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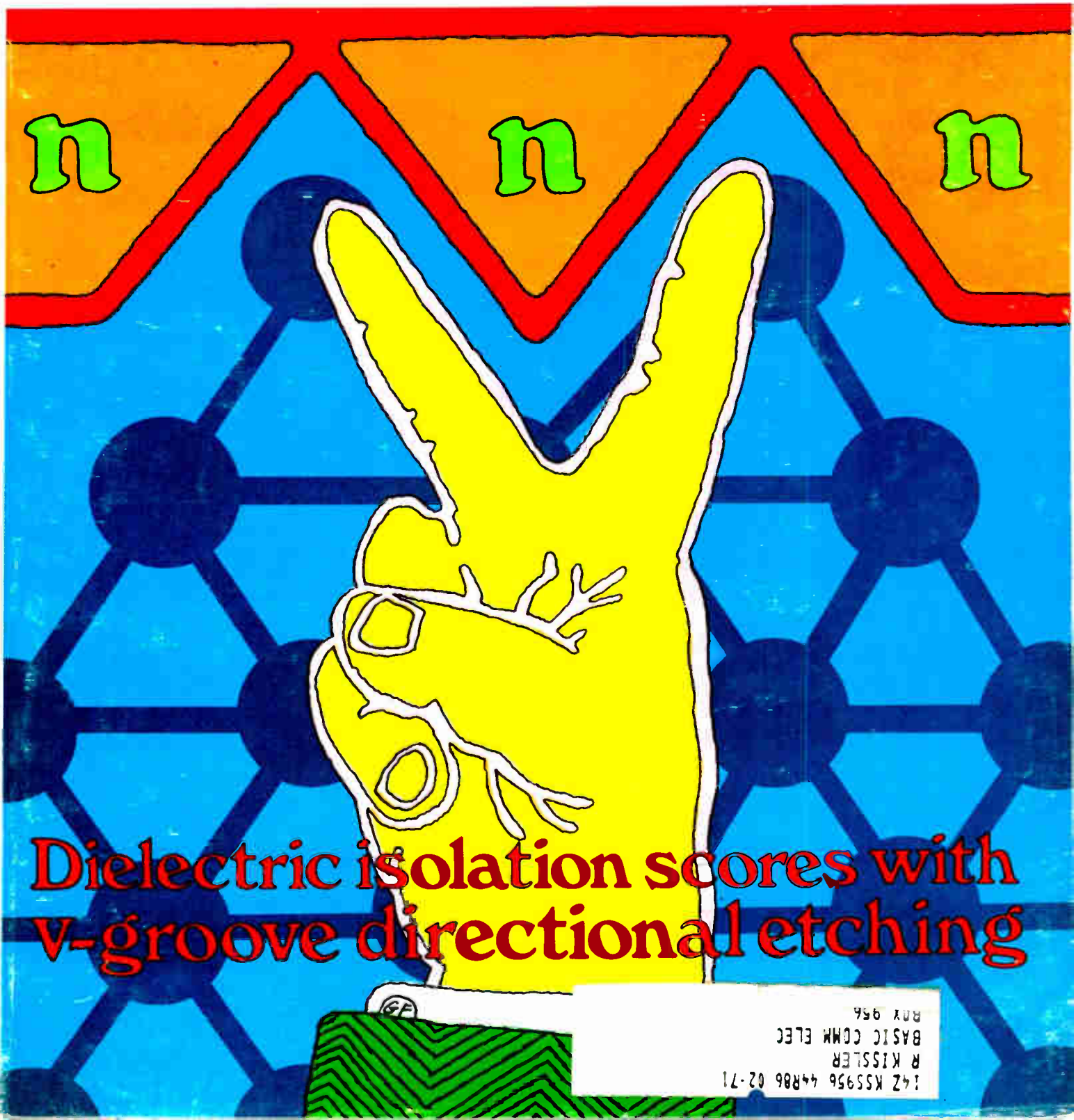
May 12, 1969



# Electronics®



## All counters count. This counter thinks while it counts.

Our new 1159 Reciprocatic Counter reduces frequency measurements to a single step: connecting the unknown signal to the input terminals. The counter's built-in computer then takes over and *immediately* gives you a six-digit readout of *any* input frequency between 0.6 Hz and 20 MHz. Ranging is taken care of automatically by the counter, and decimal point and unit of measurement are automatically and clearly displayed. Where speed and the need to safeguard against human error are important factors, the foolproof and automatic operation of the 1159 has tremendous value.

How does this counter measure frequencies down to 6 Hz with six-figure resolution in 0.1 second (and to 0.6 Hz in 1 second)? By means of a built-in, IC computer that converts a multiple-period measurement into a frequency readout. In numerous low-frequency applications, precise frequency measurements have been made up to now only by time-consuming and tedious measurements and calculations. The 1159 not only reduces measurement time to 0.1 second in most cases but it also does most of your thinking for you.

To accommodate unusual operating conditions, we have provided some secondary controls and concealed them behind a hinged door on the front panel. They include the display-time and signal-conditioning controls, all of which are programmable.

Since normal operation of the 1159 is completely automatic, this counter makes an ideal system component. External instructions to the counter are minimal and infrequent as they concern only secondary functions. BCD output for six digits of data, decimal point, and measurement units is provided at the rear.

By using our 1156-A Decade Scaler with the 1159 counter, you extend the upper frequency limit of the 1159 to 100 MHz. A new scaler (1157) extends the limit to 500 MHz. With either scaler there is no sacrifice in the counter's automatic frequency ranging capability. A rear-panel switch enables you to multiply measurement quantities by 1, 10, or 100 to maintain correct decimal location when a scaler is used.

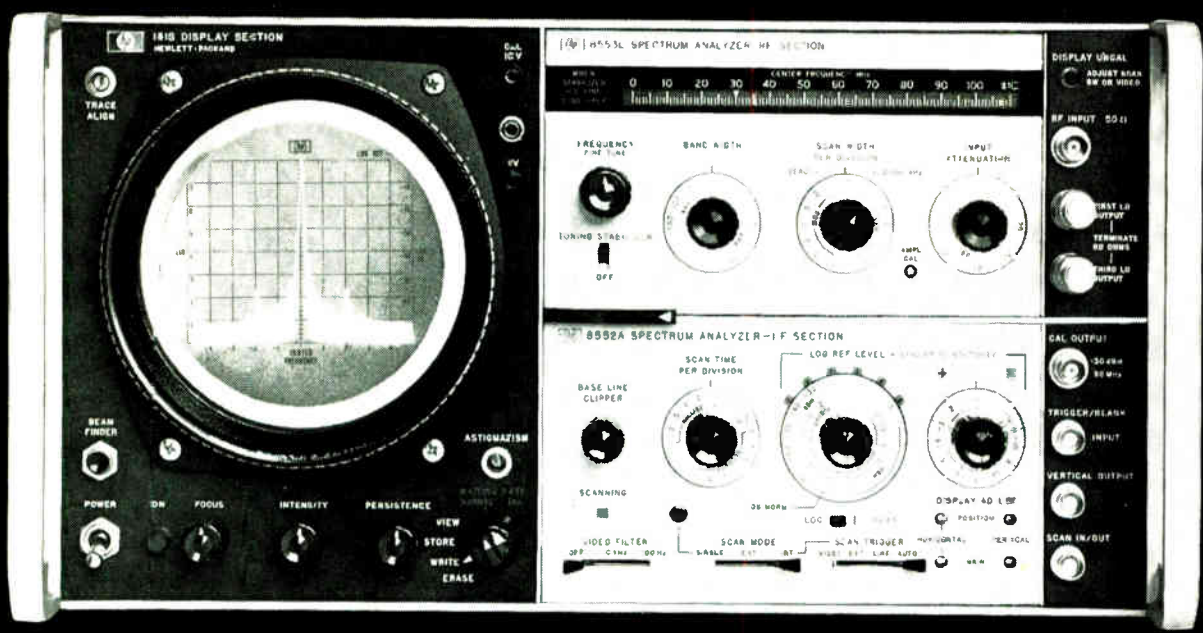
Price of the 1159 is $2100 in the U.S.A., for either the bench or rack model. For complete information, write General Radio Company, W. Concord, Massachusetts 01781; telephone (617) 369-4400. In Europe, write Postfach 124, CH 8034 Zurich 34, Switzerland.

GENERAL RADIO

Circle 900 on reader service card

# You design RF circuits in terms of frequency domain.

# Now you can measure their performance that way, too.




Forget all equipment limitations that used to plague signal analysis in the 1 kHz to 110 MHz range. The HP 8552A/8553L Spectrum Analyzer has all the characteristics—absolute calibration, high stability, freedom from internal distortion and spurious responses—that make it an indispensable tool for virtually every frequency domain measurement.

Absolute signal levels are displayed from −130 dBm to +10 dBm (0.07 μV to 0.8 V). With the wide 100 MHz scan, you see the broad spectrum quickly, precisely. Reduce the scan width in calibrated steps (to as narrow as 2 kHz) for detailed examination of individual signals. With the analyzer's distortion-free 70 dB dynamic range and narrow 50 Hz resolution, you can characterize complex signals, even in the presence of other high-level signals.

Yours for the asking—a brochure describing how these vital circuit performance characteristics are measured accurately and conveniently: *oscillator* spectral purity; *amplifier* response and distortion; *mixer* conversion efficiency; *modulation* index; *filter* response. Price of the full system—8553L RF section, 8552A IF section, 141S Variable Persistence Display section—$5225.

Your HP field engineer can give you the details on how this remarkable new instrument can solve your frequency domain measurement problems, in circuit design lab or final system evaluation. Or write to Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

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SPECTRUM ANALYZERS

# Trading off ACCURACY FOR SPEED?

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## with Hewlett-Packard's 2402A Integrating Digital Voltmeter

It doesn't make sense to keep using one of those DVMs that forces you to sacrifice speed or accuracy, does it? Why slow down your system to measure signals buried in noise? And why tolerate preamp errors and delays when measuring low-level signals?

Hewlett-Packard's 2402A Integrating DVM offers an unequalled combination of speed, accuracy, and noise immunity in a single instrument. No trade-offs necessary. It makes 5-digit measurements 43 times per second, resolving answers down to a microvolt with 0.01% accuracy at full speed. You get *lab* accuracy at *system* speed, even in noise that would slow active-filter DVM's to a virtual halt.

Full programming and BCD output are standard and make the 2402A ideal for use with digital computers and automatic measuring systems. Plug-in options measure AC, frequency, and resistance with equal ease, and a fast autoranger covers all five ranges from 100 mV to 1000 volts. Price: $4800.

Isn't it time to take the trade-offs out of your system? Start by calling your local HP field engineer for more information. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

06817

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DIGITAL VOLTMETERS

# Electronics

Volume No. 42 Number 10 May 12, 1969

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### Probing the News



### U.S. Reports



### Electronics International



### New Products





## Technical Articles



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## Readers Comment

### On the skids

To the Editor:

Regarding your analysis of the state of electronics in the automotive field [March 17, p. 84], I would like to draw your attention to the graph on page 88 showing brake coefficient of friction versus wheel slip. If the greatest braking force is applied in the 10%-to-20% wheel slip range, the blue line, "High Friction Dry Concrete," should also have a peak at the point of maximum braking force.

J.C. Flanagan

Department of
Engineering Technology
Del Mar Technical Institute
Corpus Christi
Texas

▪ The curve representing the effect of dry concrete on the tire brake force was, indeed, incorrectly drawn. At 100% wheel slip, the curve should be down somewhere about 0.77.

### Date of birth

To the Editor:

If author W.J. Moroney had searched in preparing his article on microwave integrated circuits [June 1, 1968, p. 100], he would have found that both microwave and lower-frequency MOS IC's are of the same age, having been developed as Siamese twins.

Responsible were two Scotsmen —J.T. Anderson and myself—senior staff members at AEI Research Labs in Rugby, England. We filed for a subsequently granted patent on Nov. 11, 1958.

William J. Scott

Consulting engineer
Rugby
England

### Controlled response

To the Editor:

I read with interest your New Products story entitled "Controlling power without interference" [Jan. 20, p. 140], but felt tempted

# Now from Sprague!

# All the advantages of tantalum in one LOW COST capacitor!

**EPOXY-DIPPED TANTALEX® CAPACITORS... For industrial, commercial, and entertainment electronic applications where tantalum capacitors were previously too expensive!**

⊣⊢Type 196D Solid-electrolyte Tantalum Capacitors have special epoxy-dip coating which keeps costs down without sacrifice in dependability. Positively seals capacitor section while providing excellent electrical insulation. Protects against mechanical damage in handling.

⊣⊢Radial lead design for plug-in mounting on printed wiring boards. The .250″ lead spacing will fit standard .125″ grids.

⊣⊢High stability—very little capacitance change, even at outer limits of operating temperature range.

⊣⊢Low dissipation factor of these capacitors permits higher ripple currents.

⊣⊢Meet environmental test conditions of Military Specification MIL-C-26655B.

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⊣⊢Designed for continuous operation at temperatures from —55 C to +85 C.

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# SCIENCE/SCOPE

For the first time in air-weapons history, the U.S. Navy recently launched two missiles from a single aircraft almost simultaneously and scored "hits" on two distant, widely separated airborne targets. The missile firing was a test of the Navy's Phoenix missile and its AWG-9 missile-control system, both developed by Hughes Aircraft Company. The AWG-9 is the only air-to-air system with a track-while-scan radar mode that enables it to launch several missiles and keep them on course while simultaneously searching the skies for other targets.

The Phoenix missiles scored "hits" on Ryan Firebee jet drones by passing so close they would have destroyed a full-size aircraft. The Phoenix and AWG-9 will be used in the Navy's new F-14A fighter to provide long-range air defense for the fleet and air-combat superiority for "dogfight" situations.

Some of the mysteries of Mars may be solved late this summer by earthbound scientists, thanks to the two-channel radiometers aboard the Mars Mariners NASA launched on February 24 and March 27. The precision instruments, designed and built by Santa Barbara Research Center, a Hughes subsidiary, will perform the key role of "taking the temperature" of Mars when the two spacecraft fly-by in July and August. By studying the temperature characteristics, scientists hope to learn something about the planet's surface and possibly about its atmosphere.

11 papers on ion engine electric propulsion by Hughes Research Laboratories scientists were presented at the American Institute of Aeronautics and Astronautics 7th Electric Propulsion Conference in Williamsburg, Va., recently. Hughes has been active in this field since 1958, when it won the first NASA ion engine development contract, and is currently at work on major programs for Jet Propulsion Laboratory, Lewis Research Center, and Goddard Space Flight Center.

Cameras used to film below-zero sequences for two forthcoming motion pictures -- Universal's "Airport" and Twentieth Century-Fox's "Patton" -- were checked out at temperatures as low as -20°F. in one of the temperature/humidity chambers at Hughes Ground Systems Group at Fullerton, Calif. Chambers are ordinarily used to test antenna pedestals and drive systems, high-speed military computer modules, and even tiny components like resistors and capacitors at temperatures ranging from +300°F. to -100°F.

Help Hughes develop its 4th-generation military computer. Immediate opportunities for Computer Engineers (System, Test, Maintenance, Staff)...Designers (Memory, Logic, Peripheral System)...Programmers (Diagnostic, JOVIAL, Real-Time). Requirements: engineering degree, at least two years of related experience, U.S. citizenship. Please send your resume to Mr. J. C. Cox, Hughes Aircraft Co., P.O. Box 90515, Los Angeles 90009. Hughes is an equal opportunity employer.

Belgium, The Netherlands, and West Germany have begun operating a new, three-nation electronic air defense control system, following successful completion of all tests. Advanced system, which will detect, track, and identify airborne targets and control interceptor aircraft, was built, installed, and tested by Hughes Ground Systems. Its growth into a major link of NADGE (NATO Air Defense Ground Environment) will be completed by Hughes during the next 30 months.

## Readers Comment

to make a few remarks—"tut-tut."

I was under the impression that there were companies in the U.S. making power controllers that use zero-crossover techniques. But we ourselves—as great exponents of phase control in our thyristor-controlled drives, and being somewhat involved in power control—have made zero-crossover systems in single- and three-phase forms (three and four wires) up to 400 amps. We have recently delivered (via Honeywell) several units to the United Kingdom Atomic Energy Authority, and our total kilowattage would appear to put Omnionics (the source of your story) as a back marker.

