese paper will be given on c-w Gunn diodes in composite structures, and a British paper will discuss the effect of temperature on LSA oscillations between 26 and 40 Ghz.

At the avalanche-diode session, Prof. Bernd Höfflinger of Cornell will describe his work on high-efficiency avalanche resonance pumped amplification, and researchers from Raytheon and Bell Labs will talk about a 1-watt c-w oscillator, or power amplifier, and circuits for high-efficiency oscillators.

A session on computer-oriented microwave techniques rounds out the agenda. In an invited paper, A. Wexler of the University of Manitoba will survey the new directions being taken in computer field analysis. Two other papers at that session will cover the application of computer-aided design to broadband low-noise microwave amplifiers and three-port waveguide junction circulators.

For further information contact J.B. Horton, Texas Instruments, P.O. Box 5012, Dallas, Texas 75222.

(Continued on p. 24)



No, it's not a new connector.

It's a new kind of connecting.

The little connectors above are really one connector. You take as many pieces as you need, mix them together, and use them to connect any size of p.c. board to a mother board.

That's not spectacularly new. Connector modules for use in bread-boarding have been around for a while.

But these new Mojo™ Series 6308 p.c. connector modules* are not just for bread-boards and prototypes.

Not hardly.

When used with plated-through holes on the mother board, they are one of the slickest production tricks to come along in quite a while. Contact tails combine a square wire-wrapping post with a specially designed locking feature which, when press-fitted into a plated-through hole, provides a gas-tight and reliable electrical connection.

No, you don't have to solder.

Yes, you can wire-wrap if you want.

And, yes, you'll save time and money in moving from prototype into production. Because connectors of virtually any size can be built up economically from just two sizes of modules, you don't need a large inventory. Or custom connectors. And you only have to insert modules where connectors are required, saving a few more pennies.

And, no, you don't give up a bit of connector reliability. The exclusive swaged single-beam design of the dual-readout contact provides optimum spring rate and deflection characteristics. A preload applied to the contact nose in the insulator makes sure that the contact really holds on to the card, while keeping the contacts well apart when the card is removed from the connector.

Mojo™ p.c. connector modules: Specs in brief

Material
- Glass-filled DAP

Contacts
- Cantilevered-beam, dual readout, bifurcated nose. .150″ centers. Center modules have 6 contacts. End modules have 4 contacts, molded-in card guide.

Tails
- .031″ square wire-wrapping type

Mounting
- Press fit, in .048″ dia. plated-through holes, 3/32″ to 1/8″ thick board.

For more information, write, wire, call, or TWX us for our Mojo™ p.c. connector module data sheet. Elco Corporation, 155 Commerce Drive, Fort Washington, Pa. 19034. (215) 646-7420; TWX 510-661-0.

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ELCO Mojo™ p.c. Connectors

* Patent pending

Meetings

(Continued from p. 22)

Calendar

International Geoscience Electronics Meeting, IEEE; Twin Bridges Marriott Hotel, Washington, **April 16-18.**

American Power Conference, Illinois Institute of Technology; Sherman House, Chicago, **April 22-24.**

Documentation and Debugging, Control Data Corp.; Sheraton-Silver Springs Hotel, Washington, D.C., **April 28-30.**

Aluminum Strip Conductor Symposium, Electrochemical Society; New York City, **May 4-9.**

Rocky Mountain Bioengineering Symposium, University of Wyoming; Laramie, **May 5-6.**

Electrical and Electronic Measurement and Test Instrument Conference, IEEE; Skyline Hotel, Ottawa, Ontario, **May 5-7.**

Instrumentation Symposium, Aerospace Industry Division of the Instrumentation Society of America; Frontier Hotel, Las Vegas, **May 5-7.**

Design Engineering Conference, American Society of Mechanical Engineers; Waldorf-Astoria Hotel, New York, **May 5-8.**

International Congress on Instrumentation in Aerospace Simulation Facilities, IEEE; Polytechnic Institute of Brooklyn, Farmingdale, N.Y., **May 5-8.**

International Microwave Symposium, IEEE; Marriott Motor Hotel, Dallas, **May 5-8.**

Digital Communications Symposium, IEEE; Los Angeles, **May 6.**

Conference on Power Thyristors and their Applications, IEEE; London, **May 6-8.**

Congress on Nuclear Electronics, IEEE; EURATOM Lab., Ispra, Italy, **May 6-8.**

Frequency Control Symposium, Electric Components Laboratory, Army Electronics Command, Shelburne Hotel, Atlantic City, N.J. **May 6-8.**

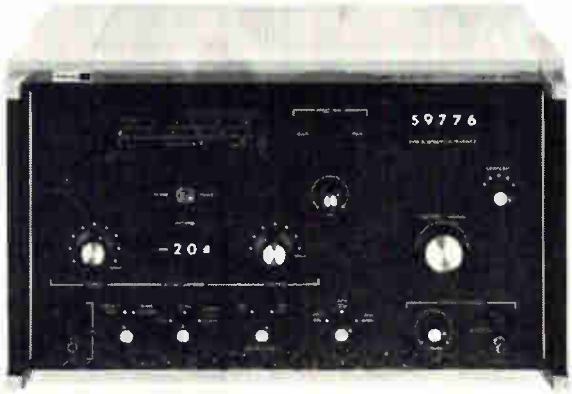
Pattern Recognition, Postal Department's Bureau of Research and Engineering and Systems Science and Cybernetics Group of the IEEE; Statler-Hilton Hotel, Washington, D.C., **May 6.**

Second National Conference, Association for Precision Graphics;

(Continued on p. 26)

This Sierra L-F wave analyzer costs $2,295.

(For about the same money, others can give you a fraction of its accuracy: ±1 Hz).



(...and about half its range of 20 Hz to 110 kHz)

Short of spending another $2,000, you cannot buy the accuracy of a Model 301B L-F Wave Analyzer. Nor its broad tunable coverage of the low-frequency spectrum. Nor its convenience and all-around usefulness.

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As a wide-range wave analyzer, Model 301B delivers precise data on individual components of complex signals. You can accurately measure fundamental frequencies, harmonic voltages, intermodulation products, and other noise and signal voltages too small to be indicated by other means.

Built-in signal generator

By looping pulse outputs back to the 301B input, you can produce a harmonic signal every 100 Hz or 1 kHz (READ or TUNE position). A built-in 1-MHz clock frequency assures the accuracy of all generated pulse harmonic frequencies in this mode. By tuning the set to any harmonic frequency and locking on AFC, you can operate it as a frequency synthesizer throughout the entire range. In this function, it provides a restored signal of high frequency accuracy at the restored output terminals.

Among other Model 301B features: dual-selectable bandwidths of 10 and 100 Hz; a meter recording output; an optional bridging line transformer (Model 129-600) that makes measurements of true dBm on 600-ohm lines possible with only 0.1 dB bridging loss.

Product File 369 discloses everything about this remarkable economic development. Write Philco-Ford, 3885 Bohannon Drive, Menlo Park, California 94025. Or call (415) 322-7222, ext. 329.

SUMMARY SPECIFICATIONS

Frequency	
Range	20 Hz to 110 kHz
Accuracy	(20 Hz to 110 kHz) ±1 Hz ±1 count
Input Level Range	
Voltage (Full scale)	30μv to 300 v in 1, 3, 10, 30 sequences
dBm (ref 600-ohm line and 0 dB on meter scale)	+50 to −90
Input Level Accuracy	±0.5 dB
Selectivity	
Narrowband	10 Hz (6-dB points) 60 Hz (60-dB points)
Wideband	100 Hz (6-dB points) 600 Hz (60-dB points)

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Circle 25 on reader service card

Meetings

(Continued from p. 24)

University of Southern California, Los Angeles, **May 7-8.**

Annual Symposium & Equipment Exhibit, American Vacuum Society; International Hotel, Los Angeles, **May 7-9.**

Textile Engineering Conference, American Society of Mechanical Engineers; Sheraton-Sir Walter Hotel, Raleigh, N.C., **May 7-8.**

International Joint Conference on Artificial Intelligence, IEEE; Statler Hilton Hotel, Washington, D.C., **May 7-9.**

Short courses

Recent advances in engineering mathematics, University of California at Los Angeles; **June 16-27;** $375 fee.

Electromagnetic science series of short courses, University of Colorado, Boulder; **July 7-18;** $300 fee.

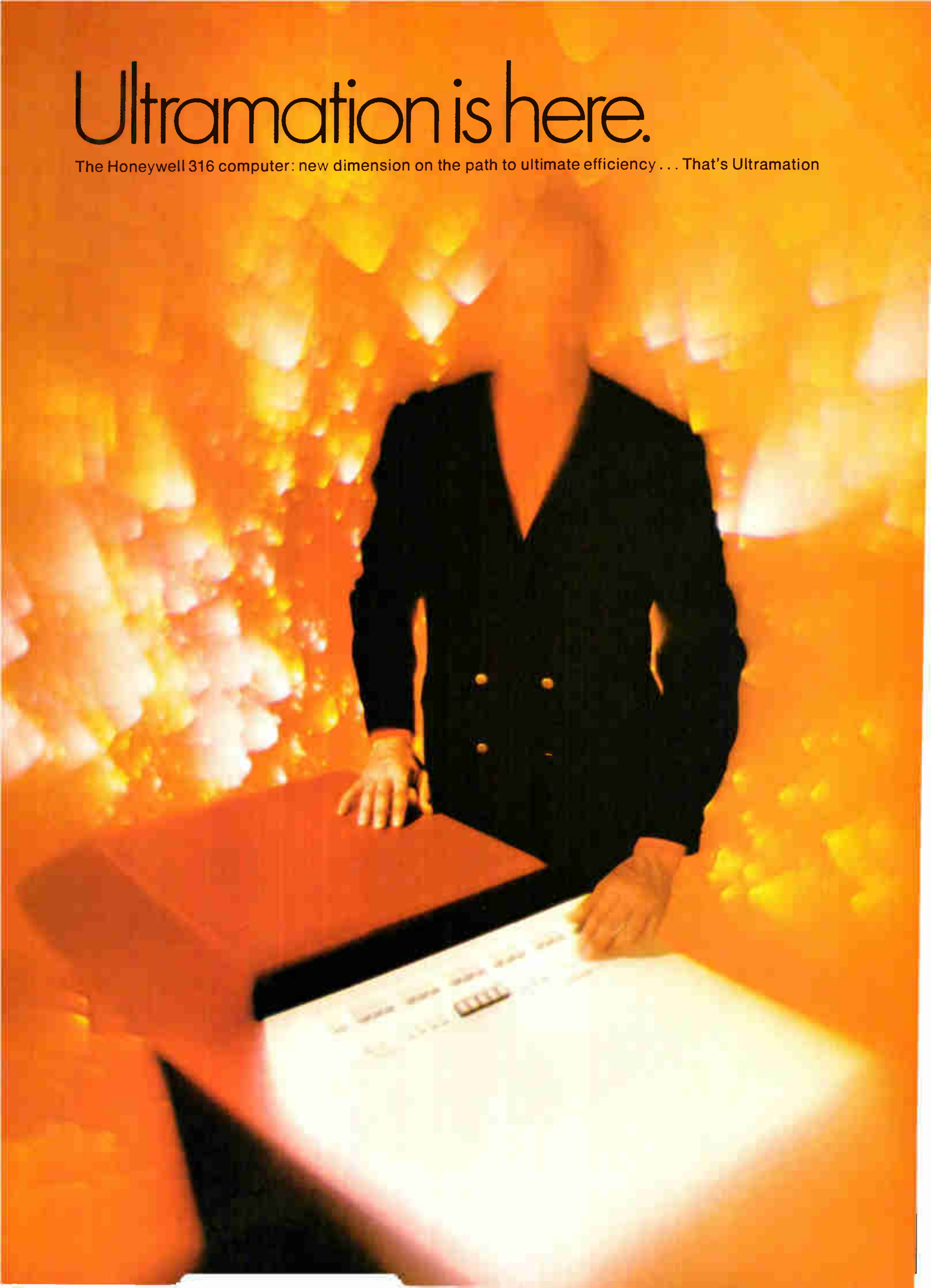
Digital process control systems, Purdue University, Lafayette, Ind.; **Sept. 15-24;** $350 fee.

Call for papers

Annual Technical Conference, Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers; Statler-Hilton Hotel, Boston, August 24-27. **May 1** is deadline for submission of abstracts to D.P. Seraphim, IBM Components Division, Bldg. 300, Hopewell Junction, N.Y. 12533.

Symposium on Reliability, IEEE, American Society for Quality Control, The American Society for Nondestructive Testing, and the Institute of Environmental Sciences; Ambassador Hotel, Los Angeles, January 27-29, 1970. **May 1** is deadline for submission of papers and abstracts to W.R. Abbott, Program Chairman, Lockheed Missiles & Space Co., Dept. 60-01, Bldg. 104, P.O. Box 504, Sunnyvale, California 94088.

Symposium on Switching and Automata Theory, IEEE and Dept. of Applied Analysis and Computer Science; Waterloo, Ontario, October 15-17. **May 16** is deadline for submission of abstracts to Professor John E. Hopcroft, Department of Computer Science, Cornell University, Upson Hall, Ithaca, New York 14850.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SPECIFICATIONS

TYPE — Stored program, single address, 16-bit, binary, parallel, general-purpose, two's complement.

MEMORY — Type: Four wire, coincident current, magnetic core
Size: 4,096 words, expandable in same increments to 16,384
Cycle time: 1.6 μsecs
Add time: 3.2 μsecs

INSTRUCTION COMPLEMENT — 72

REGISTER COMPLEMENT (all 16-bit) — A-Accumulator, B-Accumulator Extension, P-Program Counter, M-Memory Information, Y-Memory Address, X-Index Register

POWER FAILURE INTERRUPT — Power failure causes an interrupt through a unique location in memory to store contents of registers in memory.

INDEXING — By hardware index register, adds no time to instruction execution. Index register addressable directly and/or as memory location Zero.

SENSE SWITCHES — Four switches on control panel are capable of being tested by programmed instruction.

INPUT/OUTPUT — Word parallel. Programmed via A Register, or, optionally, automatic to/from memory under control of Direct Multiplex Control Unit.

I/O CHANNELS — Up to 20 individually addressable channels or interfaces on the I/O bus. Multiple devices per interface or channel.

PRIORITY INTERRUPT — Basic machine has capability for up to 16 individually maskable priority interrupts. 48 additional interrupt lines optionally available.

TEMPERATURE — Room ambient.

HUMIDITY — 0-90% relative humidity with no condensation.

POWER — 475 watts at 115 volts AC ±10%, 60 cycle, ±2 cycles, single phase. Input current, 5.5 Amps.

CONFIGURATION — The basic 316 is supplied as a rack-mountable unit complete with power supply and control panel. This unit requires 14 inches of panel height in a 19″ rack. Table-top and pedestal configurations also available.

DIMENSIONS — 17.88″ wide x 24.5″ deep x 14″ high. This unit can contain the central processor, 16K of memory, real-time clock, high speed arithmetic, Teletype interface and logic for several other internal options and/or device interface.

WEIGHT —Approximately 150 pounds.

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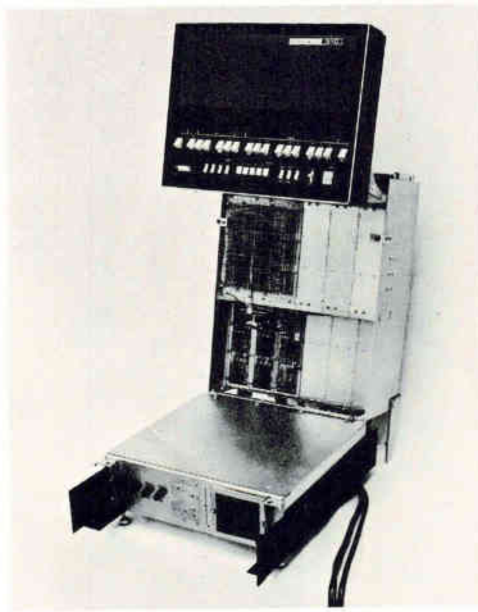

For easy maintenance purposes, access to the unit is implemented by a front pull-out and tilt mechanism.

Honeywell
AUTOMATION

Editorial comment

A tale of two cities

The Paris electronics exhibition (Salons Internationaux des Composants Electroniques et de l'Electroacoustique), coming as it did this year on the heels of the IEEE International Convention and Exhibition in New York, provided an interesting opportunity to compare the two shows. Both are truly international and both must be adjudged successful in terms of attendance (IEEE, 60,000; Paris show, 170,000). On the other hand, the managements of both exhibitions can learn by noting what the other does best, and the visitor to either show may find his attendance next year more productive and enjoyable if he keeps in mind the character of the two shows.

The Paris show is at some disadvantage in that it tries to cover all the ground that's divided among several conventions in the U.S. For example, it devotes a large section (really a separate show) to audio components, and it also accommodates a group of exhibitors who sell to the original-equipment market in the consumer field. For this reason, critics have called the show a hodgepodge.

Nevertheless, more than a thousand exhibitors were able to display their wares this year in the spacious, well-lighted, and well-appointed exhibition hall at the Porte de Versailles. In contrast, the IEEE show's biggest problem was cramming 720 exhibits into New York's odd-shaped Coliseum. (The visitor to IEEE sometimes gets the feeling he's missed a cubbyhole full of exhibits, if not an entire mezzanine.)

The visitor to the Paris show is impressed by the way its sponsors cater to its international clientele. For example, the management made interpreters and secretaries available to exhibitors and visitors alike, and Credit Lyonnais and La Banque Nationale de Paris had offices on the exhibition floor to change foreign currency. Furthermore, every booth was clearly marked with the exhibitor's name and nationality, a practice the IEEE show would do well to follow.

The Paris show has matured in its 30 years, but the decision of its management to keep it open over the weekend must be questioned. Hardware exhibits were virtually deserted on Saturday and Sunday, and even Texas Instruments' "Miracle Mile" was accorded scant attention.

Weekend visitors were in a holiday mood, gravitating to the audio exhibits, where clashing sounds and flashing lights delighted them. Others fiddled with knobs at the instrument booths, and a small crowd surrounded Hewlett-Packard's blackjack-playing computer. Some visitors brought tots and teenagers, who amused themselves by collecting data sheets and eating popsicles.

It was not until the work week began that the serious visitors arrived. As one executive put it, "They're here to do business, not drink champagne." Most exhibitors had conference rooms built right into their booths, and that's where the orders were written (and, admittedly, a modicum of wine was consumed). At least one customer brought a sketch of a custom metalization mask to the TI booth and asked the company to begin immediately to convert it into a finished mask. Visitors returned the compliments of the exhibitors, saying that the technical competence of booth personnel was outstanding. Rarely were visitors (language barriers notwithstanding) given only partial answers, as so often happens at IEEE.

Neither show has enjoyed a reputation as a showplace for significant technical papers, but the Paris program was primitive by U.S. standards. Only a handful of the 33 papers drew audiences of more than 200 people, and several were presented to fewer than a dozen. The most popular papers were those dealing with developments in integrated circuitry.

One of the most important impressions a visitor comes away with from the Paris exhibition is that the Europeans intend to mount their challenge to the U.S. by extending their "leapfrog" tactic to bypass those technologies in which they never gained a foothold. An indication that the maneuver has already paid off was found in an observation made in Paris by TI. Advanced TTL circuits account for only 50% of the U.S. logic IC market, the company noted, but the figures are 70% in France and 90% in West Germany.

The end is not in sight, either. Visitors to the Paris exhibits considered transistor-transistor-logic technically passé. They were interested in large-scale integration, metal oxide semiconductor technology, emitter-coupled logic, advanced linear integrated circuits, optoelectronics, and sophisticated instrumentation.

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Electronics Newsletter

April 14, 1969

Burroughs appears soured on thin film

After ballyhooing thin-film memories for several years, and putting them in several of its computers—notably the giant B-8500 series—Burroughs is said to have lost interest in the technology and returned to the old reliable ferrite-core arrays. **In fact, one report says a 650-nanosecond core memory will be installed in the B-8502, now a partially constructed engineering model at the company's laboratories near Philadelphia.**

Even more significant, the company is said to be taking a hard look at the buffer-memory concept that IBM is pushing hard [*Electronics*, March 17, p. 51]. This buffer, which IBM calls a "cache," would be a monolithic or hybrid semiconductor array. This new interest apparently reflects a feeling at Burroughs that semiconductor costs are rapidly dropping to the level that make thin films economical, and that **semiconductors won't present the kind of technical problems now plaguing films.**

Although Burroughs representatives are presenting a paper at Intermag in Amsterdam this week on the Illiac 4 thin film memory, only an engineering version exists and there's no production contract [see p. 47].

Equipment makers moving into MOS

Major commercial equipment makers are moving fast to build up a prototype capability in metal-oxide-semiconductor integrated circuits. Development laboratories at some companies are deep into this work. **National Cash Register and Xerox, for example, have labs working very actively in MOS.** Xerox is aiming to get MOS from three or four suppliers and has built up its MOS test lab "to keep suppliers honest."

Xerox definitely is going to MOS circuits; only the timing is in doubt at this point. **The firm plans to introduce an all-IC machine next spring, but the decision on whether the circuits will be bipolar or MOS has not yet been made.** More complex electronic subsystems than those now being used in Zerox machines are slated for prototype next year.

Two MOS circuit suppliers working with and supplying chips to Xerox are Fairchild Semiconductor and General Instrument.

Military eyes wideband receivers for surveillance

The military seems to be taking a longer look at wide-open type surveillance receivers for reconnaissance missions. **Until now, the money generally has gone to frequency-scanning rather than wideband varieties.**

The services have issued at least three requests for proposals for wideband receivers in the last three weeks. "We haven't seen such interest for some time," says Donald L. Margerum, executive vice president at Raven Electronics of Burbank, Calif.

The wide-open approach had two drawbacks: it could measure frequencies only to within a general band, and it had low sensitivities. **But, says Margerum, the wide-open approach looks more promising because it now can pinpoint frequencies more accurately than scanners and has sensitivities approaching −65 dbm.**

Raytheon jumps into op-amp race

Raytheon's semiconductor operation will introduce next month a proprietary operational amplifier it hopes will take some of the play away from the hottest "second-generation" op amps around—National Semiconductor's LM107 and uncompensated LM101A and Fairchild Semiconductor's 741. Raytheon claims that its new entry, the RM4131, has higher gain at lower voltages than these competitors, plus faster slew rate and more bandwidth.

Silicon nitride passivation, a technique Raytheon has already applied to beam-leaded integrated circuits, provides voltage gains of up to 50,000 with supplies as low at ±3 volts. Slew rate is 1.5 volts per microsecond and bandwidth is 4 megahertz. With a new design for current regulation, the 4131 can produce a nearly flat 225 microamperes at from 2 to 45 volts.

The circuit is internally compensated. Raytheon, which second-sources just about every op amp on the market, describes the 4131 as only the first in a series of proprietary linear circuits.

Autonetics forms microelectronics unit

Autonetics officials, who just signed a $30 million contract to provide MOS LSI arrays to Japan's Hayakawa Electric Co. for a pocket calculator, have served further notice on the industry that they're in the commercial LSI business for keeps. All the company's microelectronics activities have been spun off into a new Microelectronics Products division. R.S. (Sam) Carlson, a vice president, has been named general manager of the new unit, while Alvin Phillips, formerly director of microelectronics planning, is director of operations, Earl Schaefer is chief engineer, and Charles Kovac is director of market development and program management.

Pair of TI aces form MOS company

The two men most responsible for getting Texas Instruments into the commercial MOS business have resigned and formed their own company. They are L.J. Sevin, head of TI's metal-oxide-semiconductor operation and one of the pioneers in MOS design, and Louis Sharif, head of MOS manufacturing. Sharif is the man who discovered the aluminum-gold bonding phenomenon—known as purple plague—during the old Minuteman program; he joined the MOS group two years ago and helped bail it out of some manufacturing difficulties.

Reportedly, Sevin and Sharif left because they were unwilling to move to Houston, as they were called upon to do under TI's recently announced plan to broaden its production base.

Sevin and Sharif are said to be planning an MOS manufacturing company, to be situated in Dallas.

U.S. airlines eye British navigator

U.S. airlines are taking a hard look at a British navigation system, and at least one, Eastern Airlines, may place an order soon. The carrier has been testing an area-coverage land and sea navigation system made by Decca Ltd. for the past 18 months; if it buys, other airlines can be expected to follow. The lines may find the system all the more attractive now that ITT has bought Decca's U.S. distributor, Decca Systems Inc., because the new setup can provide nationwide service.

Addendum

Systems engineering for some of the avionics on the Navy's F-14A attack fighter craft will be done for Grumman Aircraft—the prime contractor —by Sperry-Rand. Under a $500,000 contract, Sperry-Rand will carry out analysis and simulation studies in the swingwing plane's weapons delivery, navigation, and gunnery systems. First report is due in July.

The Case for a *Driftless* Op-Amp

Almost all op-amp applications suffer in one way or another from the effects of offset and drift. Changes in ambient temperature of only a few degrees (or even just the passage of time) can cause drift errors . . . errors which can completely obliterate small signals in circuits built around conventional amplifiers. Now you can forget the whole troublesome problem! Our new model 232 is almost driftless . . . Voltage drift low as $0.1\mu V/^\circ C$ and $1\mu V$/month is practically negligible. (In fact, long term tests show drift will never exceed $5\mu V$!)

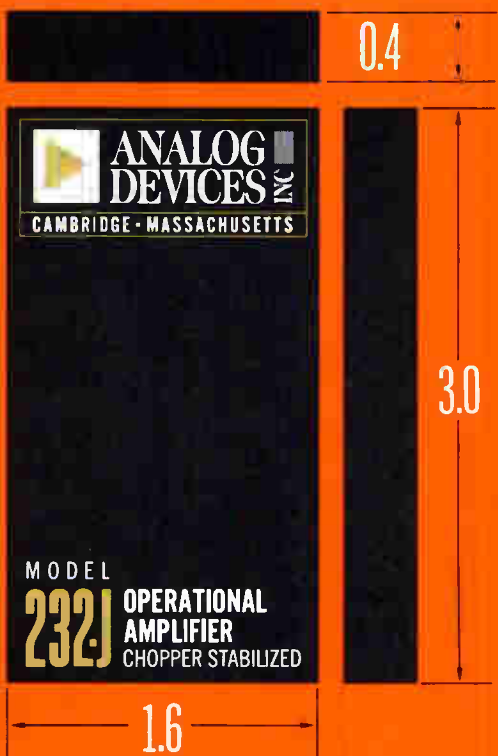
Drift performance like this (coupled with only $15\mu V$ offset to begin with) means that you can forget balance pots (and periodic adjustments) forever. Of course, chopper stabilized amplifiers have been available for some time, but **never** at these prices. The 232 J at just $54 in OEM quantities means that now all of your designs can be "driftless".

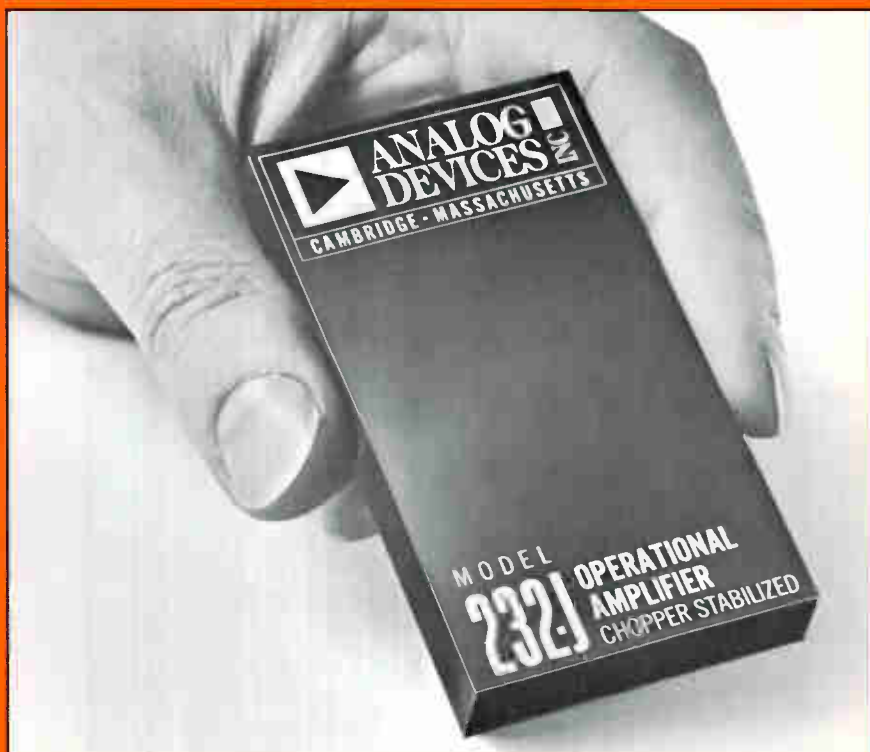
One more thing, this incredible amplifier is in a new "flat pack" case . . . perfect for P.C. card racks.

Check the complete specs on the back, then use the attached "instant action" reply card to request an evaluation sample. No obligation to buy, of course.

$54

(232 J, 100 lot)





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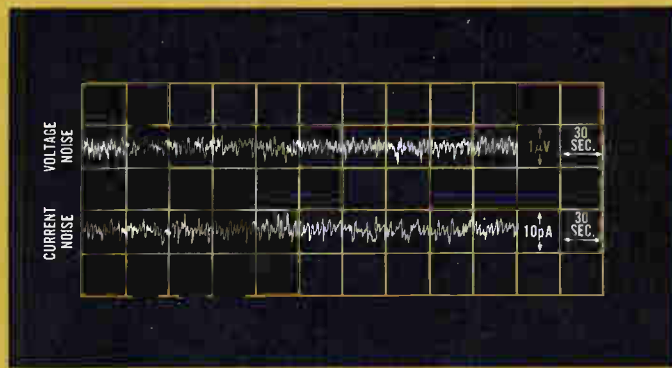
OPEN LOOP GAIN		
dc, rated load, min	10^7	
RATED OUTPUT, min	+10V @ 4mA*	
FREQUENCY RESPONSE		
Unity gain, small signal	500kHz	
Full power response, min	3kHz	
Slew rate, min	.2V/μsec	
INPUT OFFSET VOLTAGE @ 25°C, max.	±15 μV	±10 μV
Average vs. temp 10 to 60°C, max.	±.25μV/°C	±.1 μV/°C
vs. supply	±.1μV/%	
vs. time	±1μV/mo	
INPUT BIAS CURRENT @ 25°C, max	±100pA	±50pA
Average vs. temp 10 to 60°C, max	±1 pA/°C	±.5pA/°C
INPUT IMPEDANCE		
Differential	300kΩ	
INPUT NOISE		
Voltage .01Hz to 1Hz p-p	1.5μV	
5Hz to 50kHz rms	5μV	
Current .01Hz to 1Hz p-p	10pA	
PRICE		
1-9	$64.	$99.
10-24	$58.	$90.
*For 25 mA output specify model 231		

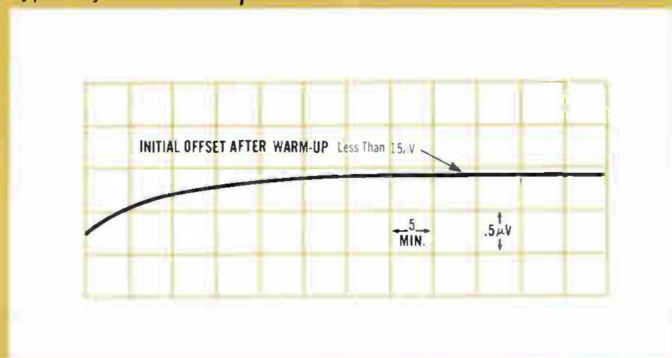
LOW VOLTAGE AND CURRENT NOISE

1Hz Noise Bandwidth



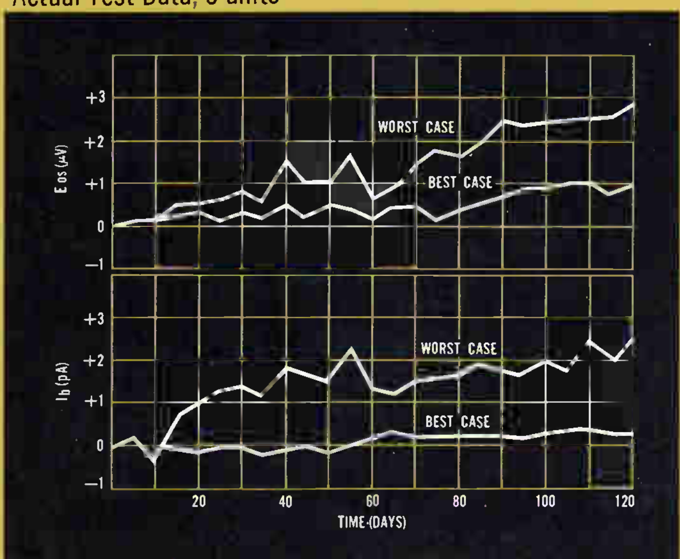
INITIAL OFFSET AND WARM-UP DRIFT

Typically Less Than 1μV



LONG TERM STABILITY

Actual Test Data, 5 units



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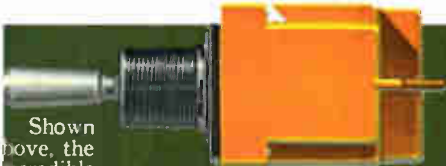

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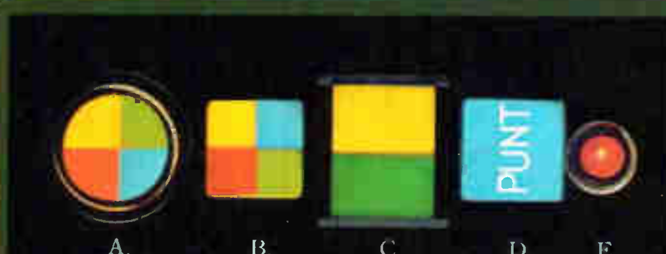

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MAGNETICS

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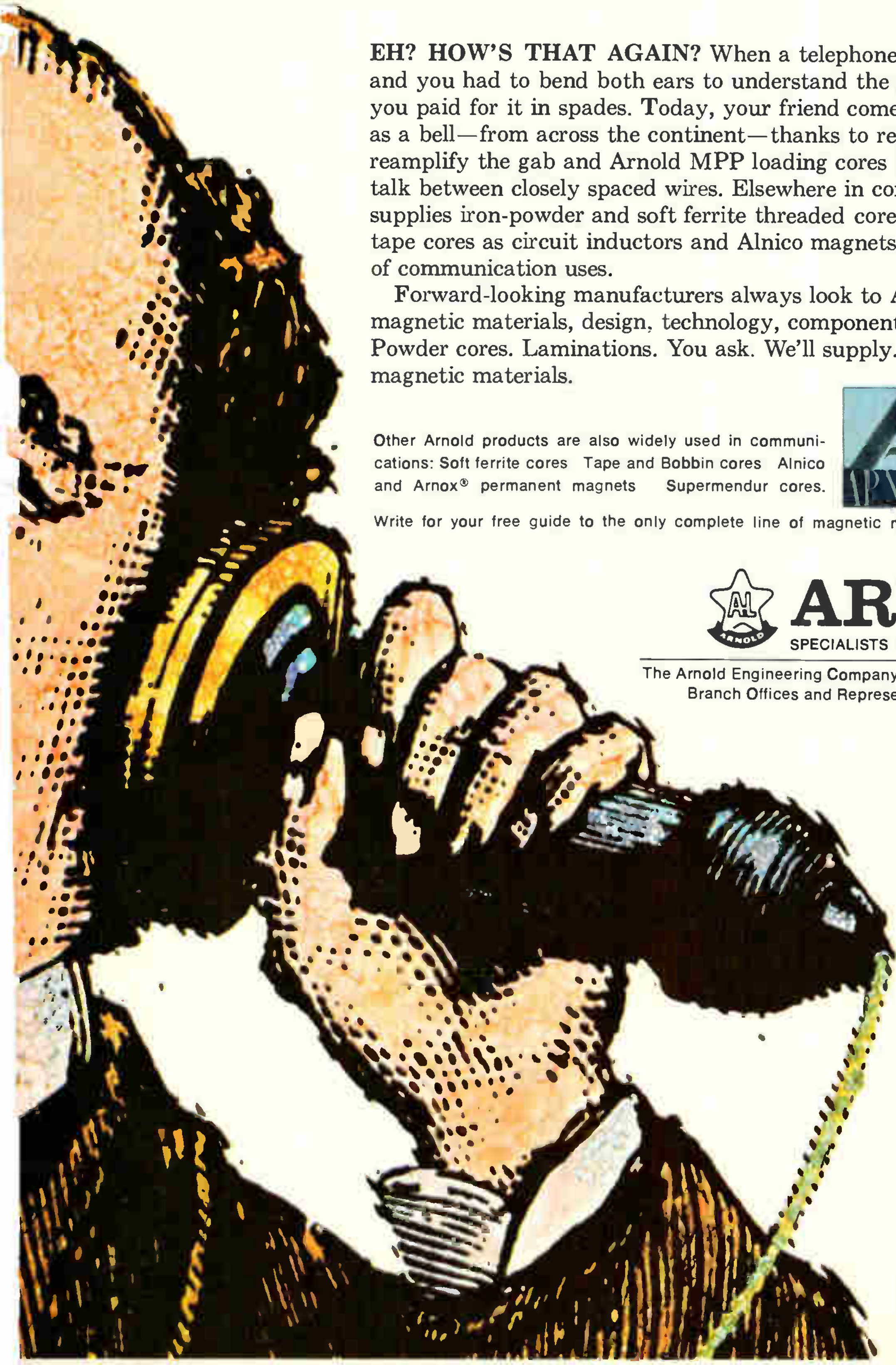

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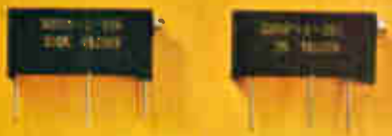


3009P 3009Y(RJ11)

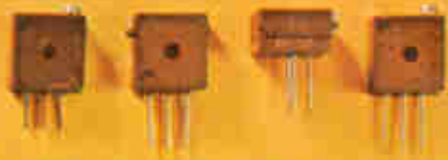
- Low Cost Industrial (RJ11 Pin Configuration)
- Power 0.75 watt at 25°C
- Resistance: 10Ω to 1 Meg.

Model 3069

3069P

- Low Cost Industrial
- Mil-Spec Immersion
- Power 0.75 watt at 25°C
- Resistance: 10Ω to 1 Meg.

Model 3282



3282L 3282H 3282P 3282W

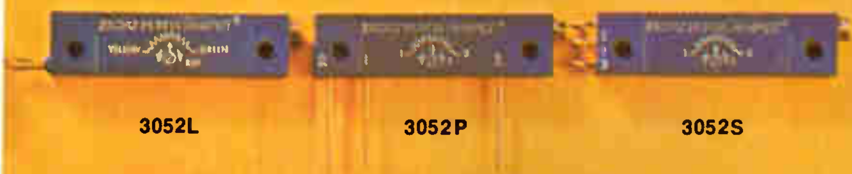
- Meets requirements of MIL-R-22097
- Power 0.5 watt at 85°C
- Resistance: 10Ω to 1 Meg.

Model 3012

3012L 3012P

- Meets or exceeds MIL-R-22097, Style RJ11
- Power 1.0 watt at 70°C
- Resistance: 10Ω to 1 Meg.

Model 3052



3052L 3052P 3052S

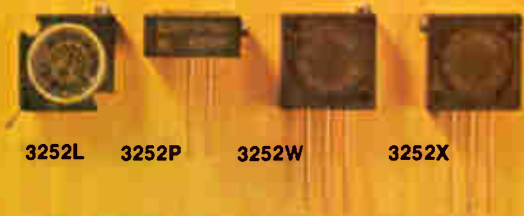
- Meets or exceeds MIL-R-22097, Style RJ12
- Power 1.0 watt at 70°C
- Resistance: 10Ω to 1 Meg.

Model 3262

3262W 3262P 3262X

- Meets or exceeds MIL-R-22097
- Power 0.25 watt at 85°C
- Resistance: 10Ω to 1 Meg.

Model 3252



3252L 3252P 3252W 3252X

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- Resistance: 10Ω to 1 Meg.

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3059L 3059Y 3059P

3059J

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- Resistance: 10Ω to 1 Meg.

Model 3292

3292L 3292P 3292W 3292X

- Meets or exceeds MIL-R-22097, Style RJ24
- Power 0.5 watt at 85°C
- Resistance: 10Ω to 1 Meg.

Model 3082

3082P

- Only .10″ x .15″ x .50″
- Power 0.3 watt at 85°C
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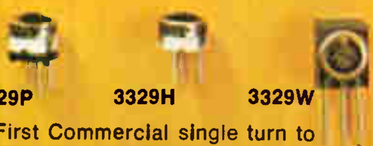

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- Resistance: 10Ω to 1 Meg.

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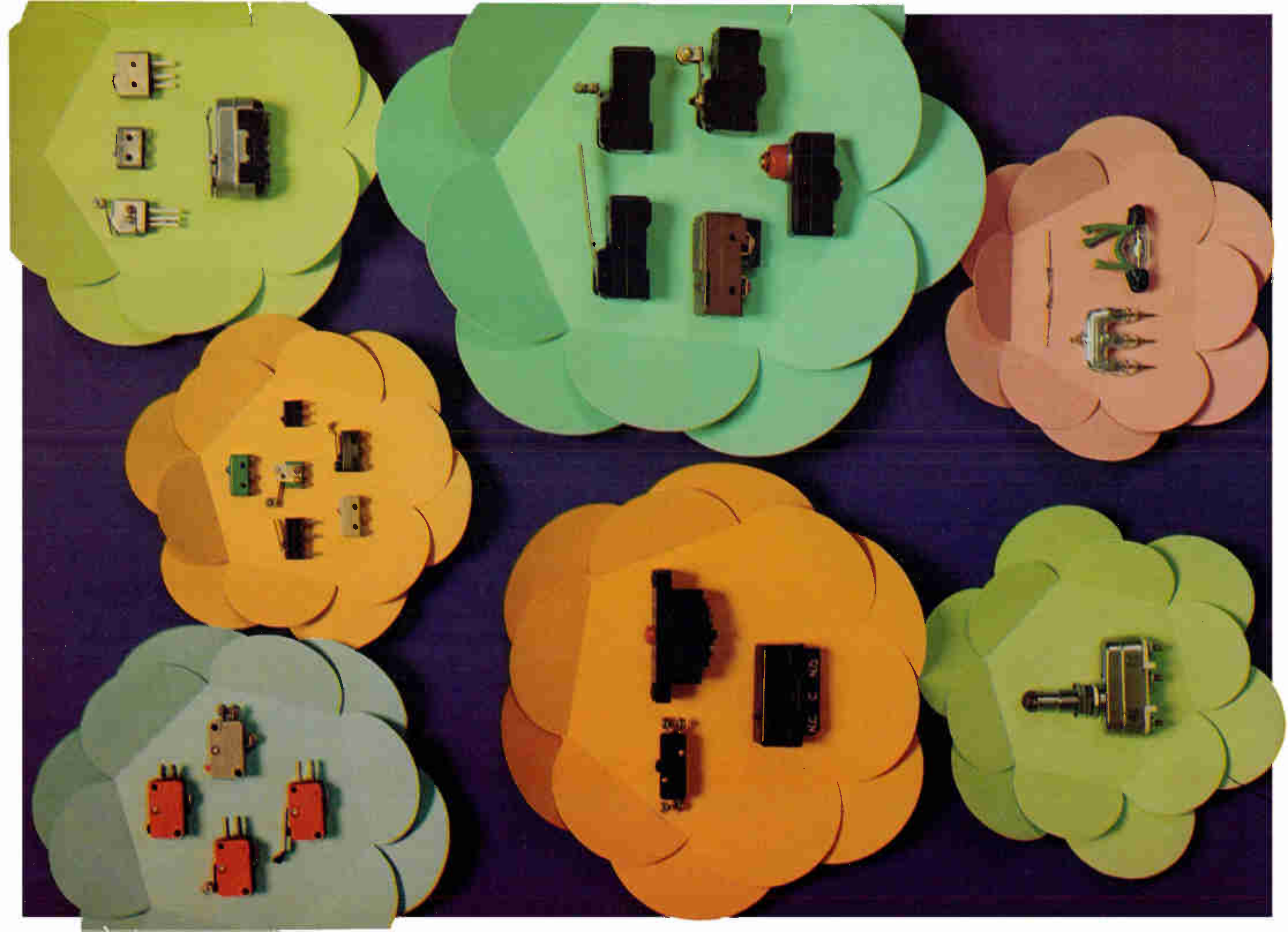

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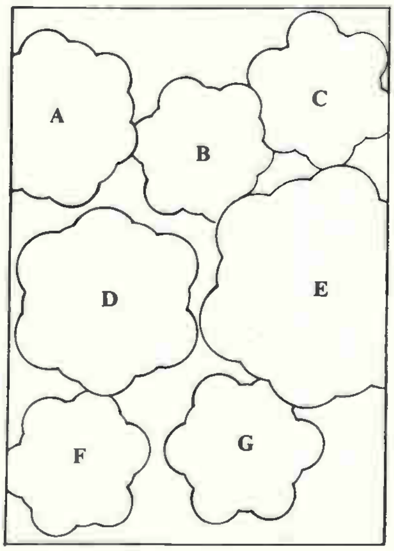

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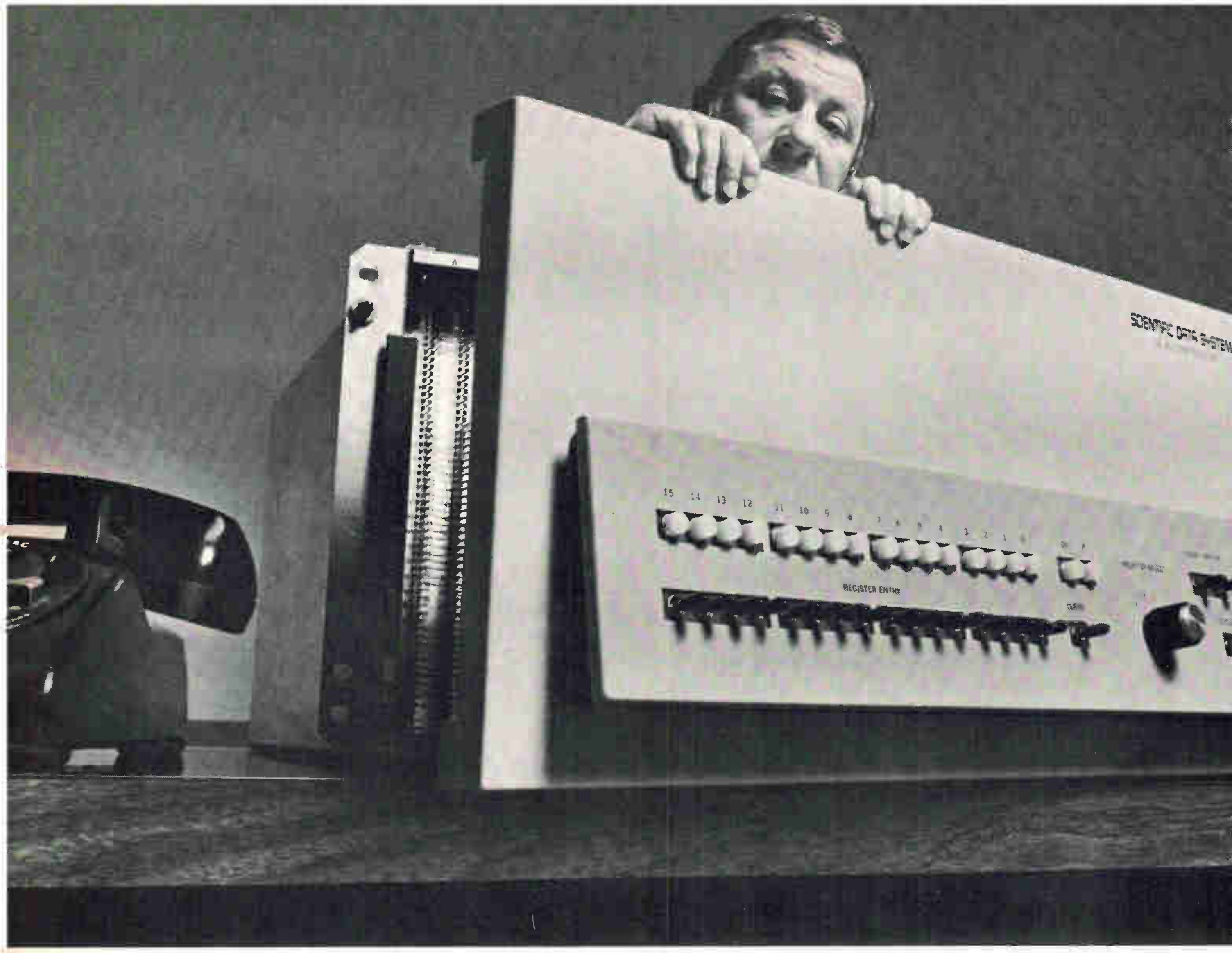

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Automatic I/O isn't a high priced option. Neither is a teletype, nor three priority interrupts, one of which is indefinitely expandable. They're all standard. The only thing you might pay extra for is speed. The CF16 can do a fully signed software multiply in 42 micro-seconds. But it costs a little more than the CE16 which takes 126 micro-seconds (which isn't bad) for the same job.

Don't take our word for all this. Drop us a line asking for:

• A brochure with straight from the shoulder specs so you can compare.

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Circle 46 on reader service card

Short circuits snag Illiac 4 program

Medium-scale IC's, ordered from TI, have been dropped from Illinois' supercomputer; size and cost problems loom as Burroughs shops for second source of standard IC's

Illiac 4, the University of Illinois' supercomputer designed to execute up to a billion instructions per second, may never get up to speed. As a matter of fact, it's now possible that the system may follow its predecessor, Illiac 3, into partial oblivion [*Electronics*, Oct. 14, 1968, p. 56]—although no one directly connected with the project is quite this pessimistic.

While Illiac 4 has been tagged all along by some as a technological white elephant [*Electronics*, May 15, 1967, p. 141], its current woes stem from skyrocketing costs and some unexpected difficulties experienced by Burroughs, the prime contractor, and its subcontractor, Texas Instruments, with the medium-scale integrated circuits from which the huge parallel-processing system was to be built.

Illiac's speed was to be obtained by simultaneously putting as many as 256 conventional machines to work on different portions of the same problem. For smaller problems, the array would be divided into 64-processor quadrants and a single control unit.

Inflationary spiral. The MSI circuits originally planned are now out and it is the shift to standard IC's that some people believe may make the billion-per-second execution rate unattainable. Moreover, money problems could conceivably kill the complete 256-processor system. Already, costs have risen from the initial estimate of $14 million for the entire system to $26 million for the single quadrant (64 processors) section—the only part of the project that's been funded so far. Simply extending this figure would push the total system price to over $100 million.

The three remaining Illiac 4 quadrants, which are not yet funded, could well be casualties, even though a top official in the Pentagon's Advanced Research Projects Agency, which is footing the bill, believes the entire system is still a "perfectly viable program."

In the lurch. Much to the dismay of Burroughs and Illinois, TI dropped the MSI project altogether; then early this year, the decision had to be made to eliminate MSI from Illiac 4. The original contract called for TI to furnish complete 80-pin packages which were made up of several MSI chips on a single substrate. TI will say only that "the work stopped because of time, schedule, and cost requirements for the program. All of this was not compatible with what was required to develop the technology."

Burroughs adds to that: "It recently became evident that MSI of the very high-speed logic would not be available economically on a schedule compatible with planned completion of Illiac 4." Nevertheless, the company admits that the "circuit change has resulted in a delay in delivery and resulting increase in development cost."

Burroughs wanted emitter-coupled logic, for which TI had a well-established and growing capability. But TI, according to one report, didn't deliver a single MSI circuit to Burroughs. The company reportedly shipped some standard ECL IC's for breadboarding, but these had a failure mode. This source says TI's MSI problems were threefold: yield, test, and the substrate. TI denies any problems with testing, saying "the job never got to the test stage." Other sources say that the company couldn't cope with the circuit's power dissipation or had difficulty with multilayer interconnections.

Another observer in the semiconductor industry claims the circuits were so badly designed to start with that when an open bidders' conference was held a few months ago in the hopes of getting a second source for the TI design, he doubted that anyone bid to such a spec.

Solo. A computer industry source says the big reason TI got the Illiac 4 contract from Burroughs was because it was the only bidder. This man, who is not with Fairchild, notes Fairchild Semiconductor tried to convince Burroughs to

Into the breach?

In an attempt to recoup some of the lost space and speed on Illiac 4, as well as to cut costs, Burroughs and the University of Illinois are seriously considering going to semiconductor memories in place of the magnetic thin-film units that were originally planned.

Burroughs put out a request for quotes several months ago for up to 256 semiconductor memories of 2,048 words (64 bits), one for each processor. Five companies were said to have responded, including TI, National Semiconductor, and Fairchild Semiconductor. The Fairchild entry is a large bipolar memory with some complementary transistor logic in the peripheral circuitry. Cycle time is 200-250 nanoseconds.

Going to semiconductor memories would, it is hoped, offset part of the higher costs resulting from the use of standard ECL IC's rather than MSI. The move would also help take some of the curse away from increase in system size that will stem from going to standard ECL circuits.

For some time now, Burroughs has been telling bidders that the award was "imminent;" but so far, none has been made.

switch to its complementary transistor logic—conventional NAND/NOR logic with an emitter-follower output stage using both pnp and npn transistors.

Burroughs is now pushing ahead as well as it can, using off-the-shelf ECL logic in dual-in-line packages. Because a given amount of logic takes a lot more room to package in standard IC's than in MSI, Burroughs is having to redesign the logic. Aside from being a costly proposition, this rework tends to slow down the entire machine. Moreover, going the "discrete IC" route means that the size of the Illiac 4 processors will be boosted by as much as from 15% to 20%.

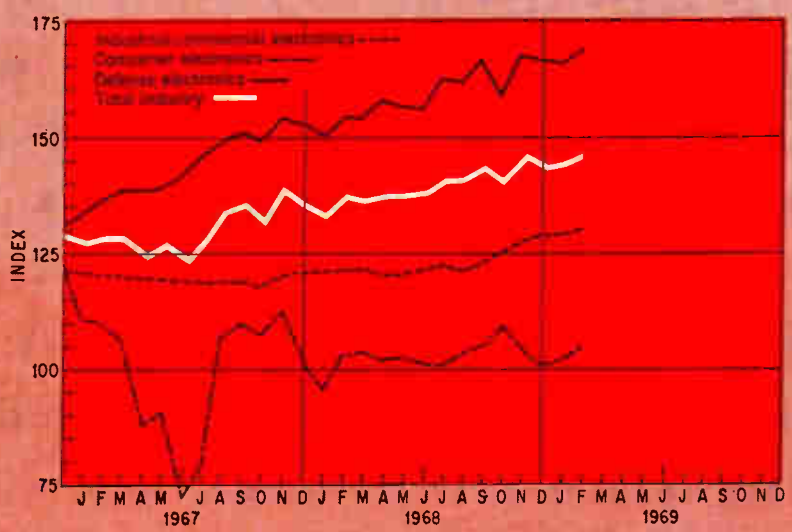
TI says it is now delivering to Burroughs custom ECL circuits with "complexities that approach MSI." However, a knowledgeable insider says these dual-in-line packages are really discrete IC's with a complexity of about three gates.

Solicitations. There's no question that Burroughs and Illinois will finally decide on two sources, particularly in the light of their experience with TI. And some months ago, another request for quotes went out to industry on the ECL IC's. The field has now been narrowed down to three or four companies, and a decision on procurement is expected within the next week or two. As it happens, however, there's also little doubt that TI will be one of the suppliers.

Daniel L. Slotnick, head of the Illiac 4 project at the university, won't comment on current problems or delays. But scheduling on the program has certainly slipped. Although he originally expected to have his system running this year, Slotnick won't get it, at best, until late next year.

Electronics Index of Activity

April 14, 1969



Segment of industry	Feb. 1969	Jan. 1969*	Feb. 1968
Consumer electronics	105.1	102.1	103.2
Defense electronics	168.2	165.9	155.3
Industrial-commercial electronics	130.5	129.0	121.3
Total industry	146.4	144.2	136.5

The index of production inched up 1.5% (2.2 index points) in February from January and 7.3% (9.9 points) from February 1968. The January figures were revised sharply downward because of a reduction in defense production. Each of the three major sectors contributed to the over-all gain. Consumer output rose 3% (3 points) from the previous month, while defense gained 1.5% (2.3 points) and industrial-commercial 1% (1.5 points). Industrial-commercial volume is expected to continue to advance over the next several months; private and Government surveys of plant and equipment expenditures indicate significant gearing up in this field.

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

Components

Taking the (beam) lead

Although some firms, Raytheon and Signetics among them, are either shipping beam-lead integrated circuits to selected customers or at least promising to do so soon, very little has been heard about the commercial beam-lead IC plans of the three companies funded by Western Electric to develop such circuits for the Sentinel Safeguard ABM program: Motorola, RCA, and Texas Instruments.

However, Motorola is now taking the wraps off its plans to market the commercial fallout from its Safeguard effort. James Newton, operations manager for the program at the firm's Semiconductor Products division, says Motorola will be the first of the three firms to introduce standard commercial IC's based on the Bell Labs' process that puts gold on silicon-nitride-passivated chips [*Electronics*, Nov. 25, 1968, p. 72]. Motorola expects to announce some new members of a transistor-transistor logic family before year's end, and will probably introduce at least one beam-lead linear integrated circuit at the same time.

Newton won't say which of the TTL lines Motorola makes—Sylvania's SUHL families, TI's 5400 or 7400 series, or its own MTTL 3—will be the first chosen for beam-lead treatment. "The only special processing required is to make the beam leads and put on the silicon nitride," Newton says, "so we can choose any of the basic TTL diffusions."

Easy choice. He explains that TTL was tapped for beam leading because of its popularity and because Motorola engineers expect to encounter power-dissipation problems when beam leads are put on the emitter-coupled logic lines. Newton is quick to add that the seriousness of this problem isn't

Only one man in a thousand needs this kind of flexibility in an angle position indicator...

(the other 999 relax knowing it's there.)

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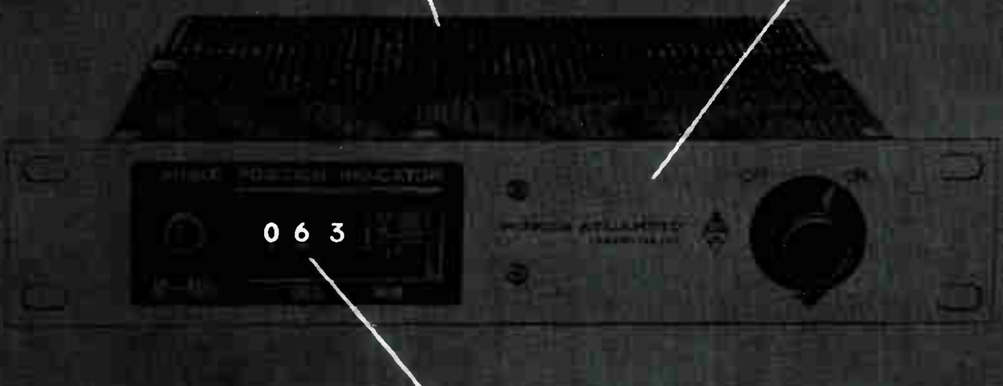

Provides continuous 0° to 360° digital readout of remote synchro or resolver shaft angle with 30-second resolution and repeatability. Accuracy 6-minutes. Servo slew speed 25°/second.

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For additional, rewarding details call a field-engineering representative (see EEM), use the reply card or call or write North Atlantic Industries, Inc., Terminal Drive, Plainview, Long Island, N.Y. 11803. (516) 681-8600.

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industries, inc.

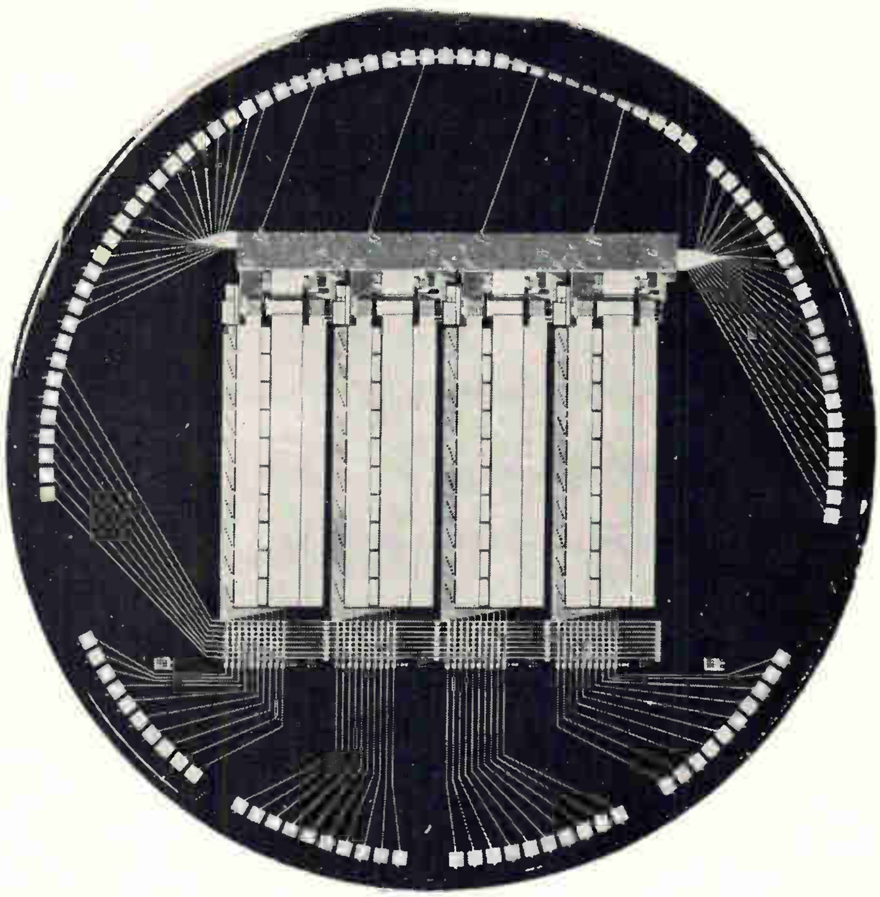
yet known because it's difficult to measure dissipation on the beams. "We may be able to get around it by using wider beams," the manager says.

The TTL devices will be offered in quarter-inch-square flatpacks and in chip form, and will be aimed at customers making high reliability military equipment and those in the multichip hybrid business. "The main thing we'll be offering," says Newton, "is the reliability of the silicon-nitride and all-gold system. We'll be selling a chip with the equivalent reliability of a hermetically sealed package, and the multichip people working with large arrays may be forced to beam leads because it's difficult to obtain hermeticity in the large packages they use.