P.A. Bennett
Managing director
P. Allen Bennett Ltd.
Sheffield
England

### Actually enhanced

To the editor:

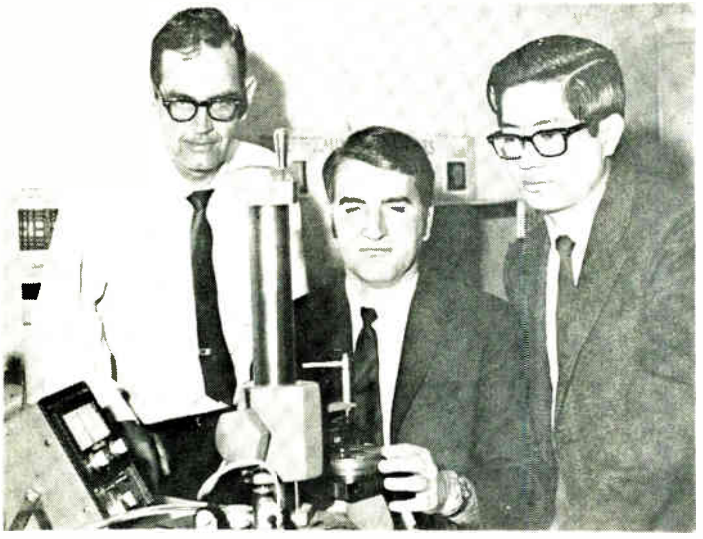
Your article about the Navy drone helicopter program, called Dash [Jan. 20, p. 50], incorrectly states that Dash was grounded because of "serious problems with its telemetry system." In fact, the telemetry system—which was designed, developed, and manufactured by the Sierra Research Corp. under a prime contract with the Navy—actually halves the attrition rate of these vehicles in those limited areas where they have been deployed.

The telemetry system monitors the performance of the Dash before and during flight, enhancing operation and maintenance of the weapons system.

Ronald W. Hershberger
Director of program management
Sierra Research Corp.
Buffalo
N.Y.

**Readers' letters should be addressed:**
**To the Editor**
**Electronics**
**330 West 42nd Street, New York**
**N.Y. 10036**

## Who's Who in this issue

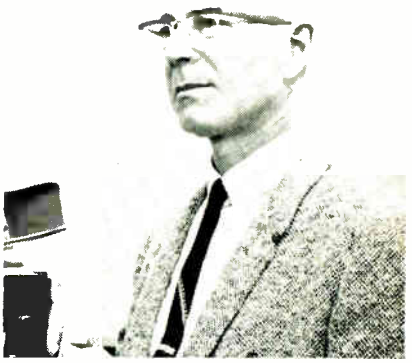


Allison Youmans Wong

**Authors and authorities,** the Signetics trio of David Allison, Albert Youmans, and Thomas Wong, wrote the cover story on dielectric isolation that starts on page 112. Allison, one of the firm's founders, holds a master's degree from Stanford University. As a vice president, his duties include extending the development of integrated circuitry in general and the dielectric isolation process in particular. Earlier in his career, he worked on double diffused planar silicon transistors at Fairchild Semiconductor. Youmans, manager of advanced process research and development in the product development group, is responsible for advanced work on dielectric isolation, beam-lead processing, flip-chip bonding, and packaging. He earned his B.S. at Furman University. Wong, a design engineer with the product development group, concentrates on bipolar digital arrays. Prior to joining Signetics, he worked at Fairchild.

**A graduate** of China's National Taiwan University in 1953, Hsu Chang, who wrote the article on thin-film memories that begins on page 120, went on to earn M.S. and Ph.D. degrees from the Carnegie Institute of Technology. Completing his studies in 1959, he joined the magnetics department at IBM Research. With time out for a stint at his alma mater as an associate professor, Chang has been engaged in the investigation of magnetization reversal in thin films; multilayer structures; and ultrafast, large-capacity memories.

**Prolific** is the word for Alvin Kaufman, author of the piece on ferroelectric memories, beginning on page 118. He's turned out over 200 technical papers and articles since graduating from Los Angeles City College in 1938. Now managing the instrumentation and nuclear studies section at Litton's applied research lab, he has also worked as an instrumentation specialist at Northrop, Douglas, and the Arnoux Corp. In between the time he spends on the job and at his typewriter, Kaufman finds time for ham radio; he's long been the voice of W6YOV.

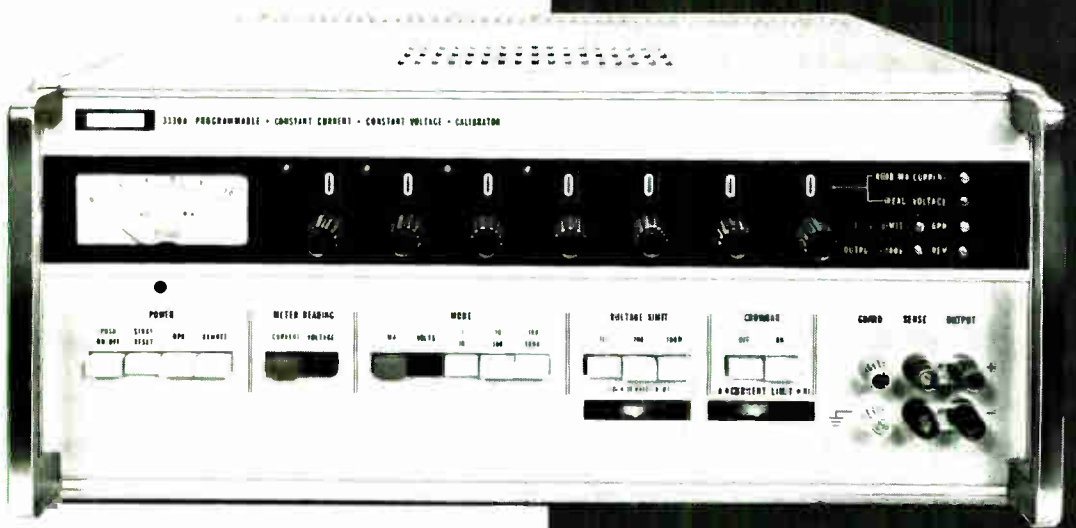


Kaufman

Rosenblatt

Dickson

**Joining forces** to produce the story on earth resources technology satellites (page 98) were associate editors Alfred Rosenblatt and Paul Dickson. Al, one of three (so far) bearded staffers at Electronics, holds a bachelor's degree from the Cooper Union School of Engineering. He has nine years experience in the industrial publications field, and in 1965 was awarded a Rockefeller-Sloan Fellowship at Columbia University's Graduate School of Journalism. Washington-based Paul won a B.A. with distinction from Wesleyan University in 1961. He spent three years in the Navy, serving a tour aboard the aircraft carrier, Franklin D. Roosevelt, as a communications officer and cryptologist. Paul's been covering the electronics beat in the capital for almost two years.



# PRECISION TESTING AND CALIBRATION MADE EASY...

## or how the new Fluke programmable constant current, constant voltage calibrator goes to work calibrating and testing precision instruments, semi-conductors, resistors and sub-assemblies.

For the engineer whose responsibility is checking out incoming precision components, the new Fluke 3330 Programmable Constant Current/Voltage Calibrator will shorten your day and heighten your nights. For the first time, computer programmed checkout over a wide range of voltages and currents is available with an off-the-shelf low priced quality instrument.

The Fluke 3330 is unique. It can be operated in either a constant current or constant voltage mode. Modes can be changed without turning the unit off. Voltage range is 0 to 1000 volts in three ranges with 10% overranging. Voltage accuracy is ±0.005%. Resolution is 0.1 ppm. Stability is 25 ppm per month. Line and load regulation are 2 ppm of range. Ripple and noise are less than 50 μv. Voltage trip is adjustable from 1 v to 1000 v. Output current is 100 ma in the 10 and 100 v ranges and 50 ma in the 1000 v range.

In the constant current mode, ranges are 0 to 100 ma in three ranges with 10% overranging. Accuracy is ±0.01%. Resolution is 1 ppm. Stability is 50 ppm/month. Line and load are 2 ppm of range. Compliance voltage is 1000 volts on the 1 and 10 ma ranges and 500 volts on the 100 ma range.

Crowbar effect through a programmable relay shorts output to limit voltage while changing loads.

Programmable functions are output range, mode, level and polarity, voltage and current limit, crowbar, and standby/operate. Programming time is tens of milli-seconds. Price is $2,995.

For full details write or call us today.

Fluke. Box 7428, Seattle, Washington 98133.
Phone: (206) 774-2211. TWX: 910-449-2850.

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Circle 9 on reader service card

FLUKE

# If you want better designs,

Fairchild MSI lets you design a system in the time you used to spend designing a circuit. A few MSI building blocks will do more work than a hundred ICs. We have versatile, compatible off-the-shelf devices that function like shift registers, counters, decoders, latching circuits, storage elements, comparators, function generators, etc. Just about all you need for any digital application. *Like a scanning keyboard encoder:*

If you'd like a simple method of converting keyboard switch closures to a binary code, you need only 5 of our CCSL building blocks and the logic diagram on the right. (Conventional design techniques would require about 30 conventional ICs to do the same job.) Besides simplicity, this design provides fast rollover, insensitivity to contact bounce, and eliminates ambiguity when several keys are depressed.

The two major elements of the design are a 64-position matrix and a six-bit synchronous counter. (The counter is composed of a 9316 four-bit binary counter and a 9020 dual JK flip-flop.) The three Most Significant Bits of the counter output address the 1-of-8 decoder (9301) forming one side of the matrix, sequentially driving its outputs "low". The three Least Significant Bits address the 9312 scanning multiplexer (the other side of the matrix), sequentially looking at its eight inputs. With this arrangement, all multiplexer inputs are scanned once for every change in the decoder output.

Each intersection of the decoder outputs and the multiplexer inputs can be used as a key position. If one of the keys is depressed, a "low" from the decoder is detected by the multiplexer and converted to a "high" on its negation output. This triggers a one-shot that inhibits the counter from advancing further and provides a "data ready" signal. The duration of the one-shot is set to cover any possible contact bounce. The output of the counter can now be used as the encoded signal, and the matrix can be arranged so that any key closure provides any binary code from 000 000 to 111 111.

The code that appears corresponds to the first key depressed. As long as that key remains down, the retriggerable one-shot continues to receive reset pulses that hold the counter at the count independently of any other switch closures on the board. Once that key is released, the counter resumes its scanning after the one-shot time period has run out.

The addition of a few more MSI elements would add even greater capability to this design. As an example, the addition of another 9312, 9316 and 9601 can result in a single serial binary PDM output group in response to each key depression. Additional control inputs could be used to restrict the range of the scan counter if only certain keys should be enabled in a certain mode as is the case in key punch machines. Addition of a 9304 Read-Only Memory would allow the selection of any code output with a single keyboard design. A single monolithic parity generator could be added to provide parity at very little additional cost. Or, you might want to add two Read-Only Memories to drive a character display and a normal output simultaneously.

Our universal CCSL logic blocks let you build circuits that you couldn't even consider with less complex or less flexible ICs. We now have 15 off-the-shelf MSI devices that you can use to lower costs and increase performance. More are on the way. Write for additional specs and application notes. We'll put you on our list for future mailings, too.

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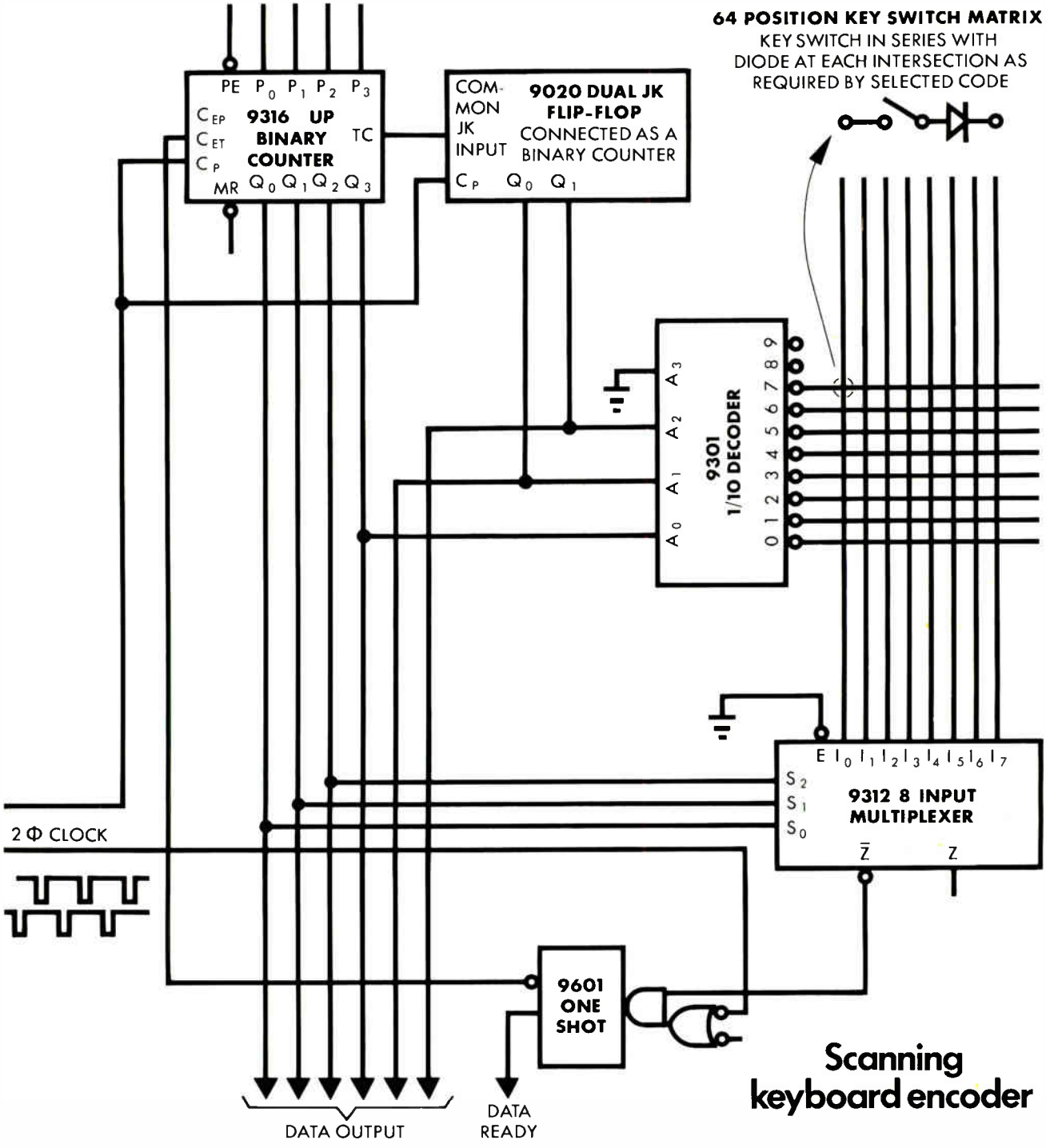
# use fewer components.