"We're satisfied that the technology does what it sets out to do," he continues. "We do 300°C back-bias tests on a few dice from each wafer after they've been sprayed with salt water. The devices take it quite nicely. The nitride-and-gold arrangement largely escapes the electrolytic effects and plague of two-metal systems. The only problem is that it's expensive."

Keeping abreast. A finished beam-lead IC in a flatpack will be competitive in price with similarly packaged high-reliability components without beam leads, according to Newton. As for chips, he predicts that the price will be about the same as customers would pay for a standard device in a flatpack that had undergone extra testing. He expects Motorola to sell more unpackaged devices than packaged ones at the outset because of the interest expressed in beam leads by multichip users.

Motorola has its sights on about $1 million worth of business in commercial beam-lead IC's next year, but Newton considers that a conservative target. He estimates that volume could grow to $20 million by 1975. What device types the company introduces after its initial beam-leaded TTL circuits will depend on how low costs can be held. If they can be kept low enough, Newton says, Motorola may then market a device family that can go in plastic packages.



Dish. Litton's 1.5-inch wafer has about 20,000 MOS FET's storing 10,000 bits. IC drivers are across top, selection circuitry at bottom.

Memories

Digging in data

Nonvolatile semiconductor memories—memories that don't lose their data during a power interrupt—are unusual. There are some read-only types, but officials at Litton Industries' Guidance and Control Systems division believe they have the jump in developing a first in semiconductor storage — a nonvolatile and alterable unit.

Litton does it by applying a layer of silicon nitride as a gate dielectric to the wafer containing the metal oxide semiconductor field effect transistors. The nitride acts as both insulator and storage medium. William L. Patterson, manager of semiconductor research in the Applied Research Laboratory, says the nitride insulator has roughly the same electronic structure as a semiconductor, except that the nitride's conduction and valence bands are much farther apart. Between the bands are discrete centers, or traps, that store one or two electrons.

"Once trapped," says Patterson, "these electrons stay in the trap. And with silicon nitride, their willingness to stay in the traps for periods of years is the basis for the long-term storage mechanism." Patterson explains that when an electric field of 3×10^6 volts per centimeter (an external voltage of 20 to 40 volts) is applied to the nitride, "there's a dramatic increase in the probability that the trapped electrons will leave the trap by tunneling into the bulk silicon."

Two of three. This means that a field greater than 3×10^6 volts per centimeter is needed to write data into the memory by tunneling, which is why the phenomenon is called "tunneling" or "charge storage" memory. Whether a 1 or a 0 is written is determined by whether the charge is moving into or out of the nitride traps; that, in turn, is dictated by the polarity of the charge. Negative voltages are used

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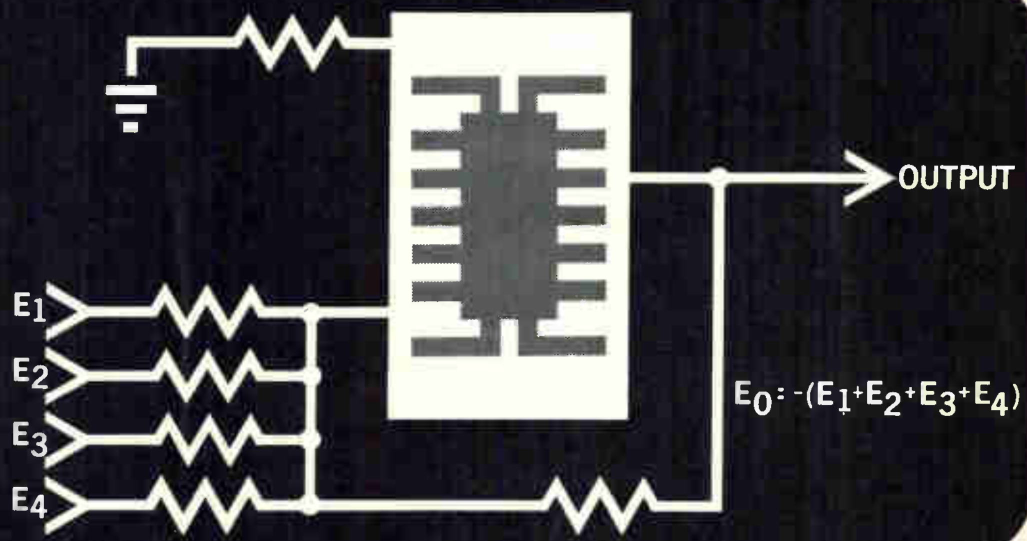

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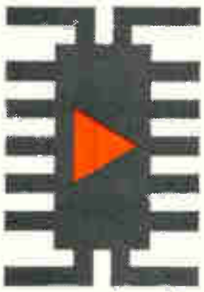

Drift error is very low in the new dielectrically isolated compensationless RA-909A. Between -55°C and +25°C offset current drift is a low 2 nA/°C. From +25°C to +125°C . . . an even lower 0.5 nA/°C! And Radiation guarantees less than 15 μ v/°C offset voltage drift over the military temperature range. Compare this performance with any 709 type op amp over this extremely wide operating frequency range. You'll pick the Best op amp for the job. The RA-909A.

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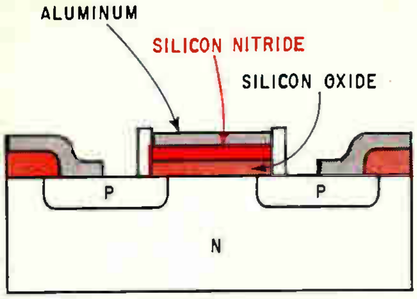


Hero. Typical MOS FET in Litton tunneling memory.

to write data into the memory; a positive voltage applied between the gate and substrate will clear all the bits in one line of the memory.

The amount of the charge determines the transistor threshold. A transistor in the 0 state has a threshold of —3 volts; a device in the 1 state has a threshold of —10 volts. The memory can be interrogated by applying a gate voltage about midway between the two, or —6 to —7 volts. This level will turn on a transistor in the 0 state but not in the 1 state. Thus, the binary value of the stored information can be determined when a bit location is sensed.

Patterson says that silicon nitride alone or nitride with an undercoating of silicon dioxide is used in wafer processing, "depending on which part of the read-write-retention tradeoff you want to optimize. You can have any two of them. You can write and read fast if you settle for a short retention time. You can write fast and retain data for long periods if you read slowly, or you can read fast and retain for long periods if you're willing to write slowly."

The tradeoff considerations suggest two kinds of applications for a tunneling memory: an alterable read-only memory for microprograms in general business machines – initially in peripheral computers—into which data is written slowly, can be retained for long periods, and read quickly; or a scratchpad for a general-purpose computer with a short retention time but fast read and write capabilities. The retention time could be that required for an airborne mission—about a week, Patterson says.

Although Litton researchers have written individual bits in as little as 0.25 microsecond, the minimum time for writing or reading in a 100-word memory will be about 1 μsec because of the use of all-MOS address circuitry to keep costs down. Litton has outside funding to deliver within a year a prototype of a packaged memory with a capacity of 20,000 to 40,000 bits per cubic inch that works at MOS computer logic levels of —6 to —27 volts. After that, Patterson says, extension of the technology to a million bits per cubic inch "is pretty straightforward and we'll pursue it as soon as the present commitment is completed."

For 2 cents fancy. Wafer processing is a simple extension of conventional MOS processing techniques. Reading, writing, and addressing circuitry are all on the same piece of silicon. "There's no problem putting nitride gates and oxide gates on the same chip as long as the nitride is kept away from the bulk silicon," says Patterson.

The Litton researcher estimates that the tunneling memory will cost twice as much as conventional MOS memory—or about 2 cents per bit even for small memories – in two years or so. He says this is about a fifth the cost of magnetic nonvolatile memories and adds that Litton test results going back more than two years indicate that data can be retained for days to years.

Litton isn't alone in developing this type of memory. Patterson says both Sperry Rand and Westinghouse have been funded for similar efforts, but he believes Litton has an advantage over Sperry based on published data showing that 83 volts applied for 10 μsec as a writing pulse produced a threshold shift of 5 volts; Patterson says Litton gets the same shift in the same time with just 29 volts. He points out that IC drivers can't handle 83 volts but will accommodate 29, so he feels Litton is ahead in large arrays that need integrated read-write electronics on the same chip with the memory elements. Patterson says he has no basis for comparison with Westinghouse because he hasn't seen any published Westinghouse data.

Consumer electronics

Stretch

Nearly two years after the first announcement, a tape machine has arrived which is not only aimed at making recordings quiet, but also at obtaining a nearly professional performance at 3.75 inches per second. The machine is the Model 40 built by the KLH Research and Development Corp., and it uses the so-called Dolby system, developed in 1966 by Ray M. Dolby, an American engineer working in England. Basically, the system reduces noise.

Talks between KLH and Dolby started in 1967 [*Electronics*, June 12, 1967, p. 40], but a management shakeup at KLH, some disagreement over licensing terms, and redesign of the basic system slowed development. Not only that, but KLH's plan to also offer a Dolby "black box" for connection to existing machines has been shelved. The Model 40 is to sell for $600.

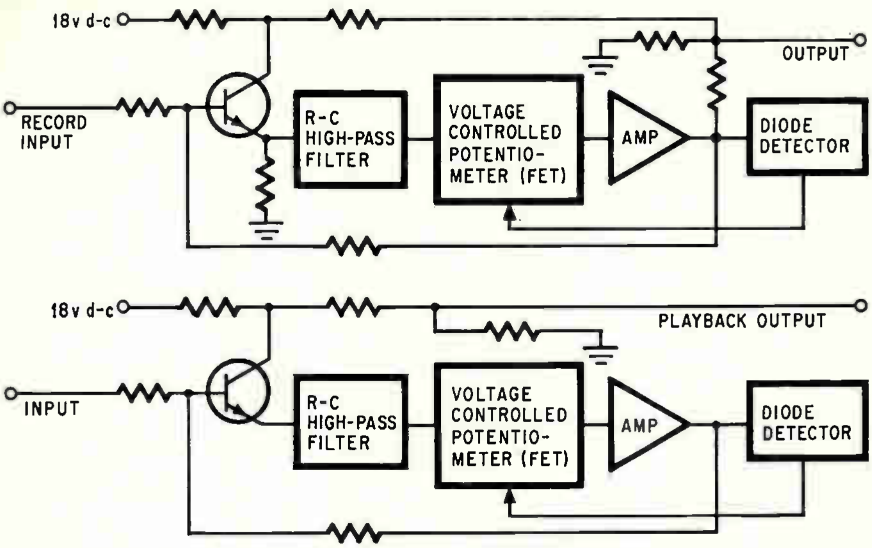
Ever since the 1950's, 7.5 ips has been the most used home tape recording speed. Slower speeds long have been available, but signal-to-noise ratios were poor and bandwidth was limited. Speeds of 15 ips still are used by professionals to maximize bandwidth and minimize noise.

Option. Though it was possible to get extended frequency response at 3.75 ips, high frequencies also brought unwanted tape hiss—thus most tape deck makers opted for either hissy highs or quiet, narrowband performance.

"We wish to make 3.75 ips respectable for the serious recordist," says Andrew G. Petite, KLH's manager of product planning and market development, "and the key is our use of the Dolby."

The Dolby reduces noise on tape recordings by amplifying weak sounds during recording and by attenuating the same frequencies—and attendant tape noise, or hiss—during playback. In the Model 40 this amplification and attenuation reaches 8 to 10 decibels, and so does the improvement in signal-to-noise ratio.

At 3.75 ips using quarter track heads, the Model 40 achieves a



The stretcher. KLH's Model 40 tape machine utilizes this noise-reduction system developed by Ray M. Dolby to raise quality of 3.75 ips operation.

signal-to-noise ratio of 68 db or more, an impressive figure compared with most home recorders claims of 50 to 55 db.

With this reduction in noise, KLH engineers were able to design the Model 40 for broadband performance; thus the deck has a frequency response of 45 to 15,000 hertz ±2.5 db at 3.75 ips.

Fast company. In dealer demonstrations the $600 Model 40 is being compared with a $3,500 ampex AG440 deck, a professional machine using half track heads and a tape speed of 15 ips. Petite claims that the only audible difference is less hiss in the Model 40's playback.

The original Dolby unit divided the audible frequency range into four bands, treating each separately to reduce noise. But this approach was uneconomical for a consumer product. Thus Dolby designed a new unit after consultation with KLH to operate in one band from about 1,700 hz to about 20,000 hz. KLH reasoned that almost all of the extraneous annoying sounds, such as hiss, would occur within this range of frequencies. Thus, the Dolby circuit for home use was far simpler and less costly than a professional Dolby even though the former retains the most audible advantages of the circuit.

During the design stage, Petite and others had the opportunity to map a marketing strategy perhaps as different as their electronics. Petite feels that the 7.5 ips speed may have held back growth of home records. "The common 1,200-foot tape reel gives only a little more than a half-hour of recording time at 7.5 ips. Longer tapes are available, but cost more—in fact the 10.5-inch reel demands three times the price for twice the tape. More costly long thinner tapes can 'print through,' break, or stretch, too. Also, it's necessary to edit frequently, to waste tape and so on. At best, the average classical recording at 7.5 ips costs more than fine records. Together with the higher price of tape equipment, records seem more economical.

"One gets twice the recording time at 3.75 ips, and thus cost is about $1 per recording. Side advantages include the ability to standardize on a single tape length (1,200 feet or about one hour)." But the primary advantage lies in the reduced cost of tape recordings that KLH hopes will revitalize the market for reel-to-reel tape recorders despite cartridges and casettes.

"We realize that at $600 we will sell relatively few machines," says Petite, "but our hope is that other companies will follow our lead to improve the quality of home recorders, and that perhaps prerecorded tapes might be made using the Dolby approach." Thus, while KLH is presently Dolby's sole licensee, it hopes to be joined by other firms.

Government

Emptiness of space

The message has finally sunk in at the National Aeronautics and Space Administration: unless something happens soon, the 1970's will not see the kind of vast expenditure for manned space flight seen in the 1960's. That message started coming across when NASA's first two budget requests for fiscal 1970 were slashed by the Bureau of the Budget. Some $425 million was sliced out of the request for manned flight before it was even presented to Congress.

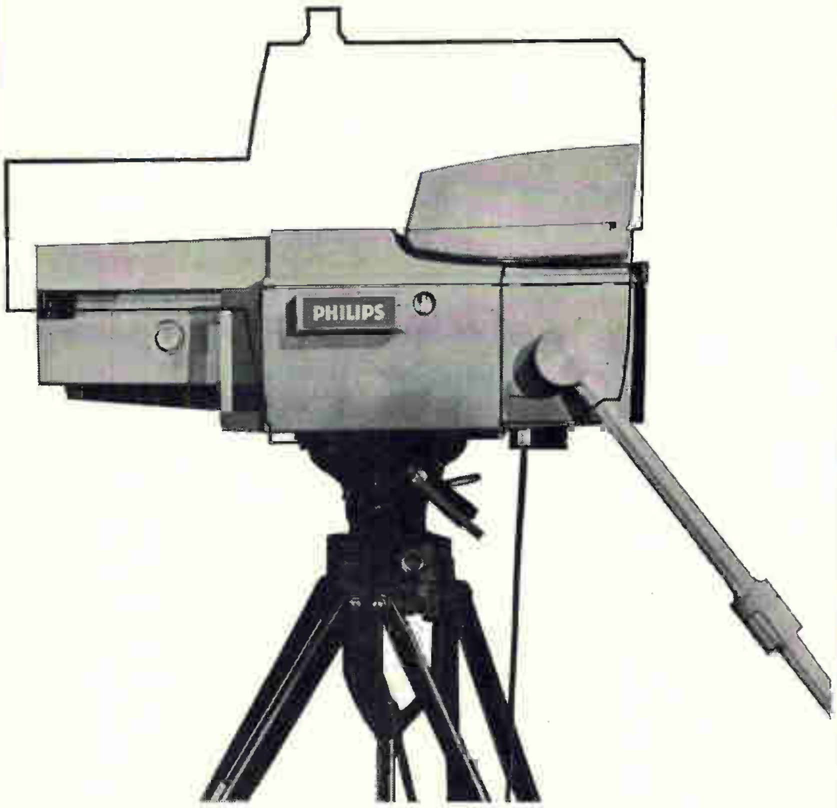
Now, with the lunar landing in sight, the message has all the more relevance. NASA must come up with some acceptable encores—and encores are not possible with the slightly over $2 billion that NASA will receive for manned space flight if the present 1970 budget is approved. Trying to turn the tide, NASA's administrator for manned space flight, George E. Mueller, has already asked the House Science and Astronautics Committee for an additional $100 million to pay for development of scientific packages to accompany the fifth through the tenth lunar landings. As it now stands only four manned landings are planned after the first; Mueller and others at NASA are lobbying for 15 to 18. The request for the packages is just the start. According to an insider in the Manned Spaceflight Office, "Congress is not going to give up an extra $100 million easily and we're going to have to fight for it."

A small team. Meanwhile, Presidential science adviser Lee DuBridge has put together a small team which, between now and Sept. 1, will come up with the flight plan for the second decade in space. The group is composed of DuBridge, NASA Administrator Thomas O. Paine, Vice President Spiro Agnew, and Air Force Secretary Robert Seamans, formerly of NASA.

DuBridge advocates "a really solid, many-faceted program." Seamans and Paine are clearly behind an ambitious program for the 1970's, which would include a national space station, establishing a

permanent base on the moon, space shuttles, and other ambitious hardware oriented programs. NASA is optimistic that the DuBridge group will come up with a set of extensive recommendations with certain concessions to economy to mollify the Congress.

According to a Manned Spaceflight official, a definite concern has settled in at NASA which has been intensified as more than one Congressman and more than one noted scientist has observed that the question may not be, "What after Apollo?" but, "Why after Apollo?" Clearly, NASA is going to have to get going soon if it's going to get going at all.



Going digital. Portable color television cameras have made life easier for remote crews, and now something has been done for the guys in the studio. At the NAB show last month, Philips Broadcast Equipment Corp. announced a new studio color camera that's half the size of present units and weighs 40 pounds less. Designated the PC-100, the camera uses digital multiplexing techniques. All signals between the camera and the control console, including power, video, color, and setup, are sent through a thin triaxial cable. Up to a mile of this cable can be used without line repeaters. The camera, which sells for $84,850, has been ordered by the CBS and ABC networks and independent stations across the country; deliveries are scheduled for early 1970.

Lasers

Fast bounce

That high-resolution laser scanning system now transmitting reconnaissance photos from Vietnam to the Pentagon is expected to have wide applications in digital data recording and retrieval systems. The reason: high scanning speed and information-packing density. Officials at CBS Labs, where the equipment was developed, think they can sell the setup to news media, hospitals, and weather forecasting organizations.

The Air Force Electronics Systems division is barely willing to admit that the laser system exists, let alone detail its operation. But a milliwatt-range helium neon (red) laser system based on the same technology, and demonstrated by CBS Labs, has a resolution of 20,000 elements per scan line with a bandwidth exceeding 50 megahertz. By comparison, the standard 525-line tv system allows for about 400 elements and 4 Mhz. The practical bandwidth capability of a laser scanning setup like the one demonstrated by CBS is said to be in the hundreds of megahertz with resolution capability limited only by the bandwidth of the transmitting data link.

Determination. Scanning is by a facet on the spinner. The size of the facet, which determines the lens aperture, also ultimately determines the quality or resolution of the scanned picture. Therefore, to achieve the highest possible resolution, the highly concentrated laser beam is first expanded so it can illuminate the entire facet. After passing through the scanning optics, the beam is modulated by the film to produce a light signal; that signal is transformed to an equivalent electrical signal by the photomultiplier, amplified, and passed on to a data transmission system. Hence the spinner provides the horizontal line scan synchronization while the film transport provides the vertical synchronization which makes the lines merge into a picture.

In the laser recorder at the receiving end, the video signal modulates the laser beam, which is then expanded. Scanner optics concentrate the beam into a fine moving point.

Military electronics

LSI takes off

What the Air Force regards as the first piece of equipment employing bipolar large-scale-integration will be delivered to the Avionics Laboratory at Wright-Patterson AFB,

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Circle 57 on reader service card

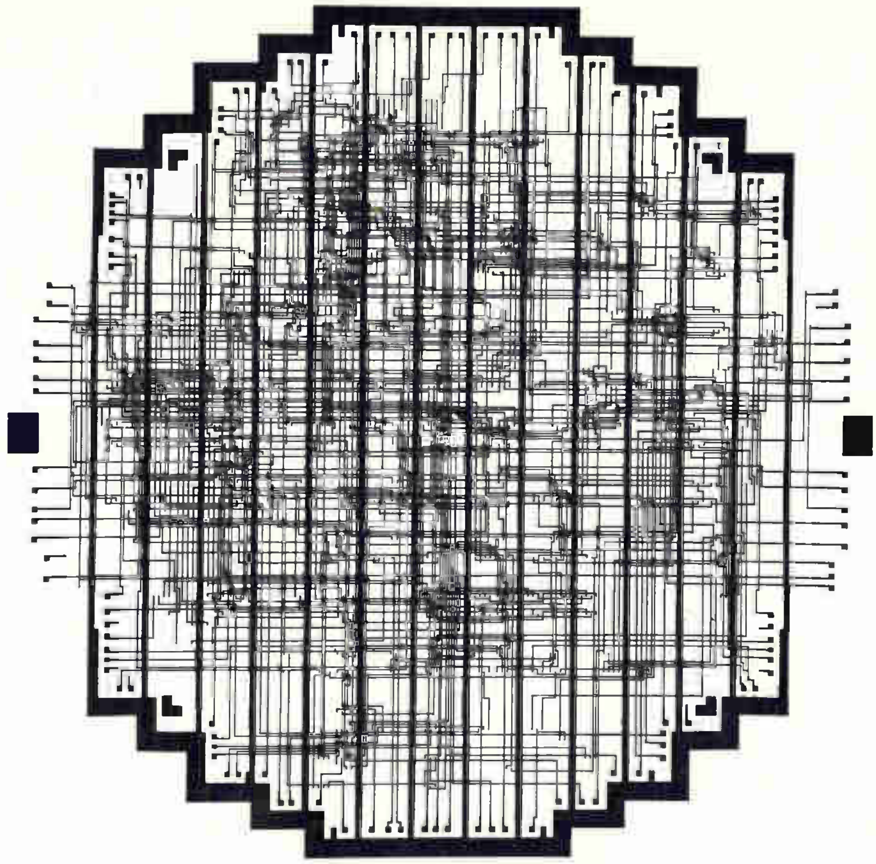
Ohio, this month by Texas Instruments. The Air Force already is satisfied that the general-purpose avionics computer [*Electronics*, June 24, 1968, p. 47] demonstrates the feasibility of using LSI and TI's discretionary wiring approach.

The TI development effort was far enough along a year ago to prompt the Avionics Lab to award a contract to the Burroughs Corp. for a multiprocessor computer using discretionary wiring. "Other companies, such as Hughes and Raytheon, are looking into discretionary wiring or modifications of it for their computers," reports Robert Werner, a project engineer in the Avionics Laboratory.

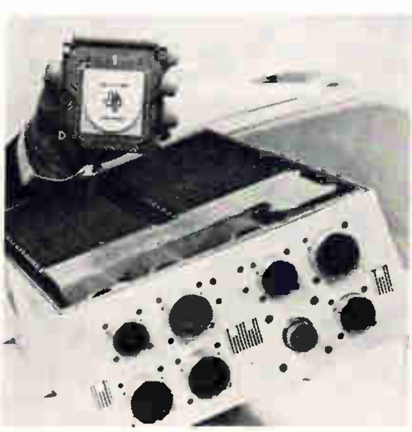
Wright-Patterson is now evaluating proposals for development of a digital filter using LSI; this is intended to provide experience in solving the problems of LSI in communications and radar systems. Discretionary wiring is under consideration for this program too.

Still around. However, the Air Force has certainly not abandoned fixed wiring. At the start of its program with TI, Wright-Patterson started a parallel program with RCA for an LSI computer using fixed-wired emitter-coupled logic instead of the discretionary-wired transistor-transistor logic used by TI. The chips are somewhat less complex in RCA's approach, however; although some arrays contain over 200 gates, the average density is about 144 gates per chip. The chips used in the TI computer have about 250 gates each.

RCA's program will be completed next month, on schedule, according to Werner. With TI, the Air Force also asked for a three-year program, but TI engineers felt they could do it in two. As it turned out, they had to ask for a year's extension. "It did take longer than we anticipated," says TI's Jack Kilby, "because of the difficulty of getting all the technologies to work together." Kilby is referring to the combined problems of partitioning, computer routing of interconnections, mask making, multilevel metalization, and packaging.



All lined up. A composite of the two masks for a typical circuit in the computer. CRT traces the hundreds of paths in just 132 seconds.



Handy. New TI airborne computer is about half size of old version.

TI plans to exploit commercially the techniques it developed during the program. The company will introduce in the next few months such discretionary-wired LSI circuits as a digital differential analyzer, a 1,000-bit shift register, and an eight-bit adder

As far as the TI's LSI computer effort, the Air Force wasn't too concerned about the piece of equipment used to prove LSI feasibility, according to Werner. "We just wanted one that would present the realistic problems in the development of the circuit and the partitioning of the arrays—getting the right logic on the chip." The computer was "just a convenient vehicle" to demonstrate discretionary-wired LSI, he noted.

Solution. TI, the prime advocate of the discretionary wiring technique, views it as a solution to the yield problem in LSI. Instead of using a fixed metalization pattern to interconnect the 100-or-more circuits on the chip, TI uses a computer to do the metalization layout. The computer remembers where the defective circuits are and avoids them when it designs the interconnection pattern. Although critics regard discretionary wiring as overly complex, expensive, and—at best—an interim solution, TI now points to actual hardware as a vindication of its technique.

The computer uses 34 LSI arrays of 14 different types. The arithmetic section uses 16 of one type,

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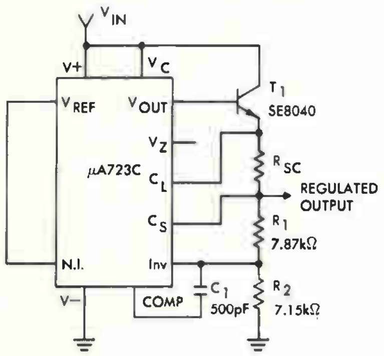

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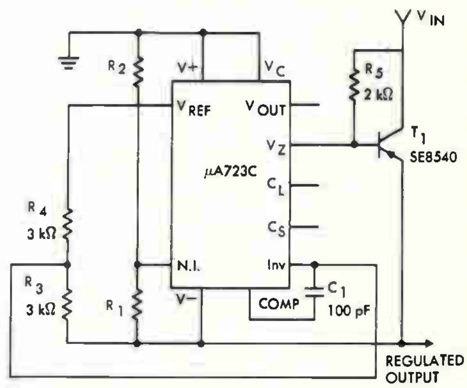

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FAIRCHILD SEMICONDUCTOR A Division of Fairchild Camera and Instrument Corporation Mountain View, California 94040, (415) 962-5011 TWX: 910-379-6435 the input-output section uses six of another type, and the control section uses 12 arrays, each different. The computer package occupies 0.37 cubic feet and weighs 25 pounds, half the size and 34% lighter than the previous version of the computer, which used 1,754 conventional IC's. TI engineers are quick to point out that the size and weight could have been cut even more, but this was not one of the goals of their program.

As for the computer, it will be put to work, even though it was intended to be only a demonstration. It will be used for compensating phasing and for range calculation in the MERA (Molecular Electronics for Radar Application) radar that TI is building.

For the record

Laird's lard. Under the pressure of inflation and demands for urban reform, the Nixon Administration called on the Pentagon to do its share of budget pruning, but the $1.1 billion in fiscal 1970 "cuts" recently announced by Defense Secretary Laird add up for the most part to paper exercises. No big programs are canceled and much of the "savings" come from deferring some buys until 1971.

The Safeguard/Sentinel ABM system would be reduced by $997 million from the $1.8 billion asked by the Johnson Administration, but the Pentagon still pegs the over-all cost of the revised system at about $7 billion. Laird would also postpone the $326 million procurement of the SRAM missile—which doesn't work yet. And by cutting the FB-111 program to 60 planes, the Pentagon would save $428 million during fiscal 1969 and 1970.

At the same time, Laird would add $23 million to the Advanced Manned Strategic Aircraft (AMSA), which the Air Force dearly wants, so that engineering development can begin in fiscal 1970.

Among other significant changes: $43 million more for an expanded satellite early-warning system, $15 million less for the Airborne Warning and Control System (AWACS), and $55 million less for the "McNamara Line" in Vietnam. Also, the Navy's Dash reconnaissance helicopter program is being dropped [*Electronics*, Jan. 20, p. 50] for a saving of $8 million, and a stretched-out acquisition schedule will shave Minuteman 3 by spending $135 million.

A look before baking. A backscattering thickness gage is helping to keep turbine blades off the scrap heap. Jet-engine makers bake an aluminum-silicon coating onto the blades, and if the coating is too thick or too thin, the blade has to be scrapped. Now the thickness can be checked before the coating is baked on. The backscattering gage, made by the General Nucleonics division of Tyco-Laboratories Inc., shoots beta particles from a krypton-85 source at the coated blade and counts those that bounce back. The number of backscattered particles is proportional to the thickness of the coating. The gage, built to the specifications of a large jet-engine maker, checks out one blade every 15 seconds.

Original cast. Julius Blank, one of the eight founders of what has become the Fairchild Semiconductor division and the last to hold a position at the division, has resigned to join Gordon Ness Associates, a Palo Alto, Calif., venture capital firm. Not a scientist, Blank served as business manager in the early days at Fairchild. He had lately been concerned with long-range planning and the selection of new plant sites.

Ties that bind. Eugene G. Fubini, who is leaving his post as corporate vice president and group executive at IBM to become a private technical consultant, has already signed up one of his first clients—IBM. Fubini joined the company in 1965 after a stint as Assistant Secretary of Defense and deputy director of defense research and engineering. At IBM, he was in charge of the Research and Advanced Systems Development division.

Subtracting color. Early detection of cancer of the pancreas is the aim of subtract and dual-channel color scanning techniques now in use at the Hines, Ill., Veterans Administration Hospital just outside of Chicago. The Picker Nuclear Corp., which has modified a scanner to accommodate the subtract and color circuitry developed by researchers at the hospital, is marketing the unit for about $30,000. Four have been delivered thus far, including the prototype at Hines.

Adapted to a Polaroid camera, the scanner provides printouts—color photographs of the scans appearing on the unit's oscilloscope—showing the liver, which obscures the pancreas, in two contrasting colors. Scanning information is stored on a four-channel tape recording, with one channel each for horizontal and vertical information, and two for the system's color information.

Two isotopes are used in the scanning—radioactive gold for the liver and selenomethione for both the liver and pancreas. Thus, when the gold image is subtracted from the liver scan, the liver image is eliminated altogether from the printout, and the pancreas can be examined.

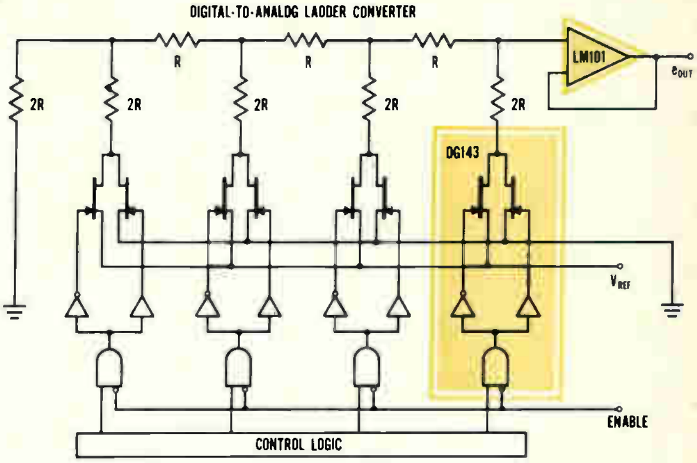
Sheriff's helper. The Ampex Corp. has sold its Videofile information system to the Los Angeles County Sheriff's Department. Described as the first application of the Videofile concept to law enforcement, the system combines videotape recording and computer technologies for the storage of visual records. Key features are file compression, rapid access, and flexibility for updating.

To be installed in 1970, the $5.6 million system will store law enforcement records, including fingerprints and photographs, on videotape in a master file and make them immediately viewable at 15 sheriff's substations throughout Los Angeles County. Equipped with filing consoles, tv monitors, and printers, these stations will be able to enter fingerprints and other documents into the master file remotely, and retrieve documents as tv images or printed copies. The sheriff's department figures it will save $1.5 million annually in record-keeping costs by going to the Ampex system to store its visual information.

Siliconix offers over 32 integrated driver/switch combinations particularly suited to data transmission systems. Choose from a wide variety of junction or MOS FET switches, depending on your system requirements. These, combined with a Siliconix OP AMP, can be applied to a great variety of data transmission requirements.

Functional Description	Type	Max. $r_{DS(ON)}$ (ohms)	Switch Type
SPDT 1-CHANNEL	DG136 SI3002	600 600	PMOS NMOS PMOS
SPDT 1-CHANNEL	DG113 143 144 146	600 80 30 10	PMOS N N N

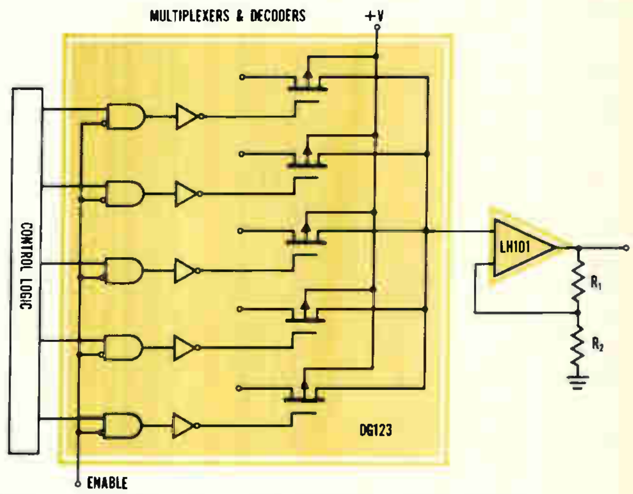
A number of switches with the ON resistance ranges best suited to your application are available from Siliconix. These driver-switches accept standard DTL, RTL, and TTL logic control inputs.



We recommend Junction FETs for this popular digital to analog converter, but if you prefer MOS FETs, we have them, too.

Functional Description	Channels	Type	Max. $r_{DS(ON)}$ (ohms)	Switch Type
ENABLE DG123	2	DG102 103 104 110 111 112 133 134 141 147 148	100 100 100 600 600 600 30 80 10 600 40	N N N PMOS PMOS PMOS N N N PMOS PMOS
	4	DG116 118	600 600	PMOS PMOS
	5	DG123 125	600 600	PMOS PMOS

System requirements will dictate which of the above combinations are best for your multiplexer combination.



Only one TO-86 package is required to accomplish the above switching functions. Packages include switch drivers that accept standard DTL, RTL, or TTL logic signals.

SILICONIX OP AMPS	Max. input offset voltage −55 to +125°C	Max. input current	Min. open loop gain	Output voltage swing	Slew rate	
LM 101 LH 101 (Internally compensated)	6 mV	200 nA	50K	±12V	.25V/μsec.	• Operation from ±5 to ±20V power supplies • Low current drain • Continuous short circuit protection • Same pin configuration as 709 amplifier
L 120	200 mV	50 pA	100	±12V	20V/μsec.	• Low input leakage • High slew rate • Unity gain stable • Ideal for sample and hold, integrating and fast voltage comparisons

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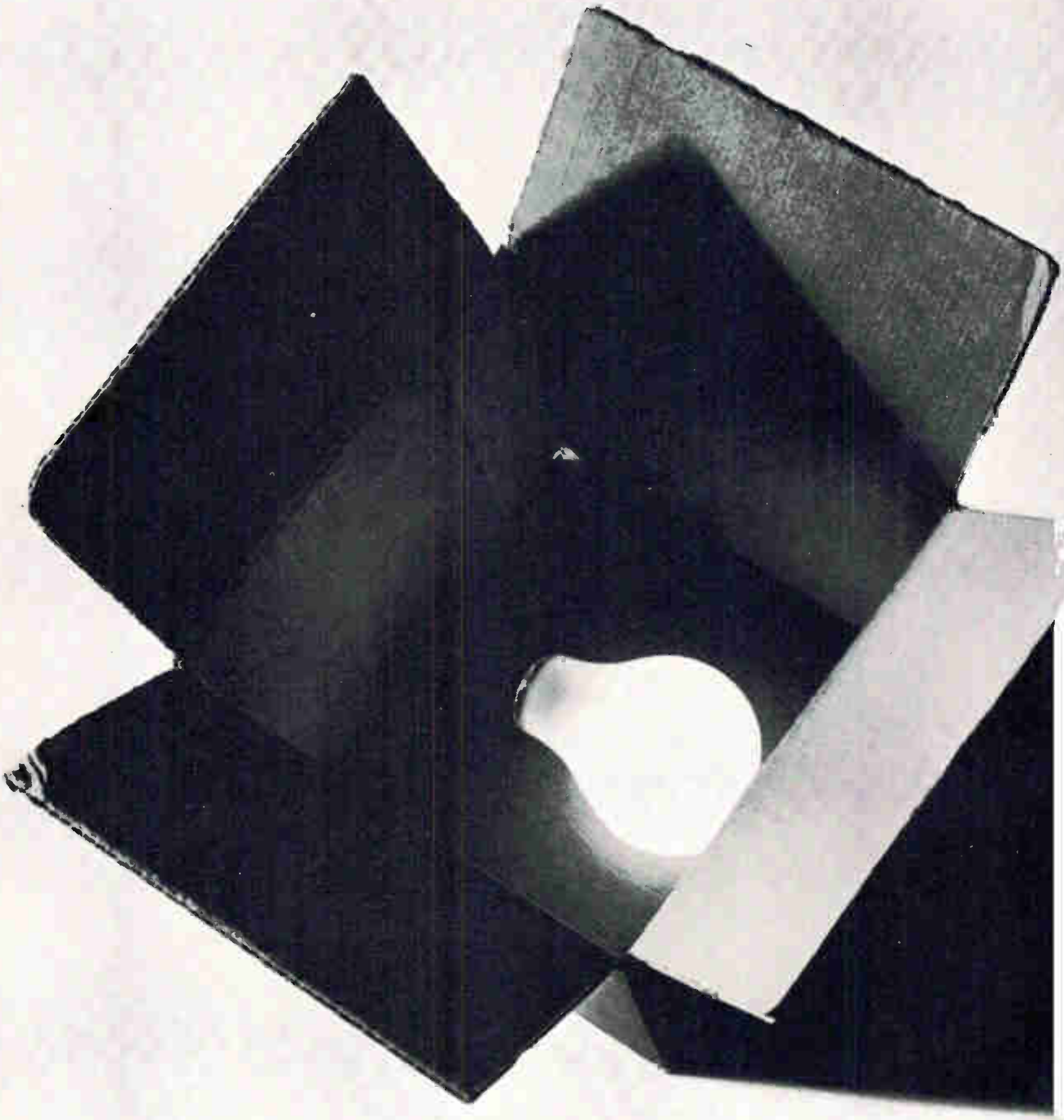

Many wafers ago Raytheon drafted a blueprint for success in the semiconductor industry. It's drawn around some very sharp idea men to nudge the state-of-the-art ever forward. Plus a production line that can turn ideas into products and pour them out en masse and on time. Here's a roll call of results, delivered and on the way.

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Linears: Industry's broadest line of popular types. 17 circuits, including standard and 'A' versions of 100, 4100, 700 and 4700 Series.

Transistors: More than 400 standard and high-rel mil types. Switches, drivers, choppers. And amplifiers—general purpose, low level, high frequency, differential, dual and Darlington.

Diodes: 1800 types of switching and general purpose diodes, ranging from IN91 to IN4308, at speeds down to 1.0 nanoseconds.

And ideas for tomorrow

But the best is yet to come. Here's what's cooking for delivery within one year. Beam lead, of course. Plus 2-layer metal interconnects. 64-bit random access memories. 256-bit read-only memories. Multi-chip memory arrays. Very high speed logic. High speed NPN and PNP single and quad core drivers. Monolithic diode arrays. RF transistors.

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Just promises? Not so. We're working on everything on that list, logging day-by-day progress toward production. So keep your eye on us. Because we intend to be getting the ideas—and delivering them—for a long time to come.

Browse through one of our detailed, just-completed catalogs. Yours for the asking. Raytheon Semiconductor, Mountain View, California, (415) 968-9211.

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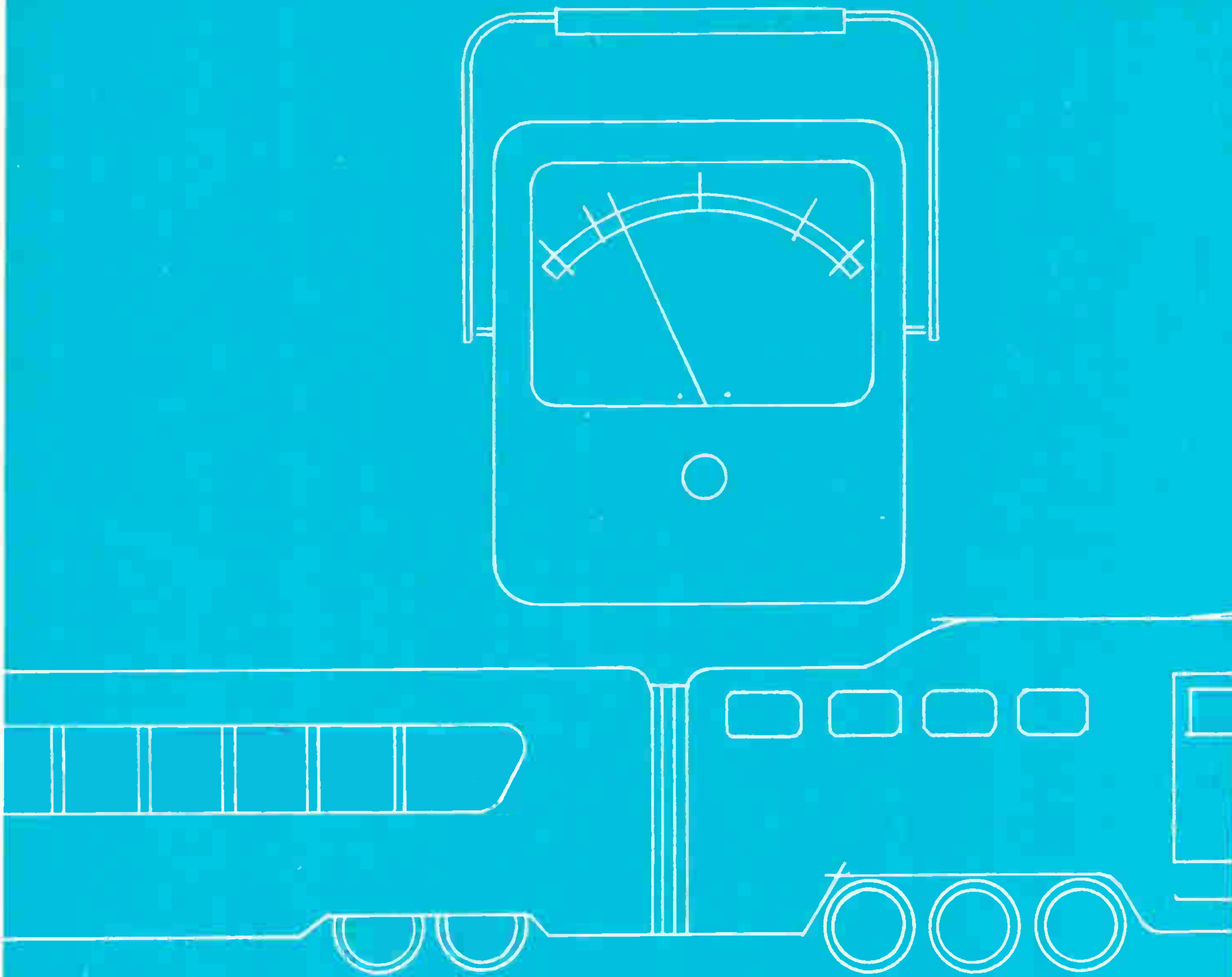

Circle 67 on reader service card

Washington Newsletter

April 14, 1969

Army takes to IC's in plastic packages

With all the hullabaloo these days over whether plastic packages for integrated circuits are reliable enough for military applications—the makers saying yes and the services, particularly Rome Air Development Center, still saying no—one Army project has quietly been using plastic-encapsulated IC's operationally for several months.

In a highly-classified research and development program, plastic-packaged IC's have been designed into a fuze. And since last year, small lots—1,500 to 2,000 rounds—of shells using the fuze have been employed in Vietnam. Apparently, the results have been highly successful. A large buy is expected, possibly this month.

The overriding factor in favor of the plastic-package was its shock resistance. This benefit overruled any misgivings that the Army might have had about the plastic packages' moisture resistance.

FCC seeks a study of microwaves . . .

Within the next few weeks the Federal Communications Commission will request proposals for a comprehensive analysis of microwave-spectrum allocation. The contract will be awarded in June. According to a high-ranking engineer at the FCC, the study will concentrate on the techniques now used to determine the assignment of microwave frequencies, and on ways in which new technology can permit more effective use of these frequencies.

Meanwhile, the FCC is considering a follow-on effort to implement the results of a land-mobile-spectrum study the Stanford Research Institute is just completing. The commission would like to keep outside contractors working in this area, but it faces the question of where the funds will come from.

. . . and expert advice on black-box tariff

Watch for the "Carterphone case" tariff to get hot again at the Federal Communications Commission. The tariff, as set up by Bell Telephone, requires a "black box"—supplied by Bell for $2 a month—between foreign attachments and telephone lines. Manufacturers of foreign attachments are starting to complain loudly about it. The FCC will be pressured to drop the tariff and allow customer-supplied devices to be directly joined to the lines. Common Carrier Bureau Chief Bernard Strassberg will soon call informal conferences on the question. The conference has been held up until the selection of a "prestigious" advisory panel is completed.

Meanwhile, the new tariff has enabled the Xerox Corp. to offer long-distance transmissions of copies of documents at prices sometimes competitive with telegraph rates, and the FCC is starting to think about how this will affect Western Union and its domestic telegraph monopoly.

Plan data systems at 40 Army posts

Later this year, the Army is expected to decide what system and software components it wants for COCOAS, Continental Army Command Class 1 Automatic System. Now undergoing prototype evaluation at Fort Sill, Okla., the computer system would completely automate about 12 post administrative and bookkeeping functions, such as finance, supply, and personnel. An IBM 360/30 is being used in the evaluation but won't necessarily be the final main frame. The Army wants to put the system in about 40 U.S. posts [see page 14].

←Circle 68 on reader service card

Washington Newsletter

Project overruns face triple threat

Watch for increased Pentagon and Congressional attention into the problem of cost overruns on military contracts. Defense Secretary Melvin R. Laird acknowledged before Congress this month that he's "uncovered" overruns amounting to $1.8 billion in current programs such as the Army's Cheyenne helicopter, the Air Force's C-5A (both made by Lockheed) and F-111 A/E/D aircraft (made by General Dynamics), and Navy shipbuilding programs. **Contractors whose projects are not in trouble might also put pressure on Congress to act.** These contractors are understood to be worrying that their own projects might get cut back or squeezed out because of money diverted to pay for overruns.

Packard may be kept muzzled after falling into a credibility gap

Some observers expect Defense Secretary Laird to keep his deputy, David Packard, under wraps for a while. **Packard embarrassed the Pentagon twice recently in testimony on the Safeguard/Sentinel system before Senate questioners.** Once, when asked if he'd consulted with any scientists outside the Defense Department on the ABM program, he named a man who later told the Senators that his contact with Packard was limited to a brief, casual conversation at an airport. **Moreover, the scientist turned out to harbor some "serious engineering criticism" of the program.** In the other instance, Packard tried to discredit another expert by referring to him as an opponent of the Polaris missile program; **this the man vehemently denied.**

NASA succeeding in long-range sell for space station

While there are no major funds in the fiscal 1970 NASA budget request for a national space station, **NASA officials are using House and Senate budget hearings to "presell"** the mammoth mid-1970 program. In spelling out details, NASA is dwelling at length on the valuable applications. The national space complex would be planned for 10 years of continuous operation, requiring highly reliable subsystems as well as design provisions for maintenance and repair. The complex would be composed of separately launched modules—such as laboratory systems, crew quarters, and storage modules—which would be added to expand the size of the basic station. **Thus far, the trial balloon has not hit any snags and Congressmen seem more interested than skeptical.** Initial cost estimates are about $10 billion for R&D, administration, and initial operation.

Addenda

The Government appears to be backing down in its battle with the Allen-Bradley Co. over the Milwaukee firm's Negro hiring practices [*Electronics,* Jan. 20, p. 48]. Secretary of Labor George Schultz has asked that the original three-man panel meet April 17 to try to work out a program for hiring more Negroes. In the past, Allen-Bradley insisted it was not willing to agree to any programs that might give Negroes an advantage over whites. Labor Department lawyers handling the case have maintained that Allen-Bradley has had plenty of time to comply with regulations applying to Federal contractors. They sought to bar Allen-Bradley from Government contracts until the firm complies, but Schultz wants to avoid a showdown. . . . **William Scranton, ex-Governor of Pennsylvania, has been named to succeed Ambassador Leonard Marks as head of the United States delegation to the International Telecommunications Satellite Consortium.** With the lackluster showing of the U.S. in the first round of Intelsat negotiations, Scranton has been handpicked by the President to bolster the U.S. position in the 68-member Consortium.

2760 watts and 7″ panel height?
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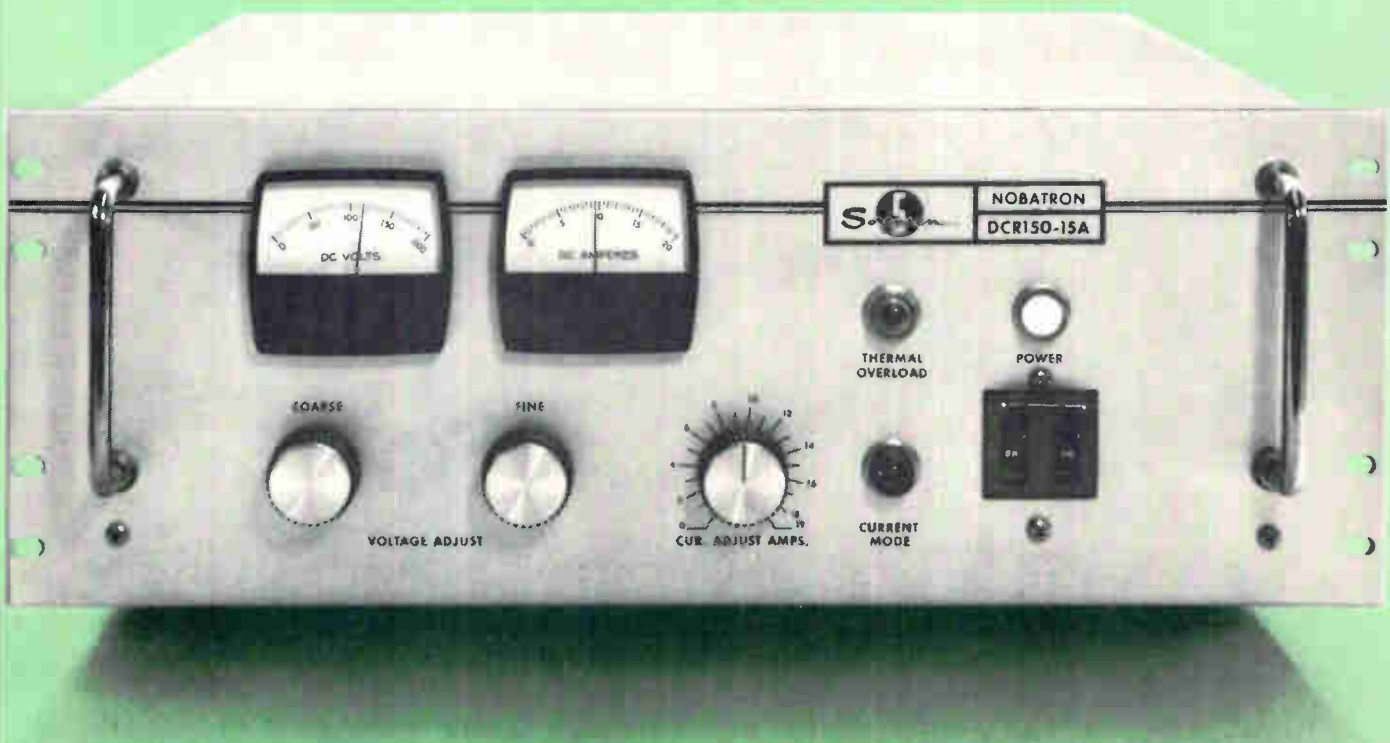

The multi-temperature rated DCR Series (115% I_o @ 30°C/100% I_o @ 55°C/65% I_o @ 71°C) contains eleven models which are available from stock in the 7″ high package utilized by model DCR 150-15A. They cover the voltage ranges of 0-20, 40, 60, 80, 150 and 300Vdc at currents to 144A.

Features include: ▪ ±0.075% voltage regulation and current regulation with automatic crossover ▪ optional overvoltage protection ▪ compliance with MIL-I-26600 and MIL-I-6181D ▪ 25,000 hour MTBF.

The versatile and proven performance of these models make them ideal for industrial or scientific applications such as: life testing or production aging of semiconductor devices, forming electrolytic capacitors, controlled charging and discharging of batteries, precision electroplating and controlling magnetic devices.

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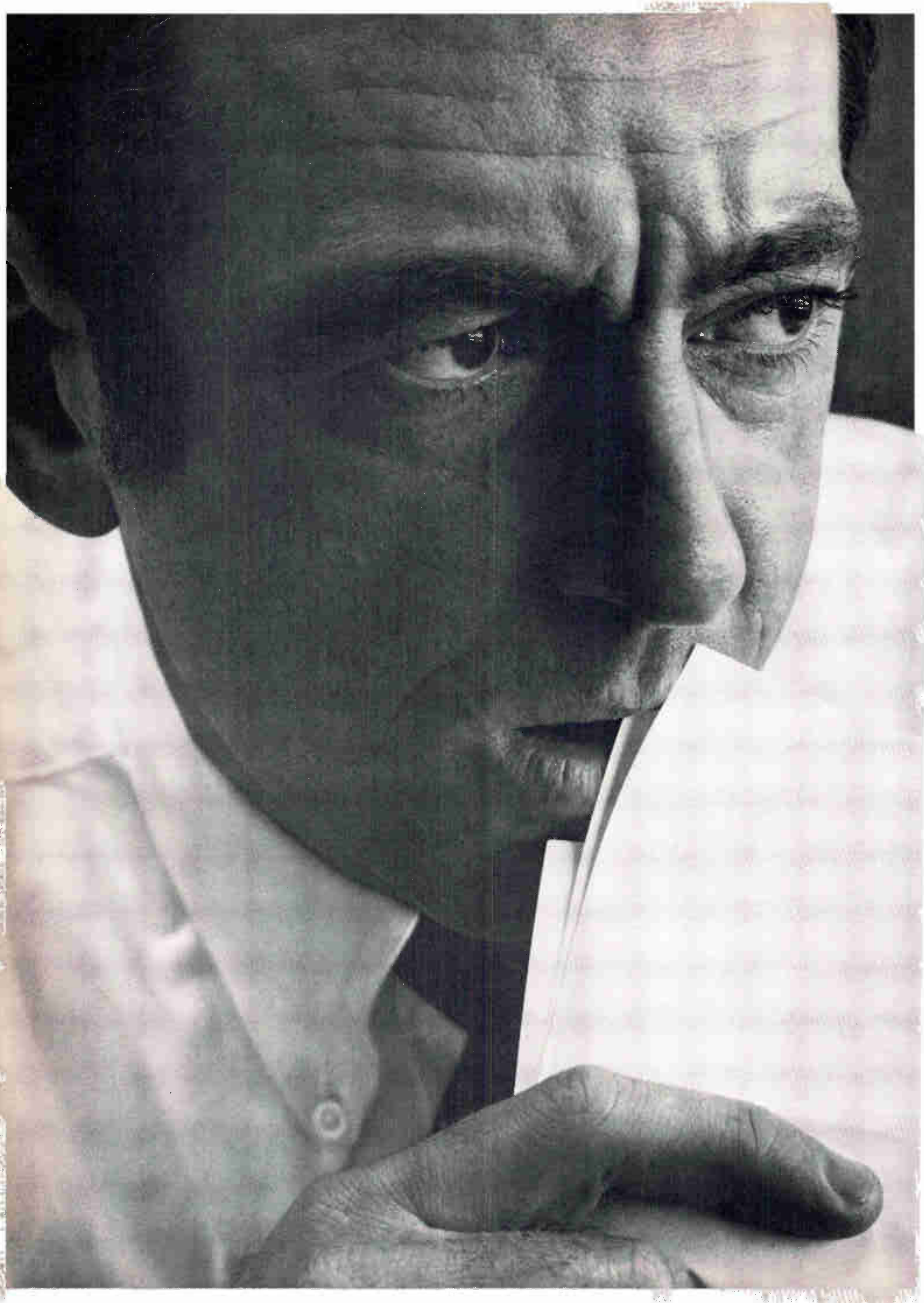

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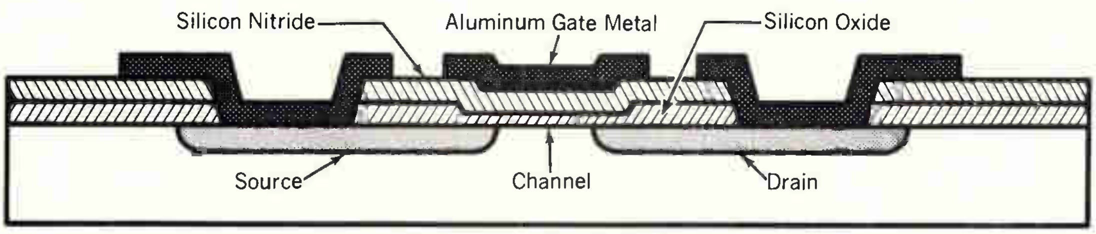
first it was MOS...
then it was MTOS...

now it's...

The Nitride "Sandwich"



Cross-section of MTNS device

General Instrument's MTNS (Metal-Thick Oxide-Nitride-Silicon) represents the latest stage in the development of Large Scale Integration that began with MOS and continued with MTOS. The exclusive Silicon Nitride process signifies the achievement of goals General Instrument has intensively pursued since pioneering in this technology...constant improvement in reliability, performance and cost reduction in LSI.

At the basis of this latest advance in the technology is the Nitride "sandwich." The low threshold voltages achieved (typically 2 volts) allow General Instrument LSI circuits to be directly compatible with existing TTL, DTL circuits — ie, they can be driven from and are capable of driving bipolar ICs. The importance of eliminating the interface circuitry usually required in any given system can hardly be stressed enough in terms of the resulting systems' cost saving, performance and reliability. Several good things happen right off.

- First, there is a reduction in the number of system power supplies required. The –27 volt supply is eliminated completely. The existing 5 or 6 volt supply used for the bipolar devices can be used as one of the nitride device supplies. The only other supply needed is –12 volts which is often available in the system.
- Second, elimination of the interface circuits, which often cost more than the LSI circuit they interface, eliminates additional propagation delays which degrade system performance.
- Third, the reduced parts count and reduced number of interconnections enhance system reliability.

The silicon nitride used in the gate structure of the device has some very desirable qualities. One of these is a high dielectric constant. It is, in fact, this feature which makes possible the low threshold voltage. The high dielectric constant also manifests itself in an electrical parameter called k′, increasing it by

MTNS

An exclusive Nitride process that makes General Instrument LSI circuits directly compatible with bipolar ICs (without input-output interfacing)

50%. (k' is the gain factor of the device.) The increased k' makes possible both faster circuits and lower "on resistance" devices.

Another property of the silicon nitride is its extremely good passivation characteristics. Silicon nitride is virtually impervious to sodium ion migration at temperatures in excess of 200°C. This has impact on cost in that devices may be encapsulated in inexpensive plastic packages . . . and impact on reliability in that in a hermetically sealed package this characteristic gives added protection against contamination.

The gate structure of these devices is actually a sandwich of silicon oxide and silicon nitride. These two materials are incorporated in the structure by two different kinetic processes which tend to compensate each other in that pinholes introduced by the one process are eliminated by the second. This reduces that normal occurrence of short circuits caused by pinholes in gate areas, raises yield and results in lower cost.

Increased Operating Temperature
An important property of the nitride process relates to high temperature operation. With proper engineering design, circuits can be made to operate at 125°C. The nitride passivation qualities eliminate concern for contamination migration at elevated temperature and therefore, MTNS devices are typically rated at 125°C. Another consideration in this rating is that the low voltage circuits typically dissipate less power than the standard voltage circuits and therefore have less internal heating which keeps junction temperatures nearer to the ambient temperature.

Reduction In Power Dissipation
One of the more dramatic results of the nitride process is the reduction of power dissipation of dc and two phase circuits. Reducing the V_{dd} supply from the usual 12 volts to 6 volts reduces power by a factor of 4 for the same operating speed.

Increased Operating Frequency
When driving into a TTL circuit, the operating frequency of the device is usually increased. This comes about because MTNS devices are typically frequency-limited by the output stage, being much faster internally. Limiting the output voltage swing to less than 4 volts by driving into TTL then raises the frequency limit.

General Instrument has been delivering thousands of MTNS circuits for selected military applications over the past six months, where particular advantage has been taken of their unique properties. A standard product line for general use will be available from distributors beginning in 60 days.

MTNS not only sets significantly higher standards of performance and reliability, but it also affords a degree of flexibility of design and application previously unattainable. General Instrument engineers are ready and anxious to assist you in exploring the vast and intriguing possibilities both in standard and custom circuits.

Write to General Instrument Corporation, Microelectronics Division, 600 West John St., Hicksville, L. I., New York. (In Europe, to General Instrument Europe S.P.A., Piazza Amendola 9, 20149 Milano, Italy.)