Scanning keyboard encoder

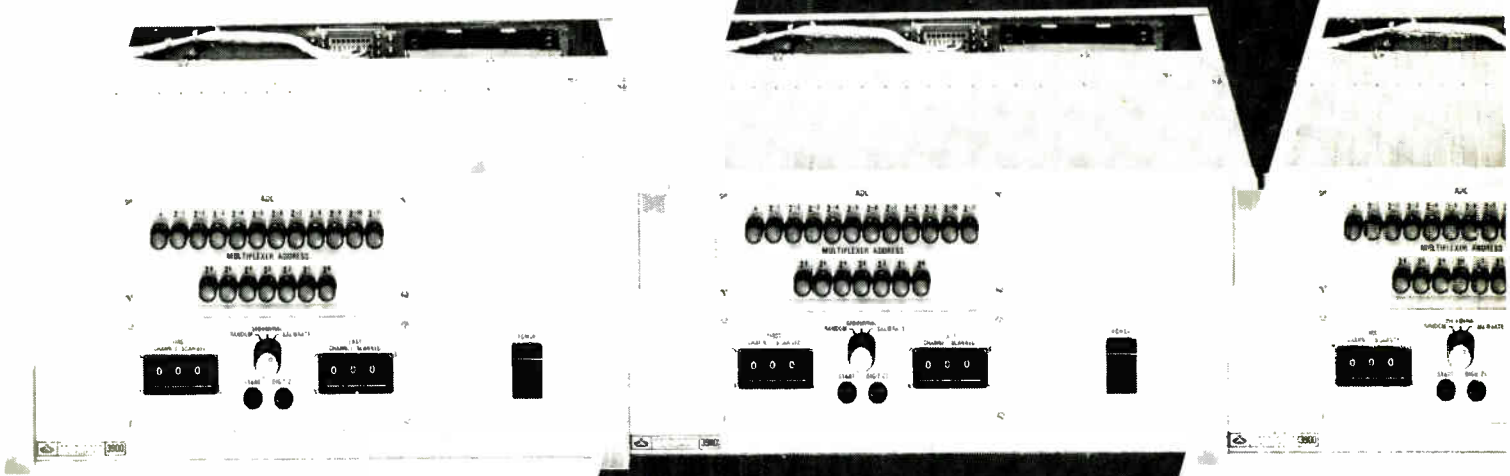


Circle 11 on reader service card

# The Versatile 100 KHZ Astroverter

## It's an ADC

## It's a Multiplexer



Absolutely—and it's a *high speed* ADC, with 5 μsec. word conversion and a double-buffered output of 11 binary bits and sign. Two plug-in cards contain all the timing, bit selection and comparator circuitry required, leaving plenty of room for additional functions. For detailed ADC information, circle number 497.

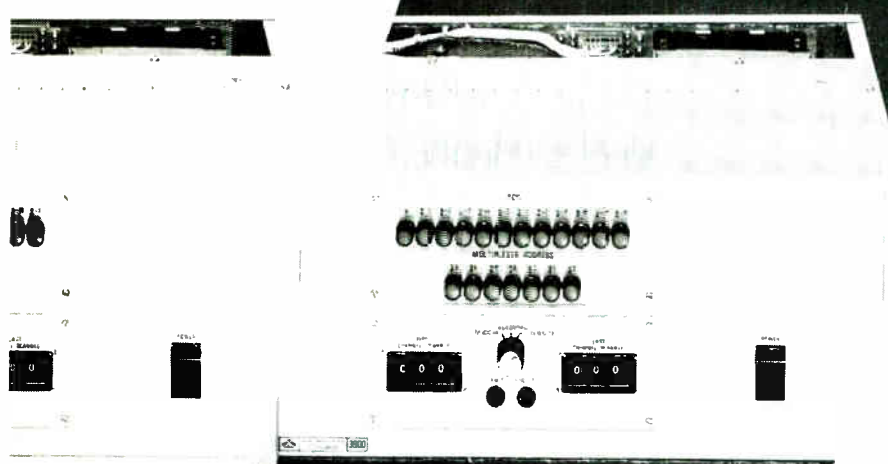
Add two more plug-in cards and you have a high-speed 16-channel multiplexed ADC. And you can have as many as 128 channels if you desire. Switching and settling time of less than 5 μsec., with 5 μsec. digitizing, provides a total thru-put rate of 100 kHz. Get more information by circling number 498.

The Astroverter is also a oscilloscopes, meters a Plug-in cards provide refe and DAC formats of 8, 11 bits plus signs; up to 14 DA be mounted for extensive " capability. Circle number 49 plete details.

# It's a DAC

# It's Simultaneous Sample & Hold

# It's a New Concept in Data System Packaging...



AC for driving
1 recorders.
ence, control
or 14 binary
cards may
uick-look"
for com-

For simultaneous sample and hold, the Astroverter can be configured with up to 16 Sample and Hold Amplifier cards in a single package. The card features ±.01% accuracy, ±.01% settling time (in 4 μsec.) and DC to 100 kHz frequency response, with a 50 nanosecond aperture. Circle number 500 for detailed information.

The Astroverter is an extremely flexible, high-speed, low-cost data acquisition instrument comprising a 7″ rack-mounted chassis, with built-in power supply, and 16 card slots to accommodate a large family of interchangeable plug-in cards. With these cards, you can "design" virtually any type of data system—and probably still have room left for future expansion. What's *your* system need? General purpose computer peripheral devices? Hybrid computer system interface? Acquisition for industrial process control systems? Whatever it is, you'll find that the Astroverter offers the versatility, speed, reliability and economy necessary to meet virtually all your operational requirements. One of the most welcome features of the Astroverter is its surprisingly *low cost*. Whichever configuration you select, you'll find the price hundreds of dollars under other available and probably slower models. Then there's economy in expansion. You don't buy another instrument . . . you merely buy another card. Get the complete story today about the versatile, high-speed, low-cost Astroverter. Write or call

ASTRODATA

Astrodata Inc., 240 E. Palais Rd., Anaheim, Calif.; (714) 772-1000.

## Who's Who in electronics

Kahl

**Confident and smiling,** David S. Kahl summarizes the problems that have plagued Sperry Rand's Gyroscope division without wincing, unusual for a Sperry executive. But Kahl, 46 years old and newly appointed vice president for engineering at Sperry Gyroscope, feels that the division is coming back to life. In his own words, "Our loss programs are pretty well washed away; there are no more bleeding arteries."

"Needless to say, we've learned from our mistakes," he goes on. "In the first place, we were bidding on contracts that would have given anybody trouble. Unfortunately, we were unlucky enough to win them. Then we found ourselves getting into the development stage of these firm fixed-price efforts with no idea what the production phase of the contract was going to cost," he admits.

**Readiness.** Now, Kahl indicates, Sperry is doing its homework properly. It's putting more money into its preparations before making proposals, making sure that its design-accuracy margins are wide enough —one of the prime causes of errors during the division's troubled times. "We're also staying away from civilian work and concentrating instead on military efforts," Kahl says with a rueful grin that brings to mind such fiascoes as Sperry's $5.4 million electronic traffic-control contract with New York City and the $25 million inertial navigation deal with Pan Am.

Kahl also feels that a new research and development organization will help in the division's resurrection. Formerly, Sperry Gyroscope was split into three technological groupings – information and communications (loran, displays, and computers), inertial systems (gyroscopes), and radar. "When we were working on a system that required, say, that our inertial people work with the electro-optics group as well as the loran staff, we found that communications between them all was anything but ideal. At best there was duplication; at worst, margin errors. Now we've lumped all three groups together under one man who has all the responsibility, and more importantly, all the money," Kahl explains.

The blood may indeed be surging back through Sperry's veins. The division, which chopped its engineer force to about 1,000 from 3,500, is now actively recruiting engineers. At the moment, Kahl has requisitions in for more than 100 experienced men. And among the programs under way is an ambitious one to design a loran-aided weapons-delivery system that would combine the best features of loran and inertial navigation.

---

**"What we need** less than anything is another invention." This statement—music to the ears of an economy-minded Administration and Congress but a cause of shudders to the electronics industry—reflects the feelings of the FAA's new administrator, John H. Shaffer, toward air traffic control. Shaffer maintains that "the technology is already there—the job is one of applications engineering. There's no big need for a large R&D program."

But the picture is not altogether black for the electronics industry's future market at the FAA; Shaffer says that though a "massive application of money" isn't needed, he would like to spend something around $250 million annually over the next 10 years. Big needs are computers, displays, and printers.

An urgent need now, for use in

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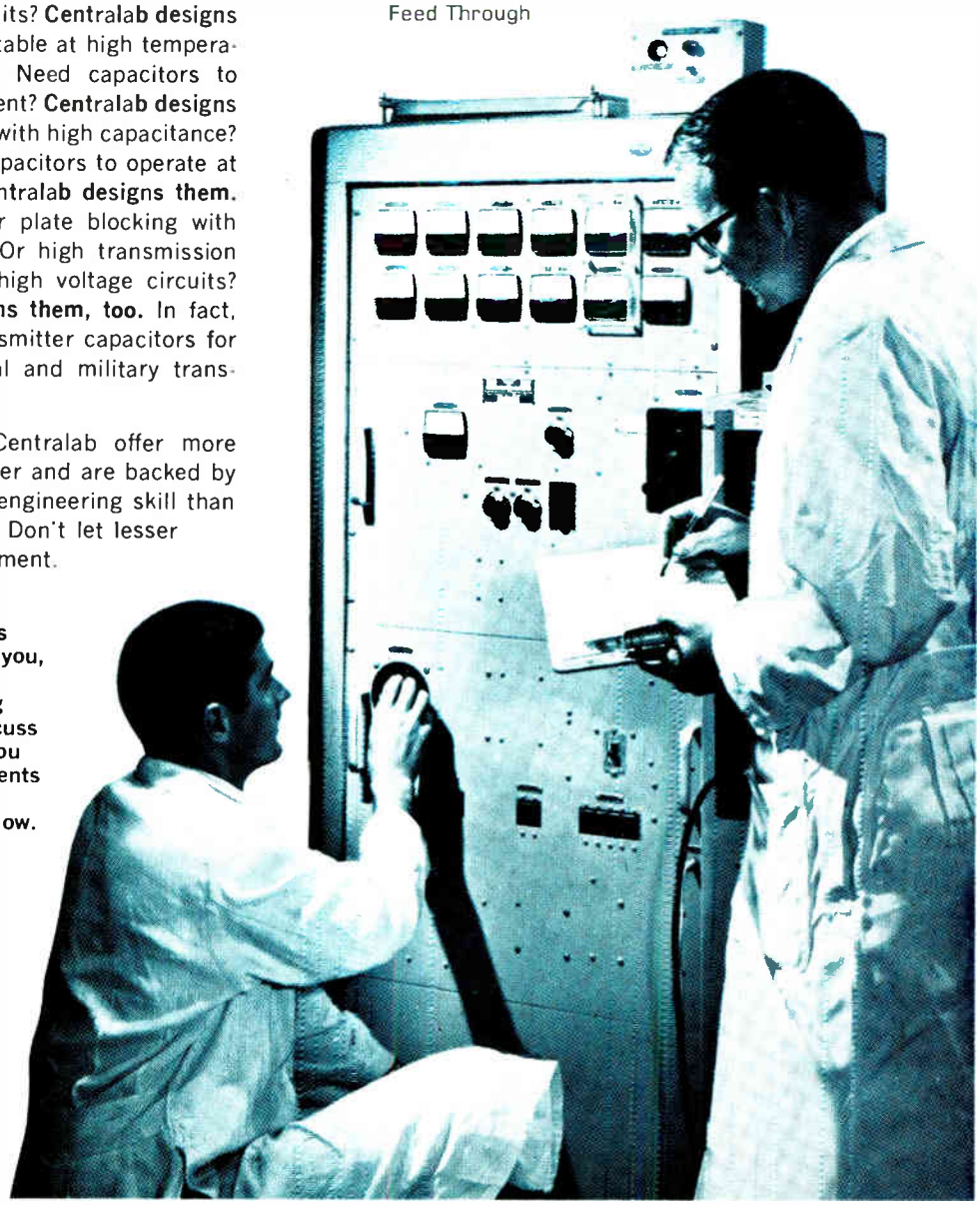


CENTRALAB

Electronics Division

GLOBE UNION INC

5757 NORTH GREEN BAY AVENUE

MILWAUKEE, WISCONSIN 53201

## Who's who in electronics

**Shaffer**

the nation's automatic air traffic control system, is a low-cost transponder. "A $1,000 piece of equipment for installation in a $3,000 plane is out of the question," he says.

Shaffer also will be pushing for the use of satellites for navigation and air traffic control. He observes that with four synchronous satellites, aircraft positions could be determined to within 50 feet.

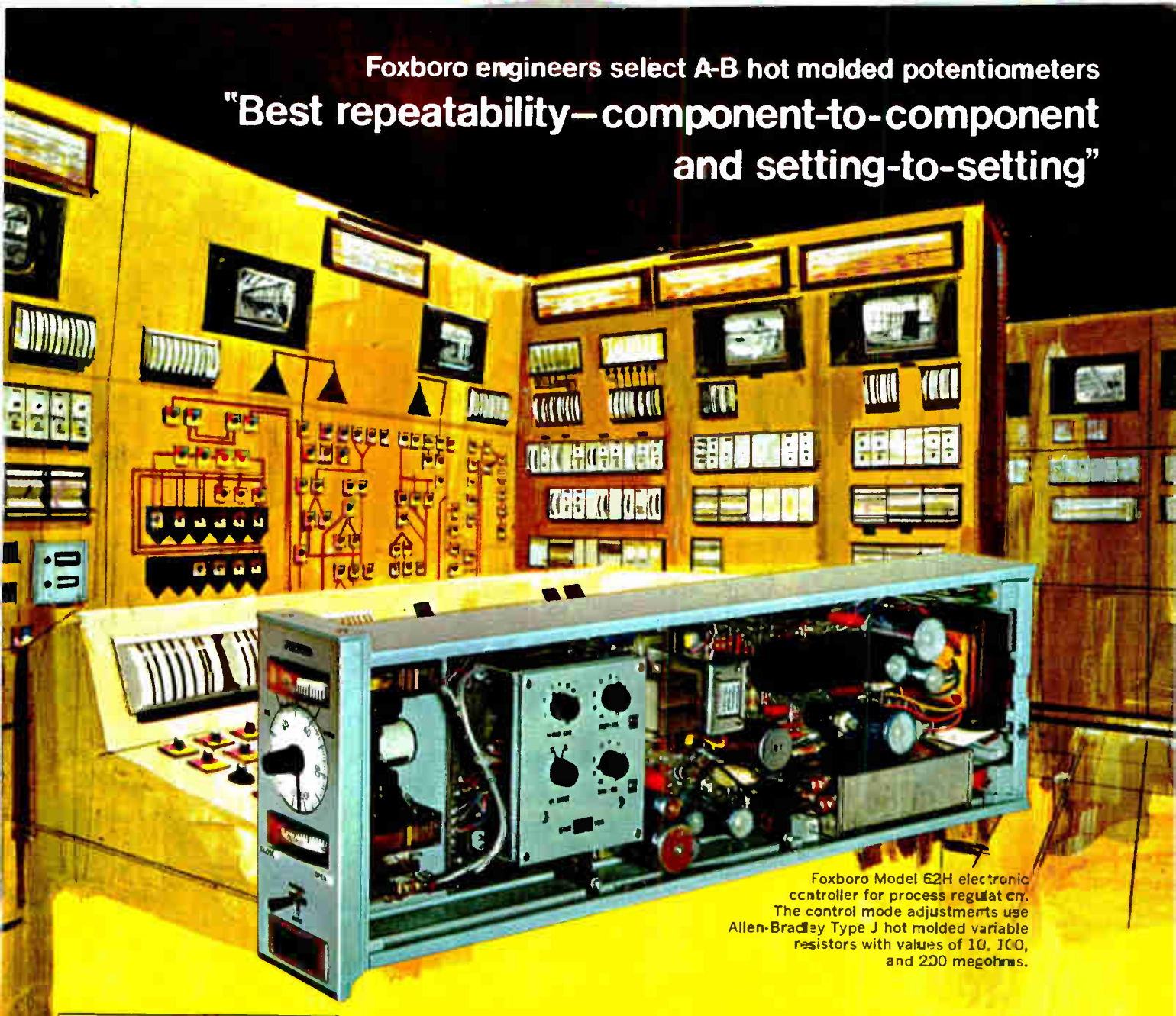
Shaffer, 50, a world war II bomber pilot and Air Force manager of the B-50 and B-47 programs, went to work for TRW in 1957. When he left to take his present post, he was in charge of the firm's Washington operations.

**Bombs away.** After only a few weeks with the FAA, Shaffer dropped a bomb on the airline industry. On the subject of overcrowded airports, he said bluntly: "Airlines have to be less cannibalistic in their scheduling. They have to stop flying half-empty airplanes that unnecessarily eat up airspace." He feels that the short takeoff and landing (STOL) aircraft may offer a partial solution to the problem and wants his agency to assist its development as much as possible.