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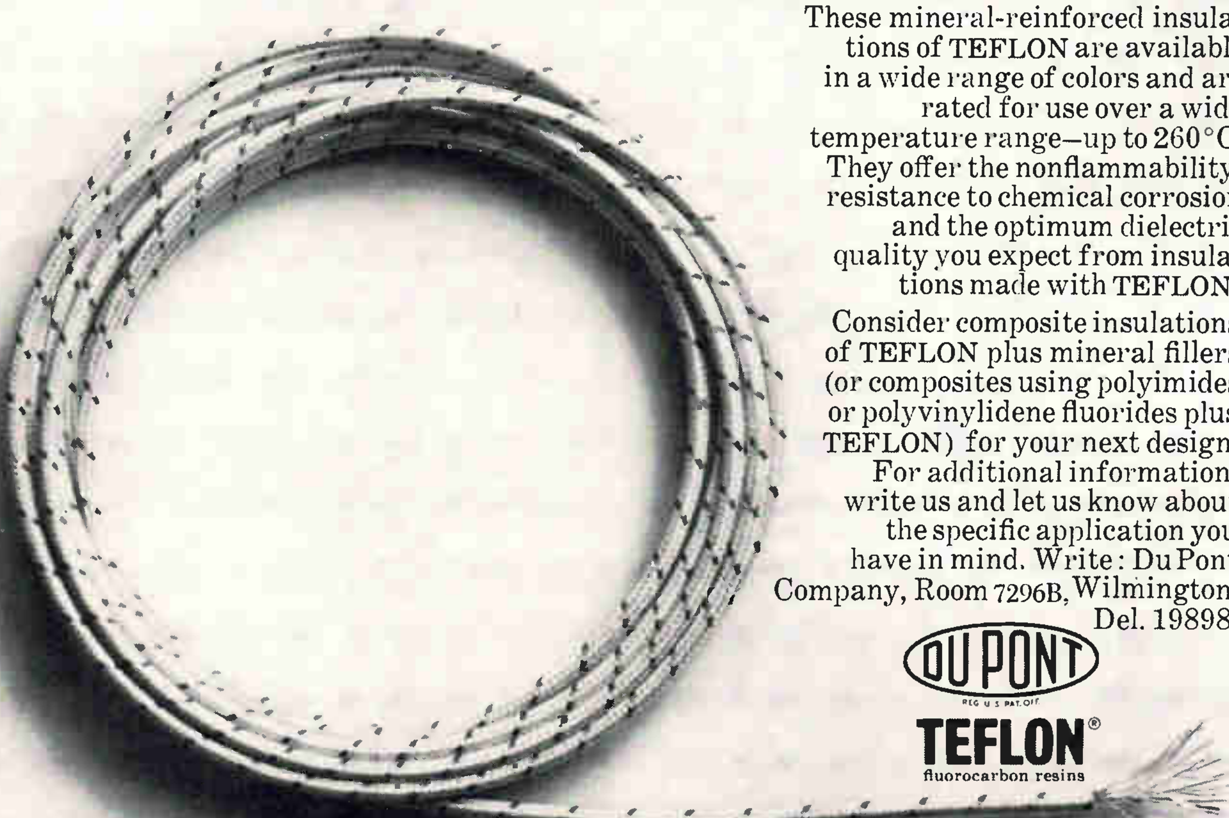
These mineral-reinforced insulations of TEFLON are available in a wide range of colors and are rated for use over a wide temperature range—up to 260°C. They offer the nonflammability, resistance to chemical corrosion and the optimum dielectric quality you expect from insulations made with TEFLON.

Consider composite insulations of TEFLON plus mineral fillers (or composites using polyimides or polyvinylidene fluorides plus TEFLON) for your next design. For additional information, write us and let us know about the specific application you have in mind. Write: Du Pont Company, Room 7296B, Wilmington, Del. 19898.



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- **Regulation** (line or load)—0.01% + 1mV.
- **Ripple**—500 μV RMS, 1.5 mV p-p. Models LP-415 and LP-425-FM only—1mV RMS, 3mV p-p.

LP Series ¼-rack models		Size: 5³⁄₁₆" x 4³⁄₁₆" x 10"				
Model	Voltage Range VDC	MAX. AMPS AT AMBIENT OF:[1] 30°C	40°C	50°C	60°C	Price[2]
LP-410*	0-10	0-2A	0-1.8A	0-1.6A	0-1.4A	$129
LP-411*	0-20	0-1.2A	0-1.1A	0-1.0A	0-0.8A	119
LP-412*	0-40	0-0.70A	0-0.65A	0-0.60A	0-0.50A	114
LP-413*	0-60	0-0.45A	0-0.41A	0-0.37A	0-0.33A	129
LP-414	0-120	0-0.20A	0-0.18A	0-0.16A	0-0.12A	149
LP-415	0-250	0-80mA	0-72mA	0-65mA	0-60mA	164

LPD Series ½-rack models		Size: 5³⁄₁₆" x 8⅜" x 10⅝"				
Model	Voltage Range Per output/Outputs in series VDC	I MAX AMPS AT AMBIENT OF:(1) Per output/Outputs in parallel 30 C	40 C	50 C	60 C	Price(3)
LPD-421-FM*	0-±20 0-40	1.7A 3.4A	1.5A/3.0A	1.3A/2.6A	0.9A 1.8A	$325
LPD-422-FM*	0-±40 0-80	1.0A 2.0A	0.85A 1.7A	0.7A/1.4A	0.55A 1.1A	260
LPD-423-FM*	0-±60 0-120	0.7A 1.4A	0.6A 1.2A	0.5A 1.0A	0.4A 0.8A	325
LPD-424-FM	0-±120 0-240	0.38A 0.76A	0.32A 0.64A	0.26A 0.52A	0.20A 0.40A	325
LPD-425-FM	0-±250 0-500	0.13A/0.26A	0.12A 0.24A	0.11A 0.22A	0.10A 0.20A	350

NOTES:

* Overvoltage Protection available as an accessory. Each output requires separate OV accessory—add $35.00 for each output.
1 Current rating applies over entire voltage range. Ratings based on 57-63 Hz operation.
2 Prices of LP series are for non-metered models. For metered models, add suffix (-FM) and add $10.00 to price.
3 Prices of LPD series are for metered models. LPD Series models are not available without meters.

- **AC Input**—105-132 VAC 47-440 Hz (ratings based on 57-63 Hz operation). For operation at 205-265 VAC, add suffix "-V" to model numbers. No change in price.
- **Temperature coefficient**—0.015% + 0.5mV/°C.
- **Auto Series/Auto Parallel with Master-Slave tracking**
- **All silicon-designed for maximum reliability**
- **Convection cooled**—no blowers, no external heat sinks.
- **Constant voltage/constant current.**
- **Designed to meet RFI** per MIL STD 826A.
- **Remotely programable.**
- **Remote sensing.**
- **Fungus Proofing Option**—Add suffix "R" to model number and add $15.00 to price.

Accessories

Rack Adapter LRA-1 Price $60.00 • 5¼" H x 16½" D
Rack Adapter LRA-2 Price $35.00 • 5¼" H

OVERVOLTAGE PROTECTION ACCESSORIES			
For Use With	Model	Adj. Volt Range	Price per Output
LP-410; (0-10VDC)	LH-OV-4	3-24V	$35
LP-411; LPD-421-FM (0-20VDC)	LH-OV-4	3-24V	35
LP-412; LPD-422-FM (0-40VDC)	LH-OV-5	3-47V	35
LP--413; LPD-423-FM (0-60VDC)	LH-OV-6	3-70V	35

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½ rack models

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Features and Data

- **0.0005% plus 100μ regulation.**
- **35μV rms, 100μ p-to-p ripple.**
- **AC Input:** 105-132 VAC, 47-440 Hz (Ratings based on 55-65 Hz; derate current 10% at 50 Hz.) 205-265 VAC on request at no extra charge ("-V" option).
- **2 meters** monitor both voltage and current simultaneously and continuously.
- **Accuracy**—0.01% plus 1mV
- **Stability**—0.001% plus 100μV for 8 hours
- **Temperature coefficient**—0.001% plus 10μV/°C
- **Multi-Current-Rated.**

LR Series ¼-rack models		Size: 5$\frac{3}{16}$" x 4$\frac{3}{16}$" x 15½"				
Model	Voltage Range	MAX. AMPS AT AMBIENT OF:[1]				Price
		30°C	40°C	50°C	60°C	
LR-602-FM	0-20 VDC	1.1	.95	.80	.64	$265
LR-603-FM	0-40 VDC	.60	.50	.42	.33	265
LR-605-FM	0-120 VDC	.23	.20	.17	.14	295
LR-606-FM	0-250 VDC	80ma	72ma	65ma	60ma	310

LR Series ½-rack models		Size: 5$\frac{3}{16}$" x 8⅜" x 10⅝"				
Model	Voltage Range	MAX. AMPS AT AMBIENT OF:[1]				Price[2]
		30°C	40°C	50°C	60°C	
LR-612-FM	0-20 VDC	1.8A	1.6A	1.3A	1.1A	$305
LR-613-FM	0-40 VDC	1.0A	0.9A	0.75A	0.6A	305
LR-615-FM	0-120 VDC	0.33A	0.29A	0.25A	0.21A	320
LR-616-FM	0-250 VDC	100ma	90ma	80ma	70ma	340

NOTES:
1 Current rating applies over entire voltage range. Ratings based on 55-65 Hz operation. Derate current 10% for 50 Hz input.
2 Prices are for metered models. LR Series models are not available without meters.

- **Guaranteed for 5 years.** The only 5-year guarantee that includes labor as well as parts. Guarantee applies to operation *at full published specifications* at end of 5 years.
- **Only 5¼" high.** Convenient ¼ and ½ rack sizes for rack or bench use.
- **All silicon-designed for maximum reliability.**
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- **Auto Series/Auto Parallel** with Master-Slave tracking.
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OVERVOLTAGE PROTECTION ACCESSORIES			
For Use With	Model	Adj. Volt Range	Price
LR-602-FM, LR-612-FM	LH-OV-4	3-24 V	$35
LR-603-FM, LR-613-FM	LH-OV-5	3-47 V	35

Prices F.O.B. factory, Melville, N. Y. All specifications and prices subject to change without notice.

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Q25AH is a wideband, high reliability FET. 1,000,000 hours logged without a single failure. TO-8 case. $180 each in 1-9 quantity.

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PHILBRICK/NEXUS RESEARCH

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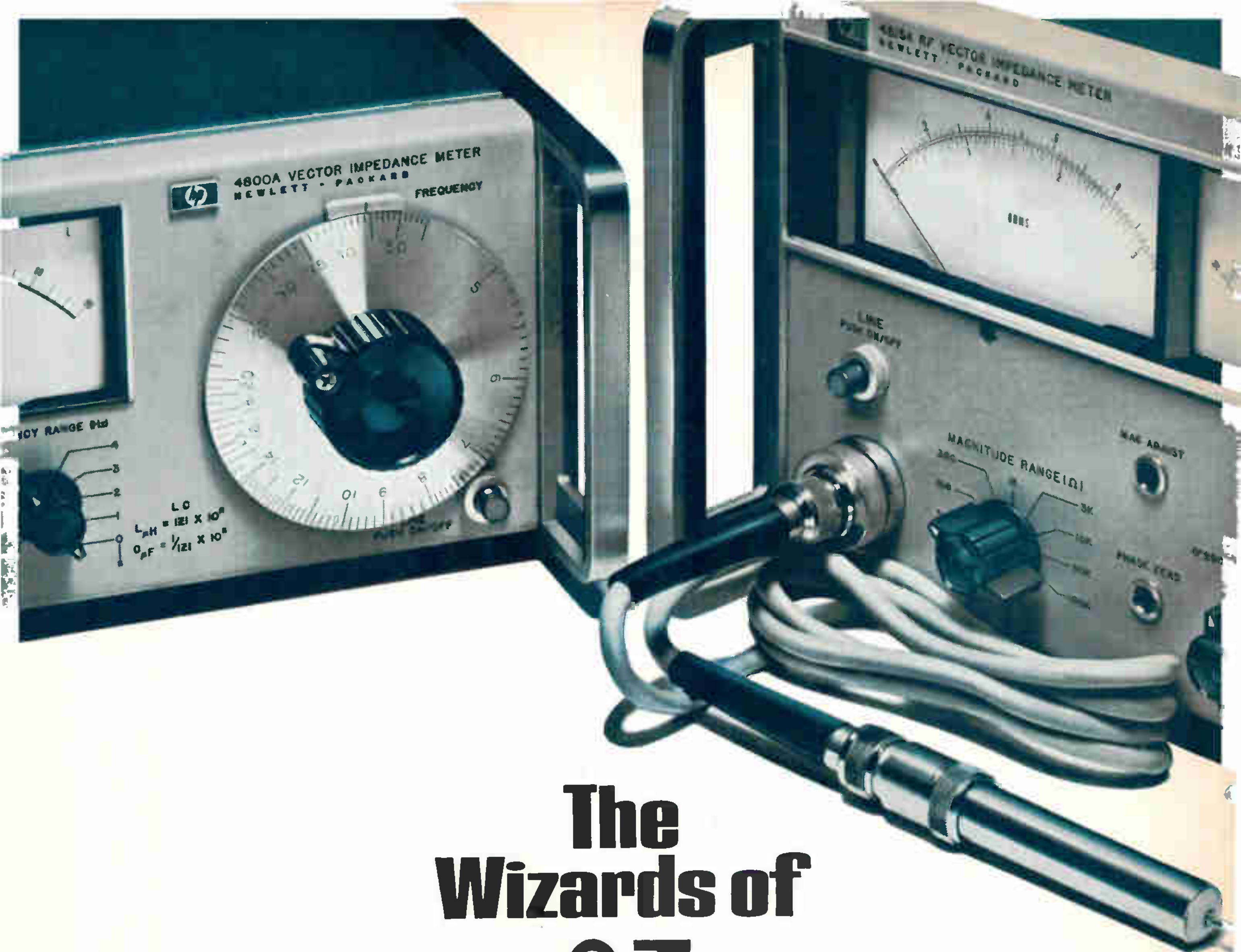

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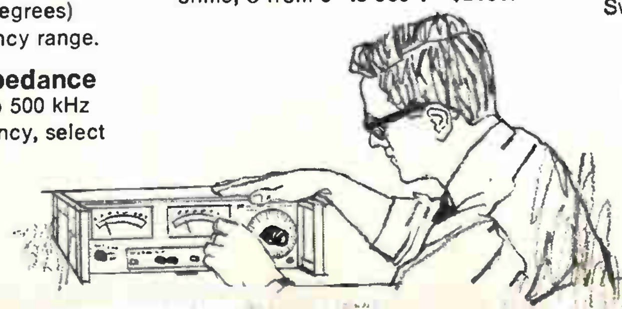

Application Note 86 describes many applications of the 4800A and the 4815A Vector Impedance Meters including the measurement of Z, R, L, and C. For your copy and complete specifications, contact your local Hewlett-Packard field engineer or write: Hewlett-Packard, Green Pond Road, Rockaway, New Jersey 07866. In Europe: 1217 Meyrin-Geneva, Switzerland.

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IMPEDANCE INSTRUMENTS

Technical Articles

Sonic film memory is a sound bet
page 90

The sonic film memory combines some of the characteristics of planar thin-film units, sonic delay lines, and magnetic drums. But unlike these others, it's capable of nondestructive readout, is nonvolatile, and doesn't require mechanical bearings and linkages. The sonic film memory takes advantage of an anistropic thin film's magnetostrictive properties to change its magnetic state or generate a readout pulse as a strain wave propagates through the substrate.

Designing lumped elements into uhf and microwave amplifiers
page 100

Circuit designers have generally avoided lumped passive elements for high-frequency jobs because of distributed reactance effects. As a rule, microstrip has been used to interconnect active devices with matching, filtering, and biasing circuitry. Now, however, RCA engineers, using photoresist techniques originally developed for transistor technology, are turning out passive elements so small that distributed effects aren't critical factors in performance. The company is putting these devices in hybrid power amplifiers operating at uhf and microwave frequencies. The amps perform as well as conventional assemblies, are smaller, and promise cost savings since the passive circuitry can be batch processed. On the cover is 40-watt amplifier built by RCA with lumped elements; it has a 16-decibel gain at 350 megahertz.

Want to be a good loser? Go about it systematically
page 112

Design failures—equipment that looks fine on the drawing board and works well in the lab but which bombs out when produced and sold in volume—may occasionally occur by chance. In most cases, however, the designer has dutifully followed some or all of these easy-to-learn, time-tested guidelines to disaster.

Active filters: part 9 applying nonlinear elements
page 116

When faced with the task of filtering or frequency-tuning in high-temperature or radiation-affected environments, designers can turn to offbeat devices like magnetoresistive and Hall-effect assemblies, which also afford space savings.

Coming

Systems engineering—myth and methodology

For better or worse, systems engineering—a concept still in search of a consensus definition—is being applied to large-scale projects in the hope of saving time, money, and effort. The verdict on its efficacy, particularly with regard to engineering creativity, is still in doubt.

Memories XVIII

Sonic film unit is a sound bet

A strain wave moves along a substrate under an isotropic magnetic film in experimental memory that reads and writes, is nonvolatile, and isn't saddled with mechanical contrivances

By Rabah Shahbender

RCA Laboratories, Princeton, N.J.

Strain waves interacting with magnetic film elements form an unusual memory—the sonic film. In the technique, which RCA Laboratories has been investigating for several years, strain waves travel at the speed of sound along a substrate under an anisotropic magnetic film, taking advantage of the latter's magnetostrictive properties to record data in it. The aim is to produce a block-oriented random-access memory (Boram), in which blocks of data are accessible randomly at electronic speed but from which data can be retrieved only a whole block at a time, not in individual words.

It's still an experimental technique; current work is primarily in improving ways to launch the strain wave and in measuring its characteristics. This research will probably continue for at least another year, after which a program must be undertaken to develop methods to deposit the film, make the transducer, package the unit mechanically, and so on—probably one or two years' more work. At that point the technique may become suitable for a commercial product, depending on the status of competitive techniques, its prospects now are bright.

Like those of the planar thin-film memory, the sonic film memory elements are a series of thin-film spots or strips deposited on a substrate of glass or similar material. But the sonic film memory is capable of nondestructive readout; whereas planar thin-film memories, in general, have destructive readout—that is, all information taken from them must be regenerated if it is to be available for later reuse. [Cylindrical thin films, or plated wires, are also capable of nondestructive readout; see *Electronics*, Nov. 11, 1968, p. 124.]

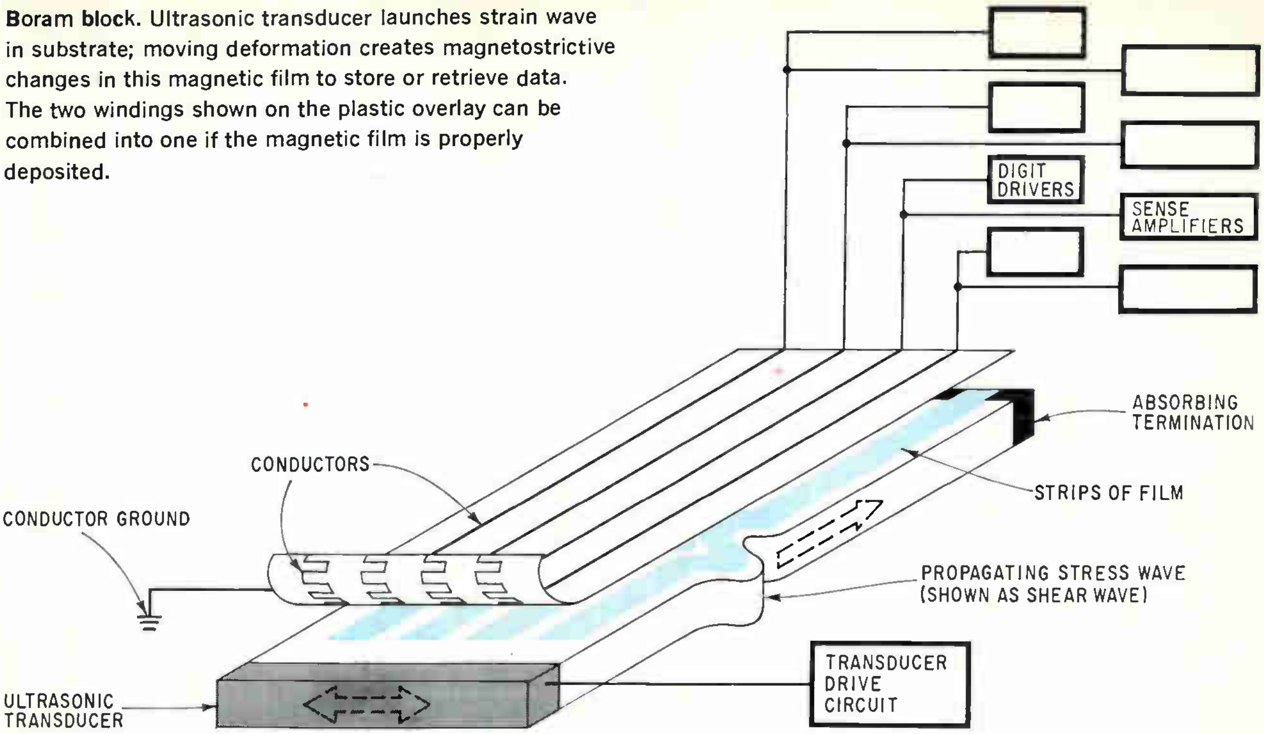
Like the sonic delay line, the sonic film depends on a piezoelectric element from which high-frequency mechanical pulses propagate through a substrate. But the sonic film memory is nonvolatile, whereas the data stored in a sonic delay line vanishes when power is shut off.

> This is the eighth installment in *Electronics*' continuing series on memory technology, which began in the Oct. 28, 1968, issue.

Like the electromechanical disk or drum unit, the sonic film memory can transfer data from individual blocks or tracks at very high rates. But the sonic film memory isn't saddled with mechanical supports, linkages, drive motors, and the like, and it doesn't have to wait an average of several milliseconds, as does the mechanical unit, before it can start reading from a particular block. Furthermore, it's capable of much better volume utilization. That is, bits can fill up every cubic inch of memory instead of being scattered about on the surface.

The simplest configuration for a memory block is a series of continuous strips of anisotropic magnetic film deposited on one surface of a glassy substrate, similar to a biologist's microscope slide, as shown on page 91, top. The best results are obtained with a substrate of fused silica. The film's anisotropy creates a much larger remanent flux in a particular direction, called the easy axis, than at right angles to that direction—the hard axis. An ultrasonic transducer of lead zirconate-titanate or similar material is attached to one end of the substrate, and an ultrasonic absorbing medium is attached to the other, to prevent echoes from generating spurious outputs. Two conductors on opposite sides of a plastic sheet are put over the magnetic film strips. One conductor is the bit line, parallel to the film's hard axis; the other is a sense line, parallel to the easy axis. One of these has a zigzag pattern; which one depends on the orientation of the film relative to the direction of strain wave propagation and on whether a longitudinal or shear wave is

Boram block. Ultrasonic transducer launches strain wave in substrate; moving deformation creates magnetostrictive changes in this magnetic film to store or retrieve data. The two windings shown on the plastic overlay can be combined into one if the magnetic film is properly deposited.



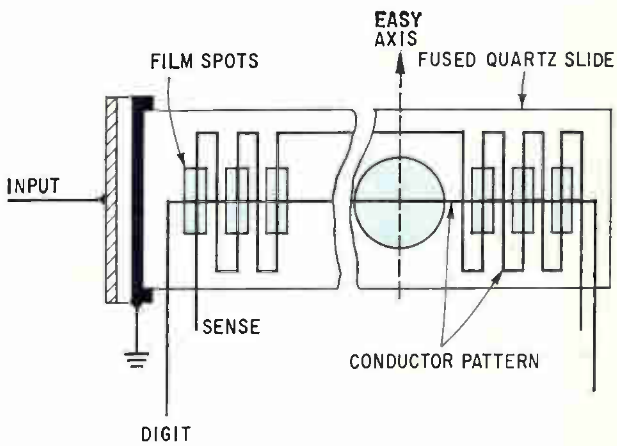
used. For the longitudinal wave, the direction of propagation is parallel to the direction of strain; for a shear wave, the two are perpendicular, with the strain parallel to the plane of the film. Any of these configurations works, but a shear wave gives the best results.

To enter data into the block, the ultrasonic transducer launches a strain wave that propagates along the glass at the speed of sound—3,760 meters per second in fused silica. For a strip 30 centimeters long, this strain wave would arrive at the absorbing medium 80 microseconds after it was launched. As it passes each bit position on its way along the substrate, the strain wave reduces the switching threshold of the film at that position, because of the film's magnetostrictive properties. Pulses of current in the bit line can reverse the magnetization of the strained regions of the film without affecting that of the unstrained regions; properly timed pulses can therefore write data in the film as the strain wave moves along the substrate.

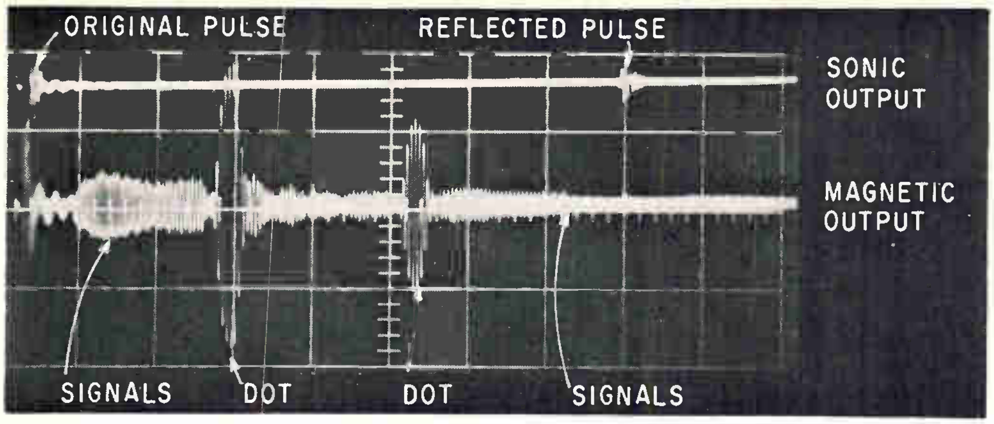
Likewise, as a strain wave passes a given region of the film in the absence of a writing pulse, the film's magnetization rotates slightly but doesn't reverse; this rotation generates a voltage in the sense winding. The polarity of the induced voltage depends on the remanent state of magnetization corresponding to the stored data.

This description is somewhat oversimplified. Actually, either rotation of the easy axis or reduction of the anisotropy field, or a combination of both, can be used for either writing or reading. But in any case, a single sequence of bits can be serially stored in the film, and serially read out again. Data can be processed several bits at a time—in characters or full computer words, for example—by using the necessary number of film strips on the substrate, each with its own digit and sense line and its own drive and sense circuits.

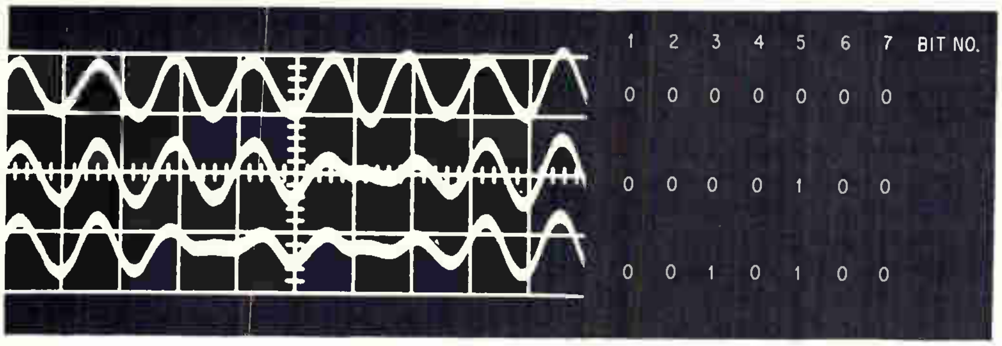
The diagrams and oscilloscope traces on page 92 show the results of tests on a sonic film memory device. These particular tests were performed on a substrate lacking an absorbing termination at the end opposite the ultrasonic transducer, so that echo signals are present. Also, the substrate had discrete film spots, measuring 20 by 50 mils, as shown below, instead of a continuous strip of film, and it had a large round patch of film in the center for testing the film's B-H loop. Other tests have shown that a continuous film strip is feasible for this memory. If



Test blocks. Initial tests were performed on this unit using individual patches of film and two separate conductors. The round spot is for testing the film's B-H loop. Later tests showed that continuous film and one conductor are feasible.



Composite signals. Upper trace shows original and reflected pulses in transducer; lower trace is signals read from film spots as sonic pulse propagates through substrate. Scales are 1 mv and 5 μsec per division.



Data pulses. In one test, pulses generated by passing sonic wave represent binary 0's; where a 1 no pulse. Scales are 0.5 mv and 0.2 μsec per division.

the film's easy axis is at an angle to the strain wave's direction of propagation, the sense and digit functions can be combined in a single winding.

The oscilloscope trace of the composite sense signal, in the top photo, also shows in its upper trace the original driving pulse and the pulse generated by the sound wave reflected from the far end of the substrate. On the lower trace are the outputs from the individual magnetic spots and a large blip generated by the round center patch. Both of these are duplicated in reverse, with reduced amplitude, as the echo pulse returns.

The sense signals from seven adjacent bit positions, expanded in the bottom photo, include 0's in all seven positions, a single 1 in position 5, and 1's in positions 3 and 5 in the three traces. A distinct change in the sense signal character is visible for the stored 1's. The encoding used in this example generated a pulse for a 0 and essentially no pulse for a 1. The reverse coding, of course, could be used instead. Timing for a series of missing pulses in succession is established by strobe signals in the amplifier.

The length of a bit in inches or centimeters is determined by the length of the strain pulse from leading to trailing edge, which is the product of the velocity of sound in the substrate and the time duration of the strain pulse. To enter data in the memory, a strained magnetic region must switch completely in less than the time required for the strain wave to pass that region.

If bits are packed onto the film at 20 per centimeter—much less than the tightest feasible packing in this technology—the strain pulse must be no more than 0.5 millimeter long. If the wave travels at 3,760 meters per second, its duration is about 125 nanoseconds, and it therefore passes a particular point in 125 nsec. Then the magnetic film must switch in less than 125 nsec—considerably less, because higher densities are more practical and there must be a margin for error. This implies a switching time of about 10 nanoseconds.

Furthermore, the current pulse that causes this switching cannot have much overdrive, or it will switch unstrained bit positions as well as the one that is strained. The switching threshold is reduced to about half its unstrained value as the strain wave passes; the current pulse should be just strong enough to clear the strained threshold reliably without affecting any unstrained part of the film.

Densities, in general, are determined by transducer characteristics. If the density is too high for a particular kind of transducer, pulse crowding will occur between adjacent bits as they interfere with one another. To a certain extent, this interference can be overcome by appropriate encoding techniques, such as phase modulation. These techniques, which guarantee at least one phase change in every bit position regardless of whether it is a 1 or a 0, are similar to those that permitted bit packing densities on magnetic tape to increase from the 556 bits per inch that was standard only a few years ago to the 3,500 or so commonly found today.

Of the various parameters of a magnetic film, the most important ones entering into the sonic film's operation as a memory are the anisotropy field, H_k, the coercive field along the easy axis, H_c, and the direction of the easy axis relative to the direction of the strain, ϕ.

The anisotropy field expresses numerically the tendency for the magnetization to lie along one of the two axes in the film. It's shown graphically in the hysteresis loops measured in the two directions, drawn below. An ideal material for the sonic film memory, when unstrained, would have a perfectly square loop in the easy direction and no loop at all in the hard direction, and these directions would interchange when the material was sufficiently strained. The best films for this purpose approach the ideal quite well. They are made from about 60% nickel, 25% iron, and 15% cobalt.

The coercive field, of course, is simply half the width of the hysteresis loop along the easy axis. It's the field necessary to reduce the remanent magnetization to zero.

Both the anisotropy field and the direction of the easy axis are affected by strain. The easy axis tends to line up with the direction of the strain—discontinuously so, if the strain is great enough and applied at right angles to the original easy axis. And the anisotropy field can increase or decrease with strain, depending on the strain's magnitude and whether it is tensile or compressive. Both the anisotropy direction and the anisotropy field as functions of strain have been derived analytically; the graphs on page 94 are plots of these derivations.

In the first graph at left, the rotation of the magnetization θ_r is plotted against the normalized strain, with the angle ϕ between the unstrained easy axis and the direction of strain as a parameter. The easy axis can be established in any direction when the film is deposited in a suitably oriented magnetic field. The normalized strain is the ratio of the actual strain to the strain that produces the discontinuous rotation at $\phi = 90°$; for highly magnetostrictive nickel-iron films the latter is 10^{-4}.

This graph shows that if the strain is applied parallel to the easy axis ($\phi = 0°$), the easy axis doesn't rotate at all. On the other hand, if the strain is applied at right angles to the easy axis, the axis jumps suddenly through 90° to align itself with the strain when the latter reaches the critical value $K = 1$, or 10^{-4}. (Of course, this is only a theoretical result, based on the analytical derivation. Truly discontinuous rotation in the mathematical sense is physically impossible. In practice, because of microscopic variations in the substrate material, the strain isn't at exactly right angles to the easy axis at every point in a sample, even a small one, nor is it exactly the same value everywhere in the sample. As a result, the easy axis rotates quickly—not discontinuously—through *about* 90° when the normalized strain is *about* 1.)

In the second graph, at right on page 94, the normalized anisotropy field, H_k, is plotted against normalized strain, again with ϕ as a parameter. Normalized anisotropy field is the ratio of the actual field to the field existing in the absence of strain. Positive strain is tensile, and negative strain is compressive; either one can increase or reduce the anisotropy field, depending on its direction relative to the unstrained easy axis. The graph shows that for positive values of K greater than 1, and with $\phi = 90°$, the anisotropy field appears to become negative. This is a result of the discontinuous rotation of the easy axis under these conditions.

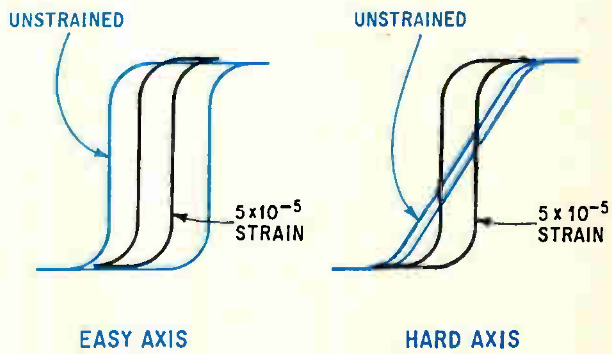
These theoretical predictions apply also to cylindrical thin films, although the details are different, of course. The predictions have been checked out experimentally.

PZT transducers

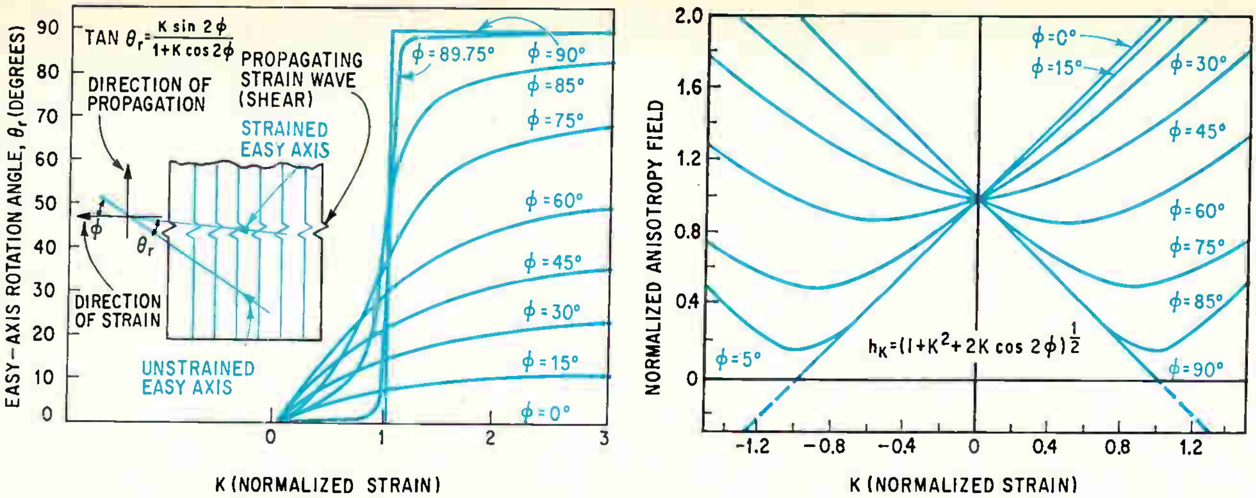
There are many piezoelectric materials, but not many that are suitable for a sonic film memory. One of the few both suitable and commercially available is lead zirconate-titanate, known as PZT from the chemical symbols for its components, Pb, Zi, and Ti. PZT transducers with a resonance frequency of 4 megahertz are readily available and are easily bonded to the ends of fused-quartz substrates; they generate ultrasonic pulses that propagate almost ideally. Unfortunately, the bit density for which this frequency is suitable is only about 25 bits per inch.

For a density of 100 bits per inch the resonant frequency is 16 Mhz. PZT transducers at this frequency are also available, but they're harder to handle, and the pulses they generate tend to travel through the substrate with velocities that are a function of frequency. Since a square pulse contains many frequencies, its shape deteriorates as it travels under these conditions, to the detriment of the output signal. The pulses are also likely to convert to other modes, analogous to the various electric and magnetic modes in a waveguide; these modes propagate at widely differing velocities, and thus produce spurious signals.

For still higher densities, up to 200 bits per inch, transducers of cadmium sulfide are being developed. These transducers are evaporated onto the substrate in somewhat the same way that the thin films are evaporated. Their resonance frequencies are in the range of 20 to 50 Mhz. These transducers, and the characteristics of the strain pulses that they generate, are the principal subjects of present in-



Toward isotropy. Sonic film's operation depends on the difference between the magnetic hysteresis loops in the easy and hard directions and the effect that strains has on them—narrowing one and widening the other.



Twist, push, and pull. Amount of easy-axis rotation caused by strain wave depends on strain's magnitude and angle relative to original easy axis, plotted at left. Inset defines the angles. Diagram at right shows how strain diminishes difference in magnetic properties between the film's easy and hard axes.

vestigations in the sonic film technology.

A sonic film memory system would comprise a large number of substrates, each carrying several film strips storing information. Each strip is equivalent to a data track, containing a number of bits depending on the bit density and the track length. These parameters in turn are limited by the resonant frequency of the driving transducers, as described above, and the attenuation of the ultrasonic pulse as it propagates in the substrate. This attenuation is not excessive in a substrate 10 inches long; if the density is 200 bits per inch, each track could hold 2,000 bits. As many as 50 tracks could be deposited on a single substrate and driven by a single transducer, resulting in a capacity of 100,000 bits per substrate. Each track would require its own digit-sense conductor with associated circuitry. Because readout is nondestructive, a small number of sense-digit circuits could be shared by a large number of tracks; data read from unselected tracks need not be sensed for regeneration.

Only 10 such substrates would provide storage for a million bits. Capacities of many megabits would thus be available in a relatively small number of substrates. In such a system the access time is determined by the speed of the circuits that select the transducers—presumably about a microsecond. After a transducer was selected and a strain wave launched along a substrate, the bit transfer rate would depend on the bit density and on the velocity of sound in the substrate—typically 32 megabits per second at 200 bits per inch density.

As mentioned previously, the sonic film memory's performance is similar to that of an electromechanical magnetic disk or drum system; its bit transfer rate is similar, but the sonic film's access time is much faster—a microsecond, compared to the drum's 30 to 40 milliseconds. In the electromechanical system the bit transfer rate depends on the bit density and on the relative velocity between the storage medium and the recording head. The velocity is limited by mechanical considerations to a few hundred feet per second, so that megabit transfer rates are obtained by packing the data at high density. In the sonic film memory, the velocity is that of sound, many thousands of feet per second, permitting high bit rates at modest densities.

From a device point of view, the sonic film memory resembles a fast thin-film memory. But, the latter's word-selection circuits are replaced by the ultrasonic transducers, each of which provides access to many more bits than the usual circuits.

Writing and reading in a sonic film memory cannot be interleaved; once a track has been selected all of it is loaded with new data, or all the old data is retrieved. This bypasses the digit transient recovery problem of other high-speed memories.

Without these transients, the sense amplifiers need not discriminate against much noise. In fact, the only noise present is the thermal noise in the amplifier itself. Because of this, even though the sonic film is block-oriented, its performance is almost as good as the performance of a wholly random-access memory. ■

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Circuit design

Designer's casebook

Transformerless d-c voltage converter is 70% efficient

By Kees Van der Geer

Jutphaas, Netherlands

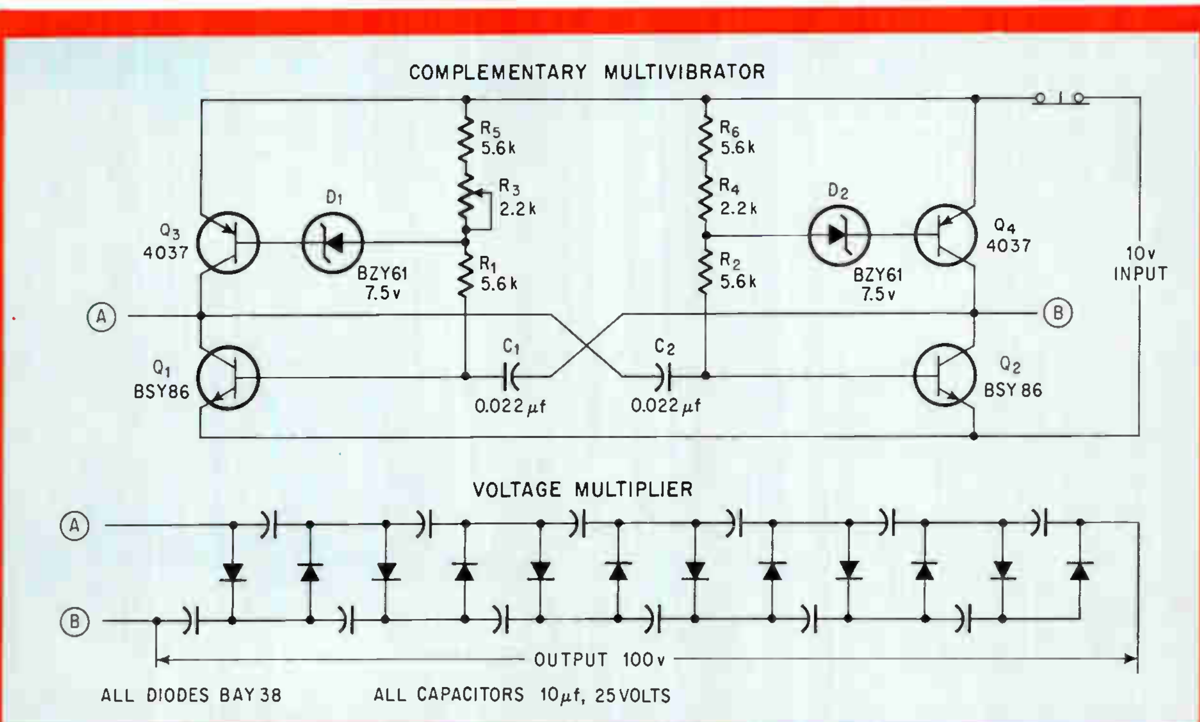
Replacing a standard multivibrator by a complementary one in a d-c voltage converter consisting of a multivibrator, a coupling network, and a standard diode-capacitor voltage multiplier increases the converter's efficiency from 1% to 70%. The complementary, unlike the standard multivibrator, has no collector resistance dissipating useful power and is therefore more suitable as the driver of the multiplier.

The multiplier, in turn, rectifies and multiplies the multivibrator's output.

The complementary multivibrator has two timing capacitors, is symmetrical, and consists of transistors Q_1 through Q_4. Q_3 and Q_4 act as collector resistances of Q_1 and Q_2. Little power is dissipated in these "resistances" because the voltage dividers $R_1 - R_3 - R_5$ and $R_2 - R_4 - R_6$ in conjunction with zener diodes D_1 and D_2 are designed so that when Q_1 or Q_2 is on, Q_3 or Q_4 is off and vice versa. This condition is met by adjusting potentiometers R_3 and R_4.

If R_3 and R_4 are too low, the multivibrator will not oscillate. If they are too high, the power dissipated can be very high and the transistors may burn out. The multivibrator does not restart itself. It can be started with a push-button in the d-c input line.

With the values shown the frequency is about 10 kilohertz. With an input voltage of 10 volts, the output voltage is about 100 volts. Power output is 280 milliwatts making the circuit about 70% efficient.



Conversion. The multivibrator's square-wave output is fed into a diode-capacitor network which rectifies the wave and multiplies the amplitude according to the number of dc stages. Either voltage polarity can be obtained at the output by merely reversing the connections of the diodes and capacitors.

One-shot multivibrator yields division up to 12

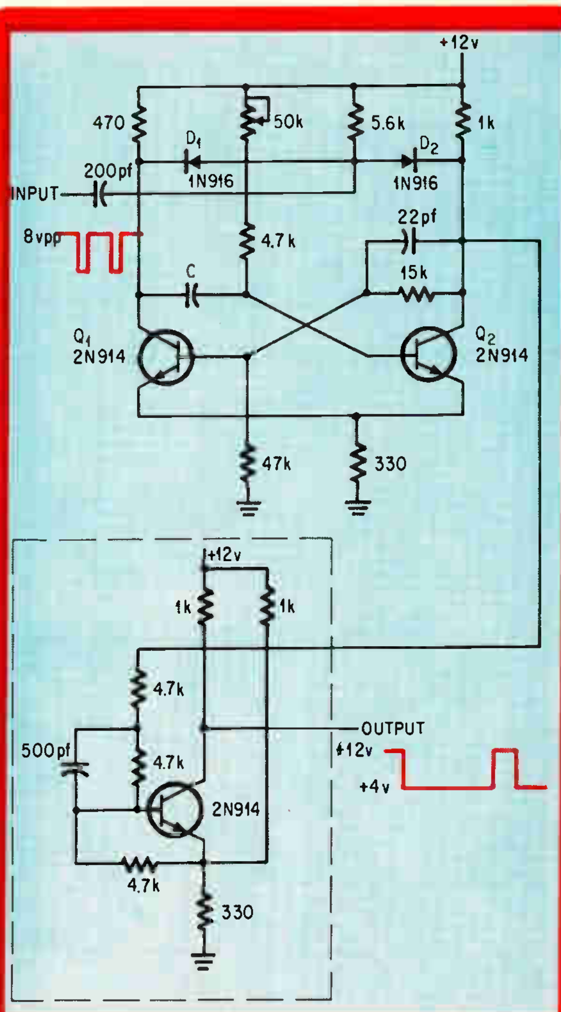
By Virgilio Mosca
Electronics Consultant, Milan

One-shot multivibrators have an advantage as frequency dividers over the more common blocking oscillators and astable multivibrators: division that can be stopped or started instantly. Precise division up to 12 was obtained with this circuit, and the generated pulse could be stopped with any positive edge of the clock pulse.

When the circuit is idle, Q_2 conducts, Q_1 is cut off, D_2 is forward-biased, and D_1 is reverse-biased. The first input pulse—a differentiated positive spike —turns Q_1 on. The circuit then behaves like an ordinary one-shot multivibrator, except that the biases on the diodes reverse. The positive spikes now are delivered to Q_2's base, adding to the discharging waveform through the timing capacitor. When Q_2's base is driven sufficiently positive, it starts conducting again and the cycle ends.

A minimum value of C is chosen and the potentiometer is adjusted to achieve a fixed division factor. The circuit shown boxed is added to generate neatly squared pulses that can be used to synchronize another divider stage.

Division up to 1,000 with a 0.01% accuracy can be obtained with the aid of a self-controlled input gate and a 1-megahertz crystal-controlled clock feeding three such cascaded circuits. The output pulse width is 1 millisecond.

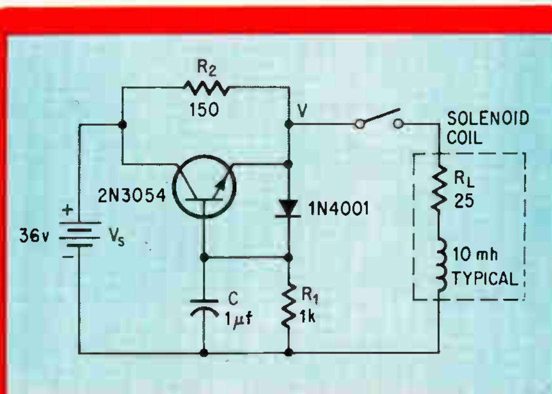


Divider. This one-shot multivibrator allows precise frequency division and can be started and stopped by the same positive-going edge of the clock pulse.

Pick-hold coil driver recovers quickly

By F.E. Mueller
International Business Machines Corp., San Jose, Calif.

Solenoid-operated devices need large currents to excite the coil if the device is to be activated quickly. The usual method is to charge a capacitor to a high voltage through a series resistor and then discharge it through the load. The capacitor supplies the energy surge for accelerating the mass, the resistor supplies the holding current. The dis-



Good timing. Slow recovery in circuits actuating solenoid-operated devices is speeded by the use of an RC network to control the timing.

advantage of this circuit, however, is the slow recovery while charging the capacitor. But using an RC network for timing rather than storage, avoids this problem and speeds recovery.

Before the solenoid is operated, the switch is opened and the capacitor is charged until the voltage, V, equals the supply voltage. The transistor is now reverse-biased from the diode drop.

To activate the device, the switch is closed and load current causes the emitter voltage to drop until the base-emitter junction of the transistor is forward biased. This reverse-biases the diode. The capacitor discharges through R_1 with time constant R_1C. V drops to a final value: $R_LV_S/(R_L + R_2)$.

When the switch is opened, the capacitor is charged by R_2 with time constant $R_1R_2C/(R_1 + R_2)$.

Photomultiplier's gain is temperature compensated

By Alexander E. Martens

Bausch & Lomb Inc., Rochester, N.Y.

Frequent recalibration of equipment is a nuisance; but an engineer may find it necessary during the initial warmup if he's using photomultiplier tubes. As the ambient temperature increases, these tubes decrease in gain. However, a relation was found to exist between the temperature of the base pins and the gain of the photomultiplier.

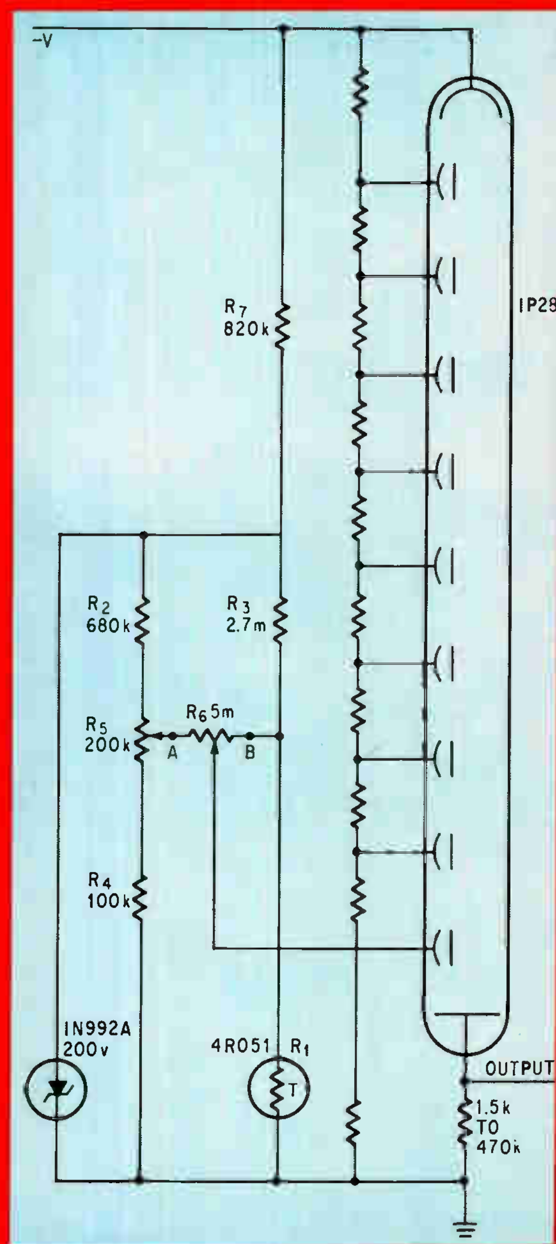
A simple circuit using a thermistor takes advantage of this relation. The circuit provides automatic temperature compensation of the gain over a limited but usually adequate range. This circuit eliminates the need for expensive temperature stabilization devices.

The thermistor, located on the tube's socket close to the connecting lugs, forms one leg of a bridge consisting of resistors R_2, R_3, R_4, and potentiometers R_5 and R_6. The voltage across the bridge is derived from the photomultiplier's high voltage supply and is stabilized by the zener diode.

The potential difference between the dynodes, as determined by the resistor values in the voltage divider, control the photomultiplier's gain. Varying the voltage on the last dynode compensates for temperature.

As soon as the equipment is turned on, the engineer feeds in constant intensity light pulses. In response to these, he balances the bridge by adjusting R_5 in such a way that moving the wiper of R_6 between its end points, A and B, produces no change in the output of the photomultiplier.

About an hour after the equipment has been stabilized at its operating level, R_6 is adjusted to restore the output pulse amplitude to its original level. R_5 is left untouched during this final adjustment. As the temperature increases, point B becomes less negative with respect to ground because of the negative temperature coefficient of the ther-



Base pins. The thermistor, located on the photomultiplier's socket, has a resistance that's a function of the temperature at the tube's base pins.

mistor, thus increasing the potential difference between the last and the preceding dynode. The setting of R_6 controls the rate of the voltage change and reaches the maximum when the wiper is at B.

The output pulse height varied less than 2% over a temperature range from 24° to 40° centigrade when gain compensation was used. Without compensation this variation was four times greater.

Low frequency waveform generator uses 3 op amps

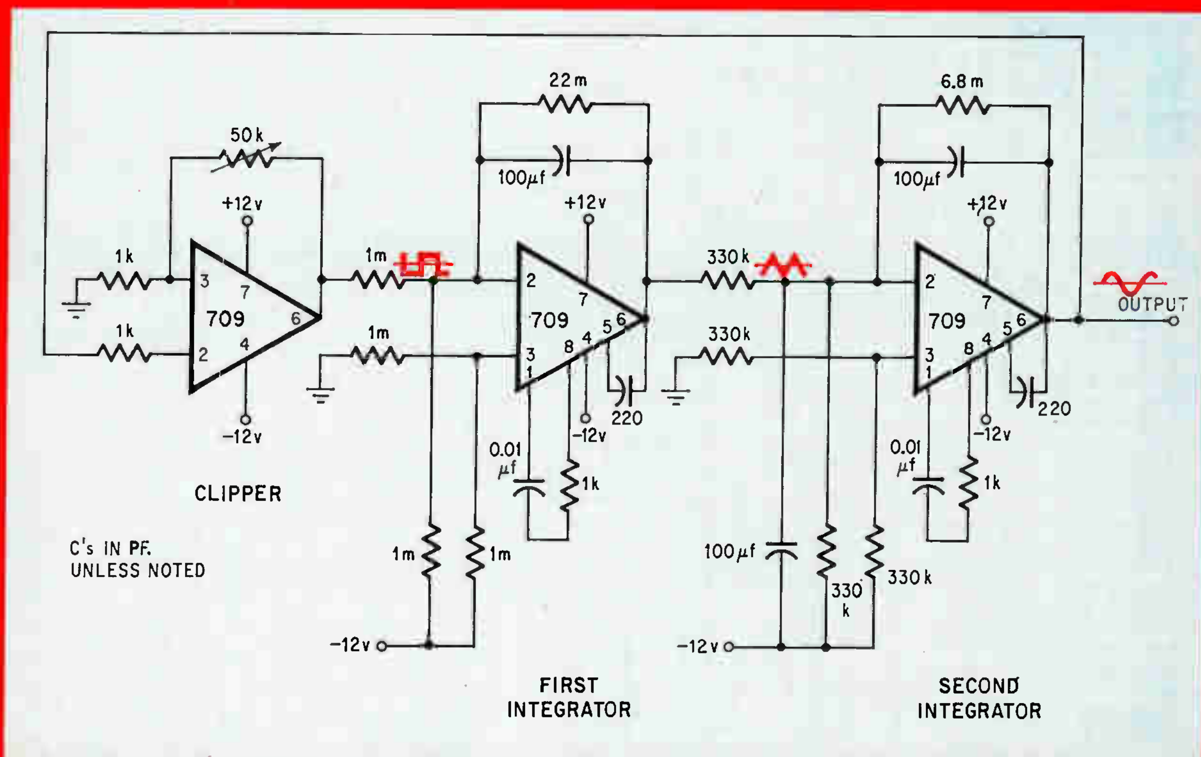
By Arthur D. Delagrange

Naval Ordnance Laboratory, White Oak, Md.

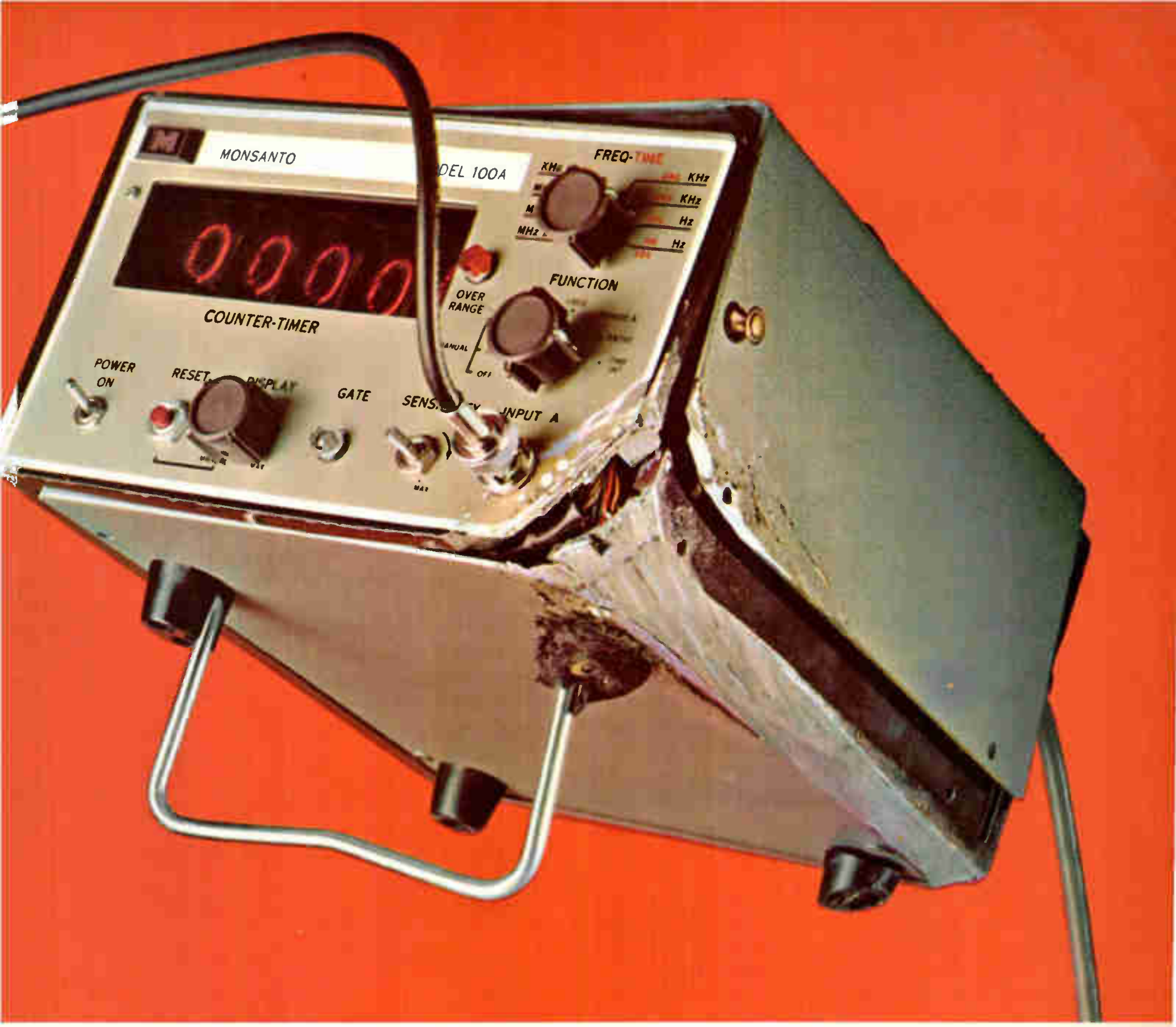
Small modifications added to a linear inverter and two integrators produce an oscillator that can deliver a square wave, a triangular wave, and a parabolic waveform that approximates a sine wave. The circuit consists of a clipper and two inverters and oscillates at a frequency of .004 hertz.

The output of the clipper is fed back to its noninverting input resulting in hysteresis that sustains the oscillations. The hysteresis acts as a phase lag which decreases as amplitudes increase. The amplitude stabilizes when the phase shift equals 360° around the loop at the frequency of oscillation. The potentiometer adjusts the wave's amplitude by controlling the hysteresis.

Each integrator uses a resistor in parallel with the feedback capacitor to fix the d-c gain of the stage at 20 and maintain a low Q. The time constant for the second integrator is shorter than the first, the amplitude of the sine wave is about the same as for the triangular wave. Normal oscillations begin when power is turned on. There are no large starting transients.



Hysteresis. The clipper consists of an IC op amp with feedback to the noninverting input, providing hysteresis to sustain the oscillations. The potentiometer adjusts the amplitude. The other op amps provide two stages of integration to produce a sawtooth and sine wave.


MONSANTO
FREQ-TIME
FUNCTION
OVER RANGE
COUNTER-TIMER
POWER ON
RESET
GATE
INPUT A

Designing lumped elements into microwave amplifiers

Tiny thin-film inductors, capacitors, and resistors can be used to construct hybrid IC power amplifiers that are far smaller—and potentially cheaper—than conventional microstrip types

By Martin Caulton

RCA Laboratories, Princeton, N.J., and

Walter E. Poole

RCA Electronic Components Division, Somerville, N.J.

Power amplifiers for ultrahigh-frequency and microwave operations need no longer be built of distributed microstrip structures. Instead, they can be made with lumped passive elements—thin-film inductors, capacitors, and resistors—designed as if they were to operate at lower frequencies where distributed reactances can be ignored. This means circuits can be much smaller than the microstrip variety—and with a more conventional design. Because their small size permits batch-processing on a single wafer the costs should be lower.