Shaffer sees his main job at FAA as that of a systems engineering director. "Systems engineering" has become a Washington management catchword, but Shaffer is perhaps the only top-ranking bureaucrat who'd define it simply as "common sense used in the broadest possible way."

Foxboro engineers select A-B hot molded potentiometers

# "Best repeatability—component-to-component and setting-to-setting"



Foxboro Model 62H electronic controller for process regulation. The control mode adjustments use Allen-Bradley Type J hot molded variable resistors with values of 10, 100, and 200 megohms.

A-B Type J hot molded variable resistor rated 2.25 watts @ 70°C. Available in single, dual, and triple units. Standard total resistance values from 50 ohms to 5 megohms. Special resistance values and tapers can be supplied.

Widely used throughout the process industries, the Foxboro Model 62H Universal Controller is a highly dependable precision instrument. During the years of painstaking development, Allen-Bradley engineers worked closely with Foxboro to provide a potentiometer having unusually high resistance values, which would provide the precise performance required.

Allen-Bradley Type J potentiometers were the answer. They have a solid hot molded resistance track which is produced by an exclusive A-B molding technique that assures extremely long operating life. Accelerated tests—exceeding 100,000 revolutions—show very slight resistance change. Control is smooth at all times with adjustment approaching infinite resolution. There are none of the abrupt turn-to-turn resistance variations inherent in wirewound controls. Furthermore, Allen-Bradley Type J potentiometers are—for all practical purposes—noninductive, permitting their use throughout the frequency spectrum.

Whether your particular circuit design can be best satisfied with one of the millions of standard Type J variations or whether it calls for unusual resistance characteristics, it will pay you to look first to A-B Type J potentiometers. Their more than 25-year history of providing superior performance is your guarantee of complete satisfaction. For full details, please write for Technical Bulletin 5200: Allen-Bradley Co., 1201 South Second Street, Milwaukee, Wisconsin 53204. Export Office: 1293 Broad St., Bloomfield, New Jersey, U.S.A. 07003. In Canada: Allen-Bradley Canada Limited.



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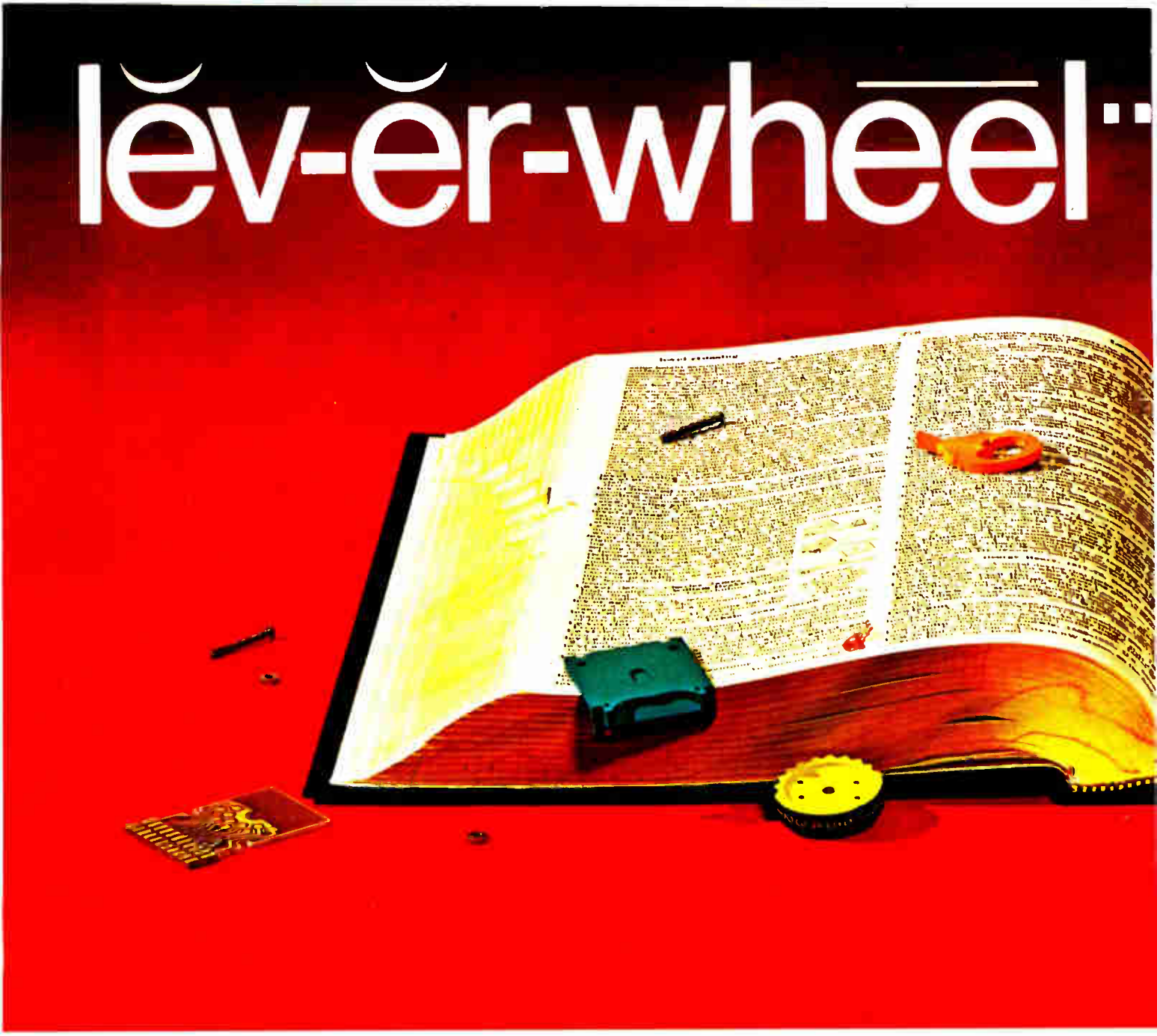

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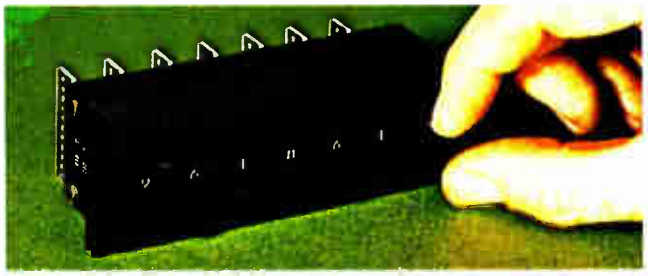

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There's instant reset at no extra cost. A simple sweep with the hand and all levers return to home position with every switch in the bank returned to "zero".

LEVERWHEEL™ *From the makers of famous, dependable precision Snap Action Switches . . .*

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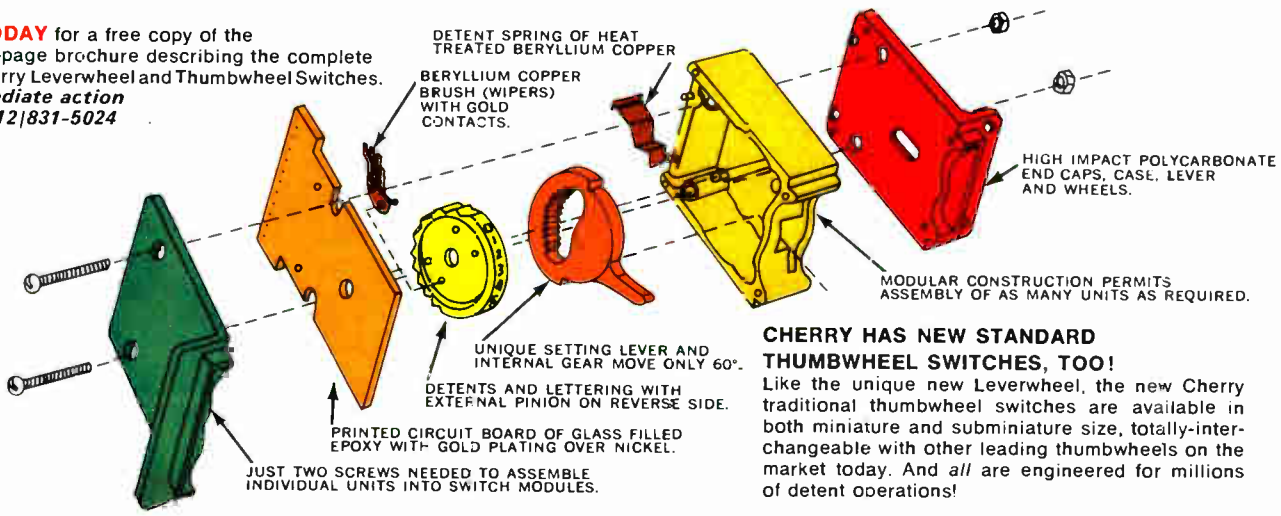


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Like the unique new Leverwheel, the new Cherry traditional thumbwheel switches are available in both miniature and subminiature size, totally-interchangeable with other leading thumbwheels on the market today. And *all* are engineered for millions of detent operations!

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**B-D cu is used in a new disc brake that provides a better solution to aircraft emergency braking.**

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This new aircraft brake is certified on the Boeing 727.

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2.8.23

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## Meetings

### Laser meeting makes room for research

**In a major departure** from form, the 1969 IEEE Conference on Laser Engineering and Applications will cover some important experimental techniques for which no application has yet been found. Though, like previous meetings, it will stress the practical aspects of laser technology, the May 26-28 Washington conference will also consider mode locking and nonlinear optical materials, neither of which has resulted in an industrial process or device.

A.J. DeMaria of United Aircraft Research Laboratories will discuss methods of producing picosecond pulses by passing laser beams through an absorbing dye. He'll also describe recent successes in chirping and compressing laser pulses in a manner analogous to radar.

In the session on nonlinear optics, Stephen E. Harris of Stanford University will cover such materials as lithium niobate, lithium tantalate, and barium sodium niobate ("bananas"), which are used in frequency doublers, optical parametric oscillators, and modulators. At the same session, Joel Falk and J.E. Murray, also of Stanford, will report on a new parametric oscillation method that eliminates some of the problems posed by the conventional use of mirrors. By passing the output of a ruby laser through a lithium niobate crystal, they have achieved a 50% conversion efficiency.

Acousto-optic deflection of laser beams—a laboratory technique that looks promising for display application—will be covered in three papers. D.A. Pinnow of Bell Labs will report on an 80-megahertz bandwidth deflector using alpha iodic acid and a lithium niobate transducer; W.H. Watson and Adrianus Korpel of the Zenith Radio Corp. will describe a technique that compensates for the optical dispersion of acousto-optic deflection cells in a three-color laser tv system; and Watson will join Robert Adler in explaining how two acousto-optic cells can be cascaded with a common electrical driving source to increase resolution in a deflection system.

**Popular source.** Several papers—and an entire session—will be devoted to the neodymium-doped yag laser. Continuous pumping of this laser by a krypton lamp will be described by Sylvania Electric Products and Westinghouse research labs, with both reporting 100 watts c-w output and the former claiming 2.9% efficiency at 1.06 microns. And Texas Instruments will outline its c-w pumping with a gallium arsenide-phosphide diode to get an efficiency of 1% [*Electronics*, April 28, p. 40].

Bell Labs will discuss its use of electrical feedback loops to stabilize a mode-locked yag laser. And F.E. Harper and M.I. Cohen of Bell will report on an unusual application of this laser—alloying aluminum junctions into n-type silicon with heat pulses.

There'll also be several papers on dye lasers and saturable absorbers, and one on a new computer-generated optical element called a kinoform, which produces three-dimensional images without the disadvantages associated with the making of holograms.

For further information, contact F.R. Arams, Airborne Instruments Laboratory, Melville, N.Y.

## Calendar

**Conference and Exposition on Underground Distribution,** IEEE; Anaheim Convention Center, Anaheim, Calif., **May 13-16.**

**Vehicular Communications Symposium,** IEEE; Los Angeles, **May 13.**

**Spring Joint Computer Conference,** IEEE, American Federation of Information Processing Societies; Sheraton Boston Hotel, War Memorial Auditorium, Boston, **May 14-16.**

**Symposium on Semiconductor Effects in Amorphous Solids,** U.S. Army; Holiday Inn, New York, **May 14-16.**

**Power Industry Computer Applications**

**(Continued on p. 24)**

# The wonderful goofproof machine.

(Model 305/360 pinpoints correct carrier levels by-the-numbers)

This is the world's first fully foolproof frequency-selective levelmeter, tracking signal generator, and spectrum display system. It combats human error with crystal-clear displays of every key measurement parameter. Each reading, each setting, each switch you push lights up. This alone makes it hard to misinterpret a reading. But for our human engineers, lighted displays were only the beginning.

Consider, for example, the direct digital frequency readouts. The frequency counter displays automatically summed outputs of both the coarse and fine-tuning oscillators. In the frequency-locked mode, the counter shows the composite frequency to the nearest 10-Hz increment. Continuous tuning gives you a three-digit display to the nearest 0.1 MHz. So you can't mistake the mode you're in.

And how are you going to misinterpret your attenuation-level settings? Bright three-digit displays on the levelmeter and generator units present automatically totalled outputs of the 10- and 1-dB per-step attenuators. Each clearly indicates level setting and polarity with reference to meter zero. Should someone absent-mindedly leave the set in calibration mode, both displays stay off.

All digital counters employ flat-plane, high-brightness displays that give you a much wider viewing angle than gas-glow tubes. The levelmeters introduce a rear-projected scale with bright, illuminated pointer, a new metering technique that does away with parallax distortions. Switchable meter-scale expansion resolves input levels to 0.05 dB.

With a range of 1 kHz to 32.1 MHz, Model 305/360 is the only test system of its kind that covers both voice and HF bands of the frequency spectrum.

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**SUMMARY SPECIFICATIONS**

| | |
|---|---|
| Frequency Range | 1 kHz to 32.1 MHz |
| Frequency Resolution: | |
| Locked Mode | 10 Hz |
| Continuous Mode | 100 kHz |
| Measurement Range: | |
| Low Sensitivity (1 kHz to 32.1 MHz) | −89 to +22 dBm |
| High Sensitivity (60 Hz to 32.1 MHz) | −109 to +2 dBm |
| Measurement Accuracy (at 1 MHz, 0 dBm) | 0.2 dB |
| Selectivity (switch selected): | |
| Wideband | |
| 3 dB bandwidth | 3100 ± 200 Hz |
| 60 dB bandwidth | 8000 +500/−1000 |
| Narrowband | |
| 3 dB bandwidth | 250 ± 50 Hz |
| 60 dB bandwidth | 1000 ± 100 Hz |

PHILCO Ford

PHILCO-FORD CORPORATION
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## Meetings

(Continued from p. 22)

**Conference, IEEE;** Brown Palace Hotel, Denver, Colo.; **May 18-21.**

**Offshore Technology Conference,** IEEE; Albert Thomas Convention Center, Houston, Texas; **May 18-21.**

**National Aerospace Electronics Conference, IEEE;** Sheraton Dayton Hotel, Dayton, Ohio; **May 19-21.**

**Biomedical Sciences Instrumentation Symposium,** Biomedical Sciences Division of the Instrument Society of America and the University of Michigan; Chrysler Center, University of Michigan, Ann Arbor; **May 19-22.**

**Mid-year Meeting, Society of Automotive Engineers;** Palmer House, Chicago; **May 19-23.**

**National Power Instrumentation Symposium,** Instrument Society of America; Ben Franklin Hotel, Philadelphia, **May 19-21.**

**Symposium on Electron, Ion, and Laser Beam Technology,** IEEE; National Bureau of Standards, Gaithersburg, Md.; **May 21-23.**

**Microwave Power,** International Microwave Power Institute; University of Alberta, Edmonton, Canada; **May 21-23.**

**System Performance Effectiveness Conference (SPECON 5),** Naval Material Command; West Auditorium Department of State, N.W. Washington, D.C.; **May 21-22.**

**Workshop on Applied Magnetics,** IEEE; Sheraton-Park Hotel, Washington, D.C.; **May 22-23.**

**Electromagnetic Compatibility Conference,** Society of Automotive Engineers; Grand Hotel, Anaheim, Calif.; **May 22-23.**

**Computer-Aided Device Analysis and Design,** New Technical and Scientific Activities' Committee, IEEE; Stevens Institute of Technology, Hoboken, N.J.; **May 26.**

**Conference on Laser Engineering and Applications,** IEEE; Washington Hilton Hotel, Washington, D.C.; **May 26-28.**

**Magnetic Powder Core Seminar,** Metal Powder Industries Federation; O'Hare Inn, Chicago, **June 2.**

**Microelectronics Conference,** IEE; Congress Theatre, Eastbourne, England, **June 3-5.**

**Design Automation Workshop,** Association for Computing Machinery, IEEE; Hotel Carillon, Miami, **June 8-12.**

(Continued on p. 26)


# Programmable.

Full-function programmability
DC to 50 MHz Counting Range
Universal counter / timer functions
BCD output
. . . all for only $1285

The new Monsanto Model 110A offers you a broader range of operational advantages than any counter/timer in its price range. Front-panel functions are tailor-made for programming with the Monsanto Model 501A Digital Programmer, or with virtually any other contact-closure or logic-level source.