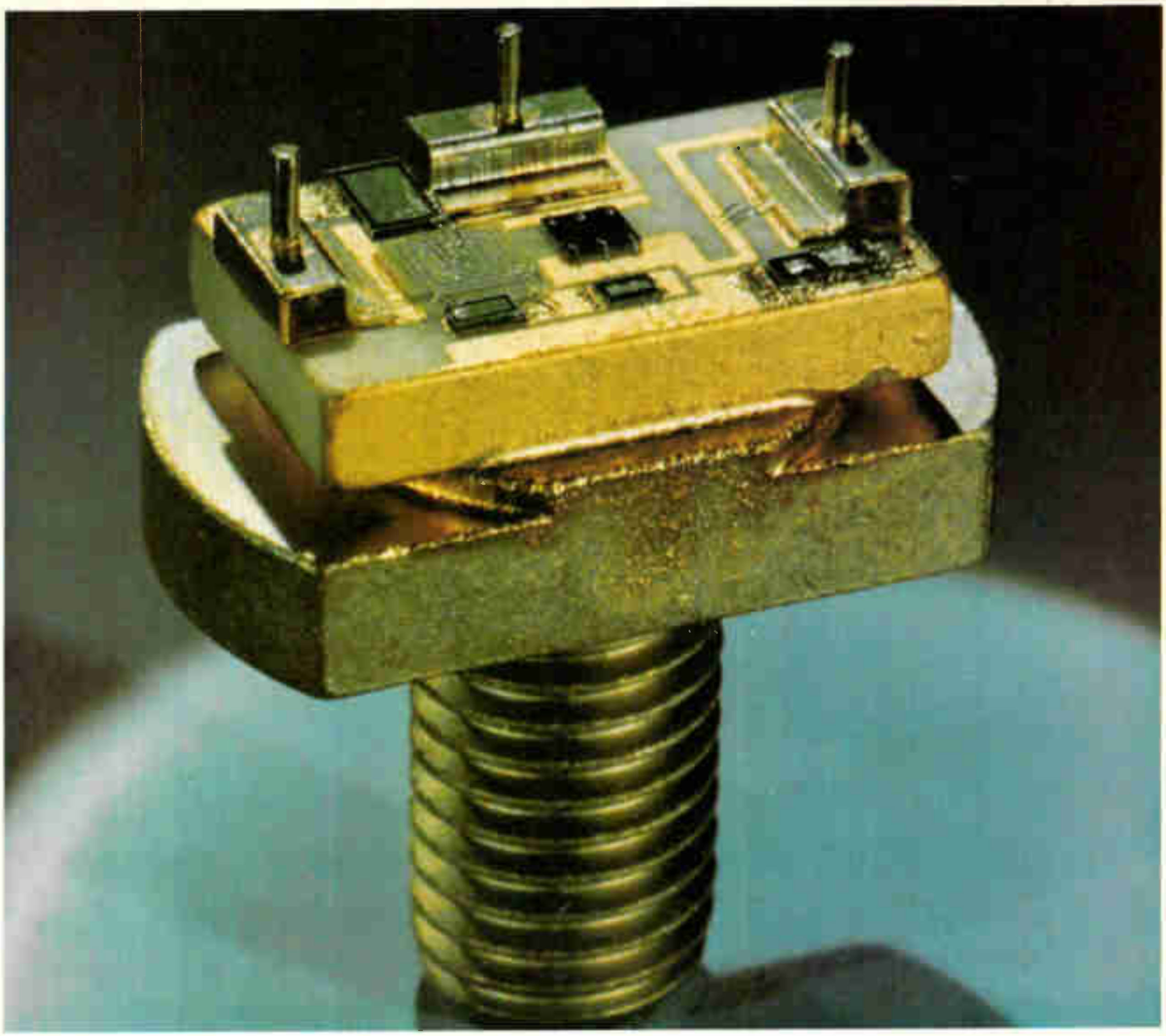
With the photoresist techniques developed for transistor technology, lumped elements can be made so that their size is only a very small fraction of the operating wavelength. Thus, no distributed reactances show up along the length of the inductors and resistors or in the dielectric of the capacitor. It was to apply these effects at high frequencies, rather than try to overcome them, that microstrip techniques were developed in the first place. But now, with thin films, an inductor behaves strictly like an inductor, a capacitor like a capacitor, and a resistor like a resistor at the higher frequencies.

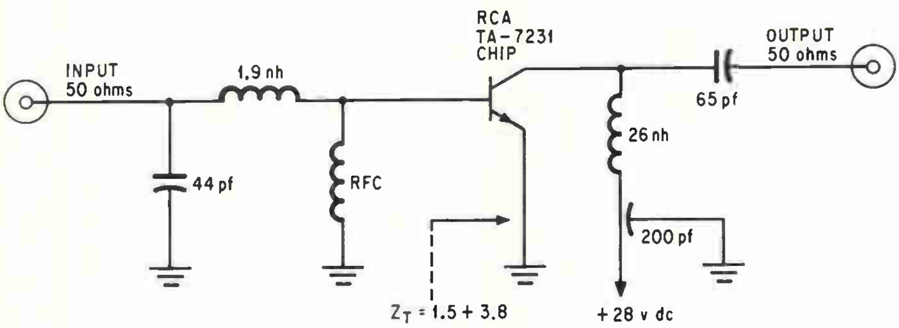
Batch-fabricated hybrid IC amplifiers using lumped elements for matching and filtering have operated at frequencies ranging from 0.2 to 2 gigahertz. Their performance is comparable to that of conventional amplifiers; power levels have been as high as 75 watts at uhf and 1 watt in the microwave region, and higher levels are expected as transistors improve. The upper frequency limit depends only on how small the elements can be made. However, the size difference between lumped-element and microstrip circuits narrows as frequency goes up.

Ultimately, complete amplifiers—with active-device chips and lumped elements integrated on a substrate—will be supplied in packages only slightly larger than those now used for discrete transistors. And functional units covering the important frequency bands will be available, so that equipment manufacturers will be able to work with matched amplifiers instead of with devices requiring complex and costly matching networks. And with these small and integrated amplifiers, the parasitic coupling effects found in conventional circuits will be minor and readily controlled.

Conventional microwave circuits use waveguide, microstrip, or coaxial transmission lines for matching. Lumped elements such as inductors are normally avoided because when the wavelength approaches the size of the element, the element radiates energy. A good rule of thumb is to keep the size of the lumped elements to about $\frac{1}{100}$ of a wavelength at the operational frequency. For example, at 400 megahertz (wavelength 3 inches), the outer diameter of a typical inductor would be 0.1 inches; at 2 Ghz (wavelength 0.6 inch), the size should be approximately 0.05 inch.

At these high frequencies, only small tuning inductances and capacitances are needed. The inductors can be built within the size limits set by the operating wavelengths. For example, tuning inductances at 400 Mhz are generally less than 25 nanohenries; at 2 Ghz, they're less than 8 nh. Em-





On top of things. In its breadboard stage, the 400-Mhz lumped-element power amplifier at left produces 10 watts and fits into a three-terminal module measuring 0.36 by 0.65 inches. The simple L-section networks in the schematic at the left transform input and output impedances.

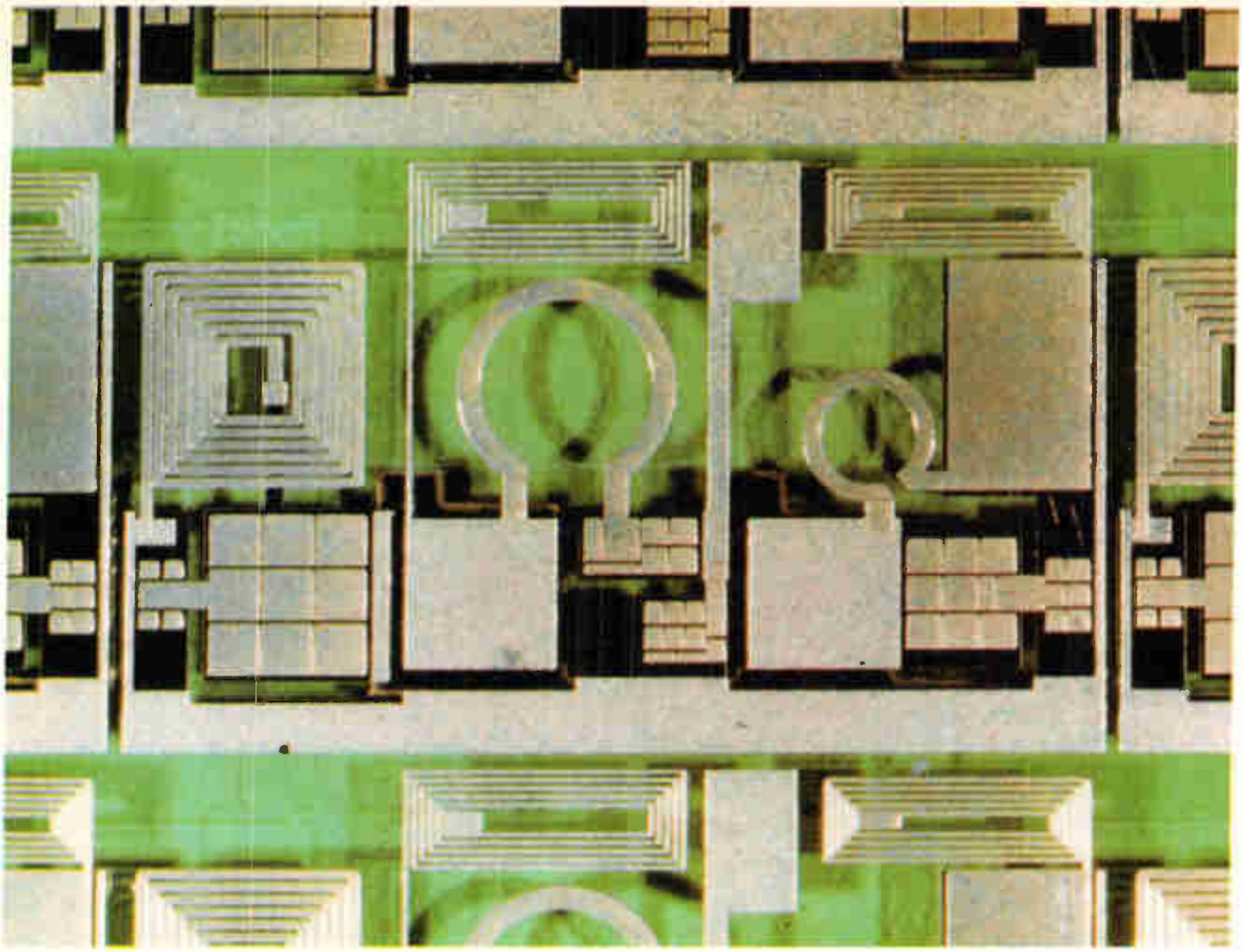
ploying IC photolithographic techniques, a 25-nh inductor with a fairly high Q can be built in a spiral ribbon less than 75 mils square. An 8-nh inductor fits in a 50-mil-diameter coil. Inductor widths on the order of mils are easy to make, and the separation between turns can be as small as a half-mil.

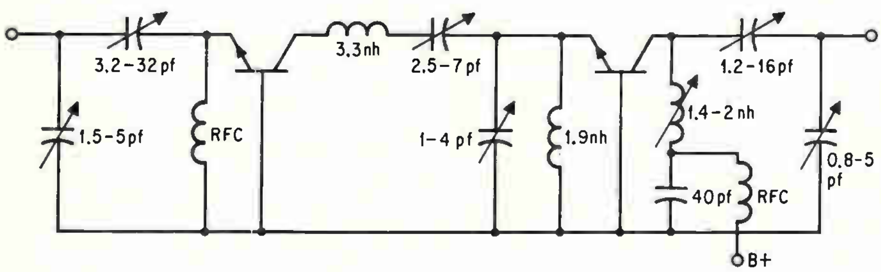
The values of thin-film capacitors at these frequencies generally run from a half-picofarad to tens of picofarads.

Lumped-element IC's are typically 10 times smaller than distributed circuits in microstrip. And more than 20 identical single-stage amplifiers, with biasing elements, have been built in a batch on a single ¾ by 1-inch sapphire wafer.

The very smallness of the lumped-element circuits, though, presents some important problems. For one thing, it's difficult to attach them to the outside world and to measure their parameters. For another, performance limits are established whenever energy is stored in a very small volume. It's hard to get sharp tuning—Q's greater than 1,000—in this case, because performance is proportional to the ratio of volume to surface.

Q's of the thin-film elements are moderate, running to about 100 for the tuning inductors and to about 50 for the tuning capacitors. (The quality





Staged. Tunable two-stage 2-Ghz amplifier uses these interstage networks to conjugately match transistors.

factors of r-f chokes and bypass capacitors are unimportant and present no problems). However, effective matching circuits can be built with these elements in efficient high-power amplifiers. But with active-device gains still fairly low at about 10 decibels, special attention has to be paid to keeping losses down.

Once one of these circuits has been designed, a thin-film hybrid breadboard should be made before the design is committed to batch processing. The approach taken to breadboarding depends on the intended operating frequency of the circuit. In the range up to 1.5 Ghz, bond wire reactances can be reasonably accounted for, and the design can be evaluated on a breadboard in which thin-film inductors, capacitors, resistors, and transistor chips are processed separately and then connected by wire bonds on a common substrate. Such a breadboard approximates closely the conditions of the final integrated structure with respect to coupling, interconnection reactances, and thermal dissipation.

After the design is optimized on the breadboard, the values of the passive elements are modified to account for any parasitics that exist, and the final thin-film circuit is fabricated on a single substrate.

In circuits designed to operate above 1.5 Ghz, on the other hand, the interconnecting leads alone may do the tuning; the chip-type breadboard is difficult to work because of critical parasitics. The designer often uses a tunable thin-film breadboard.

The networks can be capacitively tuned by paralleling portions of the deposited capacitor elements; inductive tuning is achieved by shorting portions of the deposited inductors. The final thin-film circuit is then obtained by slightly modifying the breadboard masks.

To design the matching circuits, the transistor chips must be characterized under actual large-signal class-C operating conditions. The input-impedance transforming network must match the relatively low impedance of the transistor to the impedance of the generator.

As with breadboarding, two techniques are used—depending on operating frequency—to obtain the class-C parameters. Above 1 Ghz, the transistor is mounted in the actual physical structure of the final hybrid amplifier so that residual parasitics are included in the measurements. The chip is then bonded to short 50-ohm microstrip lines brought directly up to its edge. Bias is supplied, generally with an external bias tee, and input- and output-stub or slide-screw tuners are set for the desired performance levels.

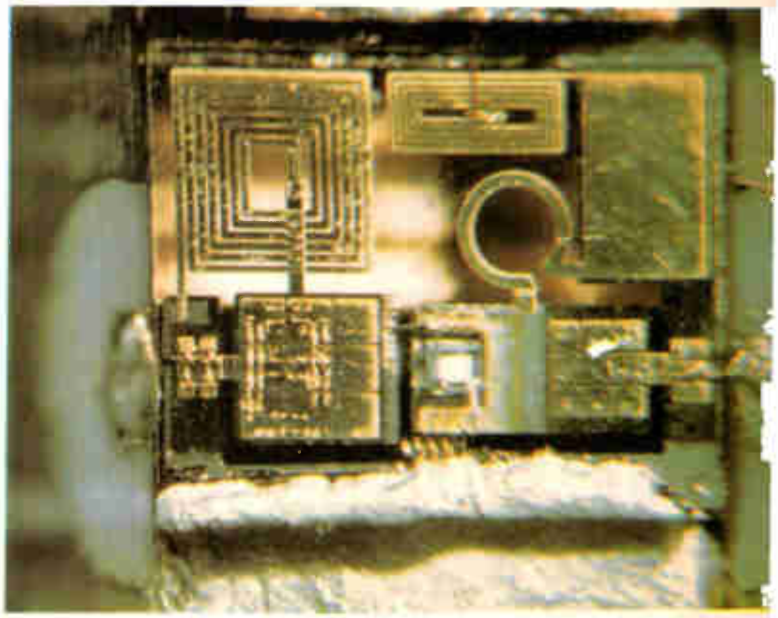
With the input assumed to be conjugately matched, the transistor's impedance is the conjugate of the stub impedance transformed along the 50-ohm line to the end of the chip bond wires. And the impedance of the output stub, transformed back to the collector terminal of the chip, represents the load required for the given output power.

The other technique is used at the lower uhf frequencies (0.2 Ghz to 0.5 Ghz), where parasitics are less critical. Here, the transistor is bonded to metalized areas on a small beryllium oxide block, which, in turn, is connected through a 50-ohm coaxial air line to the end of a slotted line. When a variable load is applied to the d-c biased collector through a stub tuner, the chip is driven to the desired operating level by the generator directly through the slotted line, and the output is simultaneously tuned for maximum output power. The voltage standing-wave ratio and phase position detected in the slotted line determine the device's effective input impedance.

The optimum output load at the collector is found by a separate slotted-line measurement of the impedance looking back from the collector into an output stub tuner. This technique isn't suitable for higher frequencies due to high vswr's.

Measuring the impedance of the individual thin-film elements used in the circuit breadboard also requires care, particularly because of the elements' small size. There are two direct measurement techniques, and the choice—once again—depends on operating frequency. Below 500 Mhz, the element is put across a 14-mm coaxial air line at the end of a slotted line. To reduce parasitics at frequencies above 500 Mhz, the element is bonded to a 50-ohm microstrip that's connected to the slotted line.[1]

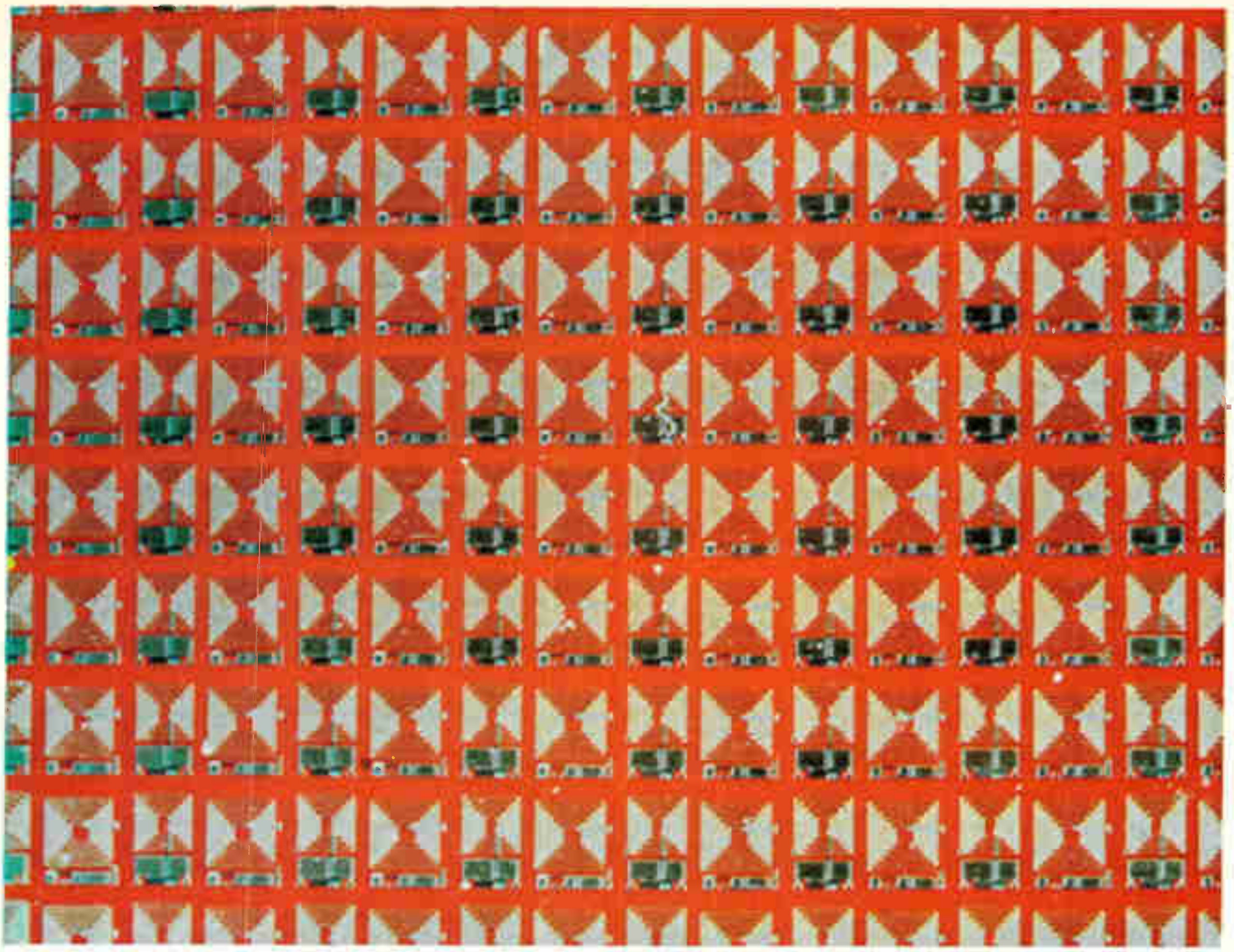
Recently, an indirect method—a resonant-circuit substitution technique—has been employed to measure high-Q elements at frequencies to X-band.[2] The resonant measurement is made with a microstrip transmission line—either a ring or straight section—that's open-circuited at one end. At the other end, the reactive element is inserted between the line and ground, and the resonant frequencies measured. A short circuit is then substituted for the element and the resonances again measured.

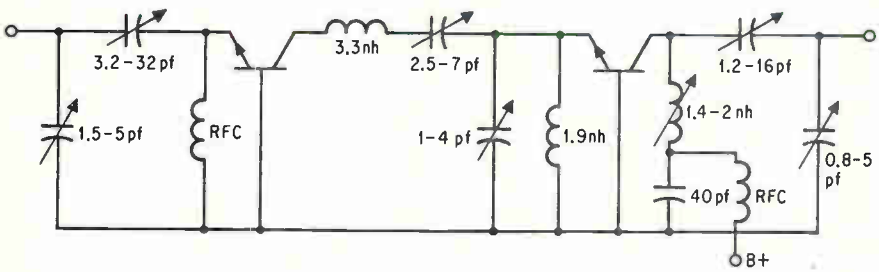


Big shrink. Breadboard version of hybrid 2-Ghz amplifier with lumped elements is almost 1/40th the size of an equivalent unit made of conventional ¾x1" microstrip.

The reactance of the element is determined by the difference between the two corresponding resonant frequencies. The element's Q is determined by the value of Q when the line is short-circuited and the system's Q when the element is in place.

Once the transistor's characteristics are known, it's fairly simple to design matching networks. In





Lumped and batched. Passive elements of a 1-watt, 400-Mhz amplifier can be batch processed. Some 160 circuits fit on a 1-inch-square substrate.

the single-stage, 10-watt, 400-Mhz amplifier shown on page 101, a simple L-section input network transforms the low input impedance of the chip transistor to the 50-ohm resistance of the generator. Measured under class-C conditions, the transistor has an input impedance, Z_1, of $1.5 + j3.8$. The L-section network consists of a series 1.9-nh inductor and a shunt 44-pf capacitor. An L-section output is also used to provide the optimum load impedance. The complete amplifier includes thin-film r-f bypass capacitors and r-f chokes.

In an optimized hybrid form, the 400-Mhz amplifier on a beryllium oxide substrate fits into a three-terminal module 0.36 by 0.65 inch. The actual area occupied by transistor, input and output matching networks, choke, and bypass capacitor is 0.3 by 0.2 inch. The small input series inductor is a wide-ribbon conductor formed directly on the substrate. A thin-film nichrome resistor in the input circuit prevents parasitic oscillations.

The 400-Mhz amplifier is one of four breadboard single-stage amplifier modules that have been developed for operation in the uhf region. Their performance is equivalent to that of similar units using packaged transistors and conventional circuitry—lumped or distributed.

Power output ranges from 1.5 to 20 watts, with gains as high as 9.5 decibels. Each amplifier is of class-C design, and is housed in the 0.56-by-0.65-inch three-terminal module, which includes a 50-ohm input, a 50-ohm output, and a d-c bias lead. The module is grounded through the case.

The 10-watt amplifier's 1-db bandwidth of 16% (65 Mhz) for a 1-watt input can be substantially increased by using broad-band matching networks. For example, a 1-db bandwidth of 41% was obtained with the same input power, the same transistor, and a three-section Chebyshev input network. Although not optimized completely, the input reflects 25% or less of the input power over the entire 225-to-400-Mhz band. The resulting output is 7.6 watts flat to +0.5 db from 265 Mhz to 400 Mhz, with better than 50% efficiency across the band at a drive of 1 watt.

From this breadboard, the design moves on to thin-film integrated form. For the higher-power uhf amplifiers, the transistor is mounted on a beryllium oxide block, and the matching networks are deposited on a glass or sapphire substrate.

The 1.5-watt, 9.5-db amplifier, for example, occupies an area 135 by 80 mils, about 300 times less space than is taken up by an equivalent amplifier with conventional components. Input and output matching networks, shown on page 104, are fabricated together in an area 90 by 50 mils.

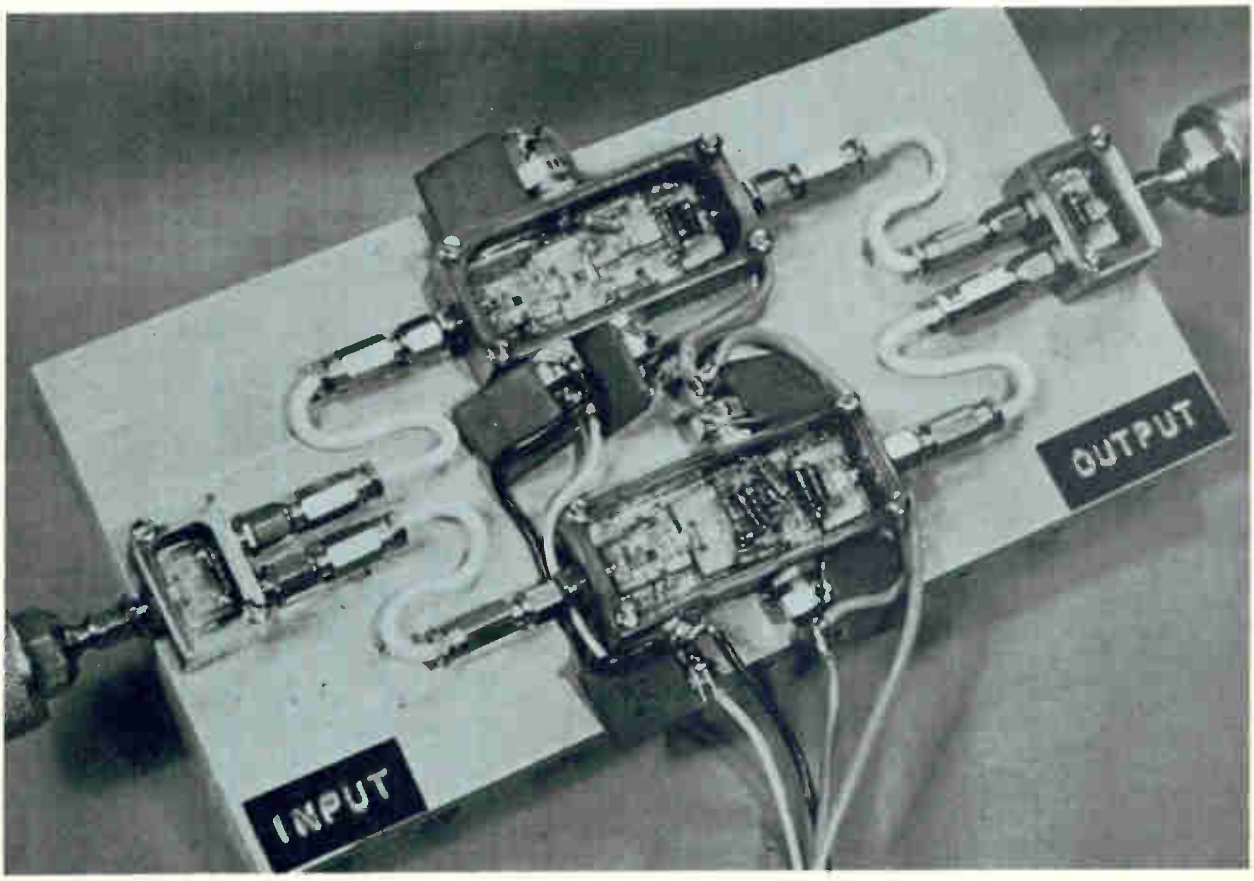
Gain and output power significantly greater than what's available with a single module can be had by combining modules at their 50-ohm-impedance input and output terminals. For example, a three-stage, 40-watt c-w module with a 16-db gain at 350 Mhz results when two 20-watt modules are paralleled through an input power divider and output power combiner and are driven by a 10-watt stage. The complete module measures 2 by 0.8 by 0.4 inches. The lumped-element power combiner/dividers used in this structure are made with thin-film inductors and capacitors and a chip resistor.

And by paralleling two of the 40-watt modules, as shown on page 105, one can get 76 watts out (50% duty cycle) for a 2-watt input at 350 Mhz.

The performance limits of passive elements and chip transistors are of greater importance in microwave power amplifiers than in devices operating at lower frequencies. Because the transistor is operating close to its cutoff frequency in the microwave range, the amplifier must have a relatively narrow band to supply any gain and power. But the narrow band makes it harder to design matching networks for the transistor, whose impedance varies with power levels. To compensate for the impedance shifts, the amplifier is designed to be tunable as previously described.

An example of a microwave amplifier built with the hybrid, lumped-element approach is the 2-Ghz unit, shown on page 103, along with a similar but conventional device. This hybrid, actually an integrated breadboard, includes d-c blocking and biasing components. An impedance-admittance Smith chart was used to match tunable input and output networks to a range of transistor class-C dynamic impedances with minimum loss. The networks also permit operation in forward-biased class-A and -B operation.

Twenty-five such single-stage microwave amplifiers have been processed simultaneously on a single polished sapphire substrate measuring 0.75



Doubling up. Paralleling of two 40-watt amplifier modules yields 76 watts and a gain of 15.8 db at 350 Mhz.

Lumped elements

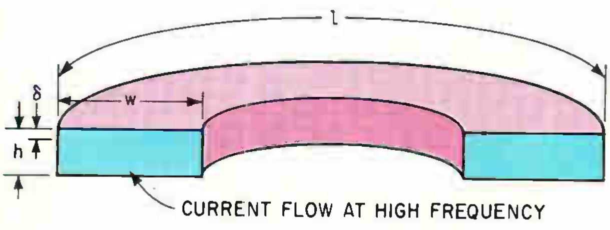
The inductive reactance required in a circuit operating at uhf and microwave frequencies can be obtained from a simple rectangular ribbon of width W, thickness h, and length l. The low-frequency inductance, L_R, of this ribbon is given by:[1]

$$L_R = 5.08 \times 10^{-3} l \left(\ln \frac{l}{W+h} + 1.193 + 0.223 \frac{W+h}{l} \right) \qquad (1)$$

where L_R is in nanohenries; all dimensions in mils.

Inductance measurements at lower frequencies agree with the values predicted by this equation, and they are only slightly lower at high frequencies. A 2-nh inductor, for example, with an l/W ratio of 20 (typical of 2 Ghz and higher), must be about 100 mils long and can be fabricated in a ¾-turn circle about 40 mils in diameter.

The Q of this inductor can be easily calculated. Assuming that current flows within a skin depth, δ, of the surface, and defining Q as $2\pi f L_R / R_{ac}$, where f is the frequency in hertz and R_{ac} is the a-c skin resistance of the inductor, the Q_R per nanohenry inductance of the ribbon inductor is:



In shape. As at lower frequencies, the values of a ribbon inductor are determined by its physical dimensions.

$$\frac{Q_R}{L_R} = \frac{2.15 \times 10^{12}}{K} \frac{W}{l} \left(\frac{\rho(\mathrm{Cu})}{\rho} \frac{f(\mathrm{Ghz})}{2} \right)^{1/2} \qquad (2)$$

where ρ is the d-c resistivity of the metal, ρ(Cu) is the d-c resistivity of copper (1.7×10^{-6} ohm-cm), and K is the factor between 1.3 and 2 that accounts for the current crowding at the corners of the ribbon. This expression is plotted below.

For the 2-nh inductor with l/W of 20, used for the one-turn inductor in the circuits shown on page 103, the product KQ is 200, corresponding to a measured Q of 100. Q's greater than this can be achieved with wide-ribbon (l/W about 15) inductances of 1 nh or more.

Flat spiral. Inductors larger than about 4 nh can be made with flat planar spirals, as shown below. The inductance of such a coil is given to within a few percent by:

$$L = \frac{a^2 n^2}{8a + 11c}$$

where n is the number of turns, $a = d_o + d_i/4$; $c = (d_o - d_i/2)$, and d_o and d_i—the outer and inner diameters of the coil—are in mils.

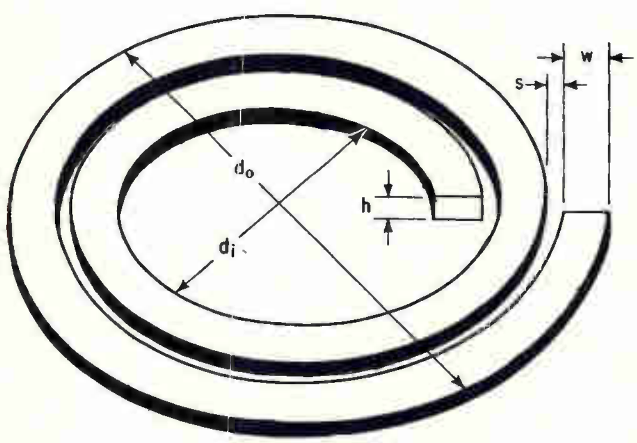
The Q of the spiral inductance can be obtained from the expression:

$$\frac{Q\, d_o^{1/2}}{L^{1/2}} = \frac{1.3 \times 10^2 W}{K} \left(\frac{f(\mathrm{Ghz})}{2} \frac{\rho(\mathrm{Cu})}{\rho} \right)^{1/2}$$

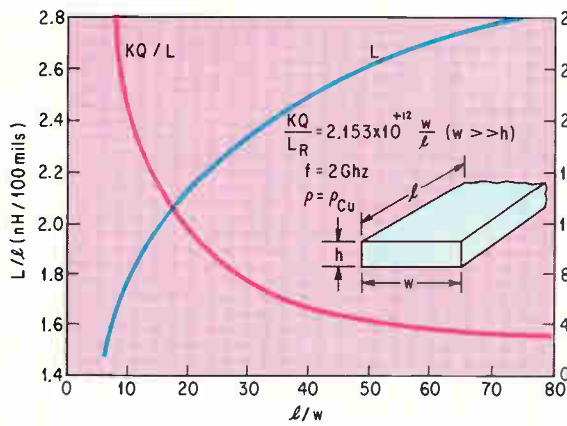
It's assumed here that current flows on the top and bottom surfaces and that the ratio of outer to inner diameter, d_o/d_i, is 5 to maximize Q.

Q increases with the width of the ribbon. To keep d_o small for a higher Q, the separation between turns should be as small as possible. However, the increase in parasitic capacitance with a small separation between turns can cause the resonance of a large inductance—generally with a higher Q.

For the same outer diameter, a circular spiral will



The worm turns. Flat planar spirals are used for inductors with values larger than 4 nh.



Inductance plot. Values of L and Q for a ribbon inductor can be found by plotting the relevant equations.

have about a 10% greater Q than a square spiral, although the inductance is about 20% less. Circular spirals are thus preferred for tuning inductors, while square and rectangular spirals are more suitable for r-f chokes.

Metal choice. Only four metals—silver, copper, aluminum, and gold—have been considered for the thin-film inductors because their a-c sheet resistance, R_S—which determines the Q directly—is very low. The four have R_S values within 30% of one another.

For higher Q's, the inductor should be reasonably square and at least three skin depths thick, and have straight sides and smooth surfaces. Such a device is fabricated either by selectively plating metal up through a thick photoresist mask on a thin layer of chrome-copper or chrome-gold, as shown below, or by evaporating 10 microns of aluminum, gold or copper on a substrate and then etching through a photoresist pattern. Plating produces a squarer cross-section but yields a higher d-c resistivity than does the evaporation-etching technique. The resistivity of the evaporated metal is close to its bulk value. However its been found experimentally that plated and evaporated coils of the same size and material have almost equal Q's.

Measurements on different circular spiral coils show that Q varies very nearly with the square root of frequency and the width of metalization as predicted by the previous equation.[2] These coils were fabricated by plating several skin depths of smooth copper through a photoresist mask and topping the plating with 1 micron of gold. Measured Q's are about 60% of the values calculated for pure copper. When the current crowding factor and the d-c resistivity of the plated metal are accounted for the calculated values generally match the measured ones.

In films. The Q of a thin-film capacitor can be found by considering the capacitor as a short length of an open-circuit RC transmission line. Then,

$$\frac{1}{Q_{cap}} = \frac{1}{Q_c} + \frac{1}{Q_d}$$

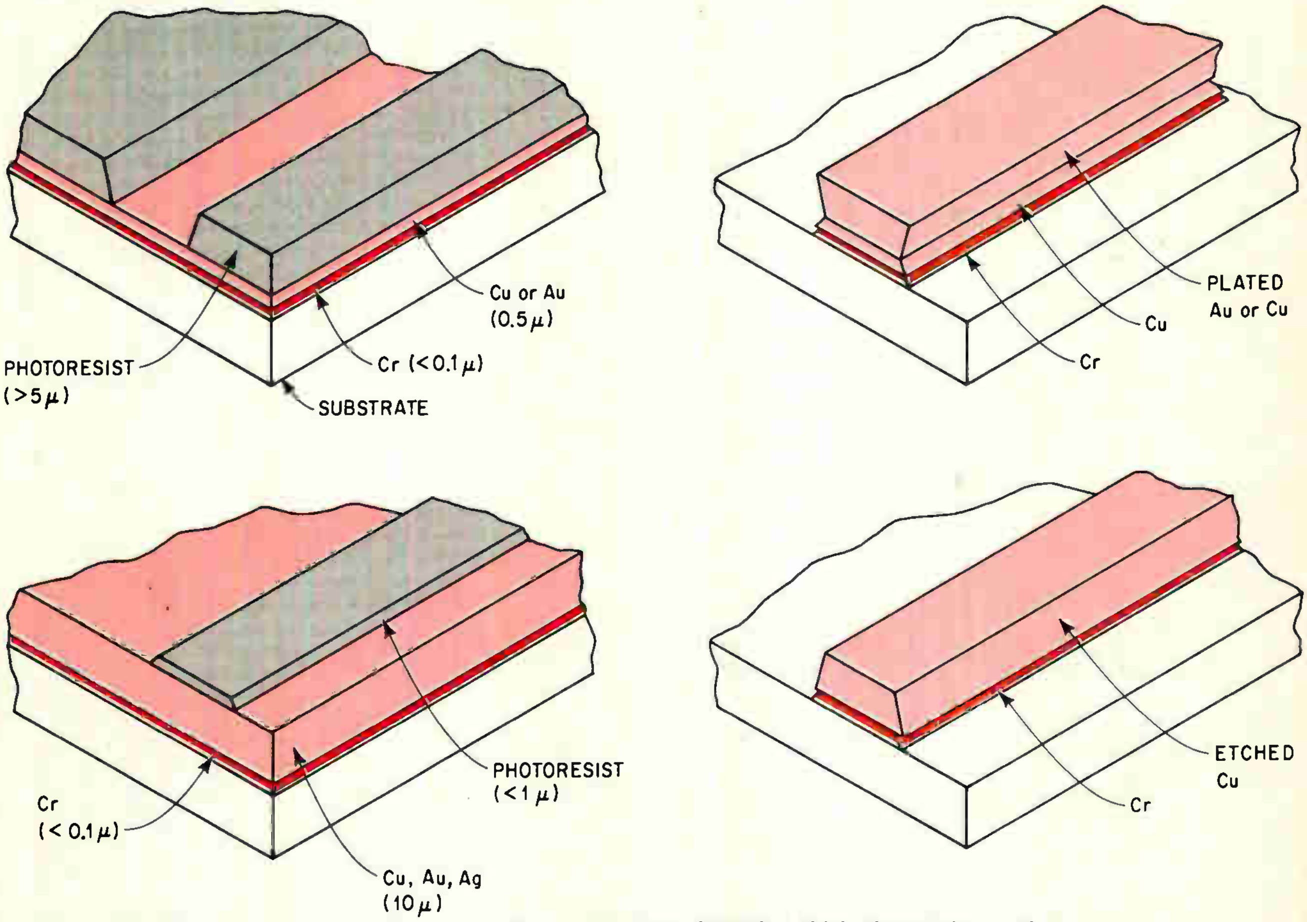
where Q_c is due to the conductor metal and Q_d to the dielectric loss.

$$Q_c = \frac{3}{2\omega R_s C}$$

where C is the capacitance of a square capacitor ($l = W$) and R_S is the surface resistance of the metal. Q_d is given by:

$$Q_d = \frac{1}{\tan \delta}$$

where $\tan \delta$ is the dielectric loss tangent.



Two routes. Inductors are made either by plating metal down through a thick photoresist mask, top, or depositing metal on the substrate and then etching it away, bottom.

At 2 Ghz, the Q_c of most metals is greater than 500; the value varies as $f^{-3/2}$ and should be greater than 500 at 400 Mhz. The Q_d for pure thin-film SiO_2 is unknown, but that of bulk fused quartz is 10,000.

In a typical thin-film capacitor made of a metal-oxide-metal sandwich, conductor thickness is one or two skin depths, or about 4 microns at 400 Mhz and about 2 microns at 2 Ghz. The capacitance is given by ϵ A/h, where ϵ is the permittivity and A is the area (Wl). For a 1-micron-thick dielectric of SiO_2 with a dielectric constant of about four, capacitance is around 0.023 picofarads per square mil. Capacitances per unit area can be increased with thinner dielectrics; silicon dioxide layers as thin as a half-micron have been used.

Choice of sandwich. Two types of capacitors have found extensive use, one a metal-oxide-silicon sandwich and the other a metal-oxide-metal sandwich. The former, which usually employs silicon with very low resistivity as one electrode, thermally grown or deposited SiO_2 as a dielectric, and aluminum in its top electrode, is used for breadboarding because it's easy to fabricate. Capacitors with values from 2 to 200 pf have been fabricated.

Metal-oxide-metal capacitors have been built from several of the metals listed in the table shown below, where the d-c resistivities given are normalized to copper's. They all have a resistance low enough so that their conductivity doesn't limit Q. However, not all are compatible with oxide dielectrics. Aluminum, tungsten, and molybdenum, for instance, adhere well to the oxides. Nickel also adheres, but its large sheet resistance prohibits its use at microwave frequencies. Among the other metals, chrome acts as an excellent "gluing" buffer between metal and oxide.

As a dielectric, silicon dioxide is deposited by a thermal reaction of oxygen and silane, SiI_4.[3] Borosilicate glass can be deposited in the same way. This is a simple procedure involving the use of a hotplate at 450°C and a glass reaction chamber. Growing to the bottom electrode and covering corners and sharp edges, the SiO_2 forms a pinhole-free and fraction-free oxide.

Heat treatment. The resulting glasses aren't very dense; their atoms can move in an r-f field, and the material has a large loss factor. The oxide can be made denser by heating it at temperatures varying from 450° to 1,000°C, but only tungsten and molybdenum will withstand temperatures above 600°C. R-f sputtering has yielded lower loss SiO_2, but vapor-deposited oxides are more easily fabricated.

The Q's of silane-deposited SiO_2 capacitors, measured from 0.3 to 2.5 Ghz, vary from 40 to 60, with a slight drop at 2.5 Ghz; the low Q's result from the flexible bonds of the unsputtered SiO_2. Capacitors with heat-treated or r-f sputtered silicon dioxide have Q's of 100 at 2 Ghz.

Thin-film lumped resistors are built much like the inductors. They must be placed reasonably far from the ground plane so that their characteristic impedance will be large and they won't behave like RC transmission lines. For all practical purposes, monolithic diffused resistors with junction isolation can be ruled out at microwave frequencies. The only alternative, then, is the thin-film metallic resistor.

As for circuit layout, the designer should remember:

- Place inductors at least one diameter from metal.
- Grounding metalization on the same plane as the tuning inductor has a negligible effect on inductance.
- In general, the use of lumped-element inductors implies that the distributed reactance to ground is negligible. The inductor is treated as part of a very-high-impedance transmission line, and the ground plane must be so far away underneath the inductor that the characteristic impedance of the line is infinite.
- All grounds should be brought to a common area to minimize inductances. If a connecting metalization is longer than it is wide, its inductance will play an appreciable role in tuning.
- Thin-film capacitors have little field leakage and can be placed near other elements, but should be wider than long to minimize parasitics and losses.

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Metals for lumped elements

Material	d-c Resistivity, ρ (relative to Copper)	Skin depth, δ, at 2Ghz (micron)	Surface resistivity, $R_s \cdot 10^7/f^{1/2}$ (ohms/Sq)	Coefficient of thermal expansion, $\alpha \cdot (10^6)$	Adherence to dielectrics ++ good —— poor	Deposition technique
Silver	0.95	1.4	2.5	21	—	Evap.
Copper	1.0	1.5	2.6	18		Evap.
Gold	1.36	1.7	3.0	15	——	Evap.
Aluminum	1.6	1.9	3.3	26	++	Evap.
Tungsten	3.2	2.6	4.7	4.6	+	Sputt, vapor
Molybdenum	3.3	2.7	4.7	6.0	+	Sputt
Nickel	5.1	0.31	55.0	15	+	Evap.
Chromium	7.6	4.0	7.2	9.0	++	Evap.

by 1 by 0.010 inch. Each amplifier measures 0.12 by 0.16 inches and is bonded to a transistor on an RCA 5-mil-high glass-metal chip carrier.

In production the amplifier's size can be more than halved by eliminating the tuning, using a SiO_2 dielectric a half-micron thick instead of 1 micron, and omitting the extra large collector metalization.

RCA TA7003 transistors mounted on the individual 2-Ghz amplifier circuits can be tuned to achieve either maximum power gain or maximum output. Because of the nonlinear behavior of power transistors in class-C operation, these objectives cannot be gained simultaneously.

Maximum gain of an amplifier is 6 db with approximately 0.5 watts output at 26% collector efficiency. Gains of more than 7 db with power outputs greater than a half-watt have been achieved with other transistors, however. Maximum output of the two-stager is 1 watt with a gain of 4 db and an efficiency greater than 30%. In coaxial circuits, similar transistors have produced a power gain of 6.3 db with greater than 30% collector efficiency and an input of 0.2 watt.

A 2-Ghz class-A amplifier yielding more than 13 db of gain at low power levels has been built by breaking the emitter-base d-c return and applying a forward bias. This unit also uses a TA7003 transistor, but its low-power linear characteristics give it a stable gain only for a 50-ohm load; the circuit oscillates with mismatched loads.

A cascaded class-A and class-C amplifier has yielded better than 17 db of gain with 0.6 watt of output. And two cascaded class-C stages have yielded 11 db at 2 Ghz with more than 0.8 watt.

Further, a 1.8-Ghz amplifier composed of class-AB, class-B, and class-C stages has been assembled from basic amplifier-chip circuits. This unit operates stably and gives a gain of more than 21 db while supplying more than 0.6 watt. The 1-db bandwidth is greater than 70 Mhz. A 2.1 Ghz amplifier has been similarly constructed that supplies one watt of power with a gain of more than 20 db.

All of these high-gain amplifiers were built by cascading the same basic IC shown on page 103 which was tunable to the different frequencies and power levels.

Match game

In a tunable two-stage amplifier, interstage networks shown on page 102 were designed to conjugately match the output of one transistor directly to the input of the other without going through a 50-ohm level. The network has a series as well as a shunt inductor. Tuning is aided by capacitors.

Loss in the higher-frequency circuits must also be considered, of course. If the unloaded Q's of the elements are about 50 and the transistor is tuned to match the loads, the calculated intrinsic losses for the input and output networks of these amplifiers are 0.5 and 0.8 db, respectively. (Intrinsic loss is that power lost in a one-way transmission with no reflections at input and output terminals.)

It remains to be seen just how feasible these lumped-element designs will be as frequencies climb. As noted earlier, microstrip circuits themselves shrink as frequency increases; at some point —probably above C band—the size advantage of lumped-element units becomes insignificant.

For example, the lumped-element 2-Ghz tunable network is much smaller than the comparable microstrip circuit shown on page 103. At this frequency, a tuning network in microstrip is about a quarter-wavelength long—a half inch in high-purity alumina. The lumped element circuit with two tuning networks is only about 0.125 inch. But although the microstrip doesn't have any r-f bypass networks, it could be made smaller by bending the shorted and open stubs closer to the signal path. And at X band (9 Ghz), the quarter-wavelength microstrip is about 0.125 inch—just a bit longer than the comparable lumped-element amplifier at that range.

Although an inductor's ratio of Q to L increases with the square root of frequency, the required inductance values decrease. Thus, fairly constant Q's can be achieved throughout the range.

Capacitor Q's of 500 are theoretically possible, but dielectrics must be improved. With Q's of 100 or less, losses in individual matching networks transforming 10 to 1 impedance ratios will be 0.4 db or greater, and this limitation probably won't be pared by more than a factor of 2 in the near future.

Loaded question

The Q limits present a problem with low-gain devices where high loaded Q's are needed, or with networks that have to transform widely different impedances. The moderate unloaded Q of lumped elements prevents their use in narrow, high-Q tuning circuits. For low, loaded Q's such as in high-power but relatively low-gain uhf amplifiers, lumped elements are fine. Indeed, microwave lumped-element IC's appear to have no fundamental power limitation so long as the elements and the devices have a good heat sink.

Integrated L-band amplifiers with outputs of tens of watts will be possible as higher-power transistors are produced. Single-amplifier modules will soon be available with 20-watt outputs flat to 1 db over the 225-to-400-Mhz band. At the microwave frequencies, better transistor chips will make possible single-stage amplifiers with the same gain the cascaded circuits now have. Output powers will hit 5 watts or more at 2 Ghz.

The use of lumped elements, as noted before, eases design. But lumped-element microwave circuits involve a more complicated fabrication process than do their distributed microstrip counterparts. Four separate depositions of dielectric and metal are required, and more if plating steps are used. Microstrip, on the other hand, only requires single depositions on the two sides of the substrate, though hybrid elements—passive as well as active —must still be added.

A fully integrated thin-film microstrip circuit may have as many components as its lumped-element equivalent. Although lumped-element circuitry

Triple-decker

Lumped-element thin-film circuits are fabricated in a three-step process that results in a deposited metal-oxide-metal sandwich, as shown below. The choice of a metal depends on the function performed by each layer. The capacitor's plates are formed by both of the metal layers, while the inductors can be formed in either top or bottom layer.

Capacitors can be made from most of the metals listed in the table on page 108 because conductor loss is small compared to that of the dielectric. On the other hand, only the metals with the lowest resistivities are used for the inductors, as noted before.

The fabrication process begins with the evaporation of the bottom, or main, metalization layer onto the substrate to a thickness of about one and a half skin depths. Additional thin layers of chromium or aluminum, for instance, can be added to top and bottom to improve the main metal's adhesion to the substrate and oxide. Standard photoresist techniques are then applied to define and etch this layer.

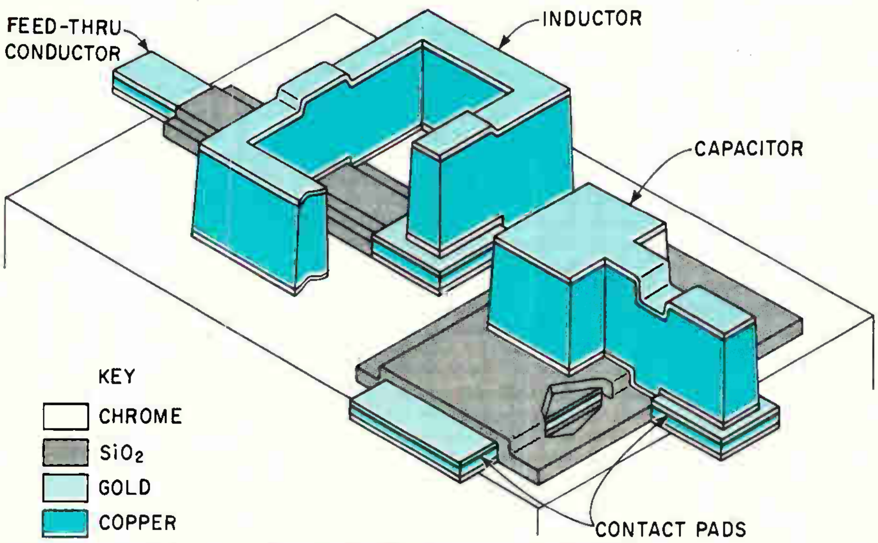
Next, a dielectric material—usually silicon dioxide —is deposited over the entire substrate, and finally, the top metal layer is evaporated, defined, and etched. Additional metal could be plated through a photoresist mask to increase Q. Gold can be used to protect the exposed metal areas.

Some of the combinations used include: aluminum —SiO_2—aluminum; chromium, copper, gold, chromium—SiO_2—chromium, copper, gold; chromium, gold, chromium—SiO_2—chromium, gold; chromium, molybdenum, gold—SiO_2—chromium, copper, gold.

As for the substrate, the material chosen should have a high bulk resistivity and low dielectric loss tangent, a very flat surface, high thermal conductivity, and a low dielectric constant.

Although glass is easy to scribe and has good electrical properties, its low thermal conductivity restricts its usefulness. Sapphire dissipates about 0.5 watt per square mil—40 times better than glass. This means that transistors that produce up to 5 watts can be mounted on it. The actual cost of sapphire is still quite high, but the cost per circuit is low and should further decrease with additional useage.

High-resistivity silicon and beryllium oxide find limited usefulness as a substrate. However, the high thermal conductivity of berylium oxide makes it a suitable mount for high-power transistors. Polished alumina hasn't been used because its surface pits can affect processing yields.



Sticking together. Lumped elements are built in metal-oxide-metal structures with metals such as chrome or nickel added to help the materials adhere. Vertical scale exaggerated.

often requires finer detail and definition, the same kind of capital equipment can be used to produce both types of amplifier.

Integrated amplifiers are not the only beneficiaries of the lumped element approach. Lumped-element low-pass filters with 2.8 Ghz cutoff frequencies have already been fabricated that yield performance equal to that of much larger microstrip units. Lumped elements will eventually be used in other circuits, such as couplers, hybrid combiners, matching networks in parametric diodes, and in such lower frequency nonreciprocal devices as circulators and isolators.

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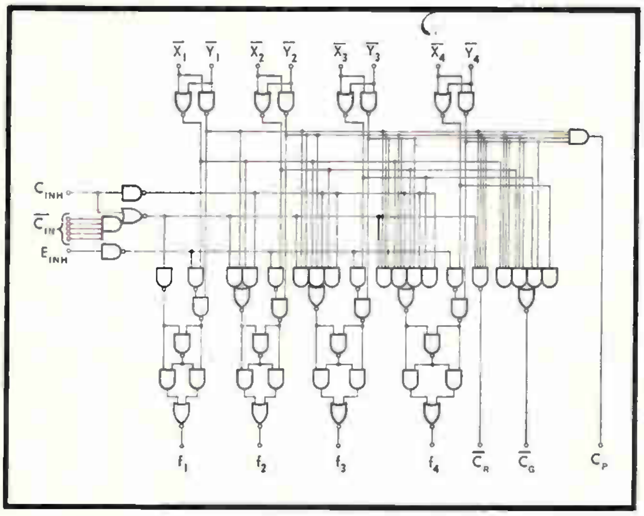
3. W.E. Poole, "Uhf Integrated Power Amplifiers, International Solid State Circuits Conference, Philadelphia, February 1968, pp. 126-127.

Test your logic.

a) **Suppose you designed the DCL MSI 8260, world's fastest adder, and its logic diagram looked like this:**



b) **And it gave a speed and package count, which beat any other IC family, like this:**

No. of Bits	Package Count 8260	8261	Quad 2-Input NAND Gates	Addition Time per Bit (ns)	Total Addition Time Input to Output (ns)
16	4	1	–	3.3	52
24	6	3	–	3.3	52
32	8	3	–	2.0	64
48	12	6	1	1.3	64
64	16	7	1	1.2	76

c) **Next, suppose you came up with eleven new MSI elements—all perfect fits with the 8260, our other MSI elements, and the entire DCL family—like this:**

8230	8-Input Digital Multiplexer
8232	8-Input Digital Multiplexer
8241	Quad Exclusive-OR
8242	4-Bit Comparator
8266	2-Input, 4-Bit Multiplexer
8267	2-Input, 4-Bit Multiplexer with Bare Collector
8268	Full Adder
8275	Quadruple Latch
8276	8-Bit Shift Register with Clock Inhibit
8284	4-Bit Binary Up/Down Counter
8285	BCD Up/Down Counter

d) **Now then: wouldn't you logically buy a full-page ad to tell the world in Electronics? And wouldn't you sign it like this:**

Signetics DCL

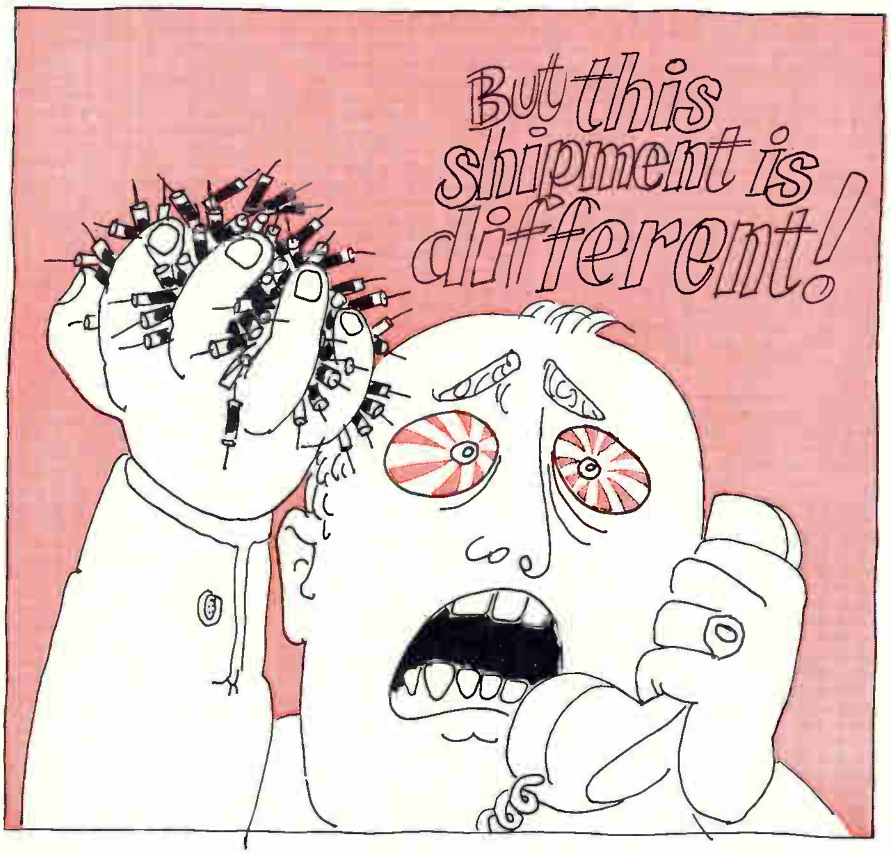
Signetics Corporation/811 E. Arques Ave., Sunnyvale, Calif. 94086/A subsidiary of Corning Glass Works

Logical afterthought: For written proof that Signetics is right in the middle of MSI, send for our DCL handbook. It's 120 pages—and free!

Want to be a good loser? Go about it systematically

Turning out gear that doesn't work shouldn't be a hit-or-miss affair or the exclusive job of production people; failure can be assured from the very start if the designer follows a few simple rules

By Matthew W. Slate
Sedco Systems Inc., Farmingdale, N.Y.



Rules of thumb go hand in hand with engineering. The designs of the future reflect the distilled and codified experience of the past. Therefore, if a designer is going to produce a failure, it's pointless for him to go about the job in a haphazard way. Not when he can fail by the numbers. The guidelines were laid down long ago and have been tested countless times. If the designer conforms to them, the results are guaranteed.

First, let's be clear that when we talk of a design "failure," we're talking about equipment that looks good on paper and works properly in the lab but bombs out when it's produced and sold in volume. Its production costs far outrun original estimates, its performance is unsatisfactory, or it's subject to excessive downtime when it finally gets into the field.

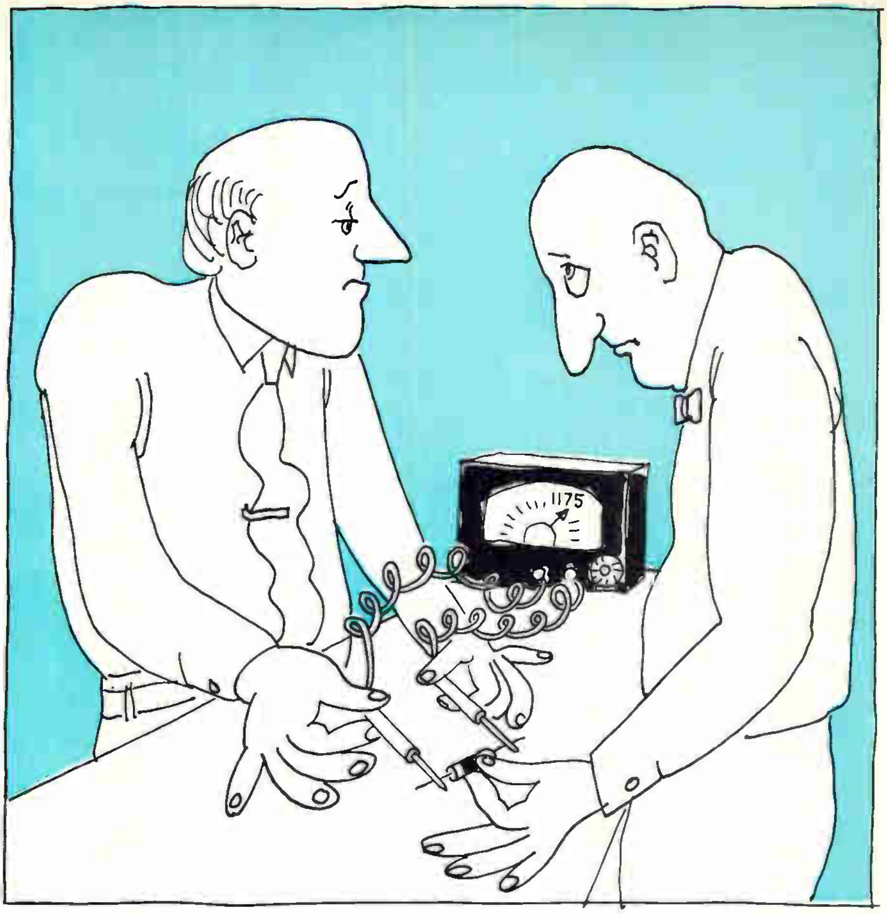
Such equipment may occasionally be turned out by chance, but in most cases the designer has dutifully followed one, several, or all of the following easy-to-learn rules. Names have been withheld to protect the guilty, but few engineers can deny that at one time or other they didn't accept at least one of these rules as true.

Rule 1: Components are components

If the breadboard works—amplifier gain and rise time meet specifications—don't waste time analyzing the expected gain distributions or frequency response of the transistors and integrated circuits.

Naturally, the myriad of components you buy next year when the vendor has his new production line going will be no different from the samples his sales representatives delivered to you.

So what if the samples were very close to the lower limit of the capacitance distribution; the production components you get won't be any more widely distributed. And there's no need to worry about your production circuits oscillating because the transistor, with a guaranteed minimum f_T of 10 megahertz—your sample was actually 15 Mhz—might next year average 30 Mhz, with some as high as 60 Mhz. You carefully, though experimentally, eliminated all feedback paths within the frequency response of your sample.



Rule 2:
Take tolerances literally

Doesn't every 1,000-ohm, 5% resistor have a resistance somewhere between 950 and 1,050 ohms? Of course it does when the manufacturer tests it before shipping it. But after it's been shipped and stored, and the leads clipped, bent, soldered, or welded, and after it has been operated under load and temperature cycling, all bets are off. Now, at time $t = 800$ hours, when the equipment is at maximum operating temperature, the resistance of this 1,000-ohm device is actually 1,175 ohms and your equipment's performance has just gone out of spec.

It's not your fault. You don't have to estimate the reversible and irreversible variations caused by internal and external heating. That requires some calculations and involves reading the footnotes on the data sheet, or even calling the manufacturer. All that's time-consuming. Besides, that technically astute sales rep said his components never go out of tolerance—well . . . hardly ever.

Rule 3:
Take ratings literally

Obviously that 200-volt rating stamped on a capacitor means that you can put 200 volts on it—forever. After all, the equipment has to operate for only 400 hours, so the 20 bypass capacitors you hung on the +200-volt line can be rated at 200 volts; there's no need to pay for a higher voltage rating. When you put the equipment into environmental tests, you chuckle to yourself about how much money you've saved. And you keep on chuckling until the unit fails.

You have no idea why it failed. There's no temperature rise you can trace to internally generated heat that might be caused by a-c current passing through a capacitor is there? You remember that there was something about that in either MIL-STD-198 or MIL-STD-199, but those specs were much too tiresome to read.

Of course, most component manufacturers have data with which mean life, or performance degradation with time, can be related to operating conditions, but to get this information would have taken a long-distance phone call, and your operation can't afford that any more than it can afford a reliability engineer.

Rule 4:
Stay out of production

If an amplifier or digital module works on the bench when hooked up to a laboratory power supply, it follows that four of them will work from one common power supply in the final product. You could, of course, calculate what filtering would be required to isolate each unit unconditionally, but these calculations might take an hour. Besides, you might even have to calculate the frequency at which two capacitors that bypass a common line resonate with the inductance of the lead connecting them.

You would then have to determine what gain, signals, and noise exist at this frequency and what damping, if any, is needed. You can see how all this snowballs. Your job could turn out to be as difficult as specifying the ground connection of a group of IC's to maintain common-impedance coupling at an acceptable level.

But if you think a bit—after all, that's why you went to engineering school—you can save yourself a lot of work. Why not wait until the prototype is delivered to you with all the components potted? Then you can have your technician do the job the easy way. It should only take him a minute to determine if the prototype oscillates, and probably just a few minutes more to determine the exact frequency of oscillation.

Rule 5:
Don't redesign

Don't fret about production. The technician who carefully put together your breadboard, who painstakingly laid out and mounted all components, and who aligned that

breadboard with a mother's loving care will also nurse each production unit right into the shipping crate.

In his 20 years of experience he's worked for engineers even more careless than you; he knows what clearance is needed to stand off 1,000 volts, so he'll take an extra hour to dress the leads carefully and position the resistor precisely. He'll also take two hours to align the amplifiers, remembering just how much each adjustment upset earlier alignments.

So get out of the loop fast! It doesn't pay to waste your valuable time improving designs to make production-line jobs easier. That's the production engineer's responsibility anyway.

Rule 6: Skip the details

Say you've developed and proven a layout with the breadboard. The high-frequency oscillator works. When you told your technician how to mount the tuning elements to achieve a maximum circuit Q, the mechanical designer was in the next room but you didn't bother to ask his advice on how to support them. You were too busy, he was too busy, and besides, it was really an electrical problem.

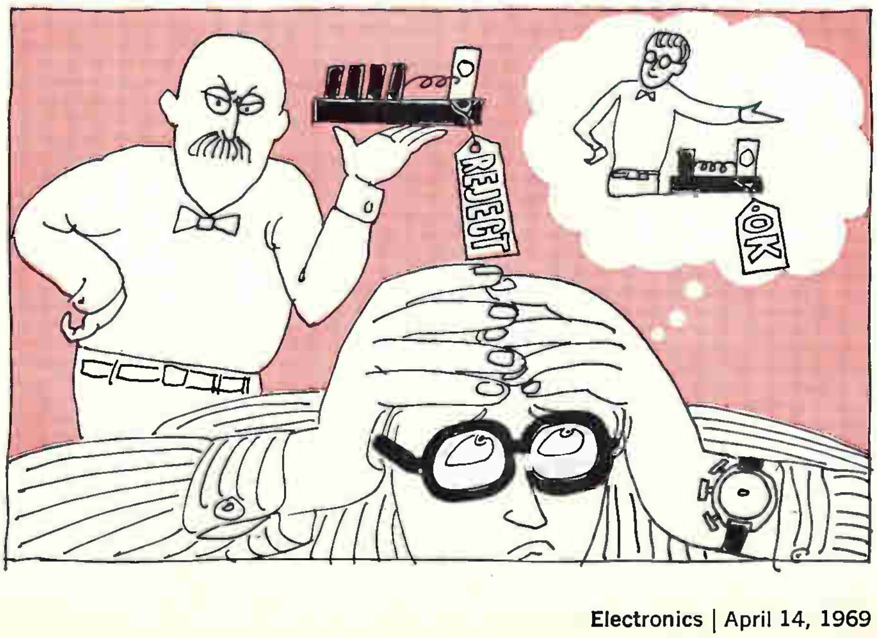
Finally, after many months of sweat, you're ready to release the equipment for production but have decided that it might be a good idea to show the president how well it works. Just as you finish telling him what a great job you've done, your technician inadvertently drops a screwdriver near the equipment. You, the president, and everyone else watch the oscillator's frequency change as though Con Edison were modulating the a-c power line.

Now the heretofore ignored mechanical designer suggests that you use a dielectric support, but the only accessible location at this stage of the game happens to be a high-impedance point of the oscillator circuit. You know he's right, but you also know that with the added capacitance of the support, the oscillator won't cover the required range unless you completely redesign the tuning circuitry. And if you redesign, you'll slip your schedule.

Well, restrain yourself. Don't redesign anything; people might think you're incompetent. Instead, take your chances on shock and vibration. Most likely you can get a waiver, or a new job.

Rule 7: Don't sweat temperature

If the highest operating temperature specified for a piece of equipment is +50°C, rate all the components for +50°C and give the matter no further thought. Of course it may be that the equip-



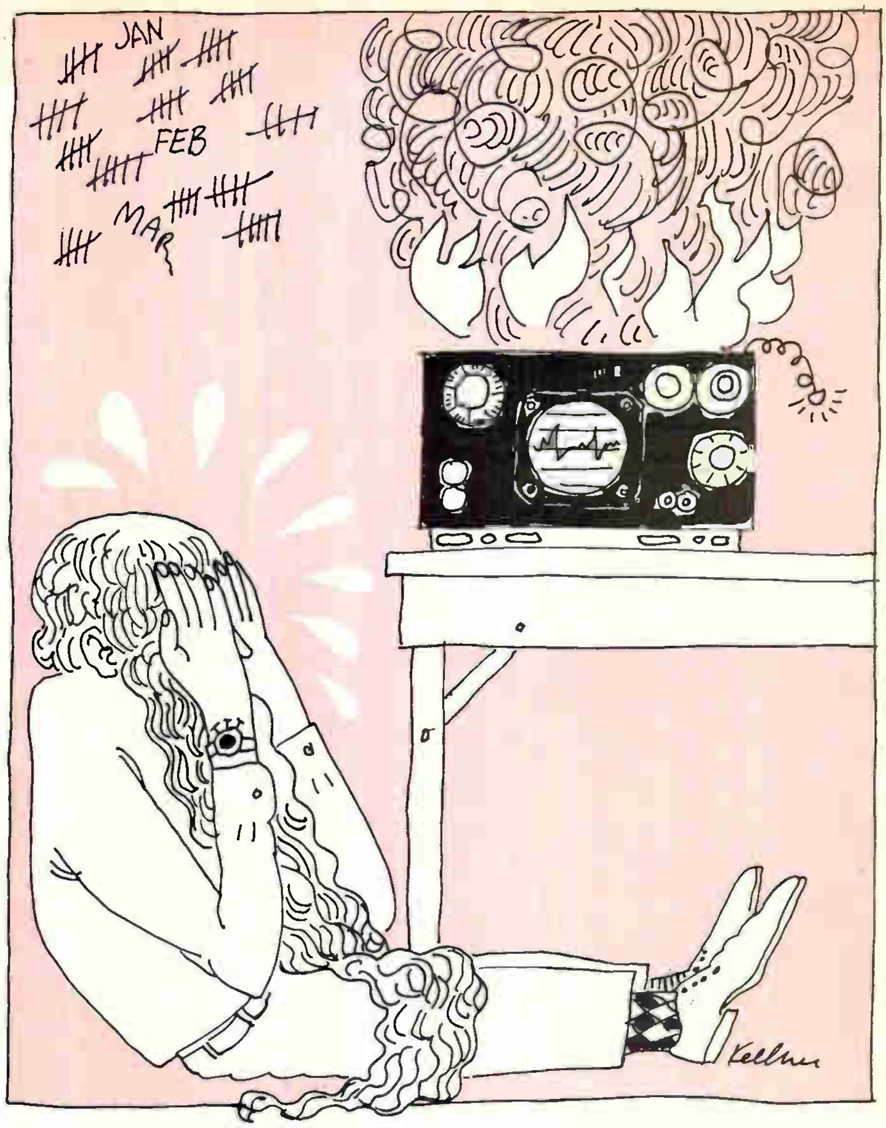
ment itself will generate some heat. And it's true that you could calculate the average temperature rise above ambient, but who remembers those thermodynamics courses. But simple common sense will tell you that those high-dissipation components you grouped together for electrical reasons will block each other's air circulation. The actual temperature in certain areas may rise as much as 50°C above ambient, which could heat nearby components to 40° above ambient. Now if the operating temperature is 50° and the equipment generates enough heat to cause an additional 50° rise, those components rated at 50°C may find it hot.

But you have enough problems to worry about; don't add to the list. Anyway, it's easier to build the equipment and see what burns up. Your customers will tell you.

Rule 8:
If you can't measure it, forget it

The first two production models of your uhf variable-tuned receiver have just failed; sensitivity is out of spec by 2 decibels. How could that be? Initially, the breadboard was 4 db better than required. After you finished the breadboard, you installed limit transistors and the sensitivity margin dropped to 1.5 db. You also allowed for component degradation, which accounted for another 0.5 db. Of course, it would have been better if you had considered all this at the beginning of the design effort, but half a loaf is better than none, and you had a 1-db margin anyway. However, somewhere between breadboard and production line an additional 3 db were lost, and you're wondering where.

Well, here's what happened. When the mechanical designer suggested a support, your technician soldered in a metallized ceramic type. You didn't care what grade of ceramic was used, because when the technician checked the support in the breadboard he found no significant reduction in gain. How could he? Who can measure degradation of 0.2 db in a single circuit? Of course, you could have calculated the actual loss by looking up the dissipation factor of the ceramic, measuring the capacitance, and computing the effect of the equivalent shunt resistance. If this loss was high, you could then have selected a better grade of ceramic to reduce it.



Also, at two points in each tuned circuit of the breadboard you used a mica feedthrough capacitor with a resin seal. However, someone suggested using a newer hermetically sealed type for improved reliability. And since the Q of both types is identical at 1 Mhz, it's natural to assume that there would be no difference at uhf. But being very thorough, you tested one in a mockup and it looked okay. In reality, though, these new capacitors turn out to have additional losses—0.1 db for the low r-f current locations and 0.2 db for the high.

Remember the sample capacitor used in the breadboard? You know, the one with a silver-plated brass terminal all the way through. Well, the newer one has a kovar terminal that's gold flashed after assembly, and this increases its r-f series resistance at uhf by several times that of the capacitor used in the breadboard. Of course, had you measured the capacitor's Q at the operating frequencies, this would have been apparent.

What else could go wrong? For one thing, the coupling capacitor was originally optimized near the extreme high-impedance end of the transmission line. But to make the capacitors easier to install in production, you repositioned them ⅛ inch down the line. Again you had the revised circuit tested, and again you couldn't measure the difference. And you were absolutely right not to concern yourself further. After all, it was only 0.2 db.

Rule 9:
Assume this list is complete ■

Active filters: part 9
Applying nonlinear elements

Magnetoresistive and Hall-effect devices can be the answer for engineers who must worry about the effects of high temperatures or radiation on either conventional semiconductors or integrated circuits

By Velio A. Marsocci
State University of New York, Stony Brook

Unconventional active elements such as Hall-effect and magnetoresistive devices can be used to good advantage as linear amplifiers in converters or gyrators. Previous articles in this series discussed the use of conventional assemblies, for example, transistors and integrated circuits, as active elements in resistor-capacitor filters. Their employment as amplifiers, negative-impedance converters, or gyrators in combination with RC networks avoids problems of bulkiness (in comparison with equivalent RLC networks) and losses in the passband. But offbeat componentry can prove helpful, particularly in applications where size is a factor or where temperature and radiation could impair the performance of a conventional device.

The magnetoresistive amplifier is one application for an unconventional element in an active RC filter network. A magnetic field is modulated by an input signal current, with an active element placed in the field. As the field changes so does the resistance of the element. The resultant variation becomes the output current.

Such amplifiers have been classified into two groups. The first comprises conventional magnetoresistive devices fabricated by placing a material that exhibits a large magnetoresistive effect in the gap of a ferromagnetic core. The second is made up of cryotrons biased to operate in the resistive transition region—that lies between the superconducting and normal resistance states of the gate element. For conventional devices, the magnetic field is varied by input signal currents applied to windings on the core. A schematic and matrix representation of a linear equivalent circuit for this type of device is shown at the bottom of the facing page. (Discussion of matrix occurs later in this article.)

The resistance, R, for the active element is

$$R = R_o(1 + \alpha_m B^n)$$

where R_o is the value of the resistance when the field is zero; B is the magnetic induction, and α_m is the magnetoresistance characteristic for the active element material. The fractional change in resistance, referred to as the zero-field value, for a varying magnetic field is expressed by

$$\frac{(R - R_o)}{R_o} = \frac{\Delta R}{R_o} = \alpha_m B^n$$

The values of α_m and n are determined by measuring $\Delta R/R_o$ for several values of B and then using analytical or graphical techniques to obtain the numbers. In most materials n equals 2, and thus a square-law relationship holds between the magnetoresistance factor, $\Delta R/R_o$, and the magnetic field.

The maximum power gain of the magnetoresistance amplifier can be expressed in the form

$$A_{pm} = K_1(S/R)^2$$

where K_1 depends on the physical characteristics of the active element, the geometry of the magnetic core and its windings, the flux density in the core, and the d-c power dissipated by the active element; S equals dR/dB.

Factors $(S/R)^2$ and K_1 are affected by the field biasing; however, plotting $(S/R)^2$ and A_{pm} against the applied field shows that the variation in A_{pm} follows that in $(S/R)^2$ very closely. Magnetoresistance amplifiers are useful as components of such devices as mixers, d-c to a-c inverters, and transducers (pressure sensors, displacement sensors, and accelerator elements).

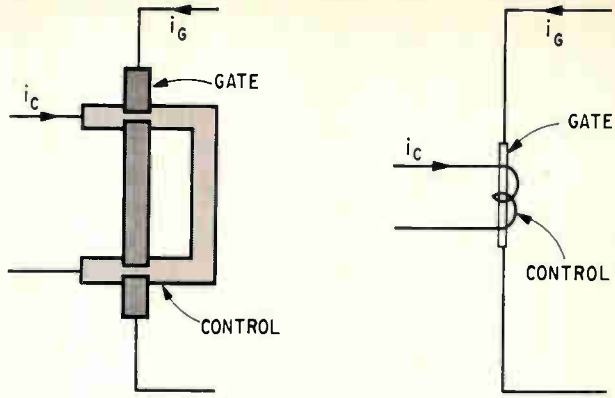
Although magnetoresistive devices have limited bandwidth and require relatively large magnetic fields, they offer good d-c isolation between the input and the output terminals. The output signal's polarity is then determined by the arrangement of the biasing batteries.

For the second group a typical cryotron element and a cryotron amplifier are depicted at the right. In linear operation, an input current applied to the control element, produces a varying magnetic field that modulates the resistance of the gate element in the transition region.

The linear output characteristics of the cryotron are derived by considering that the resistance of the gate, for operation in the transition region, is described by

$$R_g = K(ai_G + i_C - I_o)^n, \quad 0 < K(ai_G + i_C - I_o)^n < R_n$$

where R_n is the normal resistance of the gate element, I_o is a constant, I_G is the total instantaneous value of gate current, I_c is the total instantaneous value of control current, and K, a, and n are constants. A typical family of such curves is shown at the bottom of the next page together with the load line set by R_L, the load resistor.



Cryotron amplifier. Current, i_c, is applied to the control element of a thin-film cryotron amplifier and produces a fluctuating magnetic field. The field modulates the resistance of the gate element. Current through the gate is designated i_G.

If the cryotron's operation is restricted to small regions about a point in the linear region of the output characteristics, then the variation in the gate voltage can be written as

$$de_G = \left(\frac{\partial e_G}{\partial i_G}\right) di_G + \left(\frac{\partial e_C}{\partial i_C}\right) di_C$$

where e_G and e_c are the total instantaneous values of the gate voltage and control voltage, respectively. If these incremental quantities are replaced by symbols for small-signal variations in the voltages and the currents, and if a dynamic gate resistance, r_g, and a transresistance, r_m, are defined as

$$r_g \equiv \frac{\partial e_G}{\partial i_G}, \quad r_m \equiv \frac{\partial e_G}{\partial i_C}$$

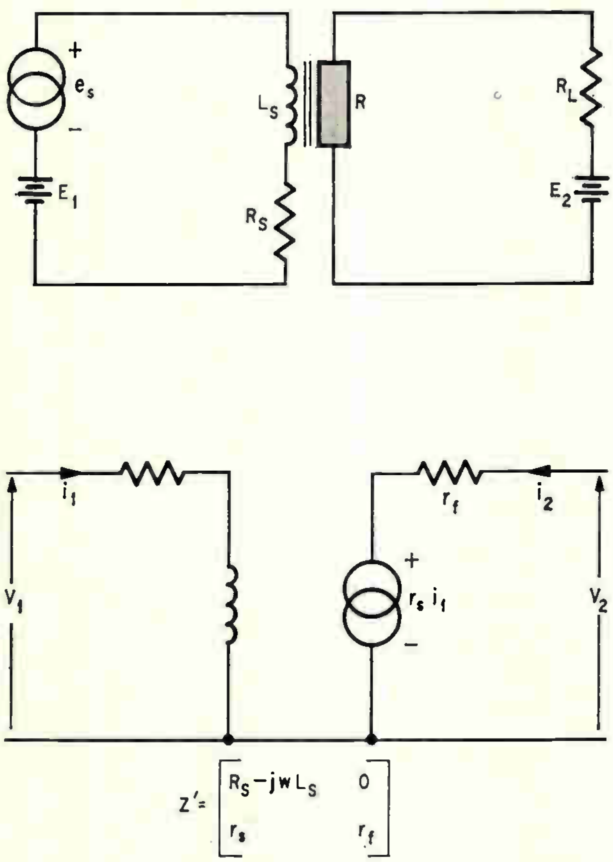
then e_g can be written in the form

$$e_g = r_g i_g + r_m i_c$$

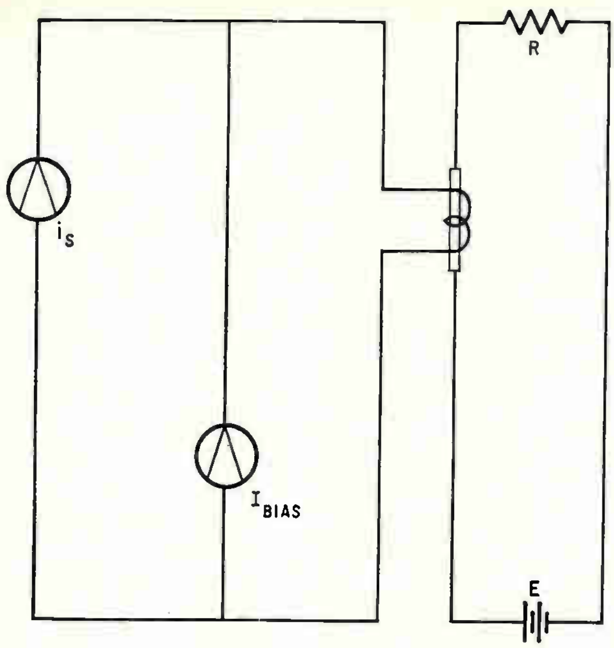
The input circuit of the cryotron can be represented as a short-circuit, since the control element is always in the superconducting state. Several small-signal equivalent circuits for linear operation that can be used to characterize the cryotron are shown at the right of page 119. These representations are referred to as the common-point, common-control, and common-gate connections. They are analogous to the three connections possible with a transistor, namely common-base, common-emitter, and common-collector, respectively.

If the cryotron amplifier is represented in terms of the linear equivalent circuit of the common-point type with a load resistance, R_L, attached to the output terminals, the current gain of the device is derived as

$$K_i = \frac{R_m}{r_g + R_L} = \frac{\alpha}{1 + (R_L/r_g)}$$



Magnetoresistive amplifier. Current i_1, through inductor, L_s, sets up a magnetic field that is sensed by magnetoresistive element, R. Equivalent circuit for the amplifier shows the result as a voltage source, $r_s i_1$.



Current mix. In the linear cryotron amplifier, current i_s and i_{bias} combine and flow through the coil, setting up a magnetic field. Output current is then induced in the gate and flows through resistance R.

where α is defined by $\alpha = -\partial g/\partial c/$ and by $\alpha = r_m/r_g$. The maximum current gain is achieved for $R_L = 0$, which is the condition for a cascaded stage in the common-point connection.

The polarity of the output depends upon the polarity of the bias generators. A reversal of the bias batteries reverses the sign of α. Current gain of the amplifier in the common-control connection is given by

$$K_i = \frac{\alpha}{1 - \alpha + R_L/r_g}$$

which has a maximum value, for $R_L = 0$, of

$$K_i = \frac{\alpha}{1 - \alpha}$$

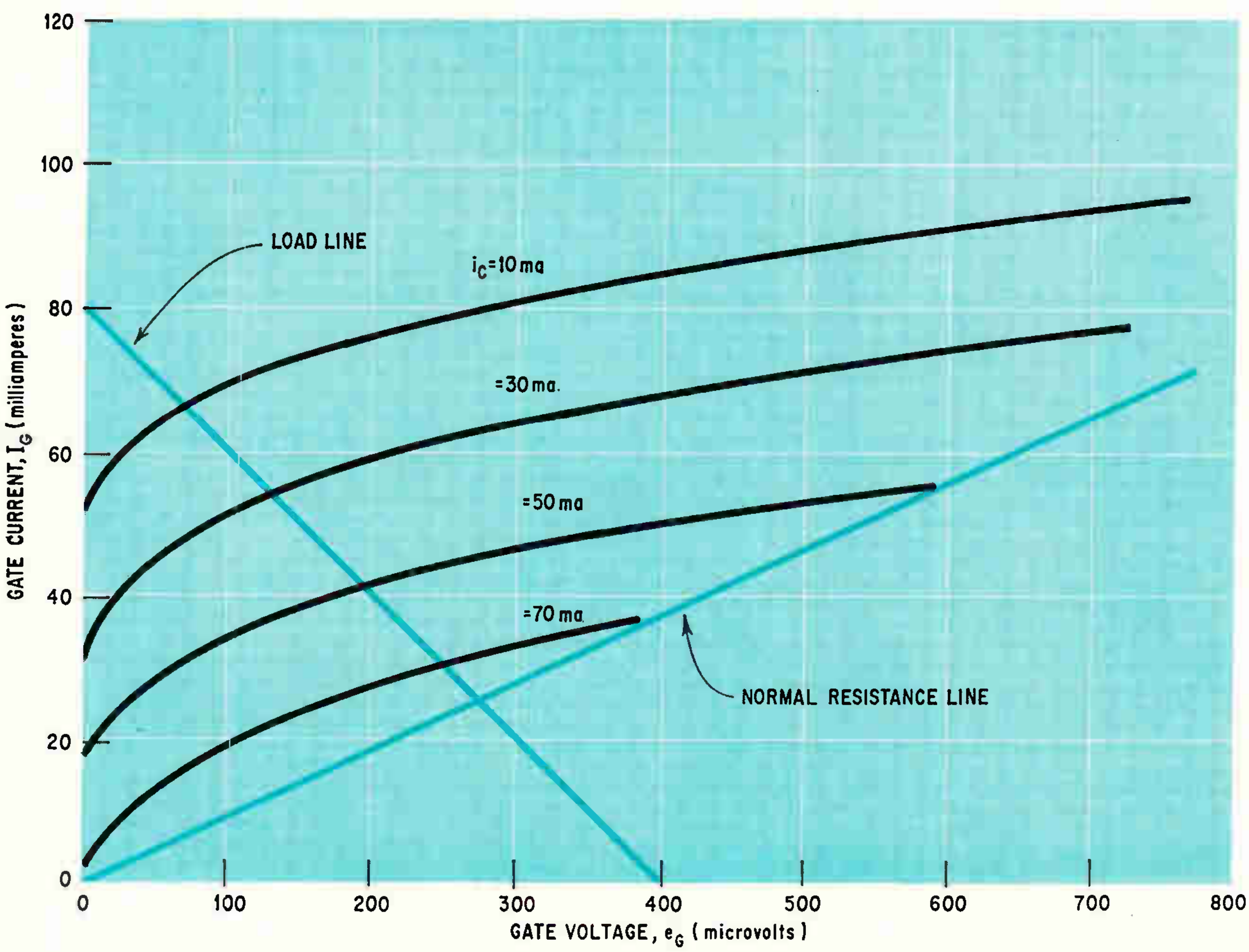
Thus, in this connection K_i can take on a large value even when α is less than unity. In the common-gate connection, the current gain is described by

$$K_i = \frac{1 + \alpha}{1 + R_L/r_g}$$

with the maximum value of

$$K_i = 1 + \alpha$$

being achieved for $R_L = 0$.



Getting an output. These are typical output characteristics of a cryotron operated in the resistive transition region.

The major advantages of cryotrons are ruggedness, high reliability and wide bandwidth, as well as the large packing densities that are possible.

If a conducting specimen is placed in a magnetic field that is perpendicular to the direction of current in the plate, the deflection of the charge carriers in the specimen produces a Hall voltage. This voltage is perpendicular to the plane set by the current and magnetic fields. A typical Hall-effect plate is depicted at the top of page 120. The effect has been used in such devices as magnetometers, isolators, transducers, circulators, resolvers, function generators, detectors, multipliers, and modulators.

A linear power gain greater than unity can be achieved with the device if a d-c current is supplied to bias the sample. The gain is measured from the input to the magnetic field to the output at the Hall-voltage terminals. Like that of the magnetoresistance amplifier, the gain-bandwidth of this device is limited.

Gyrator circuits have been developed using any one of the several network techniques and active devices [*Electronics*, June 10, 1968, p. 114]. One drawback of gyrators is that the input and the output impedances that result are not low enough for truly efficient action.

One way to obtain these low impedance levels is with cryogenic magnetoresistive devices. The conventional and the cryogenic magnetoresistive devices also produce the gyrator characteristics with only one negative-resistance element.

Almost all other gyrator configurations require two negative resistance elements. With transistor circuit configurations, these may be intrinsic in the design. With the magnetoresistive devices, the single negative-resistance element can be achieved either by using two such devices in combination or by using the conventional method for gyrators.

The gyrator is a two-port network that can be characterized by the z-parameter matrix

$$\begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} \equiv \begin{bmatrix} 0 & \pm R \\ \pm R & 0 \end{bmatrix}$$

R is an impedance developed by the network (z') in the drawing at the top of page 121 together with the external elements Z, Z_1, and Z_2. If the over-all network is to produce the ideal gyrator, conditions must be such that

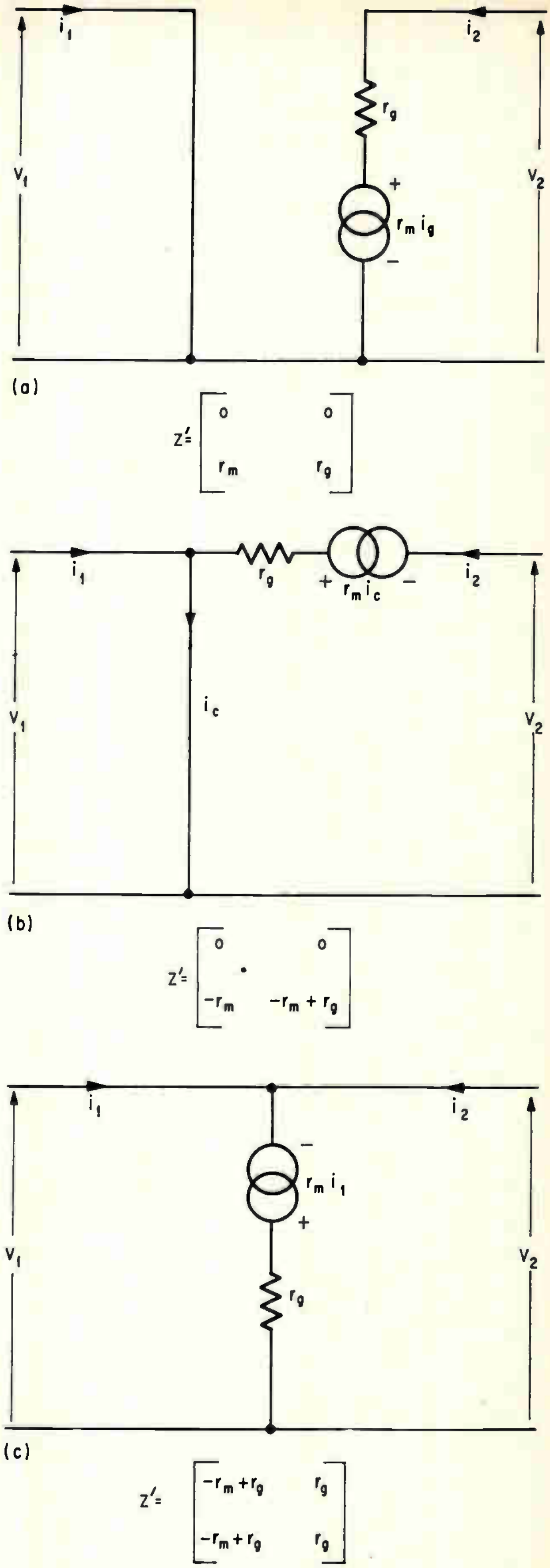
$$Z = -(z_{12}' + z_{21}')/2$$

$$Z_1 = -(z_{11}' + Z), \quad Z_2 = -(z_{22}' + Z)$$

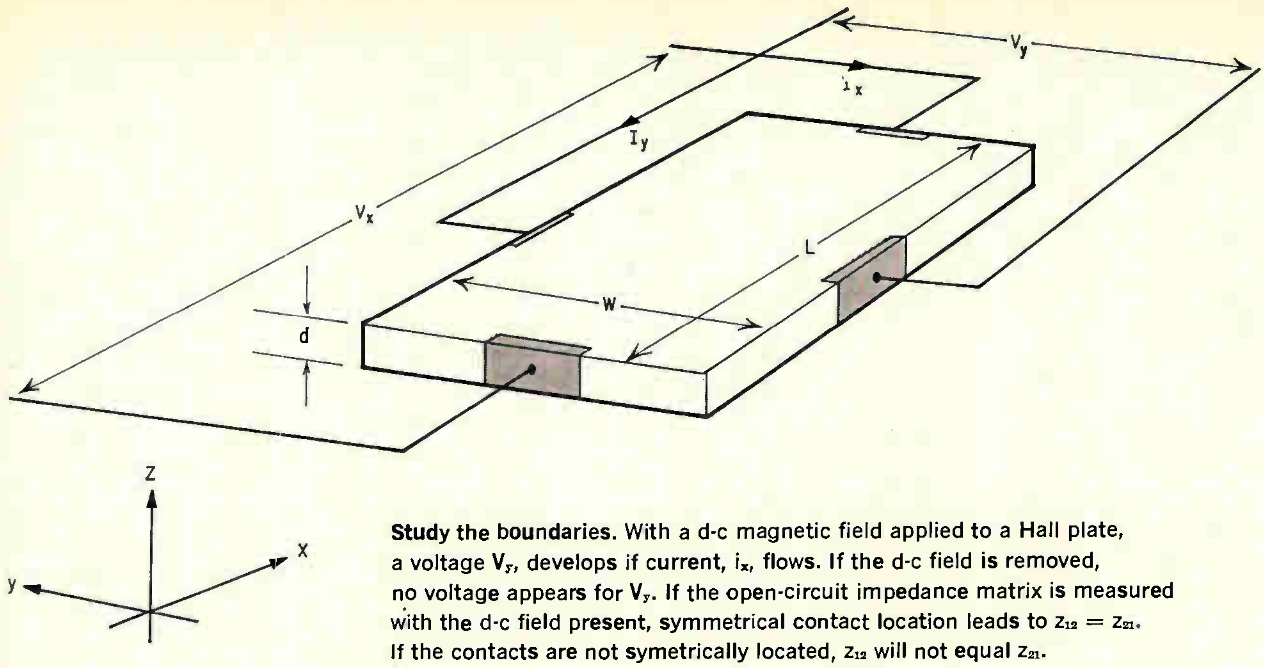
If the network (z') is to be implemented with a cryotron operating in the linear mode, then the gyrator matrix is achieved from the common-point connection—with $R = +\tfrac{1}{2}r_m$—and the external impedances chosen as

$$Z = -\tfrac{1}{2}r_m, \quad Z_1 = \tfrac{1}{2}r_m, \quad Z_2 = -r_g + \tfrac{1}{2}r_m$$

Thus, if $r_m \geqq 2r_g$, the gyrator characteristics are indeed achieved with one negative-resistance element. This condition requires that



Cryotron equivalent. A cryotron amplifier is connected in a common-point (a), common-control (b), or common-gate (c), configuration.



Study the boundaries. With a d-c magnetic field applied to a Hall plate, a voltage V_y, develops if current, i_x, flows. If the d-c field is removed, no voltage appears for V_y. If the open-circuit impedance matrix is measured with the d-c field present, symmetrical contact location leads to $z_{12} = z_{21}$. If the contacts are not symetrically located, z_{12} will not equal z_{21}.

$$\alpha \equiv \frac{r_m}{r_g} \geqq 2$$

If the cryotron is used in the common-control connection the gyrator impedance matrix is produced when

$$Z = \tfrac{1}{2}r_m, \quad Z_1 = -\tfrac{1}{2}r_m, \quad Z_2 = r_g - (\tfrac{3}{2})r_m$$

Therefore, the gyrator characteristic is still achieved with a single negative-resistance element if

$$\alpha \equiv \frac{r_m}{r_g} \leqq \tfrac{2}{3}$$

This is a much less stringent condition than the one for $r_m/r_g \geqq 2$, and these output characteristics are achieved over the entire operating range. A similar analysis for the common-gate connection yields the requirements that

$$Z = -r_g + \frac{r_m}{2}, \quad Z_1 = \frac{r_m}{2}, \quad Z_2 = -\frac{r_m}{2}$$

Again, if the gyrator matrix is to be achieved with only one negative-resistance element,

$$\alpha \equiv \frac{r_m}{r_g} \geqq 2$$

A magnetoresistive device can be operated with either polarity at its output signal. The conventional device, however does not provide the low impedance levels obtained with the cryotron.

In the linear equivalent circuit, shown for the conventional magnetoresistive device, elements R_s and L_s represent the impedance of the field-producing coil to which the input signal is applied. The impedance parameters provided by this network, when used to obtain the (z′) portion of the over-all network, are

$$z_{11}' = R_s + j\omega L_s, \quad z_{22}' = r_f, \quad z_{12}' = 0, \quad z_{21}' = r_s$$

and the gyrator matrix can then be achieved, with $R = r_s/2$, if the external elements are designed as

$$Z = -\frac{r_s}{2}$$

$$Z_1 = -(R_s + j\omega L_s) + \frac{r_s}{2}, \quad Z_2 = -r_f + \frac{r_s}{2}$$

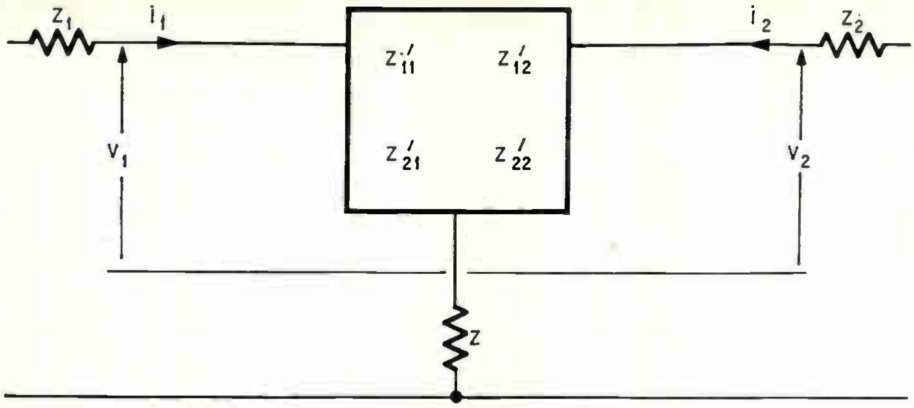
The presence of the $j\omega L_s$ term for Z_1 indicates that the gyration resistance, R, is achieved at only one frequency. The design of the magnetic circuit of the device must aim toward minimizing L_s so as not to make the useful bandwidth too low. Therefore, the gyrator characteristics are achieved with one negative-resistance element provided that

$$r_s \geqq 2R_s$$
$$r_s \geqq 2r_f$$

The magnetoresistive device can be connected in the corresponding three ways as the cryotron. For instance, the connection just analyzed corresponds to the common-point connection for the cryotron. If the magnetoresistive device is arranged in a common-control connection then the following inequalities must be observed:

$$r_s \geqq 2R_s$$
$$r_s \geqq 2r_f$$

In the arrangement corresponding to the common-gate connection, however, the gyrator is achieved with one negative-resistance element if the sole criterion



Modeling a gyrator. A typical gyrator is represented by its z matrix and series resistive elements.

$$r_s \geqq 2R_s$$

is satisfied.

Thus, a cryogenic device does provide very low input and output impedances for the gyrator network, but the magnetoresistive device can operate both at room temperature and reduced temperatures. How well the two devices compare with other methods in approaching the ideal gyrator characteristics can be seen by comparing the ratios R/z_{11} and R/z_{12} for each case. The input and output impedances are not zero in practice, and the impedance criteria for α and r_s are satisfied only for the inequality.

Experimental results for the magnetoresistive device indicate that the condition $r_s \geqq 2r_f$ is easily achieved, whereas the more restrictive statement $r_s \geqq 2R_s$ requires that the input circuit be designed to minimize the real part of the input impedance.

Hall-effect gyrators

The Hall-effect devices have been used to achieve gyrator characteristics, but the device introduces network parameters that cause the input and output impedance to vary from zero. However, to control this limitation, the Hall-effect device is connected with one negative-resistance element.

The two-port network equations for the Hall-effect plate are written as

$$V_x = z_{xx}I_x + z_{xy}I_y$$
$$V_y = z_{yx}I_x + z_{yy}I_y, \quad z_{xy} = z_{yx}$$

where z_{xx} and z_{yy} represent the internal impedances of the device. The parameters z_{xy} and z_{yx} are also functions of the Hall coefficient and of the applied magnetic induction. An equivalent set of admittance equations based on the geometry and the conductivity have been derived as

$$I_x = (\sigma_{xx}Wd/L)V_x - (\sigma_{xy}d)V_y$$
$$I_y = (\sigma_{xy}d)V_x + (\sigma_{xx}Ld/W)V_y$$

Comparing the coefficients V_x, V_y, I_x, and I_y yields

$$z_{xx} = (\sigma_{xx}L/DdW)$$
$$z_{yy} = (\sigma_{xx}W/DdL)$$
$$z_{xy} = -z_{yx} = (\sigma_{xy}/Dd)$$

where $D = \sigma_{xx}^2 + \sigma_{xy}^2$. Therefore, the impedance matrix for the Hall-effect device can be written as

$$\frac{1}{Dd}\begin{bmatrix} (\sigma_{xx}L/W) & \sigma_{xy} \\ -\sigma_{xy} & (\sigma_{yy}W/L) \end{bmatrix}$$

This situation also represents a departure from ideal gyrator characteristics in that z_{xx} and z_{xy} may not be relatively low impedances. However, the ideal situation can be approached if the Hall plate is fabricated so that $W << L$, which tends to reduce z_{yy} to a low value. The success achieved by constructing the plate in this way depends on how z_{xy} and z_{yx} are affected by variations in the geometry. Although the parameters appear to be affected only by the dimension, d, the Hall coefficient also depends on the geometry of the plate. Thus, since σ_{xy} and σ_{yx} are related to the Hall coefficient, the unbalance produced in z_{xy} and z_{yx} must be considered from the physics of the device.

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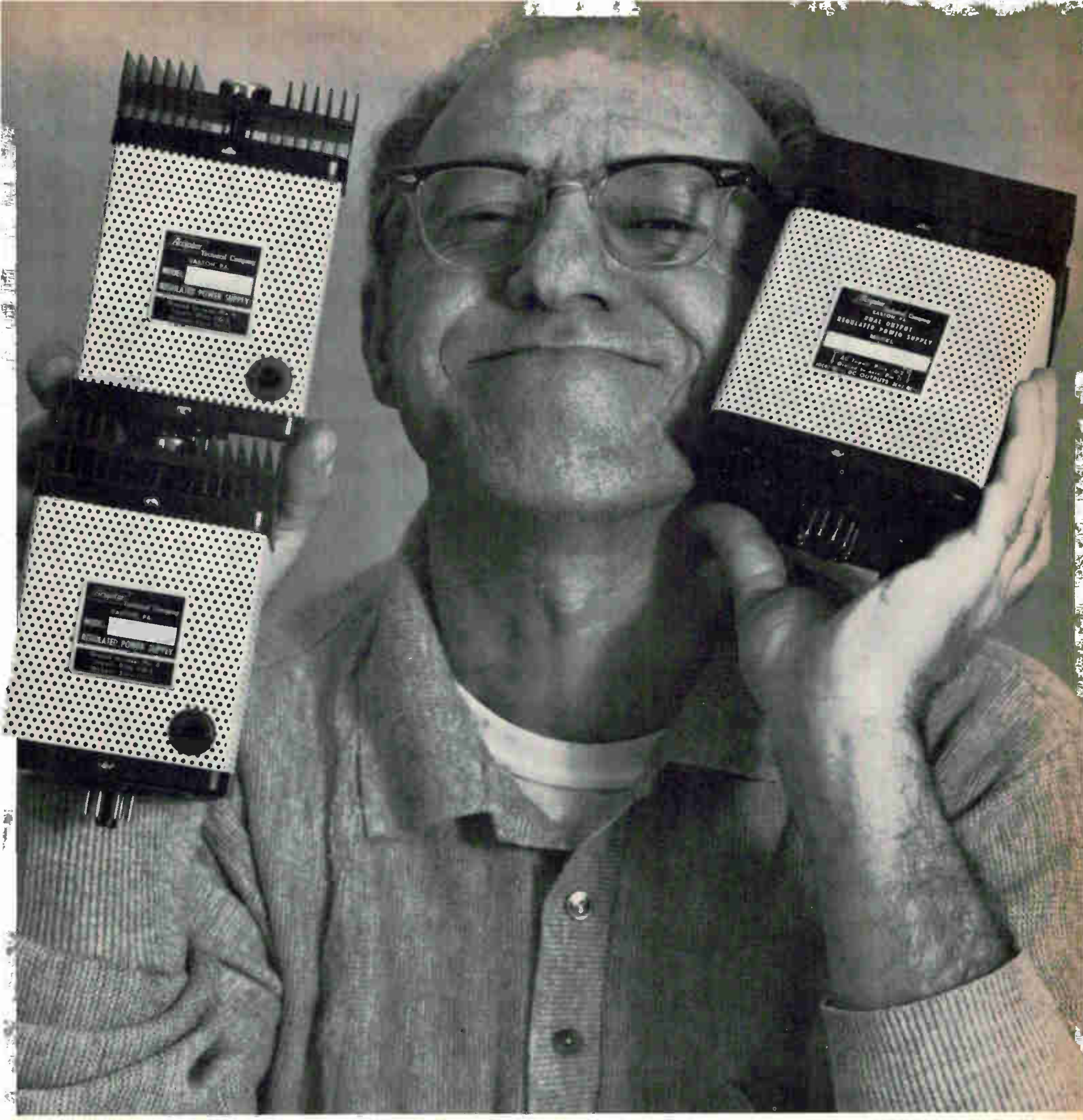

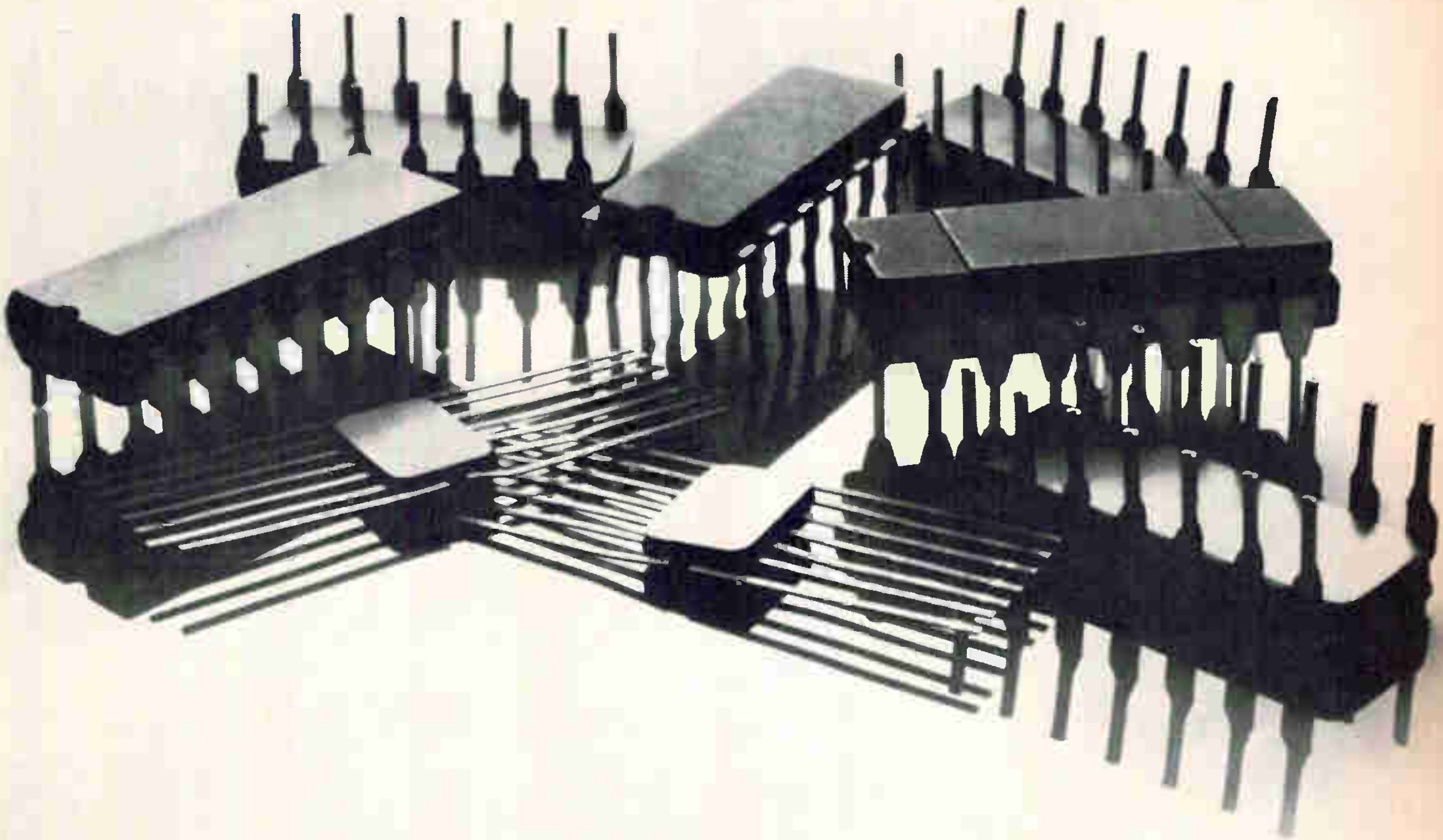

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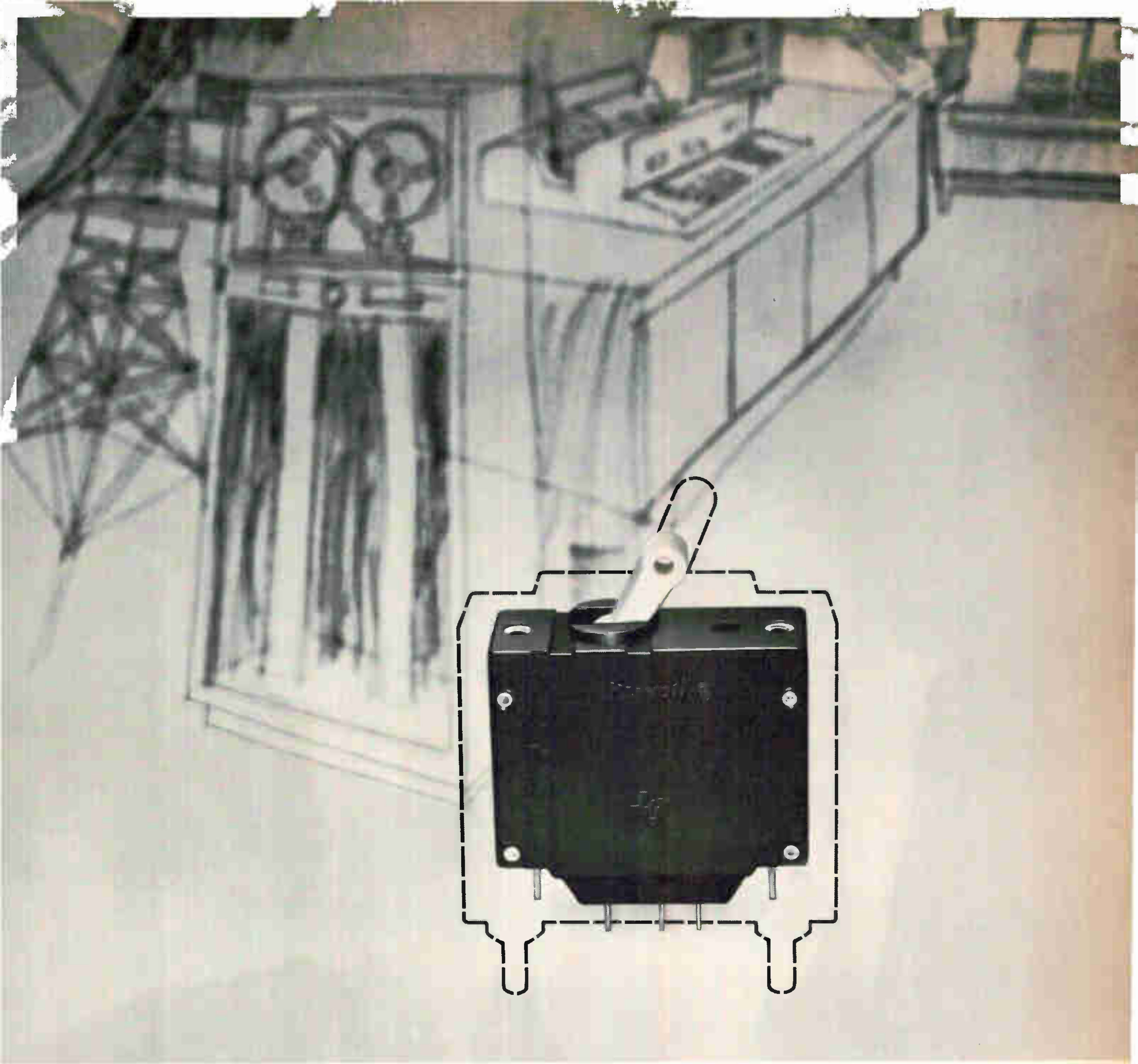

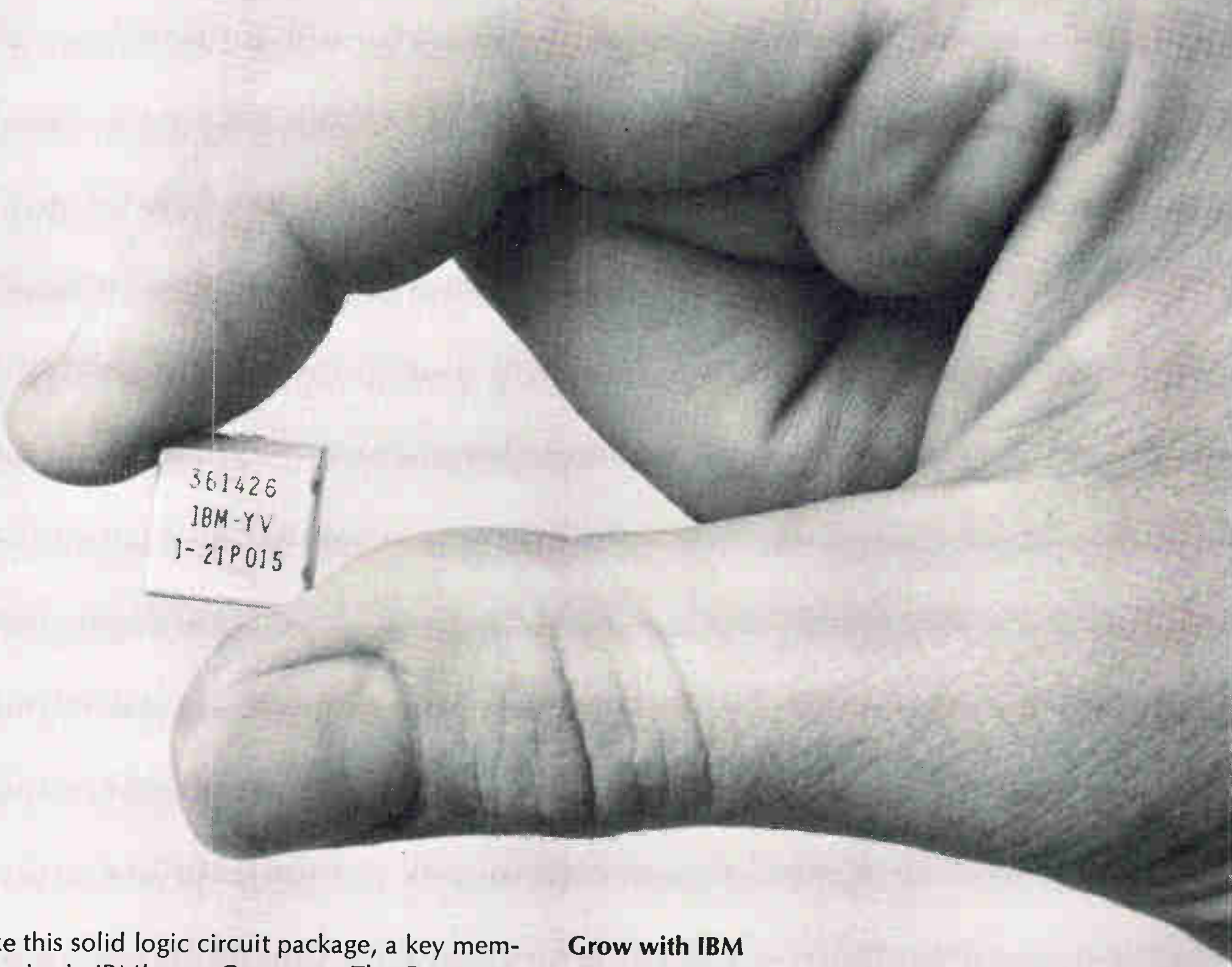

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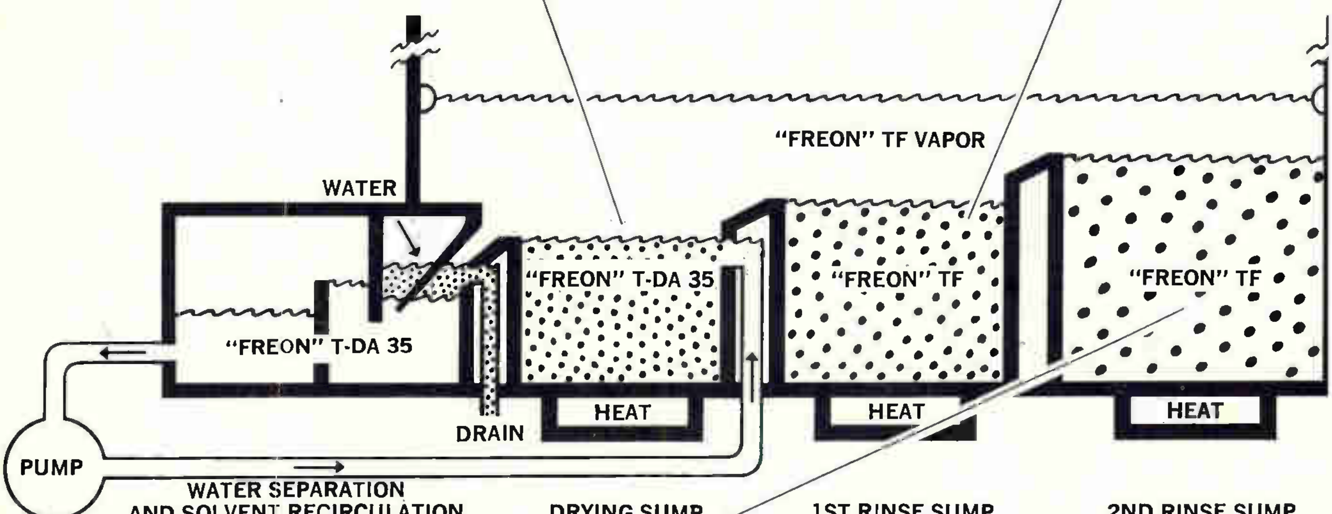

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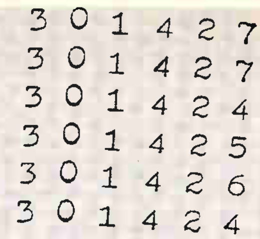

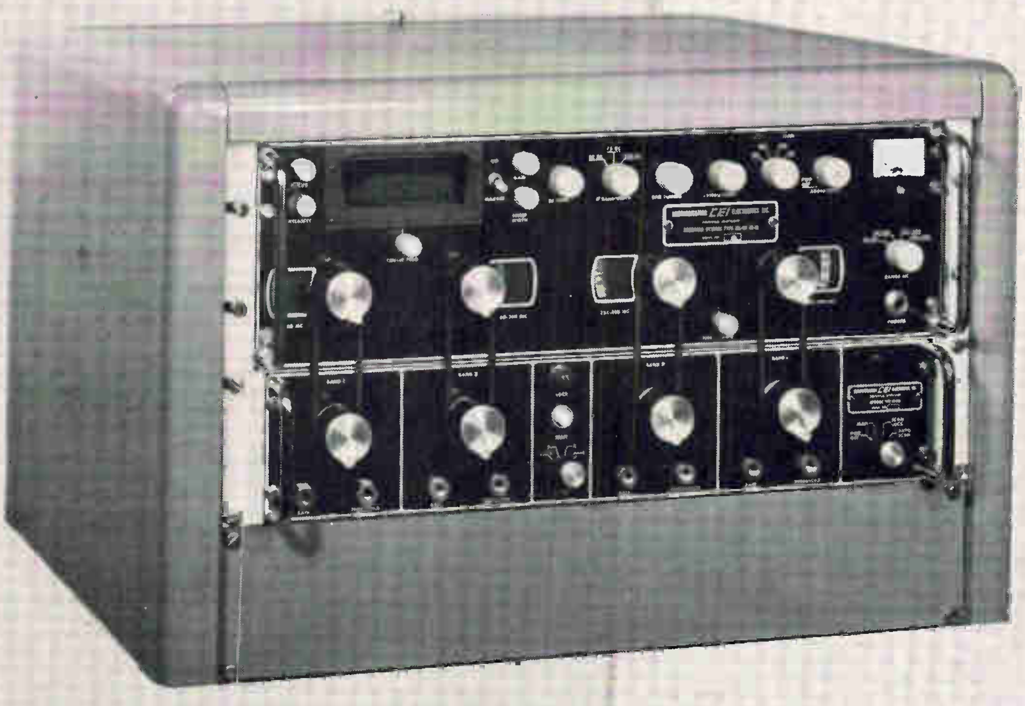

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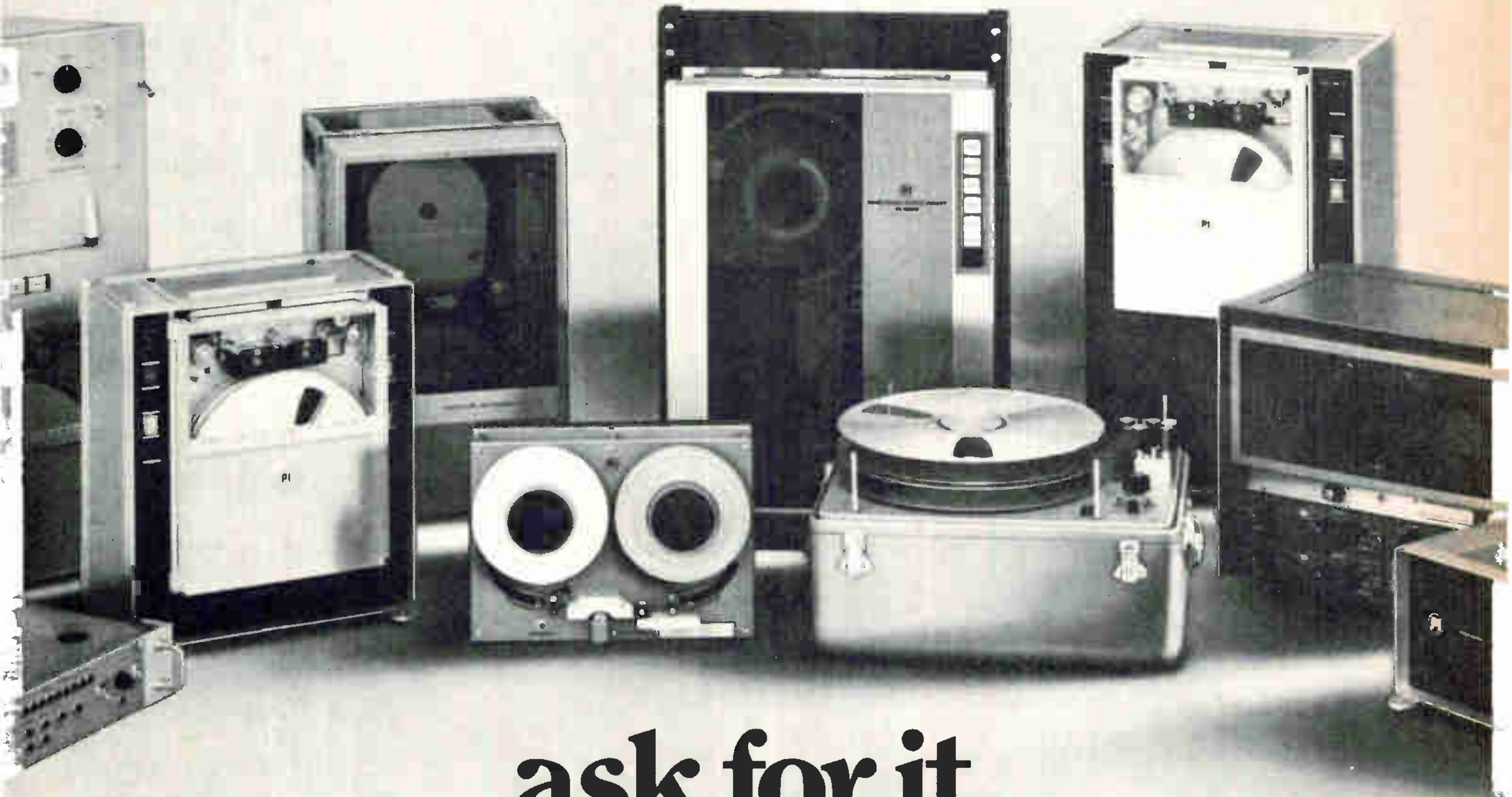

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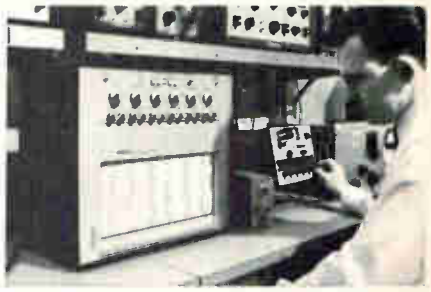

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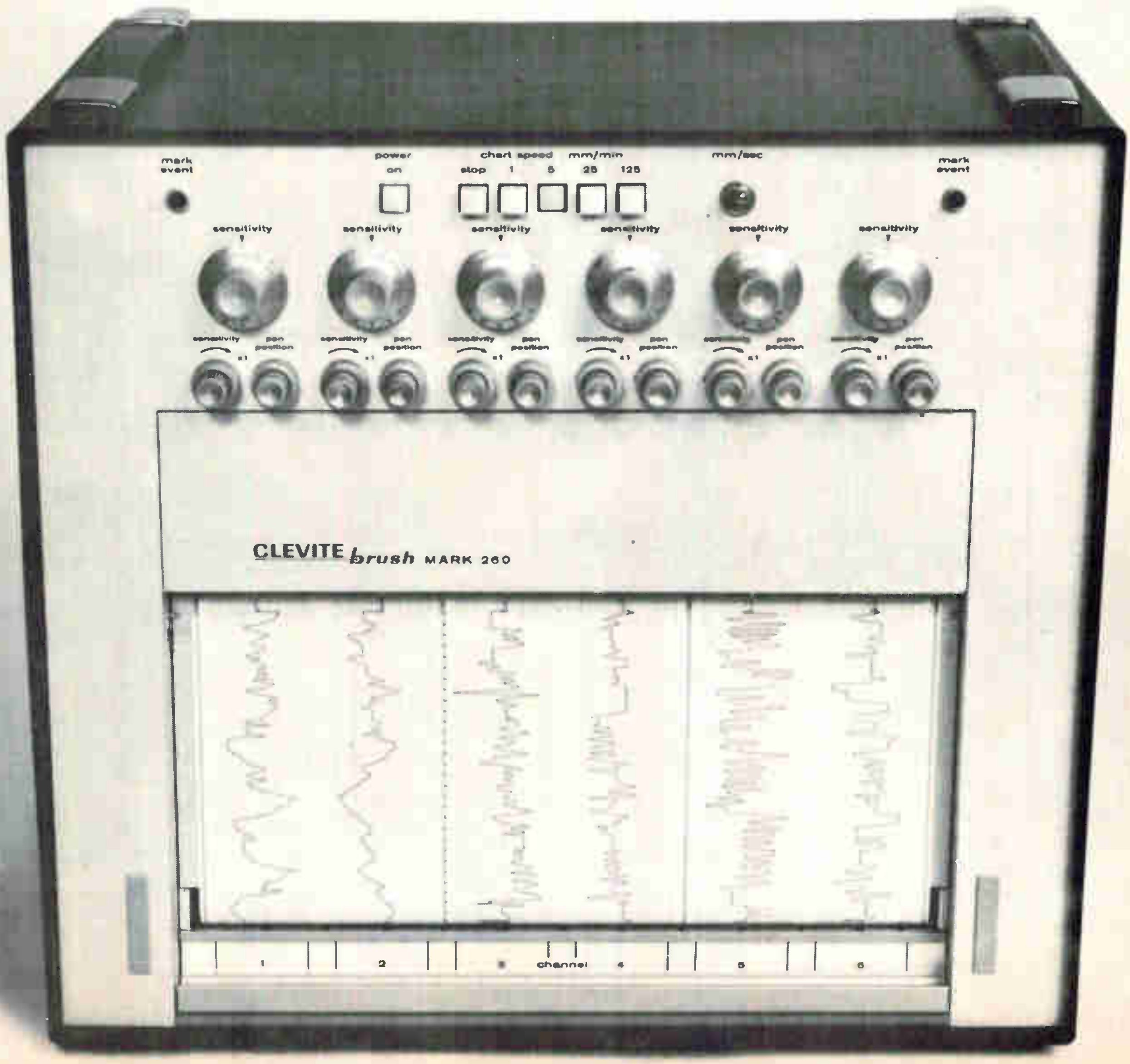
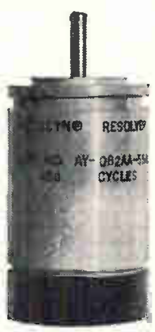


Bendix Autosyn 08 Synchros.