Now consider these other features of the Model 110A: the full complement of counter / timer functions; dc to 50 MHz counting range; marker and gate outputs; provision for external time base; and BCD output. Plus the inherent reliability of Monsanto "4th generation" integrated circuit construction. Plus the 2-year Monsanto warranty.

Price of the Model 110A is $1285; of the Model 501A, $375. For a demonstration or technical data call your local Monsanto Field Engineering Representative or contact us direct. Monsanto Company, Electronic Instruments, West Caldwell, New Jersey 07006; (201) 228-3800.

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**Monsanto**

## Meetings

(Continued from p. 24)

**Pattern Recognition Studies,** Society of Photo-optical Instrumentation Engineers; Holiday Inn and Coliseum, New York, **June 9-10.**

**Chicago Spring Conference on Broadcast and Television Receivers,** IEEE; Marriott Motor Hotel, Chicago, **June 9-10.**

**International Communications Conference,** IEEE; University of Colorado, Boulder, **June 9-11.**

**Federal Research and Development in** the 70's—its Need and Scope, National Security Industrial Association, State Department West Auditorium, Washington, D.C., **June 11-12.**

**Consumer Electronics Show,** Consumer Products Division of Electronic Industries Association; New York Hilton and Americana Hotels, New York, **June 15-18.**

## Short courses

**Automation in electronic test equipment,** New York University; United Engineering Center, New York; **June 16-20;** $265 fee.

**Communication systems and time-variant electromagnetic propagation media,** University of Colorado; **June 16-July 3;** $300 fee.

**Power semiconductors—SCR devices and application techniques,** University of Missouri, Columbia; **August 6-8;** $100 fee.

## Call for papers

**Solid State Devices Conference,** IEEE; University of Exeter, England, Sept. 16-19. **June 27** is deadline for submission of synopses to Dr. P.C. Newman, Allen Clark Research Center, Caswell, Towcester, England.

**Symposium on Circuit Theory,** IEEE; Mark Hopkins Hotel, San Francisco, Dec. 8-10. **July 1** is deadline for submission of papers to Prof. B.J. Leon, School of Electrical Engineering, Cornell University, Ithaca, New York 14850.

**Joint Conference on Mathematical and Computer Aids to Design,** Association for Computing Machinery, IEEE, and the Society for Industrial and Applied Mathematics; Disneyland Hotel, Anaheim, Calif., Oct. 26-30. **July 1** is deadline for submission of abstracts to J.F. Traub, Computing Science Research Center, Bell Telephone Laboratories, Murray Hill, N.J. 07974.

Forget your ordinary light couplers. These Light-Coupled Data Amplifiers by Develco are something else. They pipe those tenuous incoming signals through a fiber-optic light guide over distances of 40 feet or more. This assures total electrical isolation between input transmitter and receiver. Major benefits:

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All this adds up to a major advance in the art of data acquisition, a claim easily supported by the specs (sampling below).

| | 6110 Data Amplifier | 6120 Data Amplifier | 6150 Scope Plug-in † |
|---|---|---|---|
| Frequency Response | 0–20 kHz<br>0–80 kHz | 0–50 MHz * | 0–50 MHz |
| Input Range | ±1, 10, 100 mv<br>±1, 10 v | 500 mv to 10 v | 500 mv to 200 v |
| Typical SNR | 50 dB | 30 dB | 30 dB |
| Input Impedance | 1 megohm paralleled by 20 pf | 1 megohm paralleled by 20 pf | 1 megohm or 50 ohms paralleled by 20 pf |
| Drift | ±0.025% full scale/°C | 0.5% full scale/°C | 1 cm/12 hrs./10°C |
| Output | ±10 v @ 10 ma | 1 v p-to-p, 50 ohms | full scale deflection |
| Operating Temperature Range | ← +15°C to 40°C → | | |

# Cord-of-light amplifies data in total electrical isolation

For complete specifications, or a demonstration at your facility, write us at 2433 Leghorn St., Mountain View, Calif. 94040. Or call (415) 969-1600.

Prices start at $900.00. * 100 MHz available on special order. † Tektronix 344, 346 or 547

DEVELCO, INC.

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JT connectors with rear-release crimp contacts have a lot of fans. Because they have lots of advantages. But there haven't been many ways to take advantage of these advantages. Until now.

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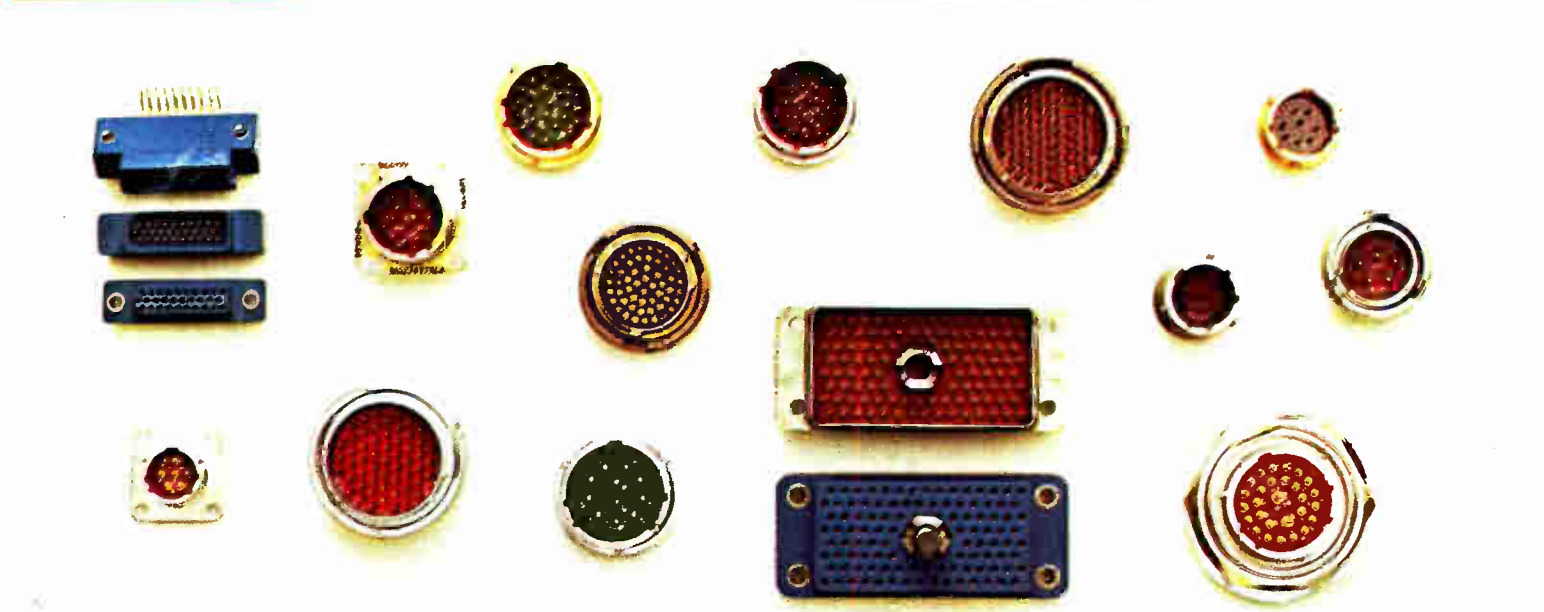
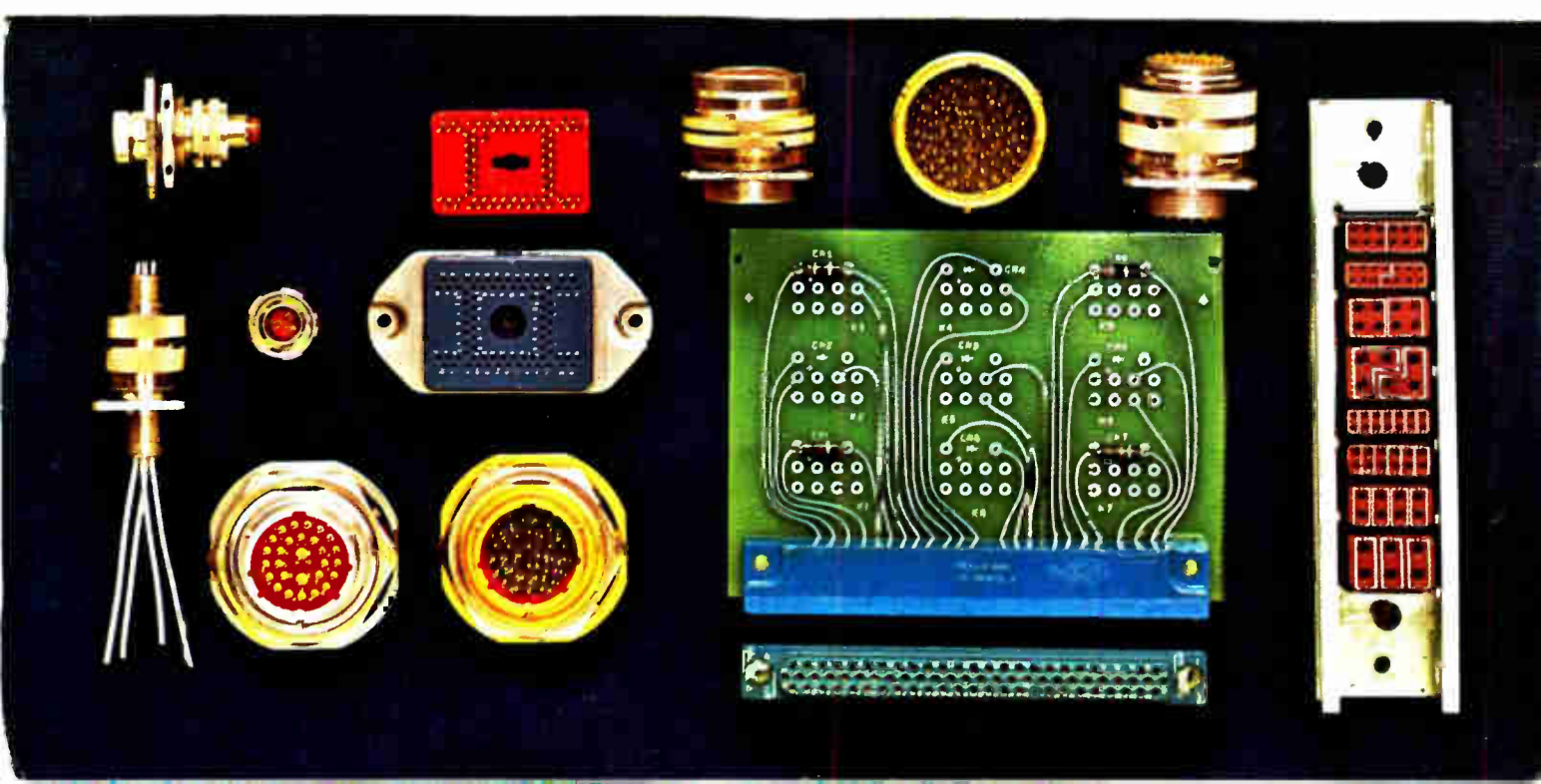
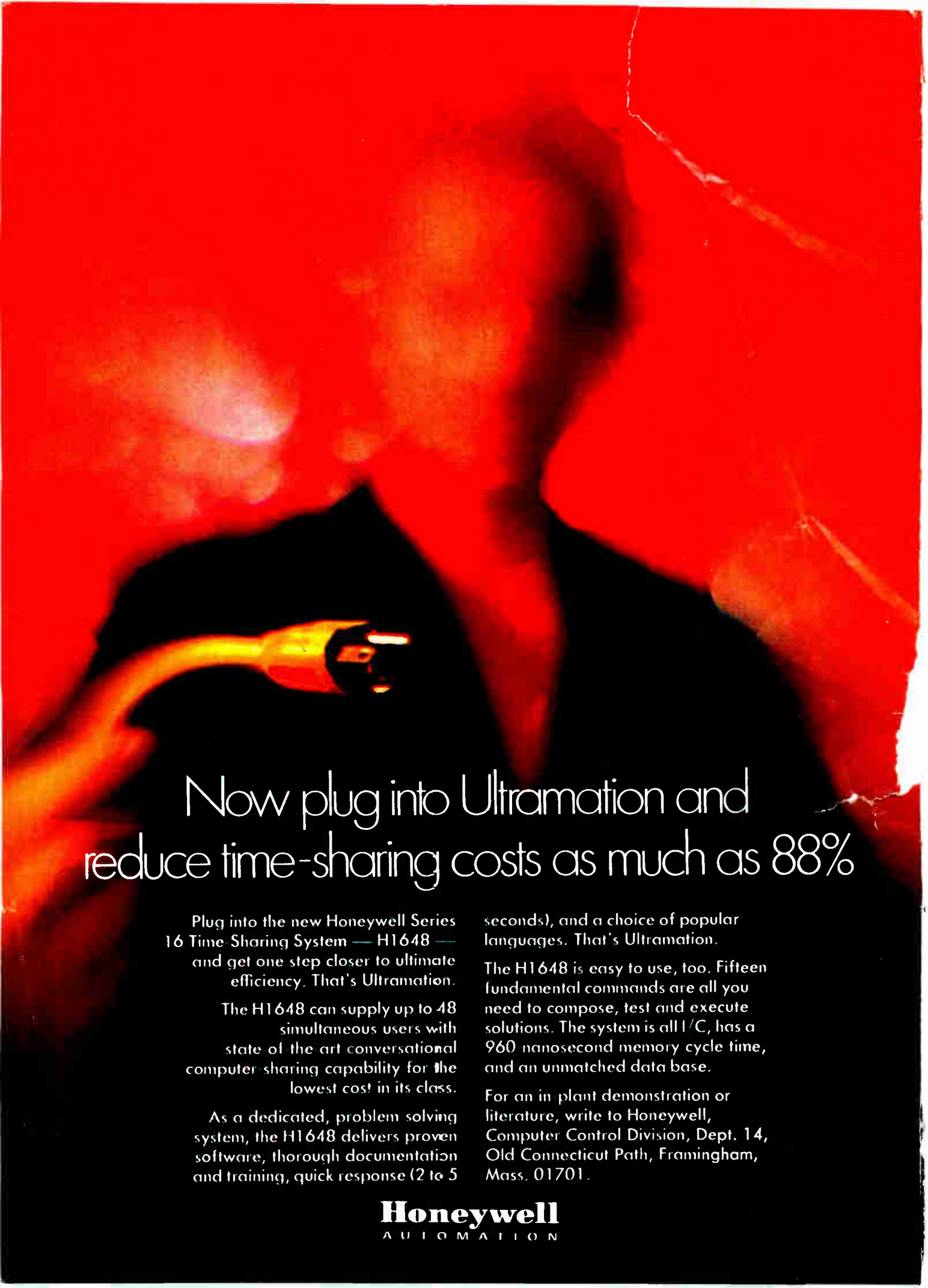
**Bendix**
**Electronics**







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Plug into the new Honeywell Series 16 Time-Sharing System — H1648 — and get one step closer to ultimate efficiency. That's Ultramation.

The H1648 can supply up to 48 simultaneous users with state-of the art conversational computer-sharing capability for the lowest cost in its class.

As a dedicated, problem solving system, the H1648 delivers proven software, thorough documentation and training, quick response (2 to 5 seconds), and a choice of popular languages. That's Ultramation.

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**Honeywell**
AUTOMATION

## Editorial comment

# Europe measures the gap . . .

**The American engineer** visiting Europe may carefully avoid mention of the technology gap, but his European host is almost certain to bring it up; it gives him an opportunity to contend there is no gap.

Protests notwithstanding, the gap exists. French, German, and British engineers recognize it tacitly by discussing its causes. On the one hand, they assert that the gap is made to seem larger than it is by the propensity of U.S. electronics firms to reveal plans for new products long before they're ready for market. Some underscore this charge by saying salesmen for U.S. companies have "larger-diameter mouths" than salesmen for European companies. And, they say, U.S. firms are not averse to "unfair practices" (price cutting) to get business. Ironically, many who comment in this vein think European companies should emulate the Americans.

One young German engineer at AEG-Telefunken's semiconductor plant in Heilbronn believes the gap is more economic than technical. "There's no technological gap in certain brains," he says. Yet the present shortage of engineers in Germany makes it difficult to convert good ideas into products. This engineer suggests that the internal organization of European companies be reshaped to emphasize projects and products, that government support of research and development be increased and made more efficient, and that engineering education be improved.

None of these steps will be taken overnight. Many companies adhere to traditional organizational structures that encourage empire-building within individual departments. Furthermore, the governments aren't inclined to vote substantial funding for projects they often don't fully understand. Finally, even the large European companies have failed to subsidize formal programs for the continuing education of their engineers. Some discourage them from pursuing advanced studies.

Nevertheless, progress is evident in Europe's recognition of the problems to be solved. Regardless of how they define the gap (or even if they don't admit its existence), they can now begin work to close it.

# . . . while the U.S. widens it

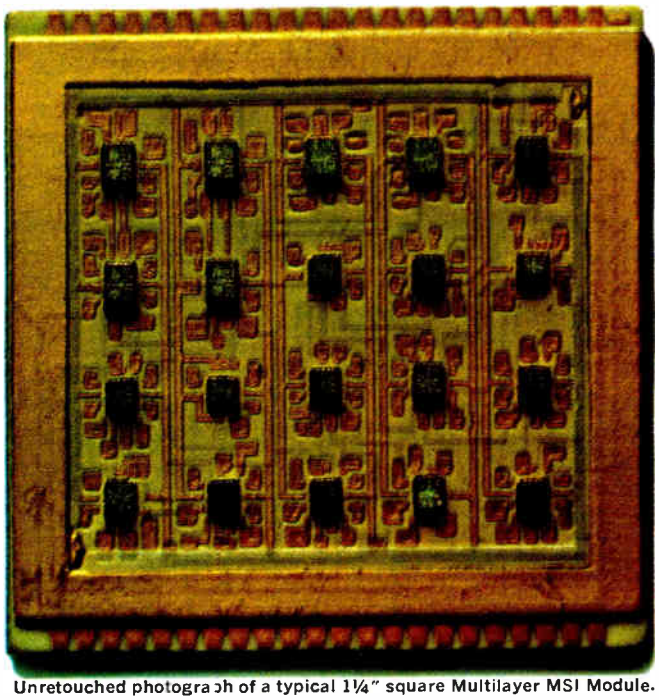
**European companies** may try to narrow the gap, but the Americans are forging ahead. Fairchild Semiconductor, for example, plans this year to invest $20 million in new plant and equipment and another $20 million in research and development at its Palo Alto, Calif., facilities. The company expects to install wire bonders that can handle 60,000 bonds in one shift; die bonders that can attach 40,000 dice per shift; and automatic test equipment that will test 92 parameters at 18,000 tests per hour.

To help launch large-scale-array technology and to solve such problems as complex network analysis, U.S. companies will invest heavily in computer-aided-design techniques (NASA estimates an annual expenditure of up to $100 million). They are abetted in their unending race to exploit technology by the ease of obtaining risk capital in this country. One wonders whether companies like Texas Instruments or Fairchild could have been launched in the stifling financial environment existing in many European countries.

American manufacturers have still another big advantage over their European rivals: the domestic markets into which they direct the bulk of their output are generally much larger than the domestic markets of any given company in Europe. They can thus cut costs through volume production and go after the international market as well.

And this is the route U.S. firms are following in pursuing their objectives—one of which is to leave all competitors far behind, be they European or American. ■

# Hybrids from United Aircraft?



Unretouched photograph of a typical 1¼" square Multilayer MSI Module.

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# Electronics Newsletter

**May 12, 1969**

## Siliconix spins off equipment division

**The equipment division of Siliconix Inc., which did nearly a million dollars in outside sales last year, will be spun off within two or three months as an independent company known as the IPT (for International Production Technology) Corp.** IPT will expand Siliconix's basic equipment—FET testers, wafer probers, and contact printers—into a broad line. Thomas S. (Stoney) Edwards, a founder of Siliconix and present manager of the Equipment division, will become president of IPT; John F. Day III, former marketing manager for the Optical Systems division of the Itek Corp., and program manager on the Itek Eye, will be vice president for operations; and Charles M. Bodine, chief mechanical engineer at the Signetics Corp., where he developed the first plastic dual in-line package, will be engineering vice president.

Siliconix will have two seats on the board of directors and a minority interest in IPT. Siliconix president Richard E. Lee said that the spin-off solved a potential management problem for his company, in that the equipment product line had largely been determined by Siliconix's internal needs, and that further expansion would require a strong commitment. In addition, Lee noted, some equipment customers were reluctant to deal with a competitor.

**IPT will build mechanical, electronic, and optical systems for semiconductor makers and users, and for hybrid circuit manufacturers.** The company will occupy the present Siliconix headquarters after Siliconix moves to its new building this summer.

## Philco-Ford division readies color seeker for military tryouts

A color seeker that can operate in two spectra and discriminate between the wavelengths of decoy flares and aircraft emissions has been developed by Philco-Ford's Aeronutronic division. **It will be incorporated into the division's study of a low-altitude, forward-area defense system for the Army's Missile Command.** RCA's Defense Electronic Products division would provide the all-weather radar for the system if Aeronutronic wins the prime contract.

**Aeronutronic is also building flight models of the seeker, with one to go to the Navy for flight testing later this year.** The Air Force hasn't purchased a system, but Aeronutronic officials expect that service to evaluate the seeker when it tests a number of sensors later this year.

## RCA receiver may sail in new destroyer

RCA's new digitally programable receiver could find its way into the Navy's DX antisubmarine and shore-support destroyer. RCA and General Dynamics are providing the ship's electronic warfare equipment.

The receiver, expected to be especially useful in processing emanations from multiple targets when friendly radar transmissions are jammed, was developed by RCA's Electromagnetic and Aviation Systems division. **It can be programed to sweep across a wide frequency spectrum with good stability over the military temperature ranges; and its pulse repetition period can be programed over a wide range.** The receiver can listen across the entire S, C, or X bands, with windows of special interest programed in.

R-f resolution in X band—20 megahertz—isn't unique, but RCA engineers believe the combination of the broad bandwidth with that resolu-

# Electronics Newsletter

tion, digital programing, and a pulse-repetition-period resolution of 1 microsecond represents a first.

## Bell has case for hologram memories

A Bell Labs researcher has built an acousto-optic deflector with a bandwidth of 80 megahertz, twice that of previous devices. **His deflector—part of an experimental 4-million bit memory that accesses any of 1,024 holograms in a microsecond—strengthens the case for optical memories in future telephone switching systems.** These now use magnetic twistor cards to store information.

**The researcher, Douglas Pinnow, bonded a lithium niobate transducer to a crystal of alpha iodic acid, and drove the unit with a 140-Mhz midband signal.** He will report on the deflector at the Laser Engineering and Applications Conference in Washington, May 26 to 28.

## Fairchild's 715 ready a year late

**Nearly a year after its scheduled introduction, the 715 operational amplifier by Fairchild Semiconductor is finally ready.** The high-speed 715 was supposed to be the star of the parade of linear devices that the company brought out last year [*Electronics*, June 24, 1968, p. 177]. The reason for the long delay: **the op amp had to be redesigned after it proved impossible to develop a standard compensation network for the original circuit.** The 715 boasts a unity gain slew rate of 20 volts per microsecond, with a settling time of 300 nanoseconds to within 0.1% of the output value. Open loop unity gain crossover is 65 megahertz.

Fairchild expects the circuit to find use in d-a and a-d converters; linear circuit marketing manager Mike Markkala says that because of the fast settling time, it will outperform discrete op amps with five times the slew rate. Price is $48 in lots of 100 for military grade circuits, and $15 for industrial devices. Markkala promises delivery from stock as of June 16.

## Post Office draws 350 from industry

The Post Office, whose research and engineering budget emerged unscathed from the Administration's pruning process [*Electronics*, April 28, p. 46] can look for increased contractor interest, if last week's Pattern Recognition Symposium is any indication. **Some 350 company representatives crowded the one-day meeting in Washington to discuss electronic zip-code and address reading.**

Among the systems discussed was Philco-Ford's flying spot scanner for zip codes. A spokesman for the firm said that the system, under development for several years, still is only 45% to 47% effective in recognizing five-digit codes.

## NASA readies RFP for ERTS program by tightening specs

NASA's request for proposals for the Earth Resources Technology Satellite program should appear within the next week [see story on p. 98]. **It appears that the schedule has been tightened so that parts of the Phase B and C studies will be completed in three months and the remainder in five months.** Two or three firms will get contracts.

Phase D—procurement of the spacecraft themselves—will be pushed up, possibly indicating that NASA doesn't want an entirely new craft. **The reason for the latest delay: the space agency was tightening the specs and making spacecraft experience a stronger criterion for selection.**





Think about promises
and prices and how they don't
amount to a hill of beans
without specs, service, integrity,
research and the resources of
an electronics giant to back them up.
Think about Fairchild Instrumentation.
On it's way to the top.

# If you've been thinking about DVMs and counters, think about this:

## Model 8220/FM01
### 500 MHz Frequency Counter, $1,795

Direct reading
7-digit display with memory
Quality IC construction
Convenient operation
Self check

**FREQUENCY MODE**

| | |
|---|---|
| Range | 10Hz to 50MHz<br>50MHz to 500MHz (Prescaler) |
| Gate Time | 0.1sec, 1sec, 10sec |
| Reads In | kHz with automatically positioned decimal point |

**COUNT MODE**

| | |
|---|---|
| Maximum Count Displayed | 9,999,999 |
| Maximum Count Rate | 50MHz |

**TIME BASE**

| | |
|---|---|
| Frequency | 1MHz |
| Aging Rate | < 3 parts in $10^7$ per week after 1 day continuous operation<br>Guaranteed < ± 2 parts in $10^7$ per month after 1 month continuous operation (< ± 7 parts in $10^9$ per day) |
| Temperature Stability | < ± 3 parts in $10^7$ over 0°C to +55°C range |

**INPUT SPECIFICATIONS**

| | |
|---|---|
| Sensitivity | |
| 10Hz to 50MHz | 50mV rms |
| 50MHz to 500MHz | 100mV rms |
| Impedance | |
| 50MHz | Approximately 100kΩ in parallel with 40pF |
| 500MHz | 50Ω resistive |

**GENERAL**

| | |
|---|---|
| Dimensions | 5¼" H x 9" W x 12½" D |
| PRICE (including FM01) | $1,795.00 |
| Optional Medium Stability 1MHz Oscillator | Price $190.00<br>Guaranteed < ± 1 part in $10^7$ per month (< ± 7 parts in $10^9$ per day) |
| Optional High Stability 1MHz Oscillator | Price $350.00<br>Guaranteed < ± 3 parts in $10^8$ per month (< ± 1 part in $10^9$ per day) |

## Model 8050
### 30MHz Frequency Meter, $650

Period, Multiple period average, Totalize
5-digit display with memory is standard
Crystal controlled time base
True trigger level control
Input impedance 1MΩ
Reliable IC construction
Self check

*Specifications*

**FREQUENCY MEASUREMENTS**

| | |
|---|---|
| Range | DC to 30MHz |
| Display | kHz with automatically selected decimal point |
| Gate Times | 10sec, 1sec, 0.1sec, 10ms, 1ms |

**PERIOD AND MULTIPLE PERIOD AVERAGE RANGE**

| | |
|---|---|
| Single Period Resolution | 100μs |
| Multiple Period Resolution (for $10^4$ periods) | 500ns |
| Periods Averaged | 1, 10, $10^2$, $10^3$ |

**TOTALIZE FUNCTION**

Gate is manually opened and closed by function select switch

**TIME BASE**

| | |
|---|---|
| Aging Rate | < ± 2 parts in $10^6$ per month |

**INPUT SPECIFICATIONS**

| | |
|---|---|
| Sensitivity | 100mV rms sine wave<br>300mV peak to peak for pulses<br>Attenuator: DCX1, X30, ACX1, true trigger level control, AC and DC coupled input |
| Impedance | Approximately 1MΩ shunted by 25pF |

**GENERAL**

| | |
|---|---|
| Dimensions | 3¼" H x 6⅝" W x 7¾" D<br>(8⅛" D including knobs) |
| Weight | 3½ lbs |
| Power Requirements | 115V ± 10%, 60-400Hz, 11 watts |

**PRICE**

| | |
|---|---|
| 115-60Hz | |
| 1-9 | $650.00 |
| 10-24 | $635.00 |

## Model 7000A
### 4-full Digit Multimeter, .01%, $1,175

Multifunction—DC volts, DC millivolts, AC volts, ohms, current, BCD
Dual slope integrating
Automatic polarity
Manual and automatic ranging
20% overranging

*Specifications*

**DC VOLTAGE MEASUREMENTS**

| | |
|---|---|
| Ranges | 1.0000V F.S. + 20% overrange to 1000V F.S. in 4 ranges |
| Accuracy | ± 0.01% reading + 0.01% F.S. @ 23°C ± 1°C for 3 months |
| Resolution | 100μV (10μV DCV only) |
| Measurement Rate | ~ 5 readings per second |
| Input Impedance | 1V > 1kMΩ<br>10V > 1kMΩ<br>100V ~ 10MΩ<br>1000V ~ 10MΩ |
| Normal Mode Rejection | > 30dB at 60Hz<br>> 40dB at 120Hz<br>> 50dB at 400Hz |
| Common Mode Rejection | > 100dB at 60cps |

**OPTIONS**

Options are plug-in cards

| | |
|---|---|
| Option 01-Auto Range | Price $125.00 |
| Option 02-AC Volts Frequency from 10Hz to 100kHz on all ranges | Price $450.00 |
| Option 03-Resistance Ranges | Price $110.00<br>1.0000kΩ F.S. to 10000kΩ F.S. |
| Option 04-DC Current Ranges | Price $175.00<br>1.0000mA to 1000.0mA |
| Option 05-BCD Output | Price $125.00 |
| Option 06-AC Volts Frequency from 10Hz to 20kHz on all ranges | Price $350.00 |
| Option 07-100mV Range | Price $175.00<br>Adds 100mV F.S. with 20% overrange |

**GENERAL**

| | |
|---|---|
| Dimensions | 5¼" H x 8¼" W x 12" D, Half rack size |
| PRICE 7000/7000A | $1,175.00 |
| with options 01, 02, 03, 04 or 07 | $1,895.00 |
| with options 01, 03, 04, 06 or 07 | $1,795.00 |

## Model 7050
### 3½ Digit Multimeter, 0.1%, $354

Multifunction—DC volts, ohms, current
Dual slope integrating
Display storage (non-blinking display)
Automatic polarity
Input impedance 1000MΩ

*Specifications*

**FUNCTIONS**

| | |
|---|---|
| DC Volts | DC Volts, Ohms<br>External Current Shunts Available<br>1.500V F.S. to 1000V F.S. in 4 ranges<br>1mV resolution |
| Input Impedance | 1.5V Range >1000MΩ<br>15V to 1000V Ranges ~ 10MΩ |
| Common Mode Rejection | Typically >60db DC to 1kHz with up to 1KΩ unbalance |
| Normal Mode Rejection | Typically >40dB at 60Hz |
| Resistance | 1.500k F.S. to 15.00MΩ F.S. in 4 ranges 1Ω resolution |

**ACCURACY FOR 6 MONTHS**
15°C to 35°C

| | |
|---|---|
| DC Volts | ± 0.1% reading + 1 digit |
| kΩ | ± 0.2% reading + 1 digit |
| MΩ | ± 1% reading + 1 digit |

**GENERAL**

| | |
|---|---|
| Dimensions | 3¼" H x 6½" W x 7⅛" D |
| Weight | Less than 4 lbs |
| Power | 115V ± 10%, 50-400Hz, 7 watts |
| Alternate Power Models Line Voltage | |
| 230V ± 10%, 50-400Hz | Order Model 7050-230 |
| 100V ± 10%, 50-400Hz | Order Model 7050-100 |

**PRICE**

| | |
|---|---|
| 1-9 | $354.00 |
| 10-25 | $324.00 |

**ACCESSORIES**

| | |
|---|---|
| Current Shunts | |
| Range | 150μA F.S. to 1.5A F.S. |
| PART #93000259 | Price $50.00 |
| Tilt Stand/Handle | |
| PART #93000258 | Price $16.00 |

PURCHASE ORDER

# Take a look at our products. Compare our specs and prices with anybody else. Then buy Fairchild because we'll do a little more for you.