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From Catalog 25	Function	Voltage	Max. Error
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AY080AA-42-A1	Receiver	26/11.8	—
AY080AA-36-A1	Control Transformer	11.8/22.5	7′
AY083AA-43-A1	Control Differential	11.8/11.8	7′
AY082AA-53-A1	Resolver	26/11.8	7′

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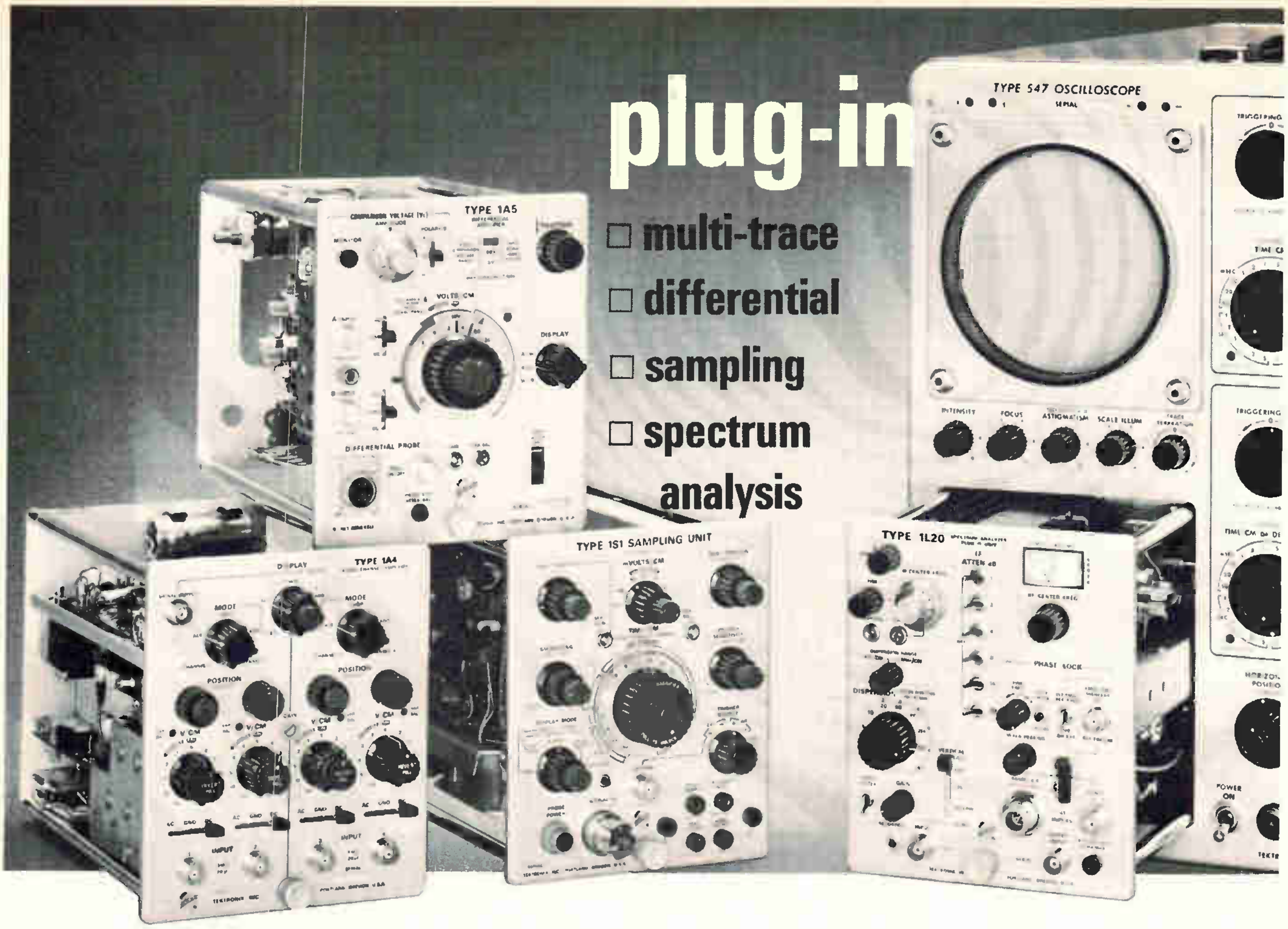

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For EE's the party's over

In all but a few critical specialties, the supply of engineering talent exceeds demand; nonetheless, salary scales continue their upward spiral

By Peter J. Schuyten
Staff writer

Demand for electrical engineers far exceeded the supply as recently as a year ago. Fledgling EE's, fresh out of school, could pretty much pick and choose what they wanted to do professionally and for whom they wanted to do it. But as the song suggests: "The times they are a-changin'." And as an official at a large aerospace concern in the Philadelphia area puts it, "This is the year of the employer."

One of the big reasons for the changed situation involves constraints in the Federal budget. Cutbacks in projected outlays for space projects and stretchouts of key defense programs are having a profound impact on the employment picture for EE's. An East Coast electronics company, for example, reports having laid off 1,000 or more of its technical staff over the last 10 months. And across the country, college placement officers and corporate executives confirm the fact that this firm's experience is not an isolated case.

John Love, employment director for Lockheed Missiles and Space division, for example, reports his company's need for new personnel is so slight that he's had to cancel interviews at a number of colleges because "we just didn't feel right taking up people's time needlessly." Lockheed recently gave pink slips to a substantial number of EE's following the completion of the research and development phase of the Poseidon contract. And a spokesman for the Page Communications division of the Northrop Corp. says that the overall supply-and-demand picture, coupled with the company's need for experienced personnel, has caused it to drop—temporarily at least—its campus recruiting program.

Neither the National Aeronautics and Space Administration nor the Department of Defense expects to be doing very much hiring this year. A spokesman for NASA reports that due to the size of cutbacks in the agency's funds, there are few spots for engineers, or anyone else for that matter. In fact, layoffs at NASA and certain military agencies—for example, the Office of Naval Research—will be more common this year than ever before.

College placement directors, like Dale Barbee of Case-Western Reserve University in Cleveland, find it's tougher to slot graduates in choice spots. Barbee reports that while there are 16% more recruiters arriving on his campus this year, the number of actual job offers is off by about 50%. He attributes this drop partly to the fact that Case-Western Reserve traditionally attracts a large number of recruiters from R&D companies where the money pinch has been particularly acute.

Feeling a draft. The elimination of draft deferments for graduate study hasn't helped the situation any, either. Many EE's who would otherwise be going on for advanced degrees are joining the ranks of those shopping around for occupational deferments. Thomas Martin, dean of engineering at Southern Methodist University in Dallas, notes that nationally, new admissions to electrical engineering graduate schools have dropped 25%. SMU has experienced about a 15%

Wanted men. Though sought after, Negro engineers like Ernest Bouey, a veteran value-engineering specialist with GE, are still relatively rare in industry.

Executive suite

Forget about next year's raise; think about becoming an executive, where the real money is. That's the advice San Francisco management consultant Jack R. Yelverton gives EE's. Along mahogany row, salaries are going up much faster, proportionately, than at the low end of the scale, he finds. "The tax structure makes that almost imperative," says Yelverton, a vice president of Wilkinson, Sedgwick, and Yelverton Inc.

"To give a meaningful increase to a man at the $25,000 level, you can't just give him a couple of thousand dollars. On his bimonthly paycheck, that's the price of a good dinner," he asserts. A large part of his firm's business involves executive search—headhunting. "We find," Yelverton says, "a technical manager's slot that paid $25,000 in 1965 will pay $34,000 today."

How does one attain these levels? Yelverton is leery of generalizing. But he says that, allowing for the inevitable exceptions, the president of an average electronics company is likely to have been educated as an electrical engineer, to have worked his way up in manufacturing or engineering, and, at some point, acquired some marketing exposure—either as a product or division manager, but not as a marketing manager. "In the electronics business, the chips are down on understanding the technology, not the market," he explains. "When it comes to picking a president, a board of directors is more likely to choose the man with the manufacturing background than the marketing type."

Careering. The first step up the ladder from the engineering ranks is likely to be as a project engineer. "At that time, the engineer is in his late twenties and making around $10,000, perhaps less," Yelverton says. "In very few instances will he get a raise, but he may move along a little faster in the normal salary progression." The project engineer may have $15,000 to spend on developing an instrument; the quality that his employers look for is good judgment. They ask if he's a rational, mature person who thinks things through and expresses his frustrations back to management, Yelverton continues. Some neophytes think that they can do anything, don't realize when they have a problem, and get into trouble, he adds.

The next step is as a section unit manager; the titles vary but the engineer has a permanent assignment that entails planning and supervising the work of others. He's about 30, and he may be making $13,000 or $14,000—in some cases as much as $18,000.

Five years or so later, the budding manager is in demand. "At 35, with solid experience, he can begin to think about some form of delayed or extra compensation such as stock options or bonuses," says Yelverton. But he can't press his luck; the offer will have to come from the company. "If he's changing jobs, he may bargain for a little more money," says Yelverton, "but after a few years, compensation evens out. And the guy who negotiates too hard may become suspect."

Bonuses are likely to be based on corporate performance. A typical stock option may be for 1,000 shares at current market price, 500 of which may be bought in two years, the rest over the next two years. A company seldom has much flexibility in this matter, Yelverton points out, because "there is just so much pie to cut. The man who wants four times his share may put himself out of contention."

Moment of decision. At this point, the engineer has a number of options. "He's no longer just an engineer," Yelverton notes, "he's a manager. He'll probably get some rotational assignments for example, being made a plant manager or being asked to find a subsidiary to acquire and then to manage it—and if he's well-known, he becomes of interest to the investment community." It's at this point that some of the more successful managers begin peeling off to start their own companies, and they have less and less trouble finding the backing.

Yelverton says that some large companies are beginning to feel the pinch of these defections, either to smaller companies or to new firms. "The big outfits have a backlog of talent, but there is a siphoning off of people in whom they have a big investment in education," he continues. "To combat it, they may have to decentralize decision making, and figure out ways to make a man's earnings a function of his contribution to profit."

—Walter Barney

decline in its own enrollment. "The situation here is somewhat unusual," says Martin. "We're in a location where many of our students can go to school, and work in critical jobs at defense plants as well."

At Carnegie-Mellon University in Pittsburgh, J. Dennis Ryan, assistant placement director, confirms that more and more students prefer to take their chances at getting an occupational deferment rather than go on to grad school. In 1967, for instance, 45% of CMU's engineers went on for an advanced degree; last year only 32% did so. This year the figure promises to be even lower.

Employers are not altogether unhappy about the draft situation since it gives them a wider range of top graduates to choose from. Richard Blue, placement director at Tufts University near Boston, says, "For the first time, recruiters are getting a chance to talk to the A student, with some prospect of success for hiring him."

Ten grand

Oddly enough, while this year's graduate may not be wholly satisfied with the job he gets, his monthly check should go a long way toward cheering him up. And much the same holds true for his more experienced colleagues in industry. Although a definite buyer's market exists, the employment picture for the electrical engineer hasn't become so dark as to adversely affect salaries. As a matter of fact, the inflationary spiral continues unabated.

"This year, for the first time, graduating EE's will have a shot at a $10,000 starting salary," says Georgia Institute of Technology's placement director Neil DeRosa. And although the $10,000-a-year-plus graduate will be more the exception than the rule, the average EE can look forward to an unusual starting salary of $9,600—about $1,000 higher than he would have made last year.

Starting pay is now determined less by a man's class standing or the prestige of his school than by what the engineer did with his summers. At Litton Industries' Guidance & Control Systems division, for example, where starting salaries range from $9,000 to $10,-

500, the grad who has done something applicable during vacations commands the top dollar, according to employment manager Frank McCarter.

California dreaming. The geographical location of the company also plays a part in the salary game for both beginning and experienced engineers. Georgia Tech's DeRosa notes that graduates who opt for jobs in California can expect to get "slightly more" than those who stay in the Southwest or Southeast. The Northeast, especially the Boston area, follows the West Coast in terms of monetary rewards. DeRosa, among others, ascribes this situation more to regional cost-of-living differences than anything else.

More significant than locale, however, is the sector of industry in which the beginning—or experienced EE, for that matter—chooses to work. Without exception, aerospace firms offer the highest salaries. There, beginning EE's have a chance to start at the $10,000-plus level, says an engineer at Westinghouse Electric's Aerospace division. But along with the high salaries comes a high degree of insecurity. Says this source: "I had a friend who made piles of money designing a spaceship noselight. But when the contract ran out so did he. He couldn't get another job at a comparable salary because his experience was too specialized and all but useless. Finally he had to start at the bottom with a new firm."

Compensation. Discounting the occupational deferment factor, job security is often a more important consideration for the beginning engineer than salary, points out Roy Holm, corporate employment manager for Beckman Instruments. Starting rates at Beckman are somewhat below the national average, about $8,100, but Holm says that his recruiters have no trouble in securing the people they want. "In fact, we're almost like kids in a candy store," he adds. Holm attributes Beckman's good fortune in attracting personnel to the nondefense character of the company's principal product lines.

Electronics firms in the consumer sector also attract top EE graduates with little difficulty, even though their starting salaries run about 5%

below the national average. Here too, the lure of built-in job security apparently outweighs monetary considerations.

Toward the low end of the salary scale are research-oriented organizations like MIT's Lincoln Laboratory. One former Lincoln Lab engineer says, "When I was hired, I was told very frankly that I could make more money elsewhere but that nobody would sit on me for eight hours a day as they do at a big company. Sure, I made less money —about $1,000 less. But I could come and go almost as I pleased, the supervision was so minimal."

Most wanted

Engineering specialties play an equally important part in determining the salary ranges. But as is the case with clothing styles, there seems to be a new vogue every year. According to Litton's McCarter, circuit designers are among the most sought-after specialists at the moment. But, he says, the time is coming when companies like Litton will replace circuitry designers with catalog items and start scouring around for systems engineers instead.

Over at Hughes Aircraft, industrial relations manager Paul Bigelow adds package designers and microwave engineers — especially those with a competency in solid state discrete power sources—to the wanted list. "Microwave specialists are so hard to find these days, that when we spot a man who is qualified, we literally go out and buy him," admits Anglos Lindsey, salary administrator for Philco-Ford's WDL division in Palo Alto, Calif.

Black is beautiful. Although most companies won't admit it, it doesn't hurt to be a skilled Negro these days. Says one college placement director: "Many recruiters have actually come to us and asked for leads on getting black engineers. And the market is so tight that they'll pay almost any reasonable salary." Litton's McCarter adds that at Howard University the recruiters actually outnumber the prospects; most predominantly black campuses in the South are literally crawling with representatives from large aerospace and electronics firms [*Electronics*, July 8, 1967, p. 135]. John Harris, head of Harris Associates, a technical employment agency in the San Francisco area, says that although companies don't come right out and say "find us a Negro," it's implied, along with an emphasis on phrases like "equal opportunity employer."

Advance to the rear

Defense cutbacks and the general surplus of engineering talent are making things tougher for those with the master's and doctoral degrees trying to get a job for the first time. In past years the holder of an MS would start in the same salary range as an EE with from three to five years experience—$10,000 to $13,000—says E.W. Moore, a vice president at Cadillac Associates, a Chicago employment agency that handles engineers. "Having a doctorate would boost his salary another $2,000," Moore adds.

But while starting salaries for the beginning BS winner have risen between 4% and 7% over the past year, those for the holders of advanced degrees have remained relatively static, according to Georgia Tech's DeRosa. "There's just not the great demand there once was for graduate degrees because of the heavy cutbacks in R&D funds," he concludes.

Company they keep. Once in the corporate fold the average engineer can expect to get a raise about once a year. At Litton, for instance, the average annual increment approximates 7%. But in common with other firms Litton rewards exceptional individual performance, reviewing men outside the annual schedule, says McCarter.

"Of course the raise situation changes the more time an engineer puts in at a company," says an official at a Boston-based firm. "On the lower end, salaries are reviewed every 12 months. But as the pay scale gets higher, say $15,000, a man will be reviewed only every 15 months, and at $18,000, every two years. In other words, the growth rate for young engineers is much steeper than for the man with 10 to 15 years experience. This is due, in part, to pressure at the bottom since college grads are getting proportionately higher salaries each year."

Tufts' Richard Blue believes that spiraling starting salaries are beginning to create a problem within the industry. Says Blue, "Although

. . . moving into management can prove to be a gamble . . .

a good increase is about 10% a year, it's not enough to guarantee an engineer with three years experience that he won't be making the same as a beginner. Discontent within the industry over this situation has now reached the point where more and more men are starting to move from company to company."

Indeed, George Morse, president of George C. Morse & Associates, an employment agency in Boston, says, "EE's have to move to get substantial raises. If an engineer stays with one company he will get gradual raises of about $1,000 a year, or about 10%—not a substantial increase today. That's one reason why they're on the move and the market's flooded."

The big money. While it's true that moving around guarantees between 15% and 20% more money at a clip, many engineers prefer to take the plunge into management and sales, eschewing the intercompany game of musical chairs.

At Beckman Instruments, for example, a nonsupervisory engineer could make as much as $25,000 a year, but most don't get there, says salary administrator Richard Sears. Even with 15 to 18 years experience most purely technical men top out around $20,000, he adds. A majority of industry sources agrees. The engineer who stays in the technical end foregoes a shot at the big money," says Hughes' Bigelow.

Moving into management, however, can be something of a gamble. Many engineers take a shot at executive-hood to make more money faster, but find to their sorrow that their technical abilities are greater than their administrative prowess, says Litton's McCarter. "It isn't all that easy to leave the drawing board and become a big success," agrees a source at a large semiconductor house.

At consumer electronics firms engineers are encouraged to move into management because of the increasing emphasis on customer service. But there again, notes Wells-Gardner Electronics Corp.'s engineering vice president, Chad Pierce, "You can lose a good engineer and gain a poor manager."

"we are not that Oh La La people any more monsieur"

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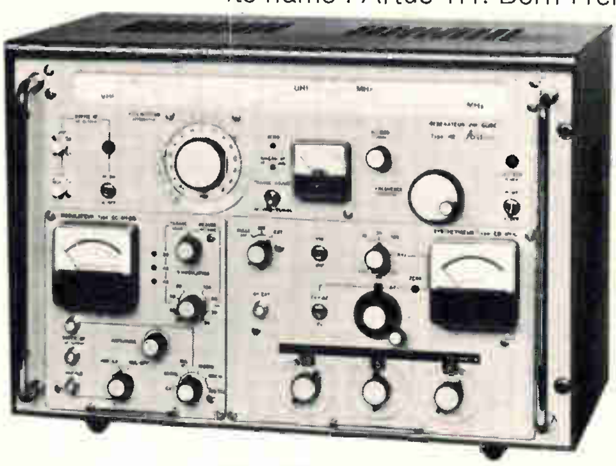

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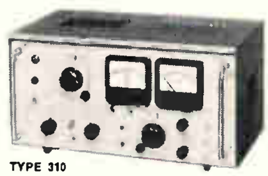

TYPE 310

TYPE 302

AM MODULATION METER TYPE 510

TYPE 105 B

Artus

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Electronics kit leaves the toy box

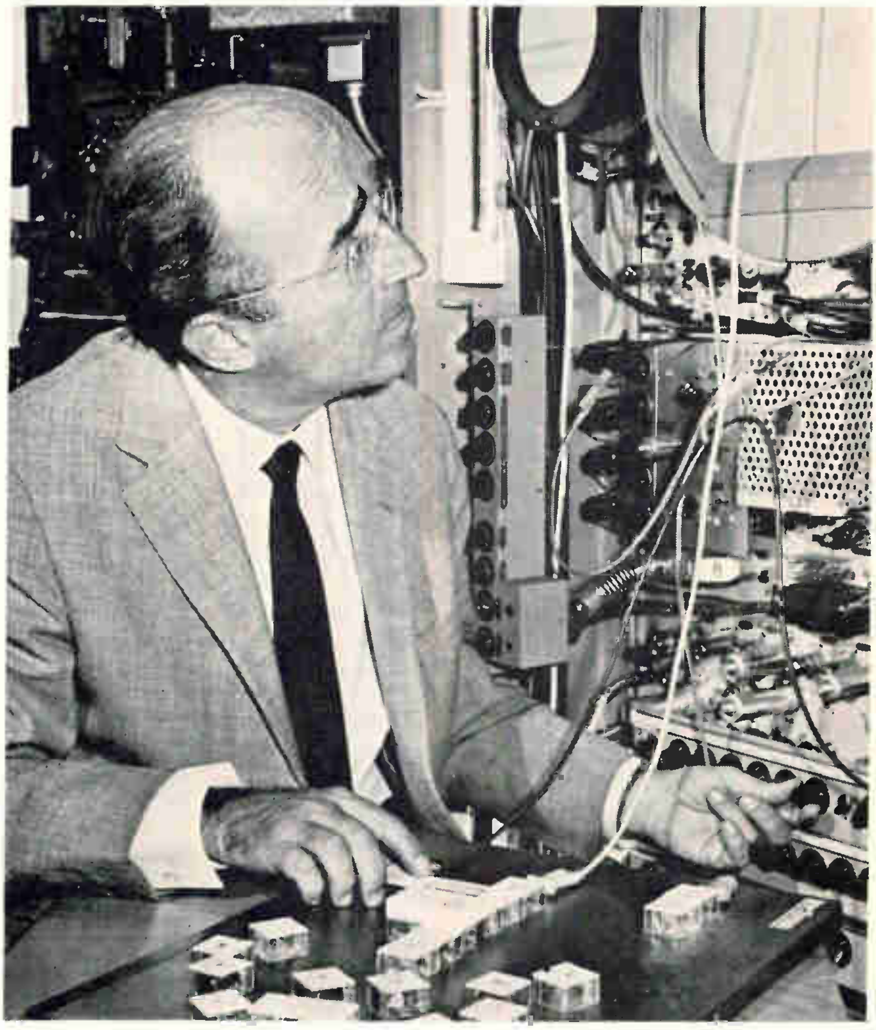
German firm's fast-selling plastic componentry blocks, designed for children, are attracting interest from companies training apprentices and research labs

By John Gosch
Associate editor

Making child's play of electronics has proved rewarding for a West German kit maker and its American marketing affiliate. The companies, Munich-based Deutsche Lectron GmbH and the Macalaster Scientific Co., a division of the Raytheon Education Co., located in Waltham, Mass., are selling easy-to-assemble sets of plastic componentry blocks, with which literally hundreds of working experiments can be done. Though originally designed with school-age children in mind, the kits have, during their short life span, proved increasingly popular in Germany at least for apprentice training and basic laboratory work.

A Lectron set includes see-through plastic blocks with one or more components—transistors, diodes, resistors, capacitors, and the like—and a metal base plate. The blocks are simply placed next to one another, domino fashion, on the plate, to form electronic circuits; small magnets keep the blocks together and provide electrical interconnections among components.

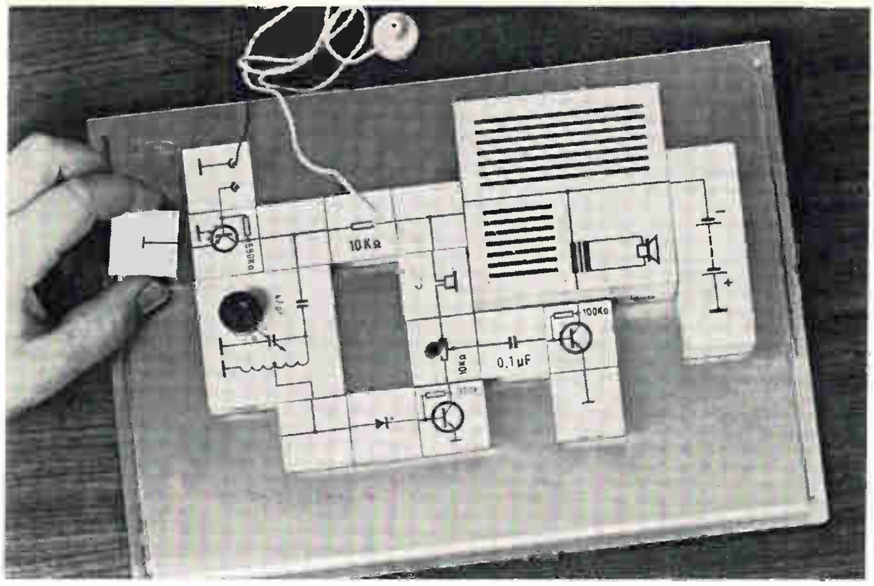
Simplicity and ease of assembly are the Lectron blocks' big selling points. Amateur experimenters and electronics novices don't have to bother with such tools as cutters, strippers, pliers, or soldering irons. Moreover, they don't have to worry about shorts, broken wires, or heat-damaged parts. And since each block is plainly labelled with an electronic symbol for what's inside there's no problem with matching components to sometimes confusing circuit schematics.



Master builder. Georg Greger, inventor of Lectron blocks and the managing director of the company making them, is always at work on advanced units.

Just by following simple instructions in the instruction booklet that comes with each kit, the neophyte can, for example, observe the effects of light hitting a photocell, determine how a diode or transistor works, and build a morse-code oscillator, moisture indicator, and even a three-transistor radio with loudspeaker. The more imaginative can devise a number of circuits that go beyond those described in the instructions.

But amateur experiments appear to be just the beginning of what



Broadcast band. Among the projects that amateur experimenters can build with their Lectron kit blocks is this three-transistor radio with loudspeaker.

can be done with Lectron's magnetic blocks. Already on the German market are kits for building such digital circuits as AND, NAND, OR, and NOR gates; shift registers; and counters. In the wings are low-voltage oscilloscope, Geiger counter, and microelectronics kits.

Success story

With its existing kits, however, Lectron has already carved out a comfortable niche in the worldwide market for small educational aids. From mid-1966 when the firm, then known as Eggerbahn GmbH, switched production from model railroads to electronics kits, business has expanded rapidly. Last year set sales rocketed to $890,000—no small amount for a 100-man company in Europe. About $640,000 worth was sold to Raytheon; the balance went to Germany's Braun AG, distributor of Lectron kits in Europe. West Germany accounted for 90% of European sales, and Austria and Switzerland the balance. Lectron estimates its business will grow by at least 10% to 15% a year.

This record is a personal triumph for Georg Greger, 46, the company's managing director. He invented the magnetic building blocks and recognized their potential as an educational tool. "From a pedagogical point of view I have always been interested in simple representations of complex technical processes," Greger says. He recalls experimenting as a boy with crystal radio sets in the early 1930's. "In those days you could see what you were doing, observe the effects of putting a lead here, or changing a component there. Everything was so simple then." That simplicity, he notes, gradually disappeared as electronics became more and more complex. "Systems can now no longer be recognizeably demonstrated, and many people, especially the young, have lost touch with down-to-earth, practical electronics," Greger says. Essentially, he wanted to make electronic experimentation uncomplicated again.

Omissions. To that end, the "learn-by-doing" methods in Lectron instruction books skip theory—formulas, equations, derivations, and the like—that often makes once-eager students lose their zest. "Rather than telling a new experimenter all about Ohm's law, I want him to see what happens to the current in a circuit when a resistor is changed," Greger explains.

At least from an educational point of view, Greger deplores assembly schemes in which one is told, in cookbook fashion, to connect a wire from point one to point two or to stick a resistor between points three and four. "It's not that high-quality, functioning equipment can't be built that way," he says. "It can. But what has a person learned about electronics?"

He himself seems to have followed the dictum of "learn-by-doing" throughout his life. Though he comes across as a college professor, he's been a working engineer all his adult life. World War II prevented him from getting a university education, but in 1943, Greger was recalled from active military duty to work as an electrical engineer at Dornier, an aircraft manufacturer. After the war he did audio acoustical engineering for several West German motion picture producers. At Munich-based Constantin Film, where he concentrated on the technolgy of sound-synchronizing for foreign films, Greger suddenly got the idea for his magnetic building blocks. The prototype kits he developed were so well received at various toy and educational-aid fairs in Europe that Constantin decided to mass-produce them at its affiliate Eggerbahn, a maker of model railroads. Eggerbahn, now Deutsche Lectron, put the first kits on the German market in September 1966.

Going partners

Raytheon officials first became aware of Lectron kits at the 1967 Nuremberg Toy Fair. They checked the U. S. market potential and made a sales agreement with Lectron later in the year. The $640,000 order was signed in January 1968, and Lectron delivered loose building blocks worth that amount between February and October of last year. Additional orders are in the works.

Plus. Though designed for children, Lectron blocks appeal to adults too.

Macalaster, which packages the blocks into kits that vary somewhat from those sold in Europe, has distribution rights throughout the Western Hemisphere. Lectron in 1967 turned over German distribution rights to Braun, a maker of consumer electronics goods with a large domestic and foreign sales organization. So far, sales in Europe have been limited to German-speaking countries—West Germany, Austria, and Switzerland. But Braun, an affiliate of the Gillette Co., is now translating instruction books and readying sets for French and Belgian outlets. Eventually the firm plans to tackle the Scandinavian countries, Italy, and The Netherlands. Just who will handle Great Britain and Japan is still up for grabs.

Promotional push. In West Germany, Lectron is getting a lot of unsolicited advertising for its kits, with the biggest boost coming from the Bayerische Rundfunk which runs Bavaria's regional television network. On BR's Telekolleg, a sort of "university-of-the-air" show, Lectron blocks especially designed for tv presentation, are used in a 13-lecture basic electricity course. Many of the program's 220,000 viewers buy Lectron kits to do their homework and for further study. As a result, a new 23-block version, selling for about $12, has been put on the German market. Later this spring, another regional tv network, the Hessischer Rundfunk—Radio Hesse—will start airing the Telekolleg program, probably providing another boost for kit sales.

Among the electronics companies and research organizations using Lectron kits for apprentice training are Siemens AG, Grundig Werke GmbH, and the German Post Office. Kits are also used in some electronic development labs, and the company has put together a 100-block set selling for around $105, to cash in on this development.

Other outlets with potential include teacher training colleges and technical trade schools. At a computer programing school at Ulm, for example, digital circuit kits are used as aids for teaching Boolean algebra. The prime business, however, comes from sales to home experimenters. Kits are sold mainly in radio and do-it-yourself stores. There are also many toy stores and some book stores in Germany that sell Lectron kits.

Production unit. The blocks are turned out in a rather nondescript factory that's a far cry from the shiny electronics production facilities which have sprung up in and around Munich. The Lectron factory, located in the Southwestern portion of the Bavarian capital, is a former field hospital that was located in downtown Munich and moved to its present site soon after the war. Since then, cement sidings have been added but they don't much improve the building's general appearance. Eventually, Greger says, production will be moved to new quarters that can accommodate more workers than the present crew of 100 or so.

"Labor is a big problem," Greger says. "With Siemens practically next door, it's tough to find workers." Still, no big production bottlenecks have been hit so far, although at times minor delivery delays have occurred because components didn't arrive in time.

Cottage industry. To keep up with the demand Lectron resorts to a practice that was once fairly common with many small manufacturers in Germany's labor-short economy. It sends out component parts to people's homes for further assembly. The company has about 20 such home-based, part-time assemblers, some of whom are employed full-time at Lectron during regular working hours.

Among the 100-odd workers at the Lectron plant, around 60, including some female Gastarbeiter—foreign workers—from Italy and Sweden, do the assembling. Twelve others man injection molding machines. The rest are employed in the shipping and accounting departments.

Producing the magnetic building blocks is a relatively simple, three-step affair. First, the plastic housings are made in an injection-molding process. Then, the electronic components and the magnets are installed. Finally, white covers with appropriate symbols are put on top of the housings. The components and magnets come largely from

West German outfits. But companies in Japan supply loudspeakers and earphones. "Pricewise the Japanese can give us the best deal on such items," Greger says.

Keeping pace. Greger himself, aided by two assistants at Lectron and occasionally by outside consultants, toils away in his lab and office designing the blocks. "I try to keep up with the latest trends in electronics," he says. Now that the low-voltage oscilloscope and Geiger counter kits are in the bag, Greger is concentrating on microelectronic blocks. They should hit the German market by Christmas and will make possible advanced types of digital and other circuits. Another one of Greger's current projects is developing blocks with MOS field effect transistors in them.

One idea Greger says he'll probably pursue is a kit for tv circuit instruction. Essentially, this one will be based on the oscilloscope kit, which will be adapted for use with tv circuits like line and test-pattern generators.

So far, there are a half dozen different types of Lectron kits on the German market. They range in price from $12 for an 18-block mini-system up to $105 for the 100-block set. The digital circuits kit, which can be used for as many as 100 different experiments was introduced at Didacta 68, a fair for educational aids held at Hanover last year. The oscilloscope and Geiger counter kits, presented at the Nuremberg Toy Fair in February, will soon go into mass production.

Commonality. A unique feature of the Lectron kits is that the blocks are standardized. Each has a base area of 27-by-27-millimeters and is 16 millimeters high. Since a block's sides are transparent, beginning experimenters can see what a transistor, a diode, etc. looks like.

The ferrite magnets keeping the blocks together are shaped like discs and installed in round indentations in the block's sides and bottom. A 12-by-12-mm nickel-silver contact plate covers each magnet. The plate is shaped in such a way that it also holds the magnet in place. In addition, the plates provide a means for attaching and soldering component leads during block manufacture.

A standard block can have a maximum of five magnets, one on the bottom and up to four on the sides, depending on the number of component leads inside the block. Blocks are kept snug on the base plate by a bottom magnet, strong enough to hold them in place even when the mounting board is tilted or hung on a wall.

In addition to the 27-by-27-mm blocks, there are bigger units which have a base area that is a multiple of the standard types. This kind of dimensioning facilitates circuit assembly and makes for a clean, uncluttered look in finished equipment. The larger blocks include, for example, an indicator, a loudspeaker, and other devices that don't fit into the standard housings. For better viewing in the case of the indicator or better operation in the case of the loudspeaker, the larger-size blocks are also a little higher. As a rule, such blocks have more magnets than the standard versions.

Fillers. Some blocks contain just a piece of wire for extending connections between component blocks. The wire runs either between two opposite sides or at a 90° angle between adjacent sides. Some wire-blocks also feature branched leads, and others provide a ground connection through the bottom magnet to the plate.

A nine-volt, 50-milliampere dry battery, also housed in a block, is the power supply for most kits. For the oscilloscope and Geiger counter kits, however, a six-volt, 200-ma unit is used because of different circuit requirements. In the oscilloscope setup, the six volts is changed to a-c in a transistorized converter circuit. The voltage is then stepped up to 250 volts in a block housing a transformer. By means of a diode-based voltage-doubling circuit, the 500 volts for the oscilloscope tube is obtained. The voltage for the Geiger counter is similarly achieved. Since all voltage processing occurs in closed plastic blocks, the danger of shocks is eliminated.

By the book

Generally, the experiments in the instruction books for the large kits fall into three main categories. The first involves studying the functions and operating principles of transistors, diodes, resistors, potentiometers, and other circuit elements.

In the next, the knowledge gained from preliminary work is reinforced by the building of functional circuits. These range from simple light-operated detection circuits and tone generators through amplifiers and a tuned transistor radio. The final stage involves methods of testing individual components, particularly semiconductors.

One interesting feature of Lectron kits is that individual blocks can easily be removed and substituted without having to take the whole circuit apart. This allows for "designing" a completely different circuit within a few seconds. It's a feature that comes in handy when kits are used in electronics development labs.

Since it's possible to buy blocks individually just as, for example, pieces of track can be bought for a model railroad, experimenters can build a stock for experiments not described in the instruction books. Lectron also provides componentless blocks that only have small sockets into which any size resistor or capacitor not normally part of the assembly kits can be inserted.

The 100 different experiments outlined for the digital circuit kit also break down into three groups. The first deals with the basic differences between analog and digital techniques. To demonstrate the difference, a binary system and a bistable multivibrator are built. The second involves basic logic circuits such as AND, NAND, OR and NOR gates. The experimenter learns basic operating principles by means of switches and relays. He then investigates these principles with semiconductor switching elements. In the third group, knowledge is put to use in building such complex circuits as a decoder, a Schmitt-trigger, circuit-based pulse shaper, and the like.

Once the microelectronic blocks are on the market, the range of circuits that can be built will be greatly extended. A typical 81-by-81-mm microelectronics block that Greger is now developing contains an integrated circuit incorporating the functions of three transistors and four resistors. External passive devices can be connected to that block by way of its ten outside contacts. With this one block as a basis up to 35 different experiments can be performed. ■

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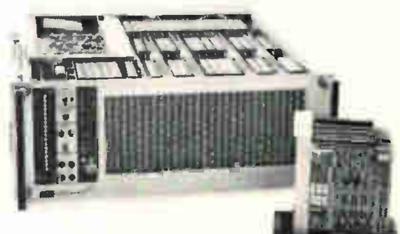

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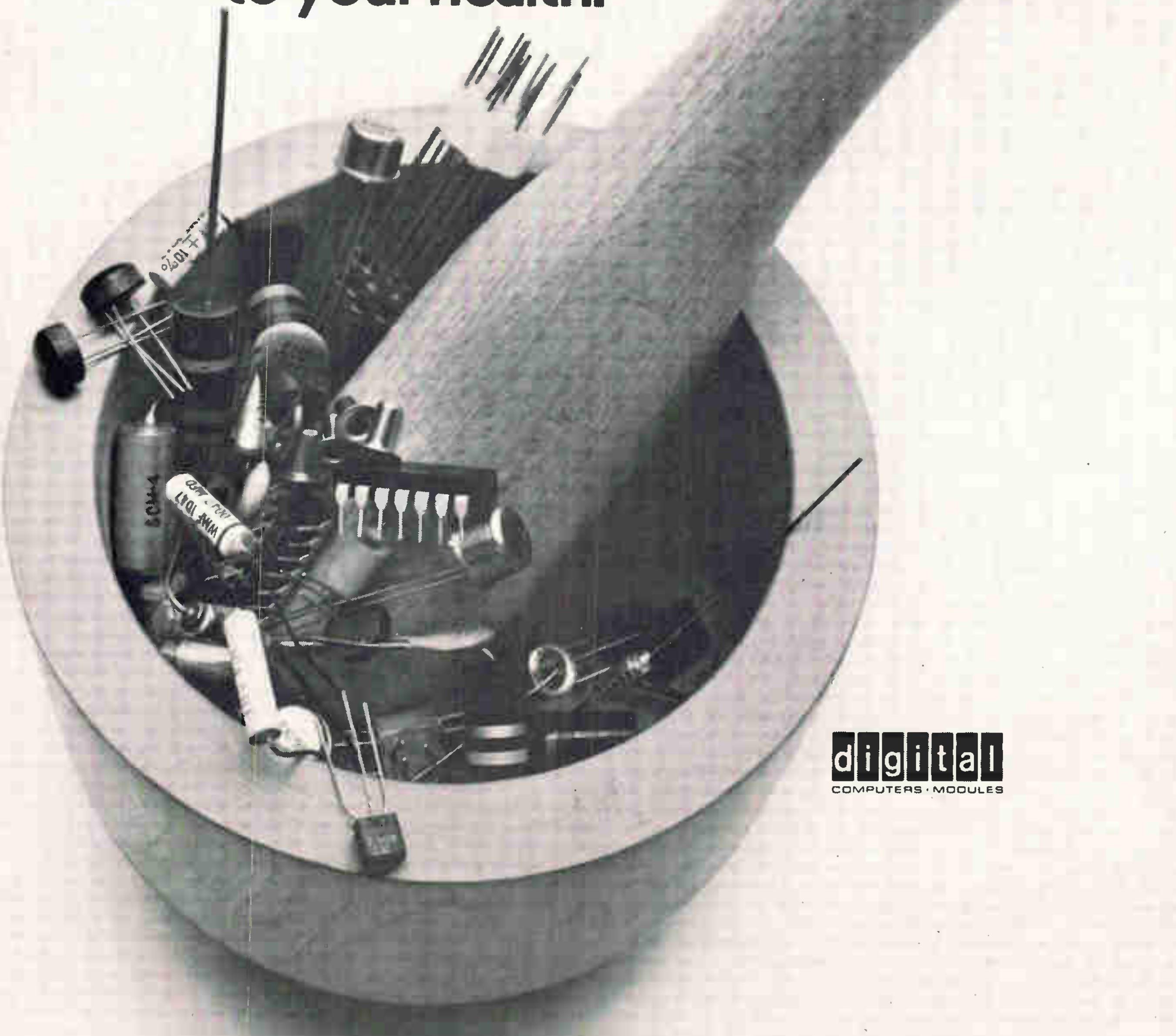

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Digital signal processors go to market

New company to introduce fast Fourier analysis machine at Spring Joint Computer Conference in Boston; Raytheon's widens its computers' applications

"The difficult we do immediately—the impossible takes a little longer." If a motto were needed for digital signal processors, it might well be this one borrowed from the military. The systems represent a potentially inexpensive way of doing many things that are nearly—if not downright—impossible in today's laboratories. They can present the Fourier components of complex signals in real time, or close to it. They can deduce not only the characteristics of the filter through which a signal has passed, but the signal's original characteristics. And they can simulate a filter with infinite Q, even at very low frequencies—a feat impossible with analog techniques.

But digital signal processors are still rare items in the marketplace. Many firms have built machines capable of fast Fourier and other processing schemes, but most are still in the lab. Until now, the Time/Data Corp.'s model 100, a relatively straightforward machine that's programed through knobs and dials on its front panel, has been the only widely available processor of this type [*Electronics*, April 15, 1968, p. 126].

The situation is changing, though. Two firms plan to unveil digital signal processors at the Spring Joint Computer Conference in Boston, May 14 to 16 [*Electronics*, March 31, p. 35]. Computer Signal Processors Inc., a new company based in Waltham, Mass., will introduce the CSS-3, a processor capable of three kinds of fast Fourier analysis, auto- and cross-correlation, convolution, amplitude histograms, averaging, and filter and modem simulation.

And Raytheon will introduce a peripheral processor called the ATP (for array transform processor) and designed for use with the firm's small 16-bit computers, designated the 703 and the 706.

Co-founder and president of Computer Signal Processors is Edmund U. Cohler, formerly a scientist at the advanced research lab of Sylvania Electronic Systems and designer of one of the first specialized digital signal processors, the ACP-1. Sylvania is apparently making such processors for in-house use only.

Responsive audience

"I frankly don't know all the areas into which digital signal processing can penetrate," Cohler says. "I originally expected to find such applications as communications research, electronic intelligence, speech studies, sonar research, and so on. But we are also attracting interest in the medical community, which would use the machines in studies of body sounds and electroencephalograms. Even less expected was the interest shown by engineers doing vibration analyses of structures as exotic as rocket engines."

Along with the basic CSS-3, he continues, "we provide a fast 16-bit general-purpose computer, sampling inputs, a cathode-ray-tube display, and a teletypewriter input-output channel." But Cohler feels that what will attract buyers is the system's "apparently simple" software. "We make digital signal processing relatively easy for neophytes," he says.

Easy does it. For example, a user can request a histogram of an input signal simply by typing "hist" on the teletypewriter. He can then sit back and watch the graph of phase versus amplitude grow on the

Analyze and display. The CSS-3 processing system includes crt display and teletypewriter printout of the signal components.

←Circle 158 on reader service card

Swimming with the stream

If the Pueblo had been able to contact Japan when the intelligence ship was first harassed by North Korean torpedo boats, it might not have been taken. But poor radio propagation conditions apparently made it impossible for the vessel to synchronize its electronic crypto communications gear with the equipment back at its base.

According to Marvin Z. Frank, marketing manager for data terminals at the Codex Corp., Watertown, Mass., "the TM-15 could have made it easier." The TM-15 is a time-division multiplex-demultiplex system capable of packing up to 15 full-duplex or 30 half-duplex teletypewriter channels, either encrypted or 'clear,' into a voice-bandwidth, 1,200-bit-per-second stream. It will be introduced during the SJCC next month.

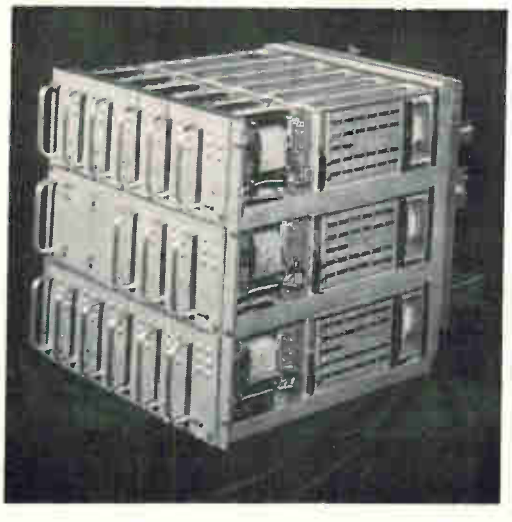
"Radio transmission is prone to fading, noise, and breakdown," Frank says, " but in the TM-15 we can be pretty sure that no bits will be added or dropped out of a stream. A redundant error-correcting supervisory code accompanies each "word" and identifies its channel. Also, if a transmission line or radio channel fails completely, almost exact synchronization with the transmitter multiplexer is retained by clock circuits in the TM-15. These clocks hardly drift, so that the TM-15 can resynchronize itself even after hour-long outages.

Pulling together. Not only does a TM-15 keep itself synchronized with other TM-15's but it helps keep secure systems properly slaved to each other. Encrypting and decrypting devices, as learned in the Pueblo hearings, usually must be synchronized with one another around a nominal clock rate.

The TM-15 can tolerate clock-rate drifts of up to 104 parts per million, absorbing bits that enter the stream too quickly in small buffer stores, and slowing its bit rate to accommodate slower decrypting devices.

It also uses a code-conversion scheme to translate asynchronous codes (like teletypewriter or ASCII into synchronous form. "We lop off the Baudot Code's 'letter start' and 'letter stop' bits, retaining the five bits that indicate which letter is being transmitted and adding a data control bit," Frank explains. The rest is just a a matter of seeing that the bits are transmitted at an even clock rate."

Codex Corp., 150 Coolidge Ave., Watertown, Mass. 02172 **[340]**



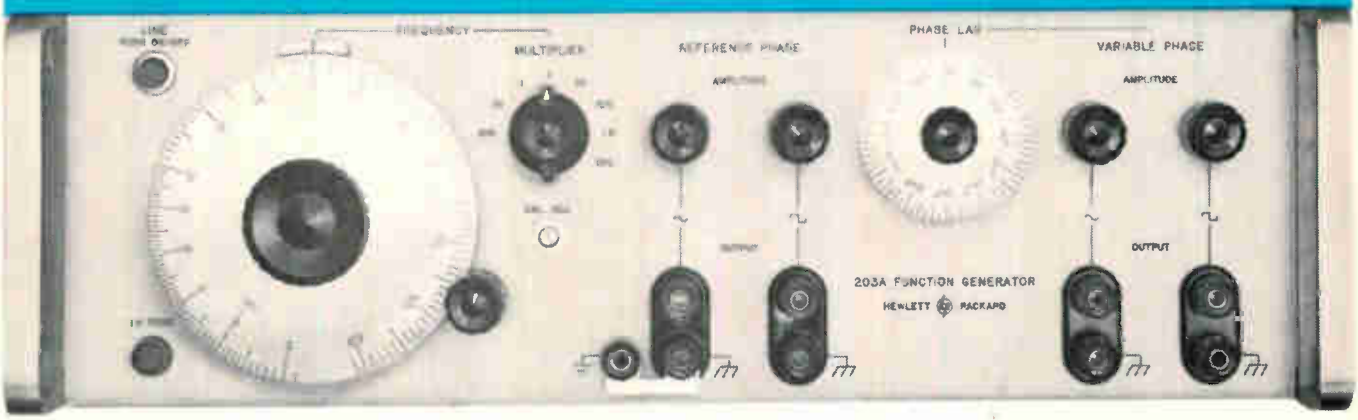
It's accommodating. Unlike most time-division multiplexers, which sample and digitize incoming data at a fixed rate, the TM-15 adjusts to the bit stream, accelerating or decelerating transmissions to suit its throughput.

CSS-3's Tektronix display screen. After waiting long enough to get the desired resolution, the operator can flip a switch to either freeze the display, store the data in the computer's memory, or request a printout on the teletypewriter.

Cohler won't give out details on on the CSS-3's software, but he does note that it's loaded into the computer through paper tape—a system he deems more flexible than front-panel controls, especially when it's used in combination with keyboard controls and almost infinitely variable control of such parameters as sampling duration and rate.

The standard processes, or pro-

a function generator with the accent on



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For complete details on each and every function, call your local HP field engineer, or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

SIGNAL SOURCES

... speed traded for flexibility ...

grams, offered with the CSS-3 include: spectrum analysis; buffered (real time) and unbuffered fast Fourier analysis; so-called zoom-FFT (which Cohler recommends for "a fine-grain look at a small section of a frequency spectrum"); correlation, convolution, and cepstrum by Fourier transform; amplitude histograming; signal averaging (to pull a weak signal out of random noise); and recursive digital filtering (including simulation of Butterworth, Chebyshev, Bessel-function, low-pass, high-pass, and bandpass filters).

Optional software provides for simple and Fourier-transform cross-correlation of two inputs; multichannel input modules are required for these functions.

Trading off

Cohler says the CSS-3 isn't the fastest digital signal processor available because speed has been sacrificed for the sake of flexible programing and operation; thus, the machine performs the repetitive multiplications of fast Fourier, for example, in its own arithmetic unit rather than in the hardwired logic used by specialized processors. Still, Cohler declares, because of the speed of the small computer (a slightly modified Varian 620-I) and some software tricks, the CSS-3 is only 10 times slower than specialized machines and is still "as much as five to 10 times faster than general-purpose machines using the Cooley-Tukey algorithm."

The CSS-3 is limited to audio-frequency analysis. Its maximum sampling rate is about 50 kilohertz, and since a sampling rate of twice the highest important mode or frequency is required for Fourier analysis, the upper frequency limit is about 25 khz.

To the core. The duration of each sample is 100 nanoseconds, and signals can be sampled repetitively over infinite periods of time. The samples are converted into 10-bit words and are stored in the computer's core memory. Since a 4,096-word memory is standard in the Varian machine, and since some of this capacity must be devoted to software, a maximum number of 2,048 samples can be stored. An 8,192-word memory is a $7,200 option, and magnetic-tape and disk memories are available for additional storage.

The first CSS-3 is to be delivered in early May and 60-day deliveries will be quoted afterward. The price is $44,850 for a basic, already programed machine.

On the other hand

In contrast to the CSS-3, the ATP from Raytheon's Computer division is a high-speed hardwired system designed to perform fast Fourier functions and other tasks as an adjunct to the company's model 703 and 706 computers.

Raytheon says it's not yet ready to sell the ATP but may be able to arrange first deliveries by autumn. Nor is it clear how the ATP will be sold; Raytheon is talking about combined ATP-model 703 systems, but it also is possible that signal processors with the necessary software would be sold separately to owners of 703's and 706's. The price of a computer plus the ATP are also sketchy, but the company claims that with the peripheral processor, fast Fourier runs can be performed about 80 times faster than with an unaided 703. This would make the ATP roughly 10 times faster than the CSS-3.

The capabilities of the machine are similar to those of other such specialized processors – convolution, auto- and cross-correlation, and averaging, for instance.

Partnership. The ATP takes advantage of its computer's memory in an apparently flexible manner with a resulting increased sample capacity. Arrays of data points are stored in the memory and transferred to and from the ATP over a direct-access channel. The signal processor uses a 16-bit floating point format that conserves memory storage space.

Through software in the computer, the ATP can be set up to run simultaneously with other peripheral gear and with the computer's mainframe.

Computer Signal Processors Inc., 176 Second Ave., Waltham, Mass. 02154 **[338]**
Computer Division, Raytheon Co., 2700 S. Fairview St., Santa Ana, Calif. 92704 **[339]**

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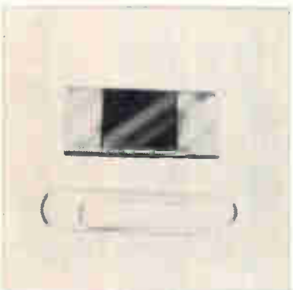
Cone-shaped fillets hold parts for soldering

Metallic liners grip components in fixed position on printed-circuit boards without need for bending leads

The big bottleneck in assembling printed-circuit boards is the difficulty in keeping components in uniformly fixed positions up to and during the soldering operation. Companies have tried various schemes: forming the component leads before they're inserted into the printed-circuit board, or bending the leads after they are pushed through the holes. Printed-circuit board liners to hold the leads have also been tried. While some of these schemes resulted in increased production, in general there was still considerable misalignment of the components, and quality was therefore not improved.

An additional and important drawback of the lead-bending technique is that whether the leads are formed by hand or by machine, the components must be held securely against the p-c board and this subjects the components to maximum heat transfer during the soldering operation. Therefore, unless these components are protected by thermal spacers, they could be seriously damaged.

Of course, semiautomatic machines are available which can do the job. Such a machine will cut



Thick film chip resistor CR05 was developed for hybrid circuit applications. Element size is 0.050 x 0.050 x 0.012 in. Resistance range is 1 ohm to 2 megohms. Temperature coefficient is —55° to 125° C, ±200 ppm. Dissipation is 1/10 w at 125° C. Unit has a glass seal overcoat, while land areas are platinum-gold. EMC Technology Inc., 1300 Arch St., Philadelphia 19107. [341]

Distributed constant, fixed delay lines called Spiradel are compact and encapsulated for maximum environmental protection. Time delay to rise time ratios of over 20 to 1 can be achieved, with excellent temperature stability and pulse fidelity. Units cover a delay range of 100 to 1,000 nsec. Standard impedance is 325 ohms ±10%. Allen Avionics Inc., E. 2nd St., Mineola, N.Y. [342]

P-c connector series 600-121-27 is a 27-dual contact unit (54 terminals) with 0.100 in. center-to-center contact spacing. A choice of dip solder or solder lug terminations is available in gold plated beryllium copper. Glass reinforced diallyl phthalate molding type GDI-30 per MIL-P-19833 has 3 integral polarizing barriers. Continental Connector Corp., Woodside, N.Y. [343]

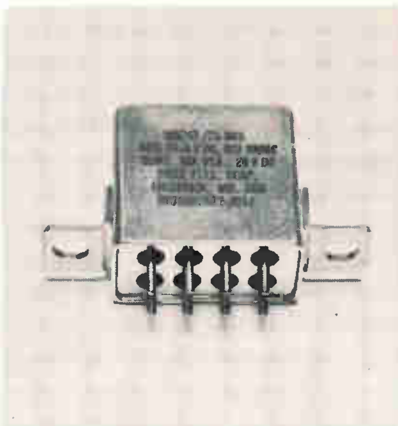
High voltage connectors series KV are less than 1 inch in diameter and will withstand 30 kv in a mated or unmated condition. They are available for various cable sizes—both flexible and semi-rigid—up through 3 inches. The connectors offer a pulse reflection coefficient of less than 1% maximum. General RF Fittings, Connector Division, Cove Road, Port Salerno, Fla. 33492. [344]

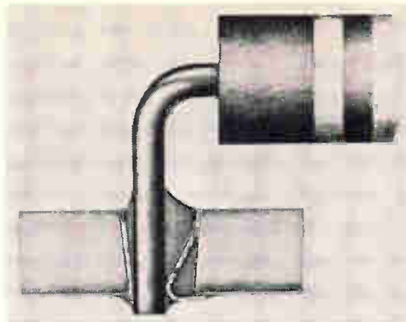
High density rectangular connector series HDR in 54-contact size features crimp-and-insert contacts on a 100-in. square grid pattern. Size 20 contacts are rated at 7.5 amps and come in two wire range sizes, 20-24 and 24-30 Awg. Contact plating is gold over nickel, selective gold, or tin. Housings are black phenolic or blue diallyl phthalate. AMP Inc., Harrisburg, Pa. [345]

Cathode-ray projection tube CK1459P- is for video presentations on screens up to 10 to 20 sq ft in size. Television, radar, or computer-generated electronic information can be displayed. It uses a special face panel with high thermal conductivity to obtain a marked increase in light output, resolution, and tube life. Raytheon Co., 465 Centre St., Quincy, Mass. 02169. [346]

Servomotor tachometer size 23 is for use in power servo actuators. The 8-pole motor has a stall torque of 16 oz. in., and a free speed of 5,000 rpm. The tachometer produces an output of 2 v ± 1% per 1,000 rpm, has a phase shift of 0° ± 1°, and linearity of ±7%, and requires 5w of power. Operating temperature is —55° to +132° C. Weston-Transicoil, Worcester, Pa. [347]

Compact reed relay GB811, in a 14-pin dual-in-line package, is completely compatible with IC logic components and p-c board pin spacing. Input is 5 v d-c for direct transistor logic drive, with the package containing both a reed relay and a diode to suppress back emf. Unit has a contact rating of 3 w. Grigsby-Barton Inc., 107 N. Hickory, Arlington Heights, Ill. 60004. [348]





Gripping. Component lead is firmly held by springlike tension on fillet.

the leads of the tape-fed components to the desired length, form them, and install them in the printed-circuit boards at rates of up to 1,600 insertions per hour per operator. While this method markedly increases production and quality, the cost of the required automated equipment is rather high and can only be justified where large production operations are involved.