☐ Model 8220—500MHz Direct Reading Frequency Counter. 7-digit display with memory. Price: $1795.00.
(additional specs on reverse side)

☐ Model 7000A—Dual Slope Integrating 4-full Digit Multimeter. 0.01% accuracy. Measures DC volts, DC millivolts (10μv resolution), AC volts, ohms, current, BCD. Price: $1175.00.
(additional specs on reverse side)

☐ Model 8050—30MHz Frequency/period meter (with 8051 pre-scaler, capability extended to 300MHz). Also measures multiple period average and totalizes. Price: $650.00.
(additional specs on reverse side)

☐ Model 7050—Dual Slope Integrating 3½-Digit Multimeter. 0.1% accuracy. Measures DC volts, ohms, current. Price: $354.00.
(additional specs on reverse side)

## OK, I looked. I compared. And I decided to buy Fairchild. Please send me the instruments I've checked.

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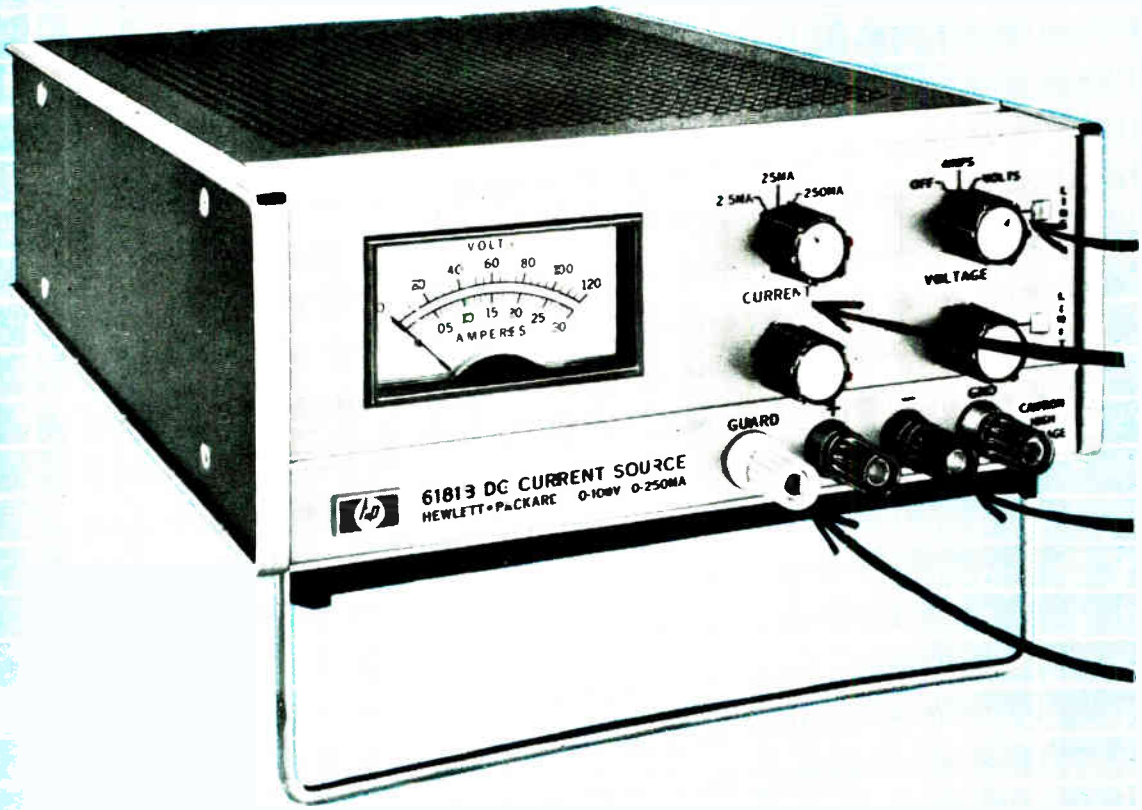
## *Like Having 2,500,000,000 Ohms in Series With 2,500,000 Volts*




**Independent Voltage Limit** — preset your voltage, light warns when complying voltage limit is reached.

**Excellent Resolution** — 0.02% of range setting, three decades of ranges.

**Precise Regulation** — 25 ppm down to 1 microampe output.

**Patented Guard Circuit** — prevents leakage paths and voltage monitoring from degrading output.

Unlike many so-called "constant current" sources, the new CCB Series has the necessary high impedance, non-capacitive output. There is essentially no stored energy to dump, delaying response to programming or load changes. Patented Guard Circuit allows the output voltage to be monitored, externally, without degradation. Further, the new CCB Series permits you to preset current and voltage before connecting your load.

Two models are now available: the 6177B at 0-500 mA, 0-50V; the 6181B at 0-250 mA, 0-100V. Either can be remote programmed (resistance or voltage) with an accuracy of 1% or better.

Other operating features are: Transient recovery time of less than 200 μsec for output recovery to within 1% following a full load change; programmed speed of less than 500 μsec. from zero to 99% of programmed current output; resolution of 0.02% of the range switch setting; rms ripple less than 80 ppm of range.

Both Constant Current Sources are 3½" high half-rack size, weighing 10 lbs., and are priced at $425.00. For additional specifications, contact your local HP sales office or write: Hewlett-Packard, New Jersey Division, 100 Locust Avenue, Berkeley Heights, New Jersey 07922 . . . In Europe, 1217 Meyrin-Geneva.

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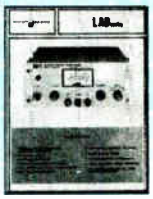
*Additional Constant Current/Voltage Models For Higher Current . . . less sophistication*

**3 MODELS**
**0 - 3A**
**Up to 50V**

**Circle 516**



**9 MODELS**
**0 - 3A**
**Up to 320V**

**Circle 517**

**Circle No. for details 515**

21906

# What's NEW at GUARDIAN?

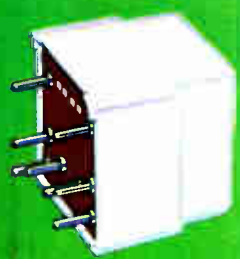
GUARDIAN ELECTRIC MANUFACTURING COMPANY 1550 W. Carroll Ave., Chicago, Illinois 60607

## NEW GUARDIAN LEVER SWITCHES

■ Available with two or three switching positions. ■ Nine versions combining off, momentary or locked positions. ■ Snap-in inserts permit changing actuator switching positions at any time. ■ Non-illuminated or illuminated with color coding. ■ Contacts rated at both 1½ and 10 amps at 115V AC resistive. ■ Up to 4 pole double throw per station. ■ .110 Quick Connect Terminals and/or Solder Terminals.

Circle No. 501 For Literature.

## NEW GUARDIAN PRINTED CIRCUIT PLUG-IN RELAY



■ Unique, compact design. ■ All terminals on .1 grid spacing for standard printed circuit board. ■ Solders right on PC board. ■ Conforms to UL requirements for Business Machines. ■ 1 watt normal power—½ watt on request. ■ 3500 OHMS coil resistance (120V AC-60Hz). ■ Standard voltages 6 to 120 AC—6 to 24 DC. ■ Mechanical life over 10,000,000 operations. ■ 3 AMP. resistive 115V. 60Hz contact rating.

Circle No. 502 For Literature.

new

GUARDIAN

## SOLID STATE RELAYS

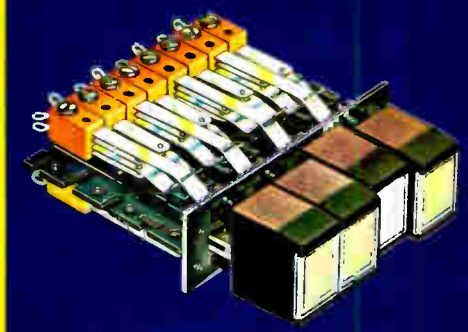

■ Universal AC or DC control voltage with complete circuit isolation from load switching circuit. ■ Externally-adjustable pull-in voltage level from 80-130V AC or DC, with close differential between pull-in and drop-out where accurate voltage sensing is required. ■ Control of high inrush lamp, inductive or normal resistive loads from 10 ma to 3 amps. ■ Internal filtering prevents random turn-on of "off" contacts.

Circle No. 503 For Literature.

NEW

GUARDIAN

## PUSH BUTTON SWITCH BANKS



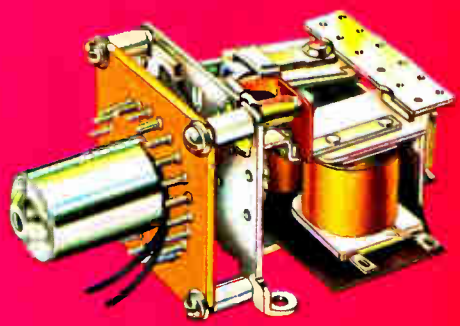
■ Sleek, compact design—only 1⅛" high. ■ Non-illuminated or illuminated with color coding. ■ Buttons on ⅝" centers. ■ Up to 12 stations in multiples of 2. ■ Contacts rated at both 1½ amp and 10 amps at 115V AC resistive. ■ Up to 4 pole double throw per station. ■ .110 Quick Connect Terminals. ■ End panel has four 9/32" tapped mounting holes. ■ Long life—100,000 mechanical operations.

Circle No. 504 For Literature.

NEW

GUARDIAN

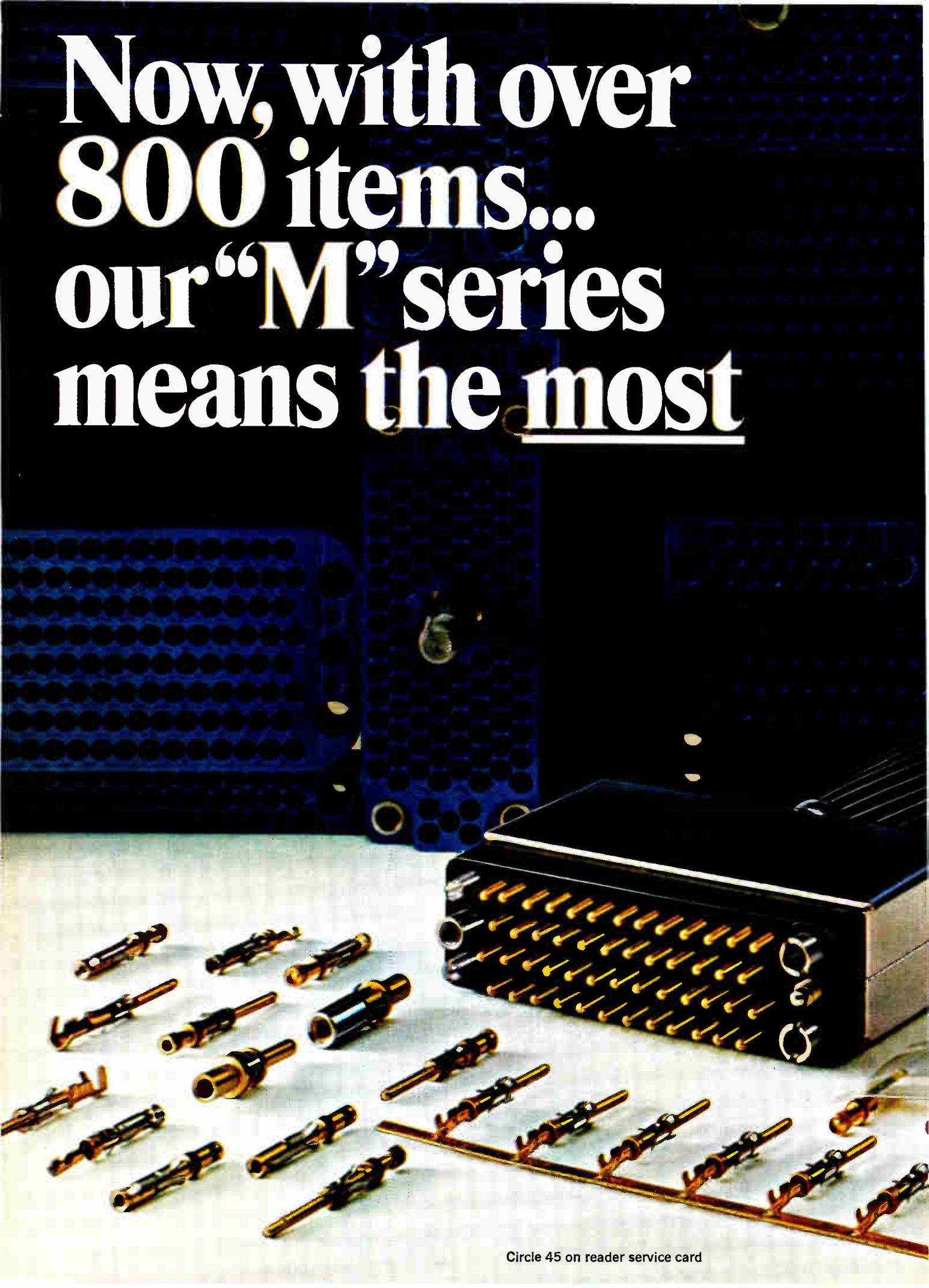
## LIFT OFF STEPPERS



All the features of the widely used Guardian MER 24 point electrical reset stepper . . .
PLUS
■ Solenoid "lifts" wiper contacts when stepping to reduce friction . . . and arcing. ■ Increased contact ratings to 5 amps resistive at 120V AC. ■ Increased function capability. ■ Increased dependability. ■ Increased life expectancy—now up to 10,000,000 steps. ■ Compact design.

Circle No. 505 For Literature.

# Now, with over 800 items... our "M" series means the most



Circle 45 on reader service card

The most choices. The most combinations.

The most reliable connectors to meet your toughest rack and panel specifications. You can choose from the industry's biggest selection of connector types and sizes, pin and socket combinations and related hardware. You also get the most in savings. Because our connectors and our automatic tooling right in your own plant give you the lowest total installed cost.

Our AMP-O-MATIC★ Stripper-Crimper Machine, for example, strips each cabled wire and crimps on pins or sockets — up to 1000 an hour. And our AMPOMATOR★ Automatic lead-making machine feeds, strips and crimps at speeds up to 12,000 finished terminations per hour. That's what we call ECONOMATION . . . economy, reliability and range of choice.