Popularity. Many manufacturers prefer to solve the problem through the use of a metallic liner to hold the components while they're being soldered. And AMP, a Harrisburg, Pa., based firm, has developed a conical shaped fillet which the company says offers all of the advantages of liners now in wide use throughout the industry.

The fillet requires only that 0.055-inch diameter holes be drilled or punched out of the circuit board. In addition, it permits center-to-center hole spacing as close as 0.110 inch nominal on the printed-circuit board. The fillet also firmly grips the component leads in standard 1/16-inch thick printed-circuit board until all the components can be assembled, at which time soldering takes place.

Less heat. The firm grip of the fillets eliminates the need to bend or form the leads either before or after they are inserted in the board. This provides the added bonus of minimizing heat transfer during soldering, since heat sensitive components can be positioned above the board. In addition the fillets ease components replacement during servicing without damaging the board.

The fillets are installed by a machine that puts either 356 fillets into a 10.8-by-12.25-inch printed circuit board or 500 fillets into a 7.8-by-11.8-inch board in less than one minute.

The bench-mounted machine inserts the fillets by the vibration and multiple punch technique which substantially increases production volume.

AMP Inc., Harrisburg, Pa. 17105 **[349]**

New components

Switch has lever action

Flip of the finger puts operating wheel through 10 detent positions

Lever-action design permits fingertip control of a new switch, called Leverwheel by the manufacturer, the Cherry Electrical Products Corp. Unlike a conventional 10-position thumbwheel device in which the operating wheel requires a full 360° rotation to complete the cycle, a Leverwheel unit needs only a 60° movement. By flipping the lever its full 60° arc, an operator effectively turns the operating wheel carrying the lettering 160°, or through 10 detent positions.

Quick reset. The new switch can be reset quickly. "Instantly" is the way the company puts it: "With a single sweep of the hand, a bank of six or seven of these units can all be automatically reset." It really isn't quite that simple. A single downward movement returns all the levers to the full down position, or zero setting. It's from this point that resetting can be quickly achieved.

Some manufacturers of thumbwheel switches offer a solenoid-operated reset feature as an option, an expensive one. Cherry's Leverwheel eliminates the need for such an option.

When going from, say, four to nine, the conventional thumbwheel switch operation requires the slow plunking or thumbing through five-six-seven-eight before reaching nine. And unless the operator is careful, he can go beyond.

Beats thumbing. With the lever action, the operator can go either full up to one for full down to zero and start from this point. Either way, the lever action is faster than thumbing the way through.

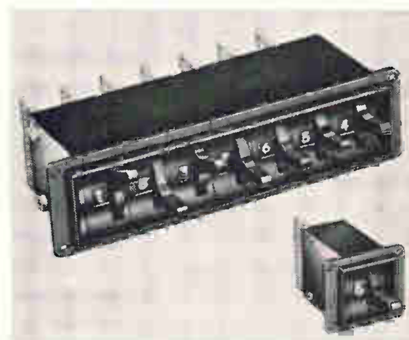
Cherry offers the Leverwheel switches in two sizes: the L11 miniature series available in both front and back mounting, and the L20 subminiature series in back mounting only.

The printed-circuit boards are mounted in the rear and on the side opposite the lever. The housing is molded from a polycarbonate material for impact strength and can be plated to minimize radio interference.

Standard codes available in both the miniature and subminiature series include 10-position decimal, binary coded decimal, bcd complement, bcd plus even parity, octal, and bcd plus odd parity.

With the 10-position decimal code, for example, a five in the readout window indicates that the common input terminal is connected to the No. 5 output terminal.

The switch has an operating force of from seven to 10 ounces,



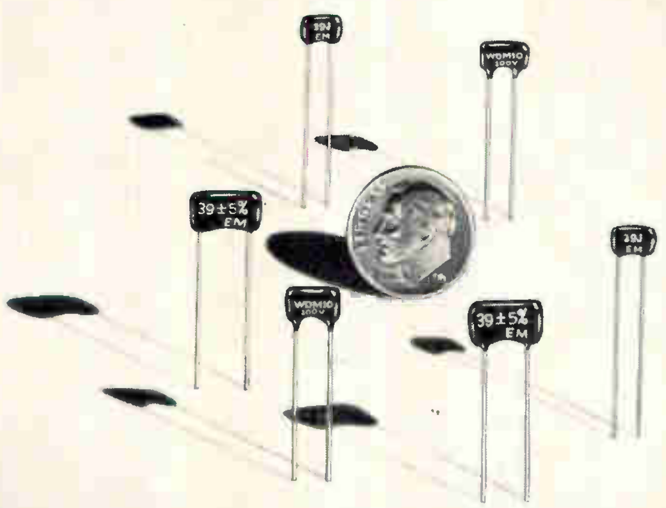
Leverage. The switch, used singly or in a bank, can be quickly reset by a flip of the finger.

contact resistance of 0.1 ohm max., insulation resistance of 1,000 megohms, dielectric strength of 1,000 volts a-c, vibration 15G, and shock 50G. Maximum electrical rating is 200 volts a-c or d-c, 0.5 amp (12 watts) per output circuit, and 1 amp (12 watts) total of output circuits.

In 10-position decimal codes and in lots of 50, the switch will be priced at $7.80, in lots of 100 at $7.60, and in lots of 1,000 at $6.45. Price continues to decrease in larger quantities.

Cherry Electrical Products Corp., Highland Park, Ill. **[350]**

El-Menco BETTER QUALITY AND RELIABILITY THROUGH CONTROL



They're Small and Reliable*

EL-MENCO DM5 — DM10 — DM15 — ONE COAT DIPPED MICA CAPACITORS

STYLE	WORKING VOLTAGE	CHARACTERISTIC	CAPACITANCE RANGE
DM5	50VDC	C	1pF thru 400pF
		D, E	27pF thru 400pF
		F	85pF thru 400pF
DM5	100VDC	C	1pF thru 200pF
		D, E	27pF thru 200pF
		F	85pF thru 200pF
DM10		C	1pF thru 400pF
		D, E	27pF thru 400pF
		F	85pF thru 400pF
DM15		C	1pF thru 1500pF
		D, E	27pF thru 1500pF
		F	85pF thru 1500pF
DM5	300VDC	C	1pF thru 120pF
		D, E	27pF thru 120pF
		F	85pF thru 120pF
DM10		C	1pF thru 300pF
		D, E	27pF thru 300pF
		F	85pF thru 300pF
DM15		C	1pF thru 1200pF
		D, E	27pF thru 1200pF
		F	85pF thru 1200pF
DM10	500VDC	C	1pF thru 250pF
		D, E	27pF thru 250pF
		F	85pF thru 250pF
DM15		C	1pF thru 750pF
		D, E	27pF thru 750pF
		F	85pF thru 750pF

Where space and performance are critical, more and more manufacturers are finding that El-Menco miniaturized dipped mica capacitors are the reliable solution. The single coat is available in three sizes: 1-CRH, 1-CRT and 1-CE.

The 1-CRH DM "space savers" easily meet all the requirements of MIL and EIA specifications, including moisture resistance. The 1-CE and 1-CRT units also meet the requirements of MIL and EIA specifications, except that they have less moisture protection because of their thinner coating; these capacitors, therefore, are ideally suited where potting will be used. Note: DM10 and DM15 units are still available in the standard 4-CR size.

Specify "El-Menco" and be sure . . . the capacitors with proven reliability. Send for complete data and information.

*Normally, El-Menco 39 pF capacitors will yield a failure rate of less than 0.001% per thousand hours at a 90% confidence level when operated with rated voltage and at a temperature of 85°C. Rating for specific applications depends on style, capacitance value, and operating conditions.

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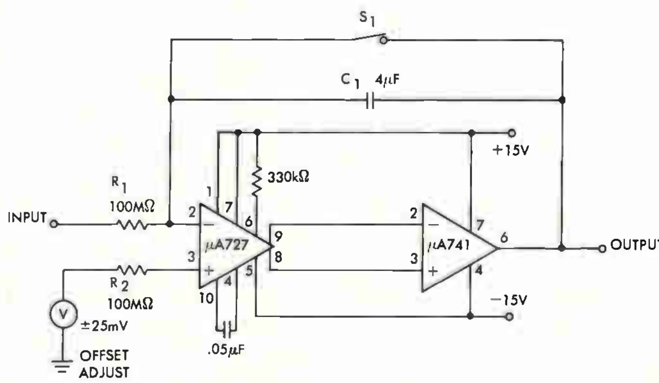

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To order the μA723, ask your Fairchild distributor for:

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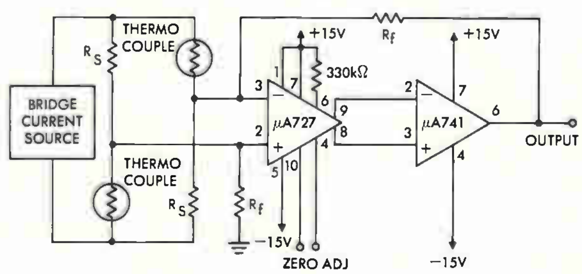

Accuracy:	**0.01%**
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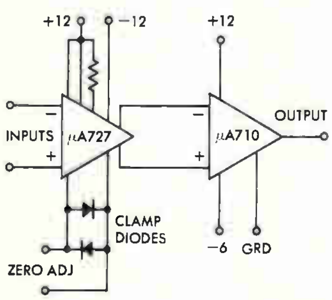

Input Resistance:	**300MΩ**
Differential Input Voltage:	**±10V**
Input Voltage Range:	**±8V**

PART NUMBER	PACKAGE	TEMPERATURE RANGE	PRICES 1-24	25-99	100-999
U5J7727312	TO-5	−55°C to +125°C	\$50.00	\$40.00	\$34.00
U5J7727333	TO-5	−20°C to + 85°C	22.50	18.00	15.00

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Data handling

160-kilobit core memory has low profile

Storage unit plus piggyback power supply fits into 5¼-inch-rack space; three-wire, three-dimensional organization helps trim costs

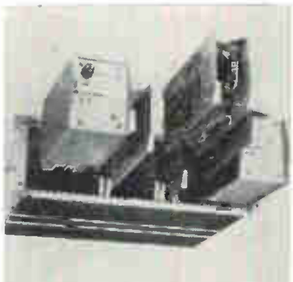
Most core memories with storage capacities up to 4,096 words by 40 bits and submicrosecond full-cycle times require a power supply that's as high as the memory itself—5¼ inches—and stacks atop the memory. Not so with Varian Data Machines' Versastore IV, to be introduced at the Spring Joint Computer Conference in Boston May 14-16. A "piggyback" power supply mounts on the rear of the cabinet, making the entire unit fit a standard rack space that's 19 inches wide, 5¼ inches high, and 24 inches deep. Andy Lucero, project engineer for the Versastore IV, says he knows of no other memory with comparable capacity and speed that doesn't double the height when a power supply is added.

The unit has a full-cycle time (read-restore) of 900 nanoseconds, a 600-nsec half-cycle time and a 35-nsec access time. It can do a read-modify-write operation in 1 nsec. The previous best in the Varian line, the Versastore III, had a 1-μsec full-cycle time, not including time to modify the data.

While Varian officials will say only that the price will be "compatible" with that of the Versastore

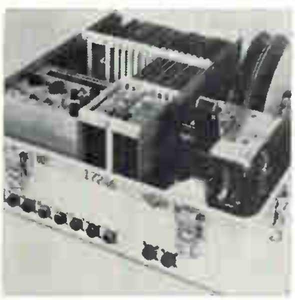
Data entry console LC-728 features a standard IBM 029 keypunch configuration on a movable keyboard. It functions as a general purpose terminal to provide two-way communications with a computer. It is designed as part of the LC-720 data entry system which permits data to be entered on magnetic disk or tape from several terminals. Logic Corp., Euclid Ave., Haddonfield, N.J. [421]

Data set called Modem 2200/24 transmits 2400 bps data over either dial-up or dedicated leased telephone lines. It is compatible with most existing four-phase units such as the Western Electric 201B. It includes circuit techniques formerly exclusive to the company's eight-phase data sets. Price is $2,350. International Communications Corp., 7620 N.W. 36th Ave., Miami, Fla. [422]



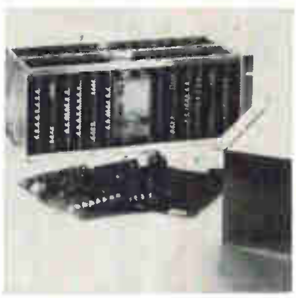
Catalog-standard core memory system FI-3 has a capacity of 4096 words by 20 bits per word. It offers a 3-μsec full cycle time (2-μsec half-cycle time) and access time of 1 μsec maximum. The system utilizes integrated DTL circuits and silicon semiconductors mounted on p-c cards. Price is $4,300; availability, less than 60 days. Ferroxcube Corp., Box 359, Saugerties, N.Y. [423]

Light-coupled data amplifiers models 6110 and 6120 employ fiber optics to transmit data via a light pipe. Major system features include: common mode rejection greater than 100 db at 50 Mhz; frequency response d-c to 50 Mhz direct, or 20 to 80 khz f-m; 500,000 v common mode voltage isolation available. Develco Inc., 2433 Leghorn St., Mountain View, Calif. [424]



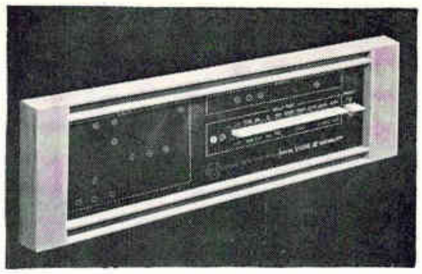
Portable data logger model 801 is designed for completely automatic operation in plant or outdoors. At preset time intervals, it samples 10 independent voltage channels over the range −9.99 to + 9.99 v, displaying data on a decimal readout and simultaneously recording them in standard code on punched tape. Towner Systems Co., 1829 Clement Ave., Alameda, Calif. [425]

Commutator count modules are single digit pulse advance units for printing or reading. They also signal the position to which stepped by a rotated brush location against a commutator board. The printing or indicating wheel can be instructed to stop at any desired position when continually pulsed. Code is either 1 out of 10 or 12. Practical Automation Inc., Shelton, Conn. [426]



Data set FM-18 is available for dial-up data communications networks. It is a low speed frequency shift keyed modem intended to link peripheral units such as crt displays or card and tape terminals to a central processor. It will operate at any speed up to 1800 bps, when used as an asynchronous modem. Rixon Electronics Inc., 2120 Industrial Parkway, Silver Springs, Md. [427]

Word generator 3903 combines push-button controls, optional plug-in repeat controls and data generators. Up to 9 plug-ins, each providing a serial word of data from 1 to 16 bits, and up to 4 repeat controls are available. With 4 repeat controls, the 3903 can deliver up to 16,320 bits. Price of the basic 3903 is $2,150. Lear Siegler Inc., Morena Blvd., San Diego, Calif. [428]


Compact. Core memory fits in standard rack space. The front panel includes self-test switches and indicators.

III, they indicate that the slight speed improvement and greater capacity (4,096 words by 36 bits for the Versastore III) have been offset in price by adoption of a three-wire, three-dimensional organization instead of the four-wire, 3-D configuration of earlier units. Use of only three wires cuts threading costs through the 20-mil-diameter cores.

New features. Lucero says that in the past, in order to change a unit from 4,096 words by 40 bits to 8,192 words by 20 bits, data partitioning was required that assigned the first 20 bits to the first 4,096 words and the remaining 20 bits to the second 4,096 words, and this could be done only in the half-cycle mode. The Versastore IV can be partitioned into 8,192 words by 20 bits full- or half-cycle, he points out. "We also offer partitioning down to eight-bit increments," Lucero notes, "so that the customer can get 16,000 words by eight bits or he can buy 4,000 words by 32 bits and partition down in eight-bit increments." This eight-bit increment capability is available in full cycle only.

Two other features that distinguish the Versastore IV are an "extendable" front panel and a customer option to buy memory cards only—without the cabinet or power supply. The front panel has all data, address, and self-test indicators, plus self-test switches. Its ability to be extended means that if a customer has a number of memories in cabinets, he need buy only one fully instrumented front panel and can pull it off to test any of his memories without disturbing the performance of the unit from which it was removed.

While most core memory suppliers offer a "cards-only" option, the cards are made to order for the

customer; Varian will supply the same units in card or packaged form, and will supply either a wired motherboard or the required wiring list for the customer to do his own interconnections with the cards-only version.

The Versastore IV will be compatible with standard diode-transistor logic voltage levels on the output and will be designed for DTL or TTL input levels. It will operate from 0 to 50°C and will have three address possibilities: random-access register (standard), random sequential access, or sequential interlace access. The last two are options. Input power required is 800 watts maximum. The memory will be available in production quantities by the end of this summer.

Varian Data Machines, 2722 Michelson Dr., Irvine, Calif. 92664 [429]

Data handling

Terminal prints fast, quietly

Data communications machine is designed for 'front office'

High speed and low noise—those are the principal design features of a data-communications terminal developed by the General Electric Company.

The TermiNet 300 will be marketed for computer time-sharing systems and for terminal-to-terminal communications.

Through use of a special printing technique, speeds of 10, 15 or 30 characters per second can be achieved. These rates are controlled by a switch on the front of the terminal. Type characters are rotated horizontally in front of a bank of hammers. Two sets of 94 type characters are included to allow upper and lower case printing. The hammers are activated, and they in turn drive the desired character against the paper through the ink ribbon. Left-to-right printing is thus employed without the need

 Circle 175 on reader service card

Table model. Data terminal is typewriter-size and portable.

for a moving carriage.

Through extensive use of electronic circuitry, the number of mechanical parts and functions is reduced to a minimum, thus making the terminal relatively quiet. GE designers stressed this approach so that the machine could be used in an office environment and not be relegated to a special room because of noise.

The terminal is also designed to fit into front-office decor. It is self-contained, with all the electronics necessary for receiving and transmitting in a unit that is about the size of an office typewriter.

An integrated-circuit logic module, mounted inside the terminal for quick access and service, is designed to make the terminal functions and options modular.

Light touch. The keyboard of the TermiNet 300 uses magnetic coupling to generate codes, and special circuitry permits rapid operation while making the keyboard light to the touch.

The terminal can be connected to telephone lines by using GE or Bell System data sets. Optional features include a photoelectric tape reader that can read at 10, 15, or 30 characters per second and can send data at 120 cps. A paper tape punch is available, and it also operates at 10, 15, or 30 characters per second. The punch, solenoid-driven to reduce noise and wear, is located in a sound-suppressing cabinet. A horizontal-tabulation option gives the user additional flexibility in formatting his output data. From a remote location or from the local keyboard, the user can set tabs at every print position on the print line. Moving from one tab position to another takes less than one character time.

GE Specialty Control Dept., Waynesboro, Va. [430]

You don't need a degree to test op amps.

Signetics' new Model 1410 is the most comprehensive, definitive, easy-to-use op amp tester on the market. And we can prove it.

Rather than shout about its many features, let us just tell you how it works and what it does:

First, you simply insert a program board (manufacturer's spec or your own) for the op amp to be tested. Plug in the device. All operations are now performed by pushing illuminated test buttons. Push the top left button and the lights immediately indicate what tests will be performed. Next, push the "Test" button. If all tests are passed all button lights go out and the "PASS" indicator lights up. If any test is failed, the button corresponding to that test stays lit and the fail light comes on.

Now, if you want to know to what degree a given parameter passed or failed its test, just push the button corresponding to that specific test. The answer is read out immediately as a percentage of the specified test limit.

We call this real "decision language."

There are fourteen tests: power consumption overrange (greater than 200%), power consumption (less than 200%), offset voltage (source resistance zero ohms), offset voltage (source resistance programmed), + supply sensitivity, – supply sensitivity, common mode rejection, bias current, offset current, gain (programmed light load), gain (programmed heavy load), noise and oscillation. And for the first time there are tests you won't find on testers selling for ten times our price: + *slew rate*, – *slew rate*.

The Model 1410 has no knobs to turn or meters to interpret. Your secretary could learn to use it in about one minute. Optional input/output boards allow you print-out or data log complete parameter measurement.

And there's more. But suffice it to say for now that we believe the 1410 represents a major breakthrough in linear testing. Many who have wanted to test op amps can now afford to do so because the 1410 makes op amp testing practical and cost-efficient.

We know that there are some prospects out there who could profit by paying eighty or ninety thousand for this tester.

We're happy to say that the price will not be more than a tenth of that. Plus tax.

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Circle 177 on reader service card

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Time Delay

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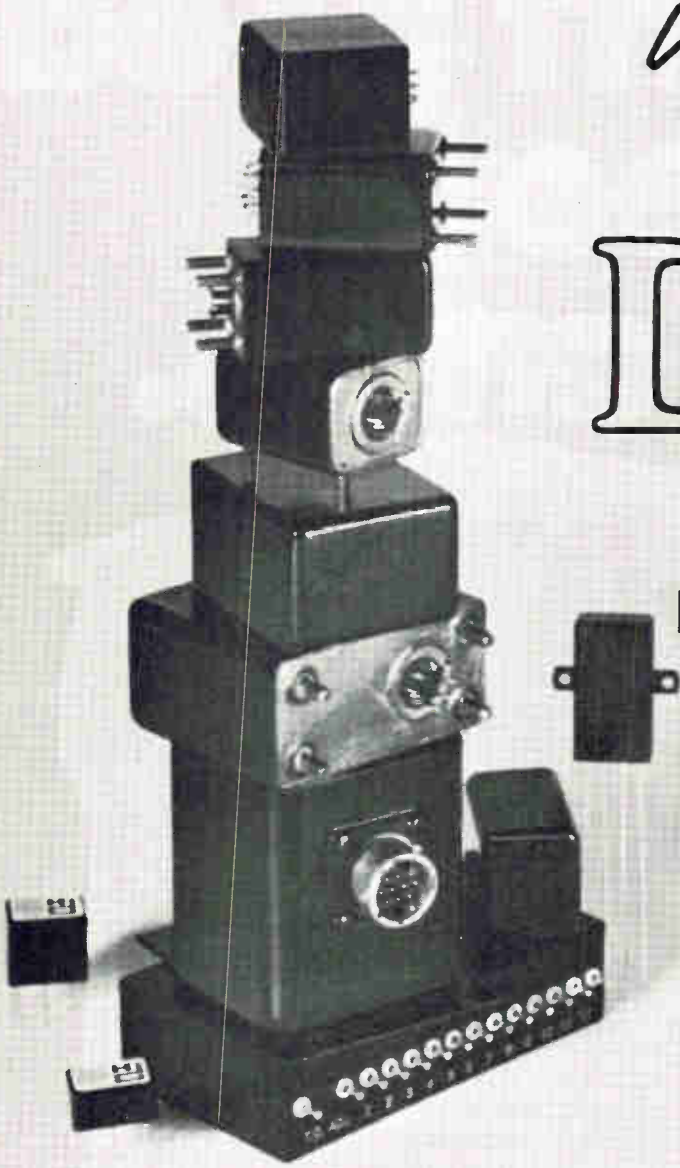

Hi-G time delays come in many packages.
In addition to the series 2400 crystal can type highlighted below, our electronics line includes:

Fixed and Adjustable Time Delays
Up to 300 seconds delay. Contact ratings up to 10 amps. Special variations available to accomplish delay-on-break and interval timing.

Solid State Timing Modules
Solid state reliability offers flexibility in choice of secondary switching capability.

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To protect phase sensitive loads against phase reversal, open or grounded phase.

The spotlight is on Hi-G's 2400 series time delay relays, which combine *solid state timing circuits* with dependable *half-size electromechanical relays* in packages only slightly longer than a standard crystal case.

Results? Small size (0.4 x 0.8 x 1.5 inch), lightweight (1.2 ounces). High current carrying capacity (see below) and the rugged performance of Hi-G electromechanical relays. Long life and fast response of hybrid circuits.
Hi-G 2400 series relays operate on 18 to 31 volts unregulated and need no external resistance or capacitance to obtain maximum timing.

SPECIFICATIONS:
Delay Times:
50 milliseconds to 100 seconds on make.
Delay Time Tolerance:
±10% (5% on special request).
Contact Rating:
2 amps resistive @ 30 VDC.
1 amp @ 115 V, 400 Hz.
Temperature Range: −55°C to +125°C.
Vibration: 20 G, 10 to 2000 Hz.
Shock:
50 G, 11±1 milliseconds duration.

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Detector spots fast-rising spikes

Three delay lines let instrument measure amplitude from 25 to 2,500 volts; it also dtermines transient's rise time and width; over-all accuracy is 5%

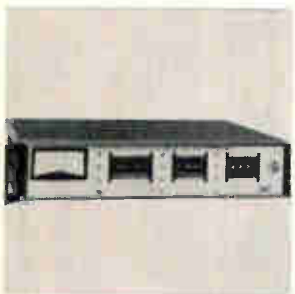
They make memories forget, logic circuits work illogically, and recording pens fly off scale. But because voltage spikes come in a wide variety of shapes and sizes, they're hard to detect, let alone analyze. And with the increasing use of high-speed switching devices such as silicon controlled rectifiers and thin-film diodes, the chances of electronic equipment being spiked are also increasing.

Engineers at Gralex Industries Inc. don't have a solution for the spike problem, but they can give a clear picture of the villain.

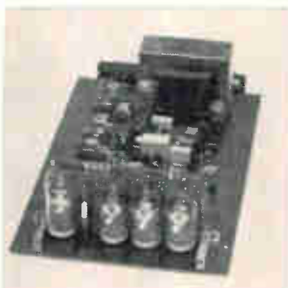
Gralex's Voltage-Spike Detector and Analyzer measures amplitudes, rise times and widths of spikes with amplitudes between 25 and 2,500 volts, plus or minus. The rise-time range is 10 nanoseconds to 10 microseconds, and the width range is 100 nsec to 100 μsec. All three measurements are done with an accuracy of 5%.

And the instrument detects spikes whose amplitudes are as low as 2.5 volts. However, between 2.5 and 25 volts amplitude, it can't measure rise time and width.

Triple play. Gralex vice president Paul Lenoble says the big fea-



Stored-charge detector QS901 is a solid state instrument for use in high-speed automatic diode testing. High and low limits are set on front-panel digit switches, and results are indicated by pass-fail lamps and by an electrical output at the rear panel. Stored charge is also indicated on a front-panel meter. Price is $3,850. Teradyne Inc., 183 Essex St., Boston, Mass. [361]

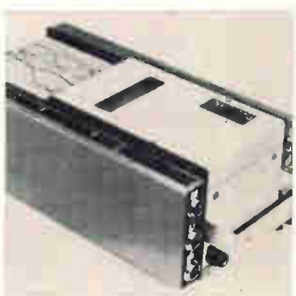


Digital panel meter model 3300 is available in any one of 4 standard voltage ranges from 0.1999 to 1999.9 v d-c; 8 current ranges from 0.1999 to 1.999 amps; and 7 resistance ranges from 199.9 ohms to 19.99 megohms. Accuracy is ±0.1% of reading ±1 digit over 20°C range from 0° to 50°C. Prices start at $175. Electro-Numerics Corp., 2191 Ronald St., Santa Clara, Calif. [362]

Crystal controlled frequency source model SS400 provides precise synchronizing pulses at 200, 400, 800, 1600, and 9600 hz. Frequency stability and accuracy of 0.005% are achieved. Unit is designed for laboratory use to synchronize RC oscillators at these fixed frequencies. It is priced at $98 and available from stock. Polyphase Instrument Co., Bridgeport, Pa. [363]

Portable megohmmeter type 667 is battery operated and suited for making accurate insulation tests of motors, wiring, appliances and other electrical equipment. Four test voltages are available: 100, 250, 500 and 1,000 v d-c with a resistance range from 0 to 10,000 megohms at 500 v d-c. Price is $175. Freed Transformer Co., 1718 Weirfield St., Brooklyn, N.Y. 11227. [364]

Waveform generator model 100 features miniature size (7.38 x 2.85 x 8.50 in.) and handle/tilt-stand. Frequency range is continuously variable from 0.001 hz to 3 Mhz, with square and triangle outputs to 5 Mhz. Output signal amplitude is ±5 v peak for positive and negative square-waves, 20 v p-p for all others, into a 600-ohm load. Exact Electronics, Hillsboro, Ore. [365]



Direct-recording oscillograph recorder called Visigraph-P is compact and portable. Paper speeds from 0.2 to 40 ips are offered in the 6-channel unit which writes at 2,400 ips using a choice of 5 galvanometer ranges with frequencies of from 100 hz to 2,000 hz. Timing lines are recorded on the margin of the 3⅝ in. wide paper every 0.1 sec. Dixon Inc., Grand Junction, Colo. [366]

Combination null detector/microvoltmeter model 155 offers 1 μv full scale sensitivity to 1000 v range. It features less than 150 nv noise, greater than 140 db common mode rejection ratio, and greater than 100 db normal mode rejection ratio, and greater than 10^{12} ohms isolation from ground. Price (1-4) is $325 each. Keithley Instruments Inc., 28775 Aurora Rd., Cleveland. [367]

Counter/timer model 1605, for general lab and shop use, measures frequency from d-c to 25 Mhz. Features include input signal conditioning, gate times from 10 msec to 10 sec, 5-digit display with storage and automatic decimal positioning and an internal crystal oscillator with stability of 1 part in 10^6/month. Eldorado Electronics, 601 Chalomar Rd., Concord, Calif. [368]

. . . spike is found by selecting proper tap . . .

ture of the detector is its wide range. And this, he says, results from the use of three delay lines instead of one.

According to Lenoble, before a detector can measure rise time, it must first measure the spike's amplitude. So a detector needs some sort of memory—usually a delay line. Lenoble says detectors with one line either have poor accuracy because of signal distortion in the delay line or have a small dynamic range.

The delays of the three lines in the Gralex detector are 200 nsec, 2.5 μsec, and 10 μsec, respectively. The lines are connected in series, with a tap at the end of each of the lines.

The 200-nsec line is a coaxial cable 130 feet long. The other two delay lines are made of discrete components.

When a spike occurs, it flows into the first delay line. Inside the instruments are two identical gated peak detectors, one to look at one 100-nsec portion of the spike, the other to look at the next 100-nsec portion. If the output of the second detector is higher than the output of the first, the spike peak hasn't yet occurred, and the gating sequence continues.

If the output of the first peak detector is higher, the gating sequence stops. A logic circuit finds the spike by selecting the proper tap in the delay line, and then rise time, width, and amplitude are measured.

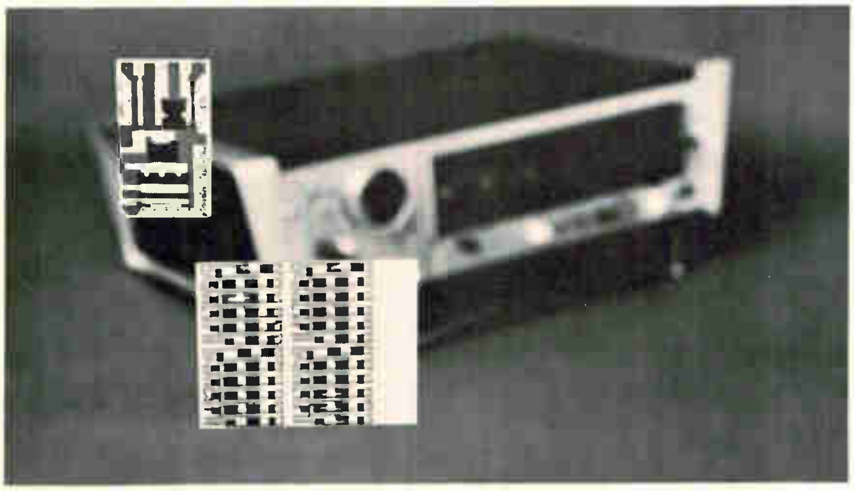
On the move. The detector comes in measurement and control-and-display sections. The measurement unit is plugged into the power line, and can be pulled out at any time and connected to some other line.

In addition to companies that want to keep an eye on voltage coming in, Gralex hopes to sell the detector to utility companies that want to know about voltages they're sending out.

The detector's price is around $10,000, and delivery time is three months.

Gralex Industries Inc., 28 DiTomas Court, Copiague, N.Y. 11726 [369]

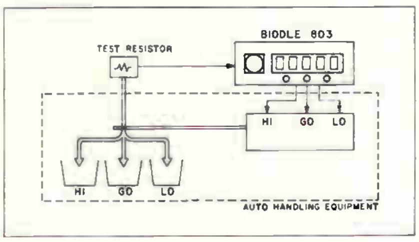
the state-of-the-art resistor tester



State-of-the-Art resistors require comparable test equipment. This is why Biddle produced the Model 803. It is the only precision resistance tester geared specifically for today's critical applications — limit testing, precision trimming and measuring, both absolute and ratio. Until now this has required a complexity of instruments and a compromise in performance. The 803 changes all that. This single instrument does the work of what is now a subsystem, and it does it more accurately, reliably, economically and faster.

Operation. The test resistor is connected directly to the 803, and compared against the desired value. A visual, interpreted indication of whether it is high, low or within preset tolerances is given, and, to control trimming and handling equipment, corresponding electrical signals appear on appropriate output lines.

Precision. The 803 is the only complete 5 digit resistance tester available. In addi-

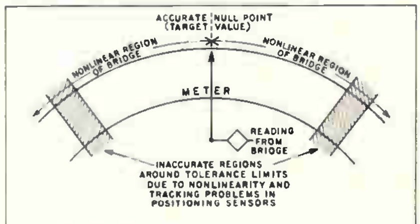


tion, it has a 10% overrange, and at the lower end, tolerances can be set beyond the fifth digit. In the 100Ω range, for instance, the 803 can look at a $\pm 60\mu\Omega$ tolerance window.

Accuracy. The 803 is exceptionally accurate in all modes of operation. Each unit is factory calibrated to 10 PPM and rated at 60 PPM for thirty days. Yearly accuracy is within 150 PPM without calibration.

Deviation Accuracy. Limit testing and trimming require tolerance ranges and automatic decision. This imposes a critical need for deviation measurement—the accuracy with which tolerance limits can be recognized. The 803 provides these advantages:

1. With the precise divider network of the 803, deviation resistances are perfectly linear, whereas conventional bridges have substantial non-linearity at wide limits.
2. Tolerance limits in the 803 are set with a ten turn pot rather than marked off on a meter scale.
3. All decision circuitry is solid state. It doesn't have the drift or tracking problems of a meter, and it is free from human error and the inaccuracies of hanging photo-devices on a meter scale.



DEVIATION INACCURACY OF CONVENTIONAL SYSTEM

Speed. Testing speed is limited only by the handling equipment. For precision trimming, the 803 will respond in milliseconds, and in completely automatic systems it can comfortably test better than 1800 resistors an hour.

Versatility. The standard 803 has six ranges from 100Ω to 11 MΩ. In addition, the options are almost unlimited: 10Ω range; direct reading temperature coefficient; BCD output; etc. In fact, no matter how special your problem is, in all likelihood, the 803 can be adapted to solve it. Why not call us and see?

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Meter maker goes digital, but . . .

Triplett introduces dpm, also shows way to improve analog meters' performance

The entrance of a new digital meter onto the market usually pushes analog meters further into the shadows. But when the Triplett Electrical Instrument Co. recently introduced its first digital meter, the company backed up its line of a-c analog meters by also introducing an amplifier that extends the analog meters' ranges down into the nanoamp region.

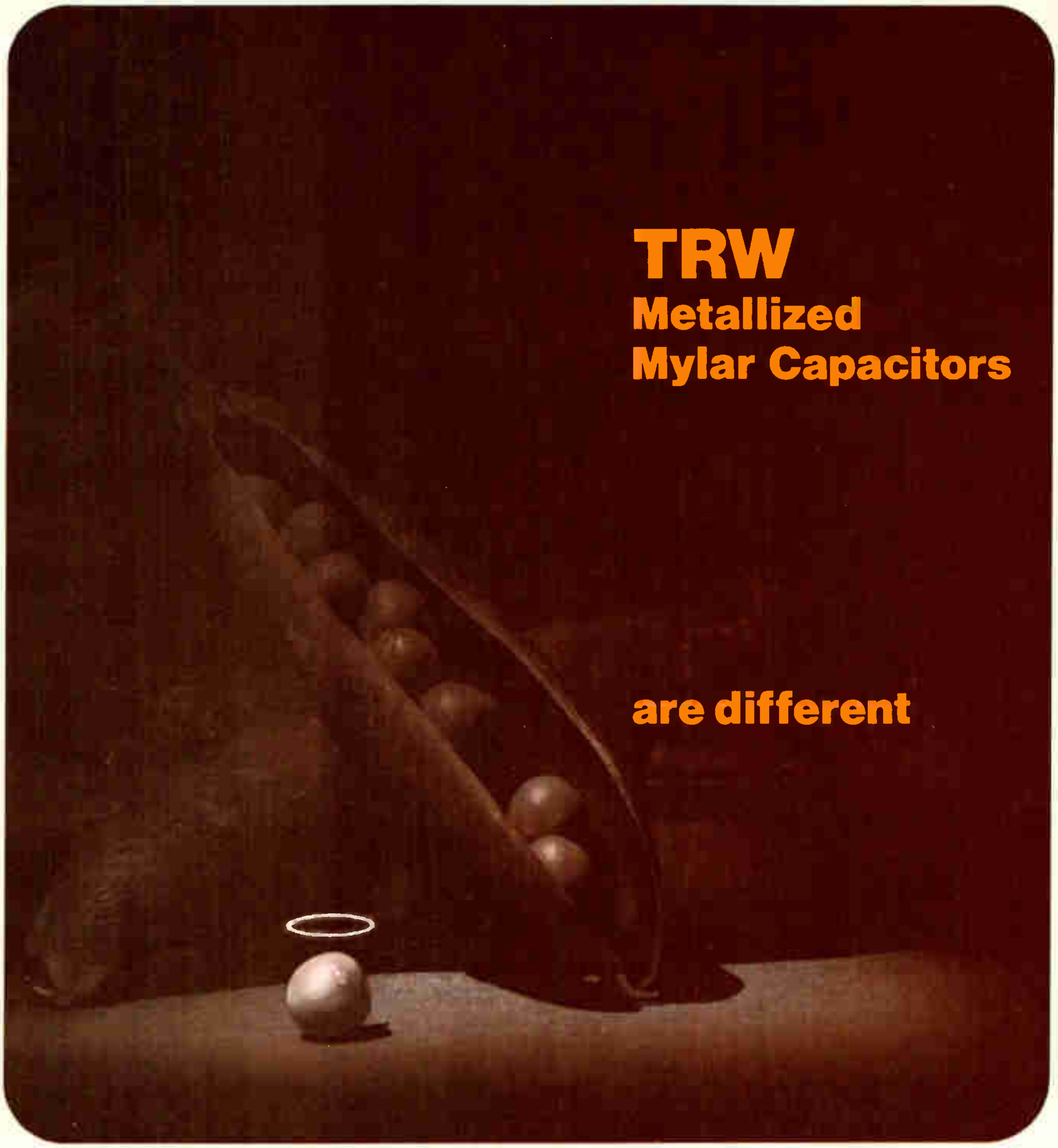
Triplett is going digital with a 3½-digit panel meter, called the Model 5000. Priced at $350 in small quantities, the 5000 costs almost twice as much as most of the newer dpm's. This, says the company, is offset by the 5000's versatility. Less expensive meters offer optional features that are standard on Triplett's dpm.

"We held up a year before coming out with this instrument," says executive vice president Norman Triplett. "We wanted to make sure that the 5000 has everything an engineer could want."

During the next few months, though, Triplett will start offering the 5000 in stripped-down versions, priced—says the company—in line with other dpm's.

Among the 5000's features are 100-millivolt sensitivity, automatic polarity indication, both binary-

A joiner. The amplifier allows analog meter to measure a-c in the nanoamp region.



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coded-decimal and decimal outputs, automatic zeroing, display-hold circuitry, and a balance control that insures equal positive and negative readings. The meter's resolution is 100 microvolts, its accuracy is 0.1%, and its input resistance is 1,000 megohms.

The meter delivers a print-command pulse, so the user can connect it to a printer without going through any interface circuitry.

Built into the 5000 is a self-regulating power supply which puts out 8 watts. The supply's common-mode rejection is 80 decibels and its series-mode rejection is 40 decibels.

The 5000 comes as a d-c or a-c voltmeter in ranges from 100 mv to 1,000 volts, or as a d-c ammeter in ranges from 1 microamp to 10 amps. Its dimensions are 2⅝ by 4⅜ by 5⅝ inches and it weighs 3½ pounds.

The backup. Triplett's analog-meter attachment, called the 300 Meter-Amp, is an amplifier, packed into a cylindrical case 2¾ inches in diameter and 2⅝ inches high. The package fits on the back of Triplett's G-series panel meters and can be connected in a couple of minutes.

The 300 boosts the meter's impedance to 10 megohms, and enables it to make full-scale readings as low as 3 nanoamps or 30 millivolts. The 300's response range is 50 hertz to 50 kilohertz. The price is $70.

Triplett Electrical Instrument Co., 286 Harmon Road, Bluffton, Ohio **[370]**

New instruments

Analyzer adapts to impedance

Sweep generator and detector with new adapter measures magnitude and phase angle

It always could measure the amplitude and phase of sinusoidal voltage; now Hewlett-Packard's 675A/676A network analyzer has an additional talent. Thanks to a

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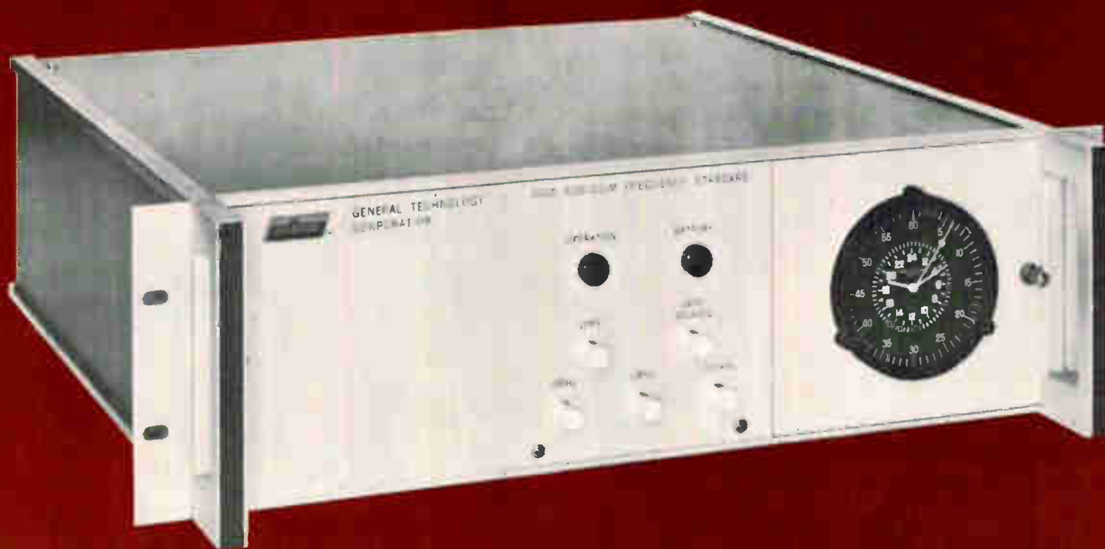

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new attachment, called the 11138A Impedance Adapter, the analyzer measures impedance, both magnitude and phase, at frequencies from 10 kilohertz to 32 megahertz. The range of the analyzer-adapter combination is 0.3 ohm to 3 kilohms at phase angles from $-90°$ to $+90°$, and measurements can be made on any two-port network.

The analyzer itself consists of a sweep generator and a detector. The sweeper sends outputs along two channels to a pair of devices—one is usually a reference—and the detector measures their outputs.

The detector's outputs are proportional to the phase difference between the outputs of the devices being tested, the log of the amplitude of each of these outputs, and the log of the amplitudes' ratio.

Usually, a two-trace oscilloscope displays the phase difference and one of the three amplitude signals as functions of frequency.

New connection. The setup for measuring impedance is similar to the setup for measuring amplitudes; the difference is that the devices being tested are connected to the adapter, which is connected to the sweeper and the detector. The sandwich-sized adapter converts the sweeper's output into a pair of identical constant-current signals, one for each device.

The voltages across these devices, which are proportional to the devices' impedances, are amplified and sent to the detector. The adapter also puts out a d-c signal proportional to the phase difference between the two signals.

The detector's outputs are one phase signal, two impedance-magnitude signals, and one impedance-ratio signal.

Restricted. One way to measure impedance with the adapter is to use a resistor as a reference and display the magnitude and absolute phase angle of the device being tested. Accuracy depends on how precisely the resistance of the reference is known, and ranges between 1% and 15%.

But these impedance measurements are only for those owning the \$3,500 network analyzer. According to H-P, the adapter doesn't work with any other company's analyzer.

The adapter's price is \$175.

Hewlett-Packard Co., 815 Fourteenth St. SW, Loveland, Colo. [371]

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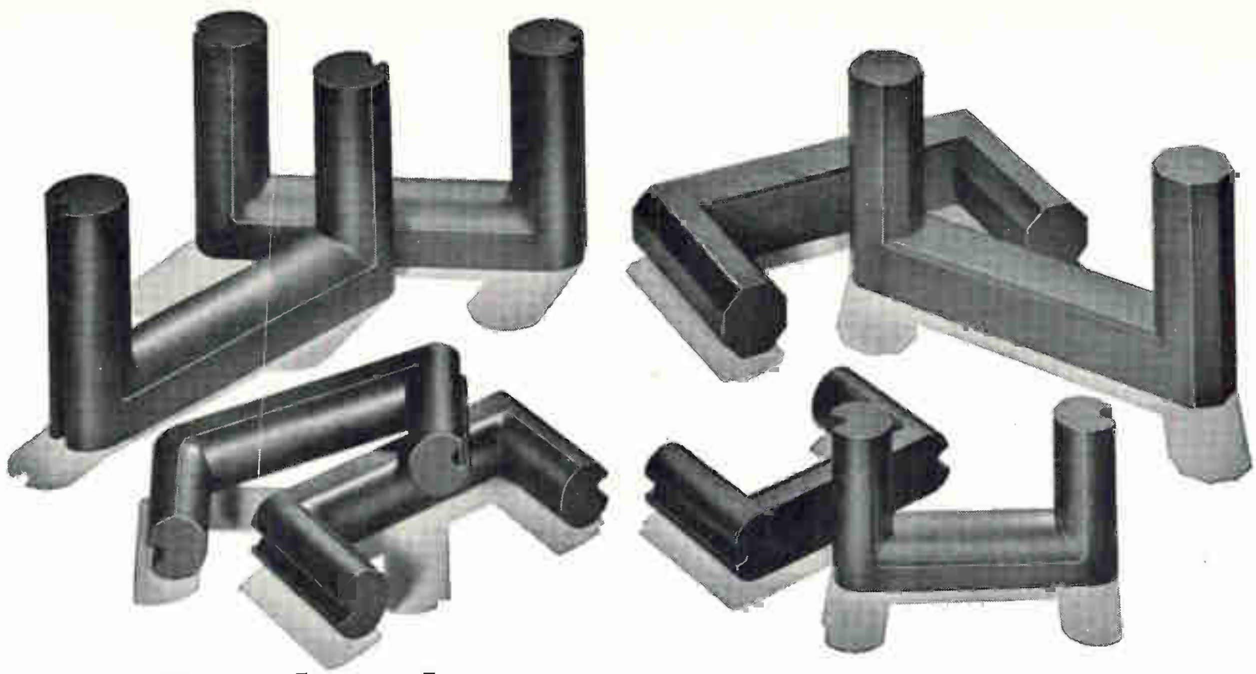
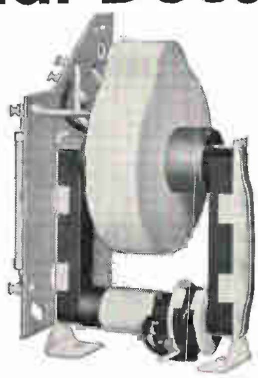


From Stackpole: A New H.O.T. Ferrite Material That Doesn't Lose Its Cool



Ceramag® 24C was developed by Stackpole engineers especially for Horizontal Output Transformer applications. Because this new material offers an unequalled combination of high power permeability and low power loss under flyback circuitry operating conditions, it provides improved efficiency and cooler operating temperatures.

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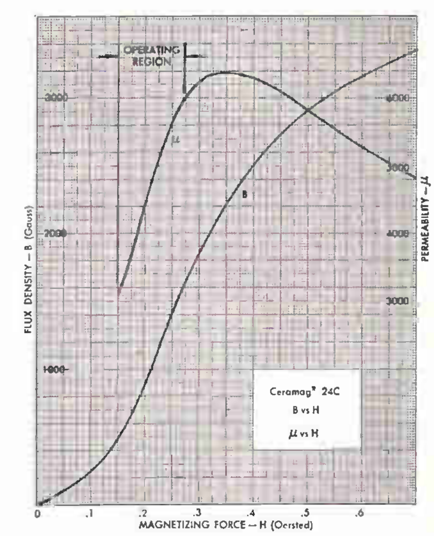
For additional information and samples of Ceramag® 24C, write or call: Stackpole Carbon Company, Electronic Components Division, St. Marys, Pa. 15857. Phone: 814-781-8521. TWX: 510-693-4511.



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ALSO A LEADER IN THE MANUFACTURE OF QUALITY FIXED COMPOSITION RESISTORS

Two firms enter MOS read-only memory race

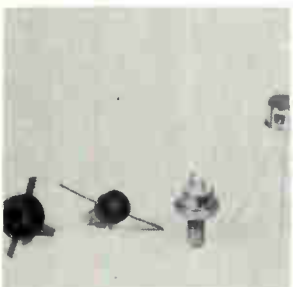
Union Carbide, National Semiconductor market static 1,024-bit capacity units; applications mushroom in code conversion, logic control, character generation

Read-only memories are getting a lot of attention these days, and with good reason. They're versatile devices, lending themselves to such functions as code conversion, random logic control, table lookup, character generation, and arithmetic subroutines. Two manufacturers are taking advantage of the ROM's popularity by introducing static MOS ROM's with 1,024-bit capacity.

The National Semiconductor Corp. is offering the MM521, arranged in 256 four-bit words, and the MM522, which is identical except that it can also be organized in 128 eight-bit words.

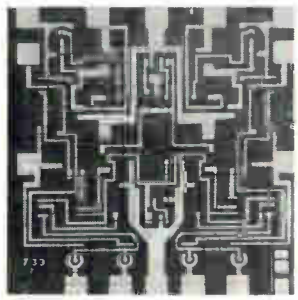
The Electronics division of the Union Carbide Corp., now in its new plant in San Diego, is offering the ROM1k in four organizations: 128 × 8, 256 × 4, 512 × 2, and 1,024 × 1. The Union Carbide product has a typical access time of 1.5 microseconds. The National unit is somewhat faster—its access time is typically 600 nanoseconds – but power dissipation is higher (220 milliwatts vs. 160 mw for Union Carbide's).

Users prefer a static ROM because its output is valid as long as a given address is sensed. (In a

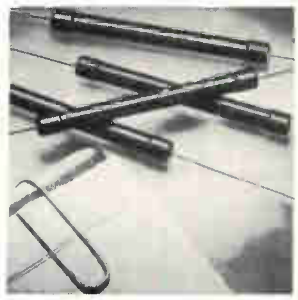


Silicon r-f power transistors and kits, including the 2N5421, 2N5423 and 2N5424, are for 12.5 v operations. The kits consist of 3 to 5 devices and are capable of delivering up to 40 w of output power from a parallel pair of outputs at a frequency of 175 Mhz. Applications include Class A, B and C r-f amplifiers. Solitron Devices Inc., Blue Heron Blvd., Riviera Beach, Fla. [436]

Full capacity thyristor type 282, designed to replace parallel scr's, permits upgrading of equipment with a minimum of external protection. When the device is water cooled, its rms current is 850 amps. Turn-on time is typically 5 μsec. I²T is 200,000 amps squared seconds, and forward and reverse voltages range up to 1,500 v. Westinghouse Semiconductor, Youngwood, Pa. [437]

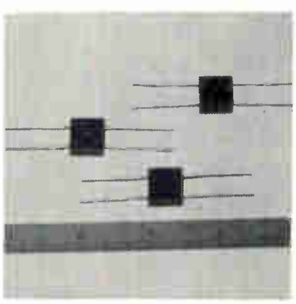


Dual operational amplifier μA739 is a linear IC that achieves high packing density with a 14-lead dual in-line package, which contains 2 identical op amps on a single silicon chip. Stable gain is maintained over a supply voltage range of ±4 to ±15 v. Power supply rejection is 50 μv/v. Slew rate is 1 v/μsec. Fairchild Semiconductor, 313 Fairchild Dr., Mtn. View, Calif. [438]

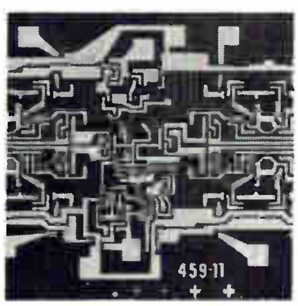


Universal high voltage selenium rectifier S-926 will withstand 2 ma forward current at 4,600 v rms input and is usable at higher potentials at reduced current. Electrical characteristics at 60 hz are: piv, 7800 max.; input voltage, 5.5 kv rms; d-c output, 2450 v at 1.8 ma max. continuous into a resistive load. Sarkes Tarzian Inc., 415 N. College Ave., Bloomington, Ind. [439]

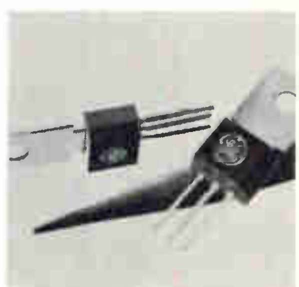
Isolated-collector, stud-mounted silicon transistors 2N5346-9 are medium-power npn devices with minimum f_T's of 30 Mhz. V_{CEO} ranges from 80 to 100 v. Minimum beta at a collector current of 2 amps ranges from 30 to 60. Units are housed in a TO-59 package. Prices are between $24 and $34.95 in quantities of 100. Motorola Semiconductor Products Inc., Box 20924, Phoenix. [440]



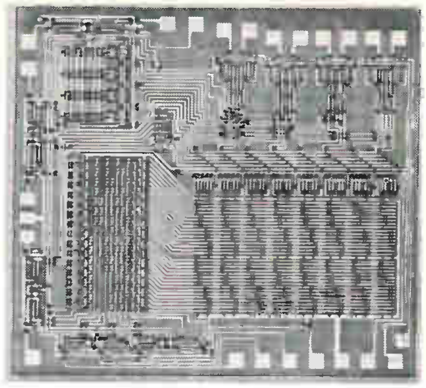
Single-phase, full-wave rectifier bridges are 2-amp units featuring controlled avalanche and reverse recoveries from 50 to 400 nsec. Each leg has a double glass seal for hermeticity. Units meet or exceed applicable reliability provisions of MIL-S-19500 and MIL-STD-202. Prices start at $1.86 each in 250 lots. Micro Semiconductor Corp., 11250 Playa Court, Culver City, Calif. [441]



Parity generator/checker series SM120 are MSI arrays that replace the equivalent of 13 IC packages. The devices perform digital logic functions, normally requiring multiple NAND gates, with typical low over-all power dissipation of 125 mw. Delay time per gate function is as low as 22 nsec per gate. Sylvania Electric Products Inc., 100 Sylvan Rd., Woburn, Mass. [442]



Complementary silicon power tab transistors are designated D27C and D27D. The former is encapsulated with red silicone for identification as an npn device; the latter, with green silicone, to show it as a pnp unit. Both offer low saturation voltages in the 3-ampere range. Prices (100,000 lots) are in the 40 to 50 cent range. General Electric Co., Syracuse, N.Y. [443]



Compatible. Union Carbide's memory can connect directly with TTL IC's.

dynamic ROM, the output remains valid only for a certain time after the data location has been clocked.) According to Robert Goldin, who designed Union Carbide's ROM, "It's easier for a customer to use a static memory and easier for us to specify. We specify the access time and the customer knows the output will be valid without the need to clock the unit."

For the Union Carbide circuit, the typical drain-supply voltage is —12 volts and the gate supply is typically —25 volts, both at 25° C. Union Carbide specifies a chip-inhibit response—the time required to float or to enable the output drivers after the chip-inhibit signal is switched—at 1 μsec typical and 2 μsec maximum.

For National's circuit, drain- and gate-supply voltages are +15 and —15 volts, respectively. A logical 1 is 3 volts maximum and a 0 is 9.3 volts minimum.

Direct coupling. The ROM's of both manufacturers are "bipolar compatible," that is, they can interface directly with transistor-transistor-logic IC's. However, the National Semiconductor device requires external resistors on the input and output to adjust the circuit to TTL voltage levels; the Union Carbide version requires a resistor only on the input. Dale Mrazek, an applications engineer with National Semiconductor, recommends an input pullup resistor value of 3 kilohms; this value provides high speed operation, he says. At the output, the resistor value is determined by whatever supply voltage is convenient; it should be equal to this supply voltage divided by 1.6 milliamperes.

Goldin says that when the decision was made to design the ROM1k, he felt more confident using silicon material with a crystal orientation of 1-1-1, but he expects to have an improved version of the ROM by midyear, with 1-0-0 silicon. He predicts that this will make the device compatible with TTL and diode-transistor logic without external resistors on either input or output. Goldin adds, "We think we'll be able to match National's access time with that circuit."

Maskmaking. Union Carbide's military-grade ROM1k (operating from −55 to +125°C) costs $103.50 for quantities between 1 and 24, $95.40 for 25 to 99, and $82 for 100 to 999. A commercial version (0° to +70°C) costs $47.50 for 100 to 999. Minimum order is 50 units, and there is a maskmaking charge of $400 for orders of fewer than 100.

National Semiconductor's MM521 costs $54 for 25 to 99, and $45 for 100 to 999. The military version (called the MM421) costs $86.40 and $72 in the same quantities. National requires a minimum order of 10 units, and adds a $1,000 maskmaking charge, which is waived on an order of 100 or more.

Union Carbide Corp., Electronics Division, 8888 Balboa Ave., San Diego, Calif. 92123 **[444]**

National Semiconductor Corp., 2950 San Ysidro Way, Santa Clara, Calif. 95051 **[445]**

New semiconductors

A solid look for vidicons

Tube with silicon target has high sensitivity for CCTV applications

Closed-circuit television systems have been plagued by two problems. The cameras, consisting of electron beam guns and glass targets covered with antimony trisulfide, burn out either when exposed to bright lights or from raster scanning. Secondly, their sensitiv-

. . . can't be damaged by exposure to light . . .

ity is too low for some applications. For example, a camera, positioned in a bank, can be damaged by light; and it may not pick up a usable picture when installed in a dimly lit factory.

But now RCA is marketing a camera tube that uses an array of silicon diodes for the target, thereby increasing sensitivity and removing the possibility of burnout. Quantum efficiency of the unit is greater than 50% in the visible region of the spectrum and about 40% at 0.85 micron (in the gallium arsenide emission region) and 50% at 1.06 microns (in the neodymium-doped laser region). Sensitivity is 580 microamperes per lumen with infrared light filtered out, compared to 150 μamps per lumen for comparable conventional vidicons. Moreover, the tube can't be damaged by its own electron beam or by exposure to intense light.

Estimated reliability of the tube equals that of conventional vidicons under ideal conditions—over 10,000 hours. But most vidicons aren't run under ideal conditions and can be damaged by light. Thus, the RCA unit should last longer.

Light spots. Picture defects from faulty diodes that show up as light spots on the RCA unit are comparable to those of other units used for closed-circuit applications. RCA says that improvements should make it possible to eventually market solid target vidicons for both black and white and color applications.

The new unit is designed to sell for $1,000 in small quantities. RCA won't swing into large-scale production before the end of the year. The price is some $800 more than antimony-trisulfide-covered units, but the company says that the higher sensitivity and freedom from burnout will attract buyers. On the other hand, it's less costly than other solid target vidicons—for example, a Texas Instruments unit that sells for $6,500. And the RCA unit has the highest resolution of any solid target vidicon; its amplitude response to a 400-television-line square wave pattern is 30%.

Similar optics. The new tube, known as the C23136, uses electron beam optics similar to those in RCA's 8541A standard tube, and a target that consists of several hundred thousand individual photodiodes. The C23136 is one inch in diameter, uses magnetic-focus and magnetic-deflection techniques, and has a low-power, 0.6 watt "dark heater."

Other advantages are its small lag and small dark currents. After the third field, lag is only 8% compared with 20% in conventional tubes. The subjective effect is to eliminate after-images. It is also interchangeable with standard vidicons. However, since the target voltage, 5 to 10 volts, is lower than the 20 to 40 volts used in conventional tubes, some cameras may require modification.

RCA Electronic Components, Harrison, N.J. 07029 [497]

New semiconductors

Transistors are radiation-hard

Military-spec devices have betas of 10 and 12 after neutron bombardment

The growing market for radiation-tolerant devices has matured to such an extent that the first such transistors made to a military specification have been introduced. Texas Instruments' 2N5332 and 2N-5399 complementary devices have a specific post-radiation minimum gain. After exposure to a neutron fluence of 10^{15} neutrons per square centimeter, the pnp 2N5332 has a worst-case h_{FE}, or gain, of 10 at 10 milliamperes, and for the npn 2N-5399, it's 12.

The two transistors have small-signal characteristics and are designed for general-purpose switching and amplifier use. They have a gain-bandwidth product, or f_T, between 800 and 1,500 megahertz, and each is enclosed in a TO-46 package.

The 2N5399 is unusual because of its low degradation of h_{FE} after exposure to the rated neutron bombardment. Its pre-radiation h_{FE} ranges between 30 and 90 (typically 50) at a collector current of 20 ma. Pre-radiation h_{FE} for the 2N5332 is 20 to 80 (typically 40) at the same current level.

Collector-base-breakdown voltage, or V_{CBO}, is 20 volts for the pnp unit and 25 volts for the npn device. Collector-emitter-breakdown voltage, or V_{CE}, ratings are 12 and 15 volts for pnp and npn units.

To obtain the 10^{15} neutrons/cm^2 radiation tolerance—reportedly the highest for complementary-pair devices of this kind—TI also uses ultrasonic bonding, which is much more reliable in a radiation environment than the more conventional thermal compression bonding.

In 100 to 999 quantities, prices are $9.40 for the 2N5332 and also for the 2N5339. Delivery time is 30 days.

TI is also marketing two new radiation-tolerant power transistors. These devices have a typical post-radiation h_{FE} degradation of only 3 to 1, in contrast to the 8-to-1 degradation common in other radiation-tolerant power transistors. The TIXP39 and TIXP40 differ only in collector-emitter voltage ratings—80 volts and 70 volts respectively. Guaranteed minimum h_{FE} is 10 for both after exposure to 10^{14} neutrons/cm^2.

Before and after. Prior to radiation exposure, the power transistors are rated at 10 amps collector current, dropping to 5 amps after exposure. Typical saturation voltage is 0.4 volt at 10 amps collector current. Minimum f_T is 120 Mhz.

Small orders for these transistors can be filled from stock, the manufacturer says; average delivery time is four weeks for quantities of 100. Price is $49.80 for the TIXP39 and $29.80 for the TIXP40 in 100-999 quantities.

IC versions. Like several other manufacturers, TI has introduced off-the-shelf radiation-tolerant integrated circuits [*Electronics*, Feb. 3, p. 137]. These are essentially versions of standard diode-transistor-logic and linear circuits with dielectric isolation and thin-film nickel-chromium resistors to provide radiation tolerance. TI uses light from a neodymium laser to simulate gamma radiation and predict IC performance.

Texas Instruments, Dallas **[498]**

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New Books

A first

Introduction to Large-Scale Integration
Adi J. Khambata
John Wiley & Sons, 196 pp., $9.95

This book, the first to address itself exclusively to the subject of LSI, is quite properly called an introduction. The technology is moving so fast that any book that tried to go further would be obsolete the day after the author submitted it to a publisher—or the day before.

What should be expected from a book bearing this one's title? Well, the package should include some historical background to put LSI in perspective; a fairly good technical description of semiconductor processing; a description of mask making; a rundown on computer-aided design and automated steps in IC production; discussions of array testing, the logic partitioning problem, and the interface between systems house and semiconductor maker; coverage of discretionary wiring techniques, custom IC's, and LSI chip packaging; a look at the MOS-versus-bipolar question; a list of applications; a timetable for future developments; and, finally, some comments on the approaches being taken by various companies.

The author serves up all this, and more. Of course, none of these subjects can be pursued extensively in a book this size, but what is said about each subject is succinctly stated and worth reading.

Khambata himself views the field from a particularly good vantage point. Now systems manager at the Univac Data Processing division of Sperry Rand, he can see not only the needs of the computer manufacturer but what the semiconductor manufacturers are doing to come up with solutions. He also has a background in semiconductors, having had the prime responsibility for development and design of the original IC's used in Univac's first microelectronic computers.

In discussing performance versus costs, he points out that the price per bit of 256-bit MOS memory arrays in quantities of 100 was between 25 and 30 cents in the second half of 1968. In quantities of

10,000 arrays, the price went down to 8 to 10 cents per bit. In 1970, he predicts, the price will have dropped to 3 to 5 cents per bit for 100-unit quantities, and to 1 or 2 cents for lots of 10,000.

One of his key forecasts, now being borne out in the industry, is that although LSI will have a considerable effect on the operations of semiconductor manufacturers, it will have an even more dramatic impact on equipment manufacturers—an impact that in many cases will be "extremely severe." LSI will generate major perturbations in the area of user-vendor relationships as it brings with it a whole new concept of systems organization and design. The future design teams for computers won't consist solely of logic and systems designers, Khambata says. Programers and even marketing men will exercise a considerable influence—and influence reaching down even to the semiconductor processing level.

Khambata's chapter on the hardware-software relationship is one of his best. He presents the problem of rising software costs and tries to evaluate the effectiveness of LSI in reducing these costs, as well as those of hardware. With estimates that software accounts for anywhere from 50% to 80% of the over-all expense of owning a system, he reasons that LSI may present little, if any, real cost advantages to the user.

LSI can help, though, with some of the housekeeping functions that impose an extra load on programing requirements. Khambata feels that some mathematical functions that might lend themselves to hardware implementation are binary-to-decimal conversion, scaling operations, subroutines such as trigonometric functions, square-roots, and table-lookup operations.

Returns are in

Principles of High-Resolution Radar
August W. Rihaczek
McGraw-Hill Book Co., 498 pp., $19.50

This book is not one that can be read casually. Though the author does his best to describe the sub-

New Books

ject without resorting to high-level mathematics, the problem he deals with is basically one of waveform analysis, which means that complex exponential functions and integrals must be included.

Primarily intended for practicing engineers, the book could be used as a college text. However, there are no problems for solution by students.

Coverage ranges from basic waveform analysis with single-target measurements, matched-filter radar, and pulse compression waveforms, up to radar mapping of distributed targets, target detection in clutter, and synthetic aperture radar.

Working from a general defintion of resolution as the capability of recognizing a particular target in the interference from all other targets, the author then can separate the problem of detection from that of resolution.

In most of the book he ignores the effects of antenna pattern by assuming that the targets are either being illuminated with the same signal strength or not at all. With the problems of antenna sidelobes thus being of secondary importance to the resolution, he can separate the antenna design from the waveform design. Primary concern is for those cases where the interaction between waveform and antenna pattern occurs because of a high signal bandwidth combined with a large antenna.

The author is a senior scientist at the Technology Service Corp. in Santa Monica, Calif.

Recently published

An introduction to Electrical Engineering, Allen E. Durling, Macmillan Co., 480 pp., $10.95
This book provides electrical engineering students with a review of concepts they'll study in depth later in the curriculum. Topics include elementary circuits and theorems, system response, superposition, circuit models, linear and nonlinear circuits, and energy conversion. While the reader should know calculus, a previous course in differential equations isn't necessary.

SCIENCE/SCOPE

The largest and most powerful communications satellite launched to date was put into synchronous orbit February 9 over the Pacific. Built for the U.S. Department of Defense by Hughes Aircraft Company, the 1600-pound experimental giant is two stories tall and more than eight feet in diameter. It is so powerful its signals can be received by all types of ground terminals, including those with antennas as small as one foot in diameter. It will be used by the U.S. Army, Navy and Air Force to determine the feasibility of using synchronous satellites for tactical communications with small mobile ground stations, aircraft, and ships at sea.

A small, speedy, fourth-generation computer, designed to meet highly sophisticated military command-and-control requirements in the 1970s and beyond, is being built by Hughes under a multi-million-dollar company funded program. Basic size is only 4½ cubic feet. It will handle up to five million operations a second and store up to 256,000 words in its memory, and is designed for modular expansion in both hardware and software to meet changing requirements.

Brazil's first satellite communications ground station, which was inaugurated February 28, was built by Hughes under contract with Embratel, Brazil's telecommunications agency. The station will handle 120 two-way broadcasts via Intelsat satellites currently in operation over the Atlantic. Other services available include telegraph, facsimile, and telex. The Brazilian station is expected to be integrated into the 64-nation communications satellite system of the International Telecommunications Satellite Consortium (INTELSAT).

An advanced forward-looking radar system built by Hughes for the U.S. Air Force's Advanced Development Program 698 DF represents a broad spectrum of sensor and system technology: radar, electro-optical, reconnaissance, navigation, and weapon delivery. System has completed a series of successful flight tests.

NASA's Project Viking plans to softland an unmanned spacecraft on Mars in 1973. The U.S. project calls for two 5,000-lb. spacecraft consisting of a Surveyor-type softlander and a Mars/Mariner orbiter, and will use a Titan 3D-Centaur launch vehicle. One of the softlander's missions will be to determine whether extraterrestial life exists. Hughes, member of the Project Viking industrial team formed by Boeing, designed and built the five Surveyor spacecraft that landed on the moon to pave the way for Apollo astronauts.

A high-level Intelsat IV task force for scientists and engineers representing international management of the commercial satellite program visited Hughes recently. Four of the huge satellites will be built by Hughes and 12 subcontractors from countries which are members of the International Telecommunications Satellite Consortium. Program is directed by Comsat, which acts as manager for the consortium.

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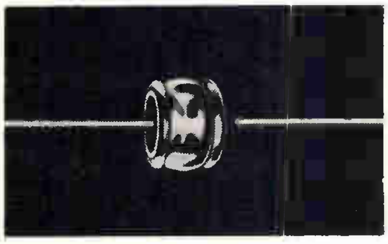

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Technical Abstracts

Surface ripples

Acoustoelectric surface-wave amplifiers
K.M. Lakin
W.W. Hansen Laboratories of Physics
Stanford University
Palo Alto, Calif.

The surface-wave acoustic amplifier may provide some competition for transistors in the not-too-distant future. The high gain that's achieved without interstage networks, high input-output isolation, and simple fabrication techniques make this kind of amplifier an intriguing item. And interest increases when you also consider that the amplifier can be used as a mixer at high signal levels—or as a variable attenuator when the drift field is varied—and that phase changes less than 30° for a gain change of 30 decibels.

Amplification, as in bulk-wave acoustoelectric devices, is provided by the traveling-wave interaction between drifting carriers in semiconductor material and a slow transverse-magnetic wave produced by the acoustic wave in piezoelectric material. With this type of amplfying mechanism, any geometry that efficiently couples such a slow wave to the drifting carriers can be used.

A surface-wave amplifier built at Stanford had lithium niobate as the acoustic medium and a thin silicon epitaxial film as the drift current region. The bidirectional transducer consisted of 20 electrode pairs fabricated by normal photo-etch techniques and matched to a 50-ohm line with pi networks.

This amplifier produced 6 db of stable terminal gain—the actual electronic gain minus transducer loss—with a continuous drift current operation of 3.5 milliamperes at 1.8 kilovolts. No acoustic noise buildup or oscillations due to multiple reflections were observed. The reason: these noise components were outside the transducer's passband and were absorbed rather than reflected by the acoustic terminations. Also, triple-transit signals were greatly reduced due to the nonreciprocal property of the amplifier.

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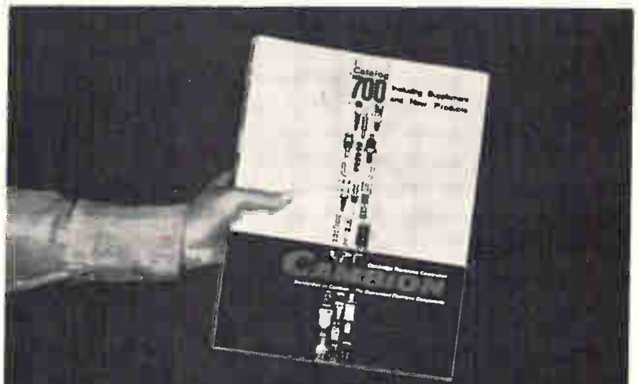

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achieved with a pulsed drift field because of the lower average power dissipation. With an amplifier active region of only 1 centimeter, the terminal gain can be varied over 100 db (—50 to +50 db) by varying the drift field from —2 kv to approximately +5 kv. To reduce the high drift field requirements, the amplifier can be cut into segments; each of these tiny amplifiers can then be operated in parallel at much lower voltages. The segments' gains can be added directly, and gains of 30 db at 185 volts have been achieved.

The maximum power output for the silicon sample used was about 1 milliwatt, or 0 dbm; however, other samples gave as high as +15 dbm. The lowest input level was —80 dbm, but this was due to the noise limitation of the test receiver, not to the amplifier.

Presented at the 1969 IEEE International Convention, New York, March 24-27.

CAM's grow up

On Integrated Associative Memory Element
R.F. Herlein and A.V. Thompson,
American Micro-systems Inc.,
Santa Clara, Calif.

For many years computer people have wanted a memory from which they could retrieve information without having to keep track of its precise location—retrieval purely in terms of the information itself. Until recently, such memories, called associative or content-addressable memories (CAM's), haven't been economically feasible, because each storage cell requires logic associated with it. But the advent of large-scale integrated circuits lowers the cost of such complex units to a point where they are of more than academic interest to the engineering community.

One such array has recently been developed at American Micro-systems, Inc. It contains eight words of eight bits each, organized for parallel access and designed to operate at 1 megahertz. It contains 1,799 p-channel metal oxide semiconductor transistors on a single substrate measuring 156 by 144

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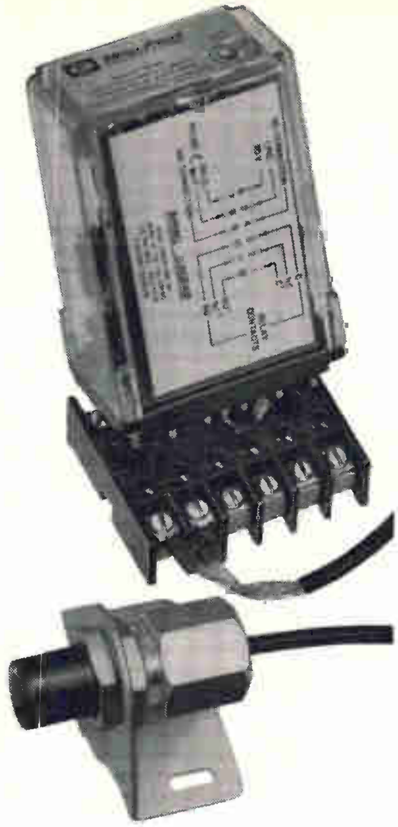

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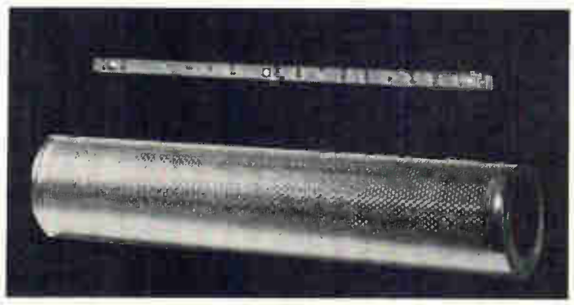

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mils and is mounted in a 40-lead dual in-line package.

A new kind of MOS circuit was developed to achieve the memory's high packing density, high speed, and low power. Like conventional four-phase clocked logic, it relies on temporary storage in distributed capacitances, but it uses only three clock phases, so that its propagation delay is reduced. Furthermore, the circuits' output impedances are low when their outputs are positive, producing good noise immunity. The clock pulses are the source of power to the circuits.

Three kinds of circuits are used in the memory: an isolating inverter, a minimum delay inverter, and a noninverting gate. The memory cells that actually store the information are each made of two isolating inverters that recirculate a bit back and forth. A minimum-delay inverter generates the complements of the address bits; NOR logic made from the isolating inverters decodes the address.

An associative memory's most critical function—that of generating flag bit outputs for words that match the unmasked portions of an input data word—is implemented here with the noninverting gate.

The new associative memory would have been difficult or impossible to build without these new circuits, which promise to be useful in many future applications as well.

Presented at the International Solid State Circuits Conference Philadelphia, Feb. 19-21.

Gain in translation

Millimeter-Wave Up-Converter With Gain Using Germanium Avalanche Diodes

S. Kita,
Nippon Telegraph and Telephone Public Corp., Tokyo

Crucial to the reliability of experimental millimeter wave systems are the solid state devices that regenerates pulses in repeaters. Usually, Schottky-barrier diodes or diffused diodes are used as varistors and varactors respectively. These diodes don't amplify the intermedi-

Technical Abstracts

ate frequency as they convert it to the higher output frequency.

However, an experimental millimeter up-converter using avalanche germanium diodes translates a 4-gigahertz signal to a 46.5-Ghz output signal—and amplifies the signal up to 3 decibels.

When this diode is used in the avalanche region the 42.5-Ghz local frequency and the -4 Ghz intermediate frequency are efficiently converted to the 46.5-Ghz output frequency by a parametric effect. Keeping both the optimum and output frequencies of the diode nearly equal creates a negative resistance. And if diode current remains less than that required to start oscillation, the negative resistance causes the higher output frequency to be amplified.

Pulse response of the up-converter was equal to the requirements of millimeter wave pcm repeaters. When input pulses with a 4-Ghz frequency and a 400-megabits-per-second date were applied, the rise and fall times of the output pulses were about 1 nanosecond.

Diode current and output power increased rapidly beyond negative bias voltages of 8 volts, reaching a maximum of —11 volts. Current at that point was about —10 milliamperes. A maximum output power of 5.1 dbm was obtained at a local oscillator power of 10 dbm and a signal power of 14 dbm.

Experiments were done with germanium silver-bonded diodes consisting of n-type germanium and a silver whisker doped with a small amount of gallium.

Presented at the 1969 IEEE International Solid State Conference, Philadelphia, Feb. 19-21.

Decisions, decisions

One view of automation for patient clinical care

George N. Webb, N.S., and
Richard S. Johns, M.D.
Johns Hopkins School of Medicine
Baltimore, Md.

Automating various phases of hospital operation is one way to improve health care. But before a hospital turns to automation, it should precisely define the problems it's

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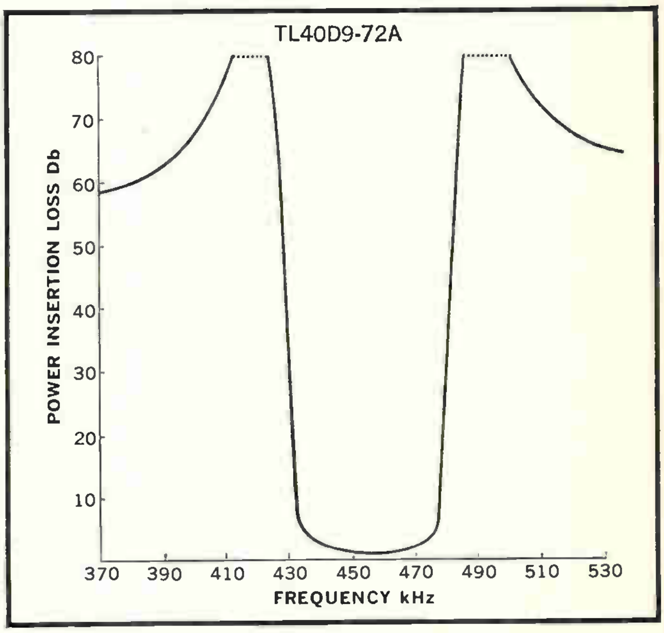

Here's the smallest (less than 0.07 cu. in.), most rugged fixed-tuned filter on the market today!

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TL40D9-72 (A or C)	40 kHz	72 kHz

***PRICES:** 1—$25 ea; 25—$20 ea; 100—$17.50 ea; 500—$15 ea; 1000—$13.75 ea; 2500—$12 ea.
(Prices subject to change without notice)

Send order or request for Bulletin 94021 to: Clevite Corporation Piezoelectric Div., 232 Forbes Rd., Bedford, Ohio 44014, U.S.A. Or: Brush Clevite Company, Limited, Southampton, England.

CLEVITE

Circle 207 on reader service card

Technical Abstracts

trying to solve. And this defining requires the cooperation of physicians and engineers, because all the skills of the systems engineer are called into play in the design and installation of an automated hospital system.

The design of a cardiac monitoring system, for instance, requires adherence to the following stringent guidelines:

Define specific goals for the system before anything else is done. Examine the reason for going to an automated system. Is it to improve patient care at any cost, to reduce medical costs, to increase the amount of care provided by the staff, or to satisfy status needs of the hospital?

Decide which functions are to be automated and which are to be done by the staff. For example, it must be decided if man or a machine is better suited to measuring blood pressure, heart and respiratory rate, and temperature. And is it more efficient for a machine to record drug orders and administrative instructions?

It must also be decided how data will be recorded, processed, stored, and displayed, what the safety requirements are, and what part of the design and construction will be done by outside contractors.

After the goals have been laid down, run a pilot study. Get all the hospital personnel involved at this stage so that later complications can be avoided. And set up training programs for all affected employees of the hospital.

Budget a fixed percentage of projected costs to pay for outside consultation.

And budget at least 10% of projected hardware costs for inhouse maintenance and modification. With the exception of one device from Hewlett-Packard, all the electronic instruments bought in the past year for a system at Johns Hopkins either required a major repair or had to be returned to the maker within three months of purchase. And this isn't to let H-P off the hook because the other equipment from them failed.

Presented at 1969 IEEE International Convention, New York, March 24-27.

 Circle 208 on reader service card

Circle 251 on reader service card

New Literature

Instrumentation. Sybron Corp., 95 Ames St., Rochester, N.Y. 14601. A four-page folder on Quick-Scan 400 series instruments describes the line's controllers, recorders, process indicators, manual loading stations, and cascade switching stations.
Circle 446 on reader service card

I-R analytical accessories. Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn. 06902, has published a 36-page handbook on its complete line of i-r spectrophotometer cells and accessories. **[447]**

Counter/timer. Monsanto Electronic Instruments, 620 Passaic Ave., West Caldwell, N.J. 07006. Characteristics and capabilities of the model 110A, a 50-Mhz programable counter/timer, are outlined in a six-page brochure. **[448]**

Power transducers. Esterline Angus Division of Esterline Corp., P.O. Box 24000, Indianapolis 46224. A-c power transducers that are virtually maintenance-free are described in a 12-page catalog. **[449]**

Tone receiver. Quindar Electronics Inc., 60 Fadem Rd., Springfield, N.J. 07081. Two-page product data sheet PDS-1-4 describes the QR-30 frequency-shift tone receiver. **[450]**

Frequency sources. Freqency Sources Inc., P.O. Box 159, North Chelmsford, Mass. 01863, has just released its new 1969 catalog describing a broad line of microwave solid state sources. **[451]**

High-current rectifiers. KSC Semiconductor Corp., KSC Way (Katrina Rd.) Chelmsford, Mass. 01824. A six-page bulletin lists characteristics and application conditions for a series of high-current rectifiers. **[452]**

Displacement transducers. Research Inc., Box 6164, Minneapolis 55424. Bulletin 508.5 covers a line of displacement transducers for remotely measuring linear motion, displacement, deflection or separation. **[453]**

Discrete devices. Fairchild Semiconductor, Box 1058, Mountain View, Calif. 94040. The 1969 transistor and diode condensed catalog gives a complete listing of the company's discrete devices. **[454]**

Electron-beam evaporation. Airco Temescal, Division of Air Reduction Co., 2850 Seventh St., Berkeley, Calif. 94710. A 12-page brochure outlines applications of electron-beam evaporation for producing optical and electronic thin-film devices. **[455]**

Automatic testing control. Theta Instrument Corp., 22 Spielman Rd., Fairfield, N.J. 07006. Bulletin 67-10 describes digital systems with primary applications in the automatic control of testing sequences. **[456]**

Voltage regulator sockets. Electronic Molding Corp., 40 Church St., Pawtucket, R.I. 02860, offers bulletin FS-11 on a nine-pin molded socket for packaging TD-66 flanged-type voltage regulators. **[457]**

Diode test equipment. Teradyne, 183 Essex St., Boston 02111, has published a 12-page brochure on its line of automatic test instruments for diodes **[458]**

High-vacuum pumps. Nelson Vacuum Pump Co., 2133 Fourth St., Berkeley, Calif. 94710, has released catalog No. 20 giving up-to-date details on a full line of high-vacuum pumps and accesseries for laboratory and field uses. [459]

Ribbon cable and assemblies. Spectra-Strip Corp., P.O. Box 415, Garden Grove, Calif 92642. Bulletin 070 describes Spectra-Sil flat ribbon cable and harness assemblies made of individual round conductors insulated with sicilone rubber. [460]

Quartz crystal and ovens. Erie Technological Products Inc., 644 W. 12th St., Erie, Pa. 16512. A 16-page brochure describes Hunt quartz crystals and ovens for accurate and reliable control of frequency response. [461]

Power supply. EMD Components Inc., Wickliffe, Ohio 44092, offers a bulletin describing the operating and performance characteristics of a new adjustable frequency power supply. [462]

Delay lines. Engineered Components Co., 2134 W. Rosecrans Ave., Gardena, Calif. 90249, has published catalog NS-16 on its miniature lumped-constant nanosecond delay lines. [463]

Sputtering sources. Semi-Elements Inc., Saxonburg Blvd., Saxonburg, Pa. 16056, has available a catalog dealing with high purity sputtering sources. [464]

Time division multiplexing. Rixon Electronics Inc., 2120 Industrial Parkway, Silver Spring, Md. 20904, has issued a four-page bulletin on its model TDX time division multiplexing terminals. [465]

Avalanche diodes. Computer Diode Corp., Pollitt Drive, Fair Lawn, N.J. 07410. A four-page illustrated technical bulletin describes the company's line of general-purpose, low-voltage avalanche diodes. [466]

Thermal switches. Standard Controls Inc., 2401 South Bayview, Seattle, Wash. 98144. Technical bulletin TSP-169 provides a quick reference for a complete family of probe type, bimetallic snap acting thermal switches. [467]

Ultrasonic cleaning. Phillips Mfg. Co., 7334 N. Clark St., Chicago 60626, has published an eight-page booklet on the principles of ultrasonic cleaning. [468]

Frequency synthesizers. Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif. 94304. A 26 page application note No. 96 describes the principles of operation and applications of fast-switching, direct-type frequency synthesizers. [469]

Wire lacing. Gudebrod Bros. Silk Co., 12 S. 12th St., Philadelphia 19107, has issued an eight-page bulletin illustrating and describing two lacing systems for electronic gear. [470]

Governed d-c motors. A.W. Haydon Co., 232 N. Elm St., Waterbury, Conn. 06720. Bulletin MM801 provides detailed data on chronometrically governed reversible d-c motors. [471]

Voltage stabilizers. English Electric Valve Co., Chelmsford, Essex, England. A four-page leaflet contains data for a full range of voltage stabilizers and reference tubes. [472]

Power supplies. Velonex Division of Pulse Engineering Inc., 560 Robert Ave., Santa Clara, Calif. 95050. A 12-page bulletin V-50 covers a complete line of d-c to d-c power supplies. [473]

Molded inductors. San Fernando Electric Mfg. Co., 1501 First St., San Fernando, Calif. 91341. A 32-page brochure details one of the industry's largest lines of molded inductors. [474]

Laser plasma tubes. University Laboratories Inc., 733 Allston Way, Berkeley, Calif. 94710. Twelve helium-neon laser tubes are described in bulletin 1009. [475]

Pushbutton switches/indicators. Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y. 11237. Catalog L-169D provides complete data, drawings, and ordering information for the 513 series pushbutton switches. Data is also given for 183 series matching indicator lights. [476]

Digital tachometers. Airpax Electronics, P.O. Box 8488, Fort Lauderdale, Fla. 33310. Preliminary bulletin DS-1 describes a line of digital tachometers, industrial devices that accept and count the signals over a given time interval. [477]

Fluidic limit switch. Corning Glass Works, Corning, N.Y. 14830. Operation, performance characteristics, and a physical description of a fluidic limit switch are provided in a data sheet. [478]

Metal plate connectors. Elco Corp., 155 Commerce Dr., Fort Washington, Pa. 19034. A 32-page design manual contains complete information for metal plate back-panel interconnecting systems. [479]

Ceramic capacitors. Sprague Electric Co., 35 Marshall St., North Adams, Mass. 01247. Type 7C radial-lead, Monolythic ceramic capacitors are described in engineering bulletin 6202, available upon letterhead request.

Soldering equipment. Ideal Industries Inc., 5180 Becker Pl., Sycamore, Ill. 60178. Soldering equipment, designed to handle the miniature and subminiature job, or the large soldering and brazing project, is deescribed in four-page bulletin No. 7. [480]

Microwave diodes. Microphase Corp., 35 River Road, Cos Cob, Conn. 06807, has released an eight-page catalog listing more than 100 types of germanium and gallium-arsenide mixer, video-detector, oscillator, switching, and amplifier diodes. [481]

Optical components. Spectra-Physics, 1250 W. Middlefield Road, Mountain View, Calif. 94040. A six-page short-form catalog includes detailed characteristics of more than 250 optical components for laser-oriented products and systems now in use. [482]

Ribbon cable. Berkshire Technical Products Inc., P.O. Box 60, Reading, Pa. 19607. Bulletin 102 details properties and advantages of new flat-bonded, round-conductor ribbon cable for aerospace, military, and industrial applications. [483]

Frequency synthesizer. Micro-Power Inc., 25-14 Broadway, Long Island City, N.Y. 11106, has available a bulletin on the model 300A microwave frequency synthesizer with 12.4-Ghz signal capability. [484]

Crystal controlled oscillators. McCoy Electronics Co., Mt. Holly Springs, Pa. 17065. Thirty-two miniature, precision crystal controlled oscillators are described in a 12-page catalog [485]

Laser plasma tubes. University Laboratories, 733 Allston Way, Berkeley, Calif. 94710. Twelve helium-neon laser plasma tubes for systems use are described in bulletin 1009. [486]

New Literature

Miniature circular connectors. Viking Industries Inc., 21001 Nordhoff St., Chatsworth, Calif. 91311. A 12-page catalog provides design, performance, and assembly data on Snap-Lock (standard) and Snap-E-Lock (environmental) miniature circular connectors. [487]

Reed relays. Wheelock Signals Inc., 273 Branchport Ave., Long Branch, N.J. 07740, has available a 24-page catalog covering over 160 of its complete family of reed relays. [488]

Components. Cambion Electronic Products Ltd., Cambion Works, Castleton, Sheffield, England, offers a revised 1969 edition of catalog 700 featuring miniature plugs and jacks among the 22,000 electronic components described. [489]

Tachometers. Dynalog Corp., 4107 N.E. Sixth Ave., Fort Lauderdale, Fla. 33308. Series T2000 solid state tachometers are described in Dynaform 2000. [490]

Copper foils. Circuit Foil Corp., 23 Amboy Road, Bordentown, N.J. 08505. Copper foils for circuits and the company's capability for production of special treated foils are discussed in a six-page brochure. [491]

Instruments. Sencore Inc., 426 W. Westgate Dr., Addison, Ill. 60101. A 12-page catalog, Form No. 458, features five new test instruments, including a sweep and marker generator, combination oscilloscope/vectorscope, color generator, and two transistor/FET testers. [492]

Readouts and decoder/drivers. Discon Corp., 1150 N.W. 70th St., Fort Lauderdale, Fla. 33309. Two illustrated brochures provide descriptive information and specifications for the DiGiCator line of numeric readouts and IC decoder/drivers. [493]

Instrumentation recorder. Newell Industries, 795 Kifer Road, Sunnyvale, Calif. 94086. Complete specifications of the AV-15000R instrumentation magnetic recorder are featured in a six-page brochure. [494]

Power spectral density system. Federal Scientific Corp., 615 W. 131 St., New York 10027. Bulletin 682 describes a fully automatic, real-time power spectral density system for fast, inexpensive analysis of vast quantities of noise, vibration, and other low frequency data. [495]

Vacuum equipment. Hughes Aircraft Co., 2020 Oceanside Blvd., Oceanside, Calif. 92057, has available two data sheets, one on a series of molecular sieve type foreline traps, and the other on eight different high-vacuum valve models. [496]

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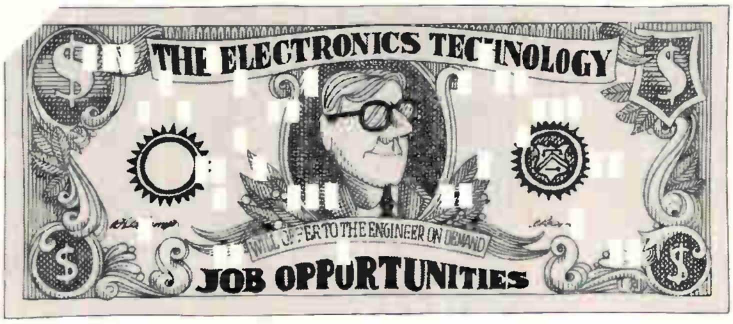

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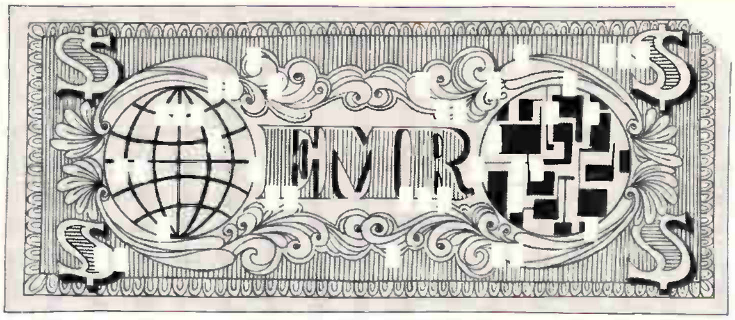

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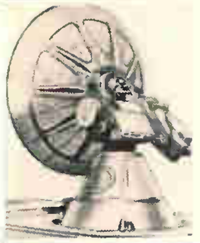

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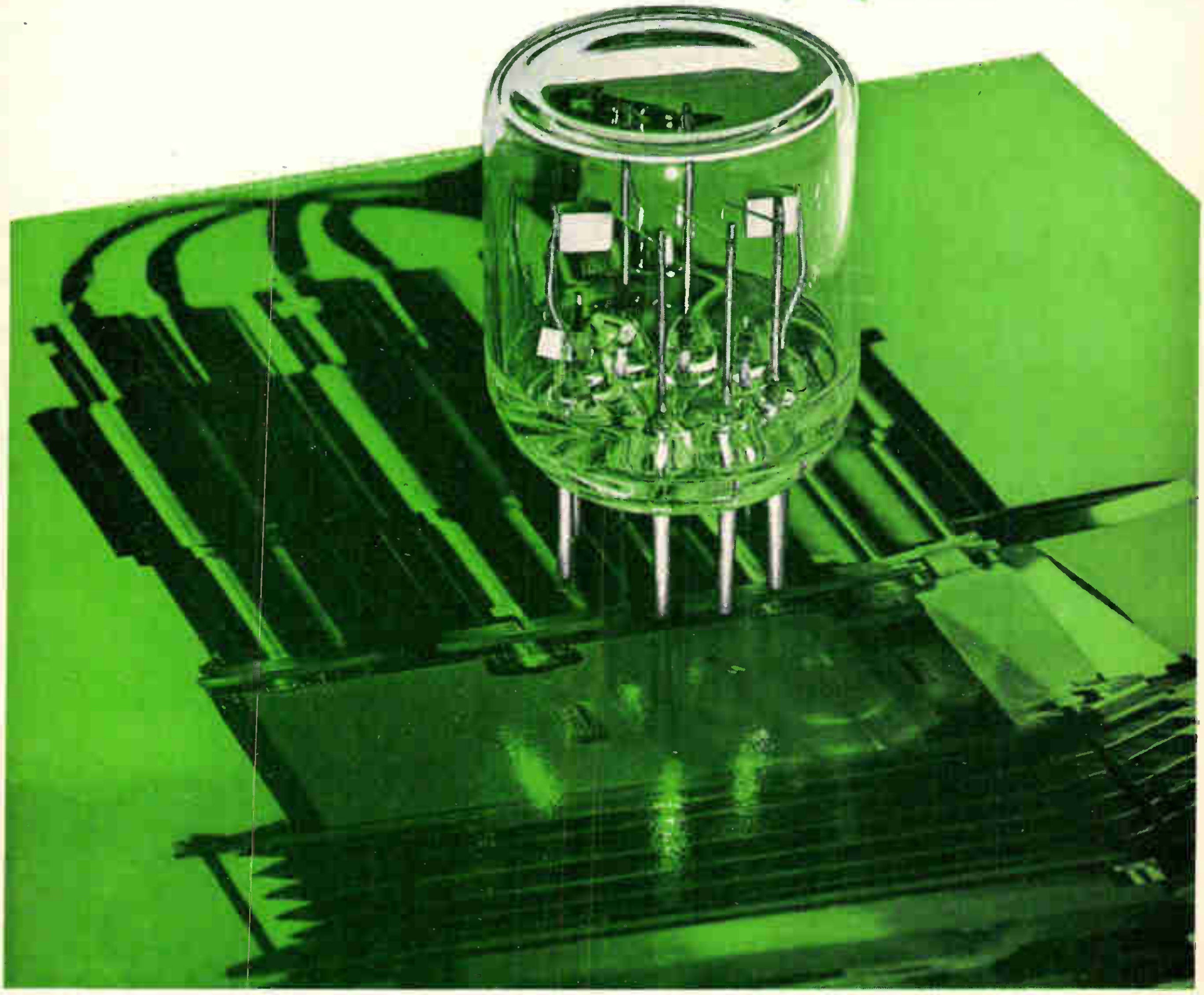
ELECTRONIC PRODUCTS DIVISION



International Newsletter

April 14, 1969

'Plan Calcul' firm set for a shakeup

France's government-backed computer maker, Compagnie Internationale pour l'Informatique (CII), may be taken over by the big Thomson-Brandt group.

If that happens, **a major management shakeup is sure to follow. CII is having major problems getting its state-subsidized computers into production. And its sales effort is lagging** because, as one executive puts it, "we have nothing to sell."

A Thomson-Brandt takeover of CII would be a back-door result of the complex negotiations now going on to restructure France's heavy electrical equipment industry in the wake of the Westinghouse Electric Corp.'s attempt to take over the industry's second biggest firm, Societe Jeumont-Schneider.

A plan now under study calls for Thomson-Brandt to turn over its 18% holding in Societe Alsthom—the country's leading maker of heavy electrical equipment—to Compagnie Generale d'Electricite (CGE) in exchange for CGE's 30% interest in CII and probably some of its other electronics interests. Thomson-Brandt, by adding this block to its present 30% share in CII, would gain majority control of the firm. **The plan, heartily endorsed by the government, would concentrate French electrical equipment and electronics producers in two strong groups.**

Production of CII's first all-French computer, developed under the government's "Plan Calcul," is reportedly several months behind schedule. That machine, the Iris 50, was due for first delivery by the end of this year. A military Plan Calcul computer, the Iris 35, is to be shown for the first time at the Paris Air Show in May. A third machine, the Iris 80, will be unveiled at next fall's Sicob business machines show.

Desk calculator makers in Japan face a shakeout . . .

Look for a thinning-out over the next year or two of the crowd of Japanese companies vying for shares of the desk calculator market.

Some 20 companies are in the business. **But the leaders have started to produce in quantities that will make it unprofitable for small producers to stay in the market.** Industry-leading Hayakawa Electric Co., for example, has tooled up for a 20,000-monthly output of the new miniature LSI calculator it will add to its line [*Electronics*, Feb. 17, p. 215].

Already there's been a dropout. The Uchida Yoko Co. phased out production of its three low-priced machines this month. Uchida, though, will continue with a high-priced machine that has programed operation. Insiders are convinced that Uchida is just the first of several companies that will opt out of an increasingly competitive market.

. . . as Sanyo tries to top Hayakawa with battery pack . . .

Much of the competition will center on technological innovations that pay off doubly: first in lower cost, second in an exclusive sales feature.

Sanyo Electric Co. is counting on an LSI miniature calculator with a built-in power pack in an effort to gain ground on Hayakawa. Sanyo says it will start sales this fall, just a few months after Hayakawa goes to market with its LSI—but line-powered—machine.

The battery pack—four nickel-cadmium rechargeable "C" cells—can run the calculator for three hours before it needs a recharge. Power drain is a mere two watts—1.2 watts for the two-phase logic circuits and 0.8

watt for the display and its drives, according to Sanyo.

Sanyo's cordless machine has 13 different MOS arrays in its logic circuits, plus four transistors, eight resistors, and four capacitors in the clock circuits. The company stoutly insists it will produce the MOS packages itself; insiders in the semiconductor business, though, maintain that Sanyo has had trouble producing bipolar IC's at a reasonable cost and almost certainly will have to turn to U.S. suppliers for MOS arrays.

. . . and Hayakawa plans power pack plus new display

Sanyo won't have the cordless calculator market to itself for long.

Hayakawa is pressing development of a power-pack accessory for its LSI miniature calculator, which draws 4 watts. The company expects to have a prototype ready by September. It will be a nickel-silver-cadmium type and will run the calculator for eight hours between recharges. With both Sanyo and Hayakawa selling cordless calculators, other producers will be forced to follow suit.

Along with a power pack, Hayakawa has another improvement in the works for competitors to fret over—a low-voltage, eight-decade Digitron display tube. The tube, being developed for Hayakawa by Ise Electronics, will operate on a 12-volt supply, compared with 25 volts for the discrete Digitrons now used. Ise will pack the eight decades in a single flat envelope 8 by 4 by 2 centimeters in size. The single tube will be cheaper than the eight discrete tubes it will replace.

Giant computer lures EEC firms

Five of Europe's big electronics companies apparently have heeded a call of the European Economic Community's commission—the executive arm of the six-nation Common Market—and may join forces to develop supercomputers for the 1970's and 1980's. Reportedly discussing the idea are Siemens and AEG-Telefunken of West Germany, Philips' Gloeilampenfabrieken of the Netherlands, Italy's Olivetti, and France's Compagnie Internationale pour l'Informatique.

The EEC has two projects in mind, spearheads of a campaign to narrow the technology gap between its member countries and the U.S. One involves a very large computer that would be based on existing technology and be ready for the market around 1975. The other would be based on LSI-and-later techniques and follow the first by five years.

Ceiling lifts for Germany's avionics makers

West Germany avionics makers face their brightest prospects in years. Now that France and West Germany have informally agreed to build the A-300B European airbus [*Electronics,* March 31, p. 177], there's a strong chance that a European combat jet will get off the ground as well. The go-ahead, which could come as early as May or June, would dispel much of the gloom that's pervaded the German avionics scene in recent years.

The project, first proposed by the Germans 18 months ago and at that time called the NKF aircraft, now involves Britain, Italy, and the Netherlands as well. The plane, rechristened the multi-role combat aircraft (MRCA), would be a successor to the current standard NATO jets, the F-104 Starfighter and the Fiat G.91.

Detailed negotations haven't yet begun, but German aerospace companies are speculating that development costs will come to between $400 million and $500 million, with a production run of something like 1,000 planes costing about $2.5 million each. Avionics would account for 20% to 35% of the total expenditure.

Sensitive radar keeps helicopters in the clear

System developed in France spots high-tension wires 1,500 yards off; a twin-antenna layout eliminates "dead" time of single-dish units

There's mixed news at Electronique Marcel Dassault (EMD) these days for low-flying French helicopter pilots.

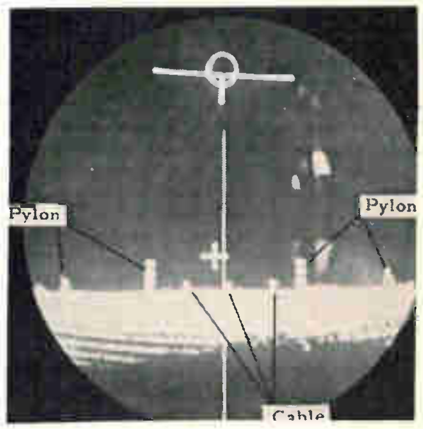
EMD, the electronics arm of the well-known French aircraft maker Dassault, has readied an obstacle-avoidance radar system so sensitive it can spot high-tension wires. Helicopters equipped with the system, called Saiga, could cruise in confidence even in bad weather at ground-skimming altitudes.

But for the moment, there's no plan to produce the radar, even though two prototypes built for the French army have performed admirably in tests. Saiga was developed to go with a new personnel-carrying helicopter whose costs have climbed to the point where the austerity-minded French government has had to eschew the radar. The helicopter in question is the Sud-Aviation 330, which Sud developed jointly with Britain's Westland Aircraft.

Despite this domestic setback, EMD still has hopes of finding military customers for Saiga in Britain, West Germany, and Sweden. U.S. officers are scheduled to get a look at the system this spring, but chances of a sale to them look very slim.

Whirling. Crucial to Saiga's performance are its 1.3° pencil beam and its twin-antenna layout. Instead of sweeping back and forth with a single dish, Saiga uses a pair of dishes mounted back-to-back in a gimbal that spins at 11 revolutions per second. This eliminates the "dead" time that's inevitable with a single dish, which has to stop at the end of a sweep before starting back in the opposite direction.

As they spin, the antennas are switched onto the radar's signal-



Good show. Pylons and high-tension lines standout on scope of French helicopter radar. Cross in center indicates course.

processing circuits to get a horizontal coverage of 160°. The vertical scan covers a 20° angle.

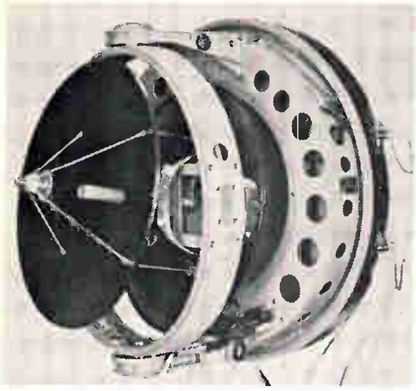
Saiga operates at a wavelength of 8 millimeters.

Guidance. The radar proper is paired with a special computer so that pilots can "fly blind" with the system. For one thing, the computer switches the field of view every time the helicopter's course changes by 60°. For another, it supplies inputs showing where the helicopter is and where obstacles are.

Actually, the pilot has two kinds of displays on the radar's scope. One is close to conventional, with obstacles showing up as pips against range markers. A special marker-line in this display indicates the braking distance—telling the pilot whether he can safely stop in midair or whether he must veer off to avoid a collision.

The second display is a television-like scan of 22 lines. It shows the azimuth and elevation rather


Bulbous. Obstacle-avoidance radar adds a big nose to test helicopter.



Dervishes. Antenna dishes spinning back-to-back do away with the "dead" time that occurs when a single dish sweeps back and forth.

than azimuth and range.

A computer-generated course marker superimposed on this display shows if there's a danger of hitting an obstacle. By flying to keep the marker in the clear, the pilot will clear obstacles by anywhere from 100 feet to 1,000 feet, depending on the radar's setting.

On the line. Saiga's tour de force so far has been spotting high-tension lines up to 1,500 yards away. The cables show up on the radar's scope as three dots.

This was a surprise, according to Gerard Collot, chief of EMD's radar department. It was first thought that the 8-mm output of the radar would bounce back from a single point on transmission lines. But apparently because the cables are twisted and the wavelength of Saiga's beam is short, there's an interference effect that gives three equally strong returns.

Great Britain

Rigged with yig

Like a lot of other companies, Mullard Ltd. is high on yttrium-iron-garnet. Just how high will become eminently clear later this week at the International Conference on Magnetics in Amsterdam.

At Intermag, researchers from Mullard and its parent company, Philips' Gloeilampenfabrieken, will tell about two prototype systems they've worked out. Both exploit the transparency of yig—under the right conditions—to infrared radiation at wavelengths from 1.1 to 5.5 microns. But the systems have entirely different end uses. One checks the pollution content of automobile exhausts; the other operates as a contactless ammeter for high-voltage electric transmission lines.

Twin beams. The pollution checker is a joint effort of Herman van Heek of Philips' Eindhoven research facility and Roger Cooper of Mullard. Its principle: the three main pollutant gases in auto exhausts are heavy absorbers of the radiation that yig will pass.

A beam of polarized light then, can be shifted by the Faraday effect in a yig modulator to pass alternately through an inert-gas sample and an exhaust-gas sample. By comparing the radiation levels picked up by an indium-antimonide detector after the light passes through each sample, the pollution content can be precisely measured—down to 10 parts per million.

Van Heek thinks that the lab setup could one day be realized in a production unit that would be no more than 20 inches long. This package would be paired with remote electronics.

Untouchable. Mullard's second yig system is a step toward a lightweight instrument that can measure current flow in electric transmission lines. The job is currently done by means of fairly bulky transformers.

The system, largely the work of Cooper and his colleague, Ron Pearson, puts a yig crystal a few inches—precise positioning is a must—from the line. The current flowing through the line sets up a magnetic field that makes the yig crystal rotate a polarized infrared beam passing through it. The amount of rotation, then, depends on the current in the transmission line.

Cooper has proved out this system in low-voltage lines. For his experimental yig ammeter, he uses a 12-volt, 55-watt quartz-iodine lamp and a germanium photodiode. This setup measured currents up to 500 amps with an accuracy of 2%, which is as good as conventional ammeters can do. A fully engineered yig ammeter, Cooper thinks, would be accurate to about 0.1%.

West Germany

Lighting the way

You'd hardly expect the designers of U.S. spacecraft to run to overseas companies for electronics hardware, but they do from time to time.

A triode made by Siemens AG flew deep into space on Mariner 4 five years ago. And Siemens has found a small niche for itself—albeit indirectly—in NASA's man on the moon Apollo program.

An electroluminescent material Siemens developed is going into readout panels that Lear Siegler Inc. makes, including some for the Apollo 11 command capsule. The Siemens material—a copper-doped zinc sulfide—will also light up the flight attitude indicator in the lunar excursion module, the craft that will carry two astronauts to a touchdown on the moon.

Siemens, of course, uses the material in its own hardware and particularly for solid state X-ray image converters.

Sandwich. The Apollo lighting panels are built up on a substrate of Nesa glass less than 3 millimeters thick (Nesa is a coated glass produced by PPG Industries Inc.). One side of the glass has a transparent coating of antimony-doped tin oxide, a semiconductor material that serves as one electrode for the panel. This layer is less than 1 micron thick and has a low resistance, 100 ohms per square.

Covering the tin oxide is the luminescent copper-doped zinc sulfide, embedded in an organic binder. This layer is from 1 to 2 mils thick and is topped by a white reflecting layer.

The sandwich is completed by printing silver bars on the reflecting layer. They form numbers, letters or symbols. These bars, actually, serve as small individual electrodes and are energized selectively by transistor circuits to get the desired display. The panel emits light only where there's an energized bar. The voltage used for the panel is 115 volts, 400 hertz.

Added ingredient. In Siemens' own electroluminescent-image converters, there's a high-resistance layer of semiconductor material sandwiched between the luminescent layer and the back electrode. The semiconductor layer changes its resistance when hit by X-rays, and there's a subsequent rise in the voltage at the luminescent layer in the areas involved. They light up while other areas on the panel stay dark. Because of the persistence of the luminescent material, the image is stored for a short time.

Siemens is using image converters like this experimentally in its X-ray engineering work.

Curie-point cure

Today's substrates for microwave integrated circuits are good, but far from ideal. For one thing, the substrates — usually hard - to - machine aluminum oxide—need holes drilled in them to hold ferrite elements like circulators, isolators, and sometimes directional couplers. For another, the bonds between the ferrites and the substrates often cause unwanted reflections in the circuit.

The cure for these mechanical and electrical problems is a ferrite material with a Curie point well below freezing, reports the Philips Research Laboratories at Hamburg. At operating temperatures from —30°C to +70°C, substrates made from these ferrites are nonmagnetic and make an admirable match for normal magnetic ferrites in microwave IC's. The magnetic and "nonmagnetic" ferrites can be sintered together for a homogeneous, nonreflecting bond.

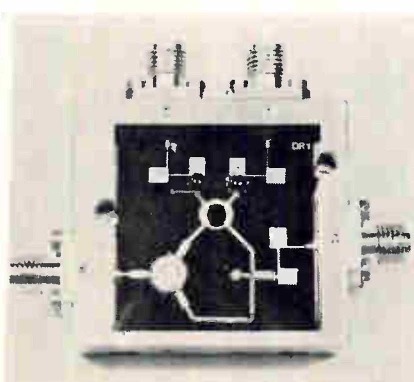
Using this new approach, Philips researchers have already developed microwave subsystems such as X-band radar front ends, X-band doppler radar components, and phase shifters. Some of these subsystems, particularly the doppler radar, are seriously being considered for production. Peter Holst and Martin Lemke, the two Philips scientists mainly responsible for the technique, will pinpoint their progress to date at Intermag later this week at Amsterdam.

Take a powder. To fabricate the ferrite IC's, preheated ferrite bulk material is first ground to a fine powder. This powder is then mixed with a small amount—about 5% by weight—of a polyester resin so that it can be easily shaped. After that, the nonmagnetic and magnetic types are packed into a die that has the geometry wanted for the IC. Subsequently, the ferrites are pressed and sintered to form a monolithic unit.

The technique gives a high-density ferrite chip with a vacuum-tight transistion between the two different ferrite materials. Its porosity—less than 5%—is about the same as that of the original bulk material. Holst says the ferrite substrates can be machined and polished more easily than aluminum oxide substrates. This, he says, is important when it comes to low-loss devices.

Choices. Two kinds of ferrite crystal structures can be used: a spinel structure consisting essentially of an iron oxide and any one of the transition elements, or a garnet crystal structure such as an yttrium-iron-garnet. To make a spinel-type ferrite nonmagnetic, its zinc content must be higher than usual. And to obtain a garnet-type nonmagnetic material, its aluminum content must be made higher than usual.

The work done by the Philips researchers indicates that electrical properties like loss tangents, dielectric constants and Q factors are roughly the same for both ferrite and aluminum - oxide substrates. Also, the average power-handling capability of ferrite substrates is more than enough for most microwave IC's.



Of a piece. Front end for X-band doppler radar is all on ferrite IC. Circulator (lower left) is built on yig disk sintered into substrate.

A ferrite substrate 30 by 30 millimeters square, for example, can carry the circuitry for an X-band doppler radar. The substrate has an integrated magnetic zone for the circulator.

The system's 15 milliwatts are generated by a Gunn oscillator. About one-fifth of that is fed directly into a balanced mixer that acts as a local oscillator. The remaining energy goes through the broadband circulator formed by a metal disk on aluminum-substituted yig and a small permanent magnet embedded in the ground plane below.

Japan

A powerful memory

Squeezing nearly 100 memory bits into the same minuscule space that a bit now takes up in a magnetic memory seems impossible, but a research team at the Kokusai Denshin Denwa Co. (KDD) thinks it can be done.

KDD is Japan's overseas cable and radio company and its memory research team has some impressive credentials in magnetics. The team leader, Shintaro Oshima, did the work that led to plated-wire memories in Japan. And it's Oshima who's giving the invited paper on Japanese memories at Intermag.

Combination. The way to pack the bits in, say the KDD men, is to combine fabrication techniques developed for magnetic memories with the photoetching techniques used to produce integrated circuits. The combination results in magnetic-stripe memory elements so fine and so close together they can connect directly to drive-circuit elements on an IC.

Because of the way the element looks, KDD calls its store a fine-stripe memory. There's still considerable development work to be done, but KDD can build memories with a density of 5,000 bits per square centimeter, against the 3,300 bits per cm^2 in an MOS memory. By the time MOS memories are available with a bit density of 10,000 per cm^2, Oshima predicts, the fine-stripe memories will be up to 17,000.

And, being magnetic, the fine-stripe memory has other advantages over MOS. Two of the more important ones: the store isn't lost if there's a power failure, and there's less heat generated.

On deposit. To build a fine-stripe store, KDD starts by vapor-depositing a thin film of Permalloy on a glass substrate. This film—about 2,000 angstroms thick—has aligned domains since it's put down in the presence of a magnetic field.

Atop the Permalloy goes a 3,000-angstrom copper layer, followed by a coating of photoresist. This is exposed to get a digit-line pattern of stripes—aligned in the easy direction of magnetization—25 microns wide on a 50-micron pitch. Because this IC technique can be accurate to about 1 micron, digit lines with a width of 10 microns on a 15-micron pitch may be practical.

To finish the digit-line layout, the stripes are electroplated so that the copper stripes end up completely surrounded by Permalloy. The magnetic domains are oriented so that the easy direction of magnetization is circumferential as in conventional plated-wire memories.

Wordy. Word lines are conductors in grooves scribed on a ferrite sheet. The sheet is placed—grooves up—against the digit-line plate, with the word lines at right angles to the digit lines. No insulation is needed; the ferrite acts as its own insulator. Return connections for the word lines can be put on a separate substrate on the other side of the digit-line substrate.

Signed up

Engineers at the Matsushita Electric Industrial Co. expect one day to do away with cathode-ray tubes in tv sets and instead use solid state matrix displays. So does just about everybody else in the business. But Matsushita, unlike most of the others, also foresees an eventual demise of the neon tube in large outdoor signs. The company is well along with its candidate for a successor—a fluorescent mosaic display.

Matsushita already has built a prototype that would make a respectable billboard—about 11 feet by 5½ feet. The display has 288 picture elements, each 8.7 inches square. They flash on and off—in any of 16 colors—under tape control to show fixed or moving patterns like advertising slogans or animated cartoons.

Big show. Matsushita doesn't see the mosaic as a gigantic tv display. The frame rate is 3 or 4 per second, compared with 25 or 30 frames per second for normal tv transmission. But for signs, the frame rate is fast enough and the mosaic displays have a potentially big edge over made-to-order neon signs. For one thing, the picture elements will be mass-produced standard modules. For another, the mosaic panels can change their colors and patterns if their control tapes are changed.

A good size for an outdoor display, Matsushita thinks, would be between 5,000 and 10,000 elements. And the company has plotted its way to a full-fledged sign. Later this year, it expects to install an 800-element sign, probably to huckster its own wares at the Osaka International Airport. Next year, the schedule calls for a sign put together from about 5,000 elements, this one near New York.

On the panel. No matter how large the signs, they'll be made up of standard four-lamp panels. For the prototype, the panel size is 22 centimeters square; but it's possible to whittle this down to 10 cm on a side. The lamps—red, green, blue, and white—lie behind a diffusing panel. They can be left off or switched on separately, in combination or all together.

For each lamp, there's a thyristor-control circuit for turn-on and a transistor circuit for turn-off. Both the thyristor and the transistor work with an AND gate so that both x and y signals have to be present to switch the lamp. The control signals are stored on a six-track audio-tape recorder.

Comfortably close. The Mitsubishi Electric Corp. is right up with the pack in the effort to develop flat-screen tv. Spurred, apparently, by a mid-March report on Matsushita Wireless Research Lab's electroluminescent panel [Electronics March 17, p. 114], Mitsubishi had one of its own to show at the International Convention of the Institute of Electrical and Electronic Engineers in New York last month. Both Mitsubishi's and Matsushita's panels sandwich an electroluminescent layer between a layer of x-axis electrode strips and a layer of y-axis strips. Coincident points during an x-y scan, then, become picture elements that emit different levels of light to form images. Mitsubishi's screen has a resolution of 80 lines and its size is slightly less than 3 by 4 inches.

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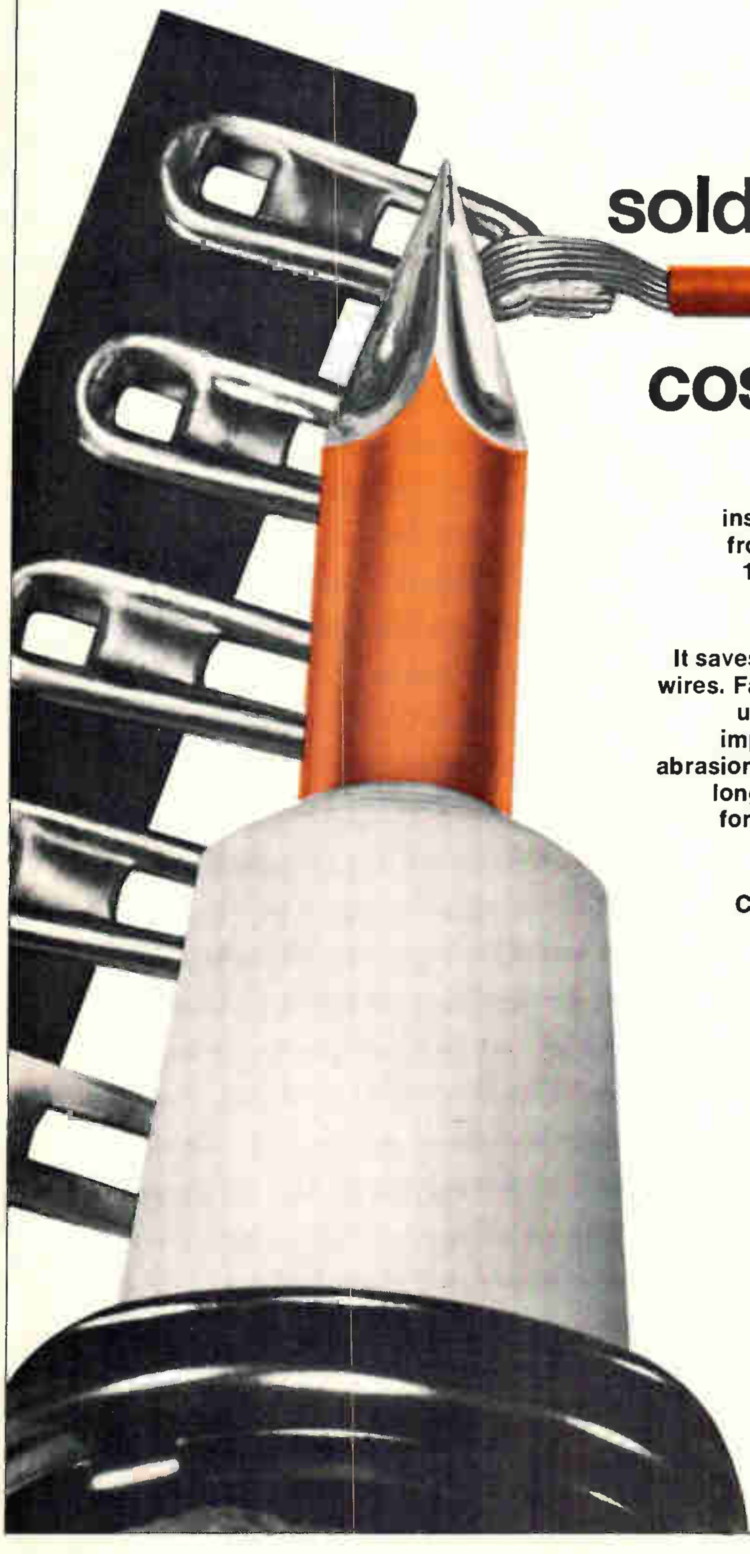

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2	21	40	59	78	97	116	135	154	173	192	211	230	249	268	287	306	325	344	363	382	401	420	439	458	477	496	515	963
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4	23	42	61	80	99	118	137	156	175	194	213	232	251	270	289	308	327	346	365	384	403	422	441	460	479	498	517	965
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14	33	52	71	90	109	128	147	166	185	204	223	242	261	280	299	318	337	356	375	394	413	432	451	470	489	508	956	975
15	34	53	72	91	110	129	148	167	186	205	224	243	262	281	300	319	338	357	376	395	414	433	452	471	490	509	957	976
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