For complete "M" Series Connector information, write to
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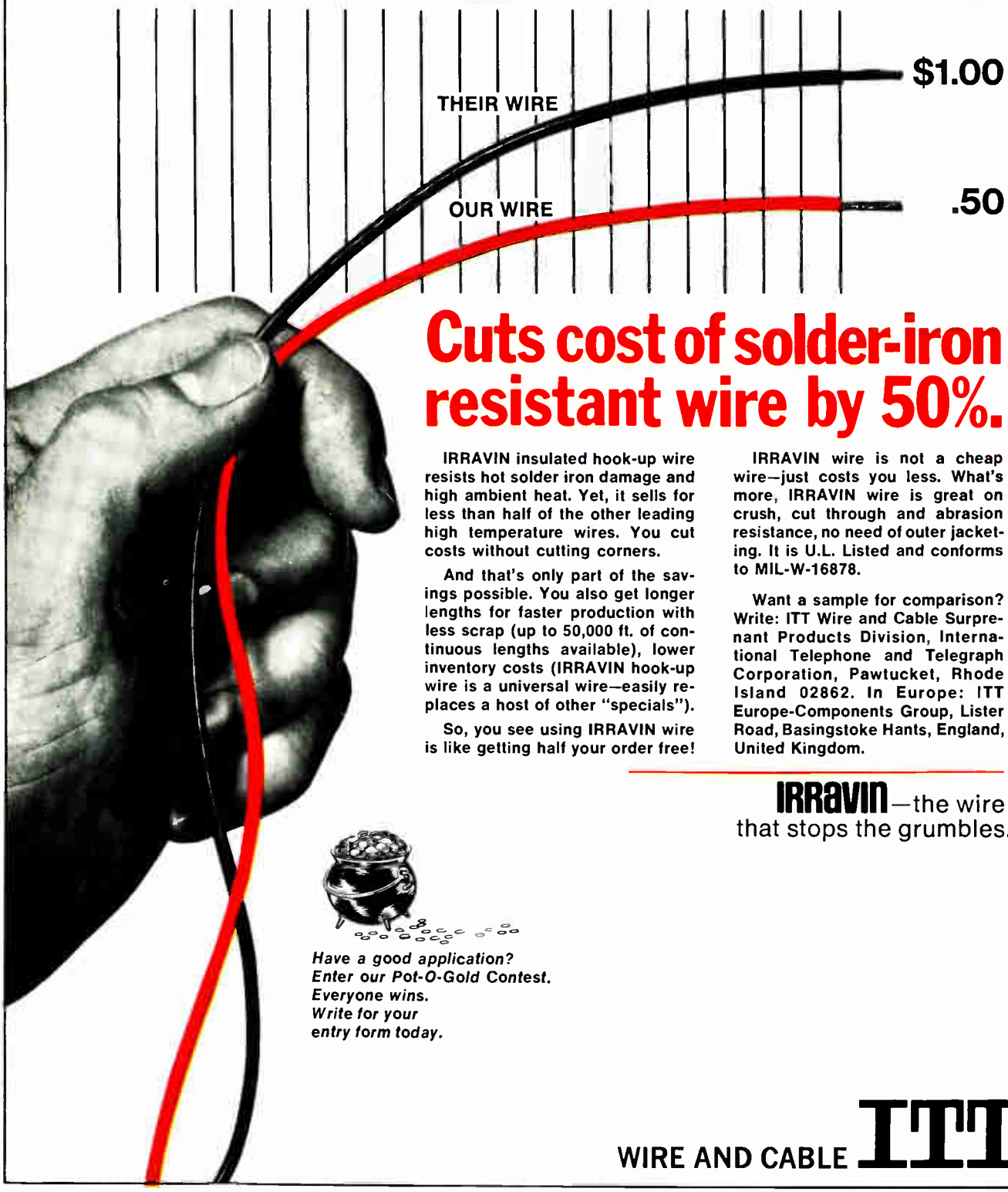
# IRRAVIN™

INSULATED WIRE




## Cuts cost of solder-iron resistant wire by 50%.

IRRAVIN insulated hook-up wire resists hot solder iron damage and high ambient heat. Yet, it sells for less than half of the other leading high temperature wires. You cut costs without cutting corners.

And that's only part of the savings possible. You also get longer lengths for faster production with less scrap (up to 50,000 ft. of continuous lengths available), lower inventory costs (IRRAVIN hook-up wire is a universal wire—easily replaces a host of other "specials").

So, you see using IRRAVIN wire is like getting half your order free!

IRRAVIN wire is not a cheap wire—just costs you less. What's more, IRRAVIN wire is great on crush, cut through and abrasion resistance, no need of outer jacketing. It is U.L. Listed and conforms to MIL-W-16878.

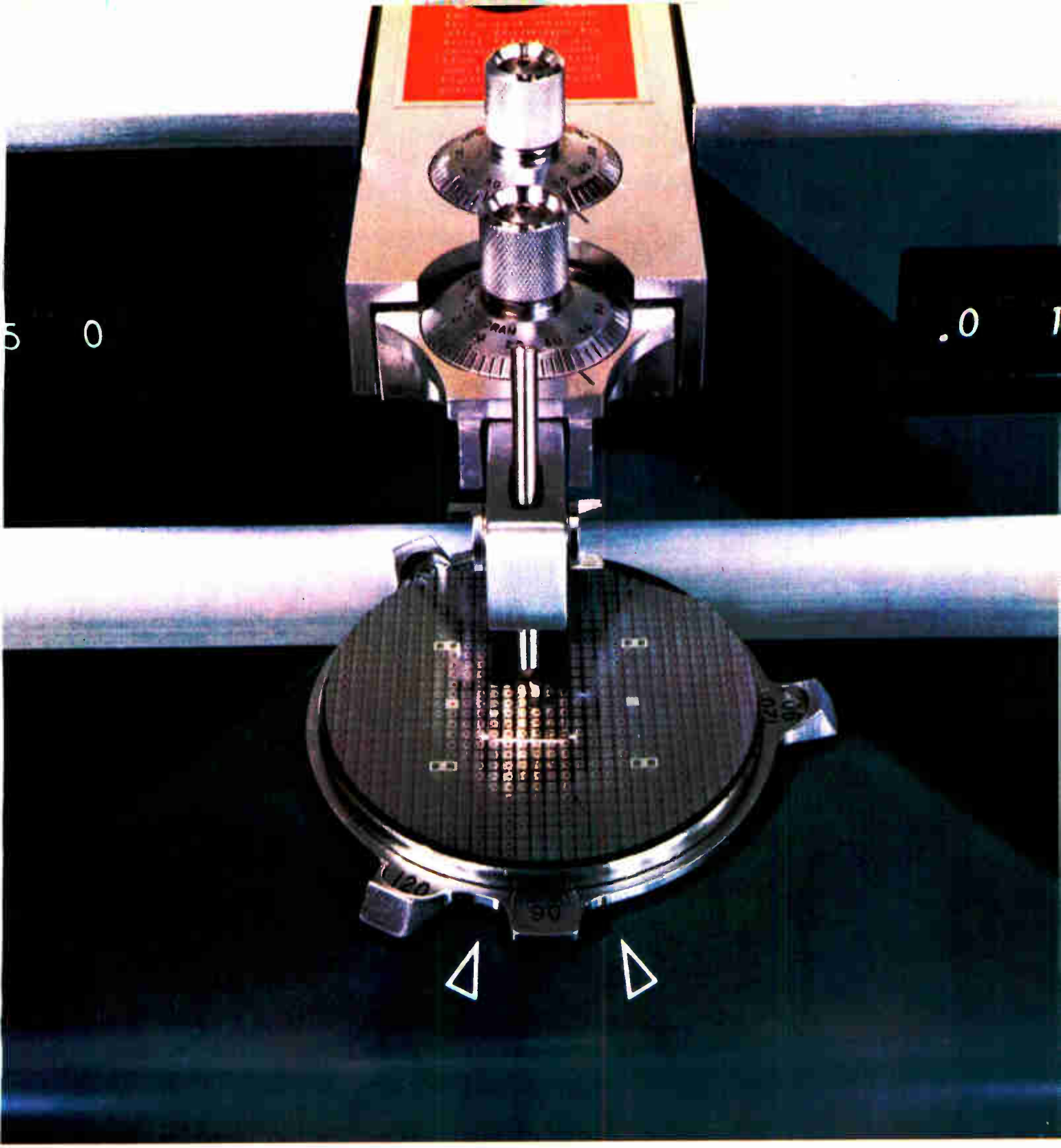
Want a sample for comparison? Write: ITT Wire and Cable Surprenant Products Division, International Telephone and Telegraph Corporation, Pawtucket, Rhode Island 02862. In Europe: ITT Europe-Components Group, Lister Road, Basingstoke Hants, England, United Kingdom.

**IRRAVIN**—the wire that stops the grumbles.



*Have a good application?*
*Enter our Pot-O-Gold Contest.*
*Everyone wins.*
*Write for your entry form today.*

WIRE AND CABLE **ITT**



# An economy of excellence

**The Tempress four-pointed, Truncated Pyramid, Diamond Scribing Tool*, a unique Tempress development, will precisely scribe silicon wafers four to six times longer than conventional diamond scribing tools** . . . an economy of excellence. Natural octahedron diamond crystals are hand selected for each tool. The diamond crystal is then ground across its natural edges to create a pyramid shape, the edges of which lie within the hardest planes of the diamond crystal. The peak of the pyramid is then truncated to form four precision cutting points of maximum wear resistance. The efficiency and economy this tool has brought to semiconductor manufacturing reflects the Tempress Standard of Excellence, inherent in each miniature assembly tool and production machine produced by Tempress.

*Shown 2 1/2 times actual size.

TEMPRESS

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Circle 47 on reader service card

# How Do You Get A Custom-Designed Receiving System 'Off-The-Shelf?'

The modular design of W-J's RS-125 Receiving System makes it possible. W-J has supplied many variations of the RS-125--each for a specific application. Yet, in most cases, components have been standard versions, right out of stock.

A wide selection of tuners, demodulators, bandwidths and ancillary devices is readily available. So you can order only those components required for the monitoring job at hand. You eliminate obsolescence by adding units as the needs arise.

The RS-125 processes received signals through a demodulator utilizing plug-in modules available in 10 standard bandwidths ranging from 5 kHz to 8 MHz. This highly versatile arrangement of equipments provides AM, FM, CW and pulse reception over a frequency range as wide as 500 kHz to 12 GHz utilizing W-J tuners.

A system covering the range of 10 MHz and above could include tuners with internal motor drives which feature sector scan, enabling the operator to adjust the upper and lower frequency limits of the sector in which he is interested.

It also could include a frequency extender-counter combination which would provide a direct six-digit readout of the tuned frequency, plus Digital Automatic Frequency Control (DAFC.)

Two basic types of the RS-125 are offered: The "B" system for applications requiring low VSWR, and the "C" system for applications requiring maximum sensitivity.

A W-J representative would be glad to assist you in the selection of components for a system to meet your specific requirements. For details write Watkins-Johnson Company, CEI Division, 6006 Executive Boulevard, Rockville, Maryland 20852, or phone Area Code 301-881-3300.

***World's largest selection of receiving equipment for surveillance, direction finding and countermeasures***

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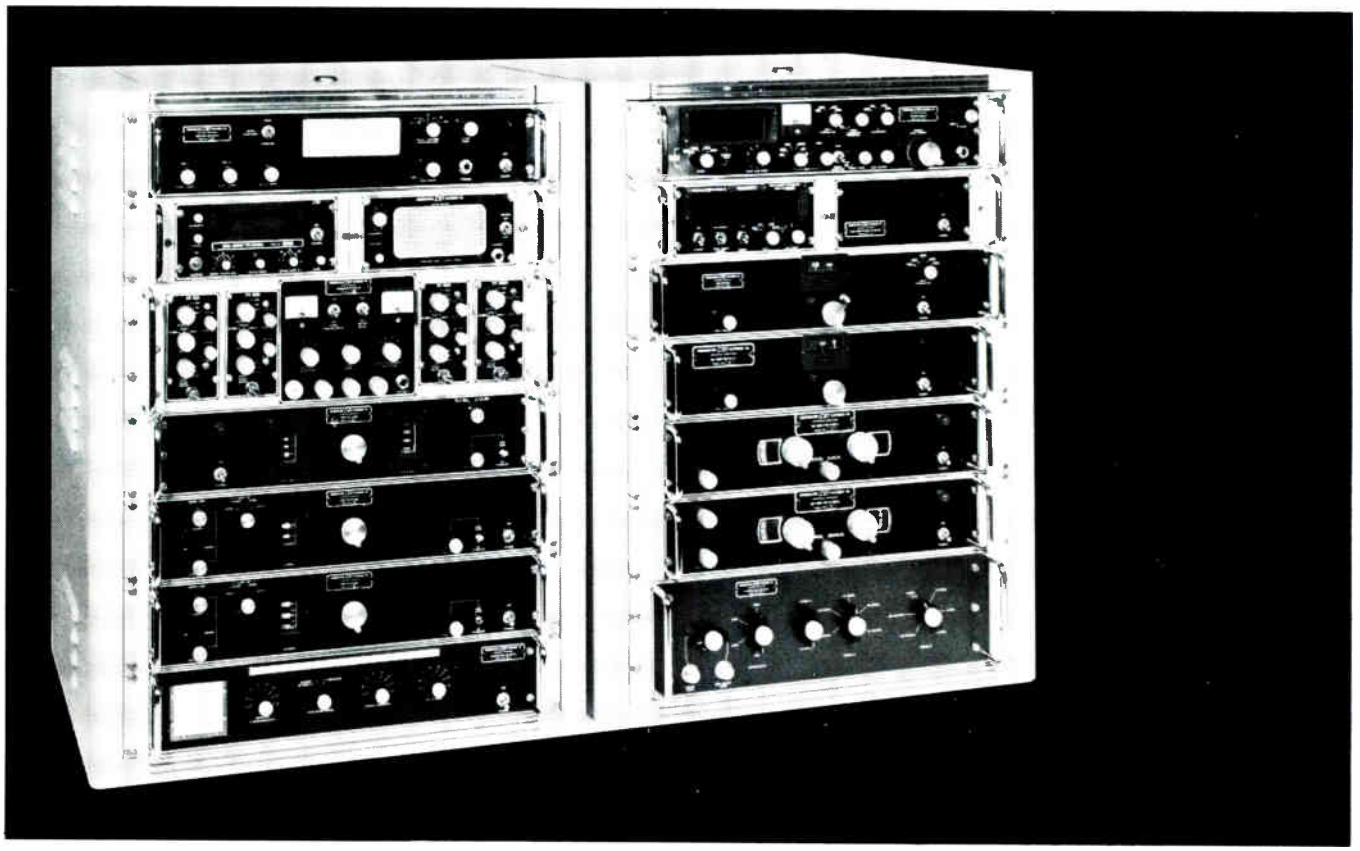

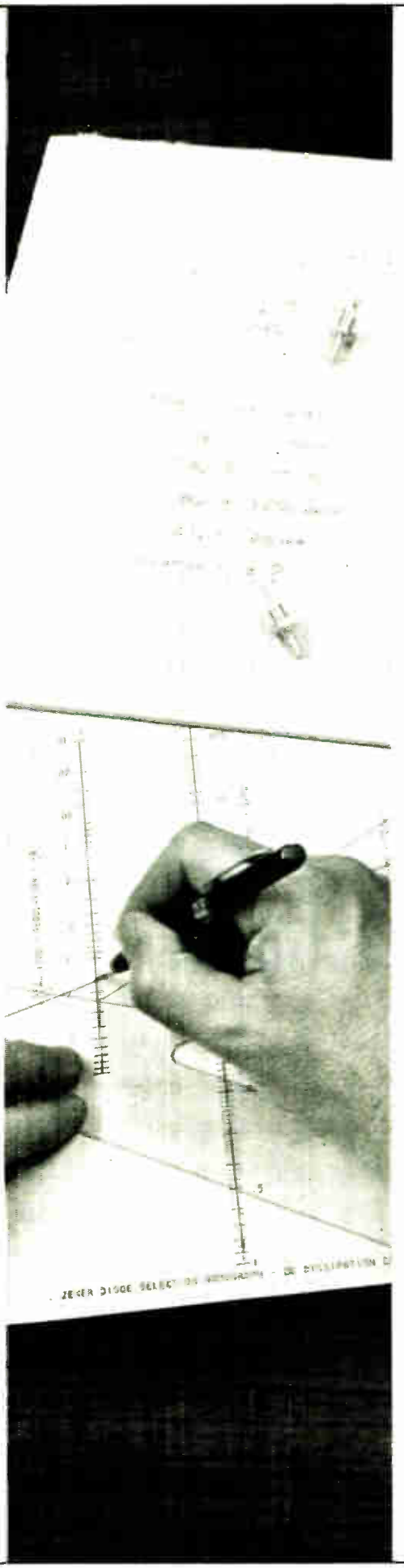

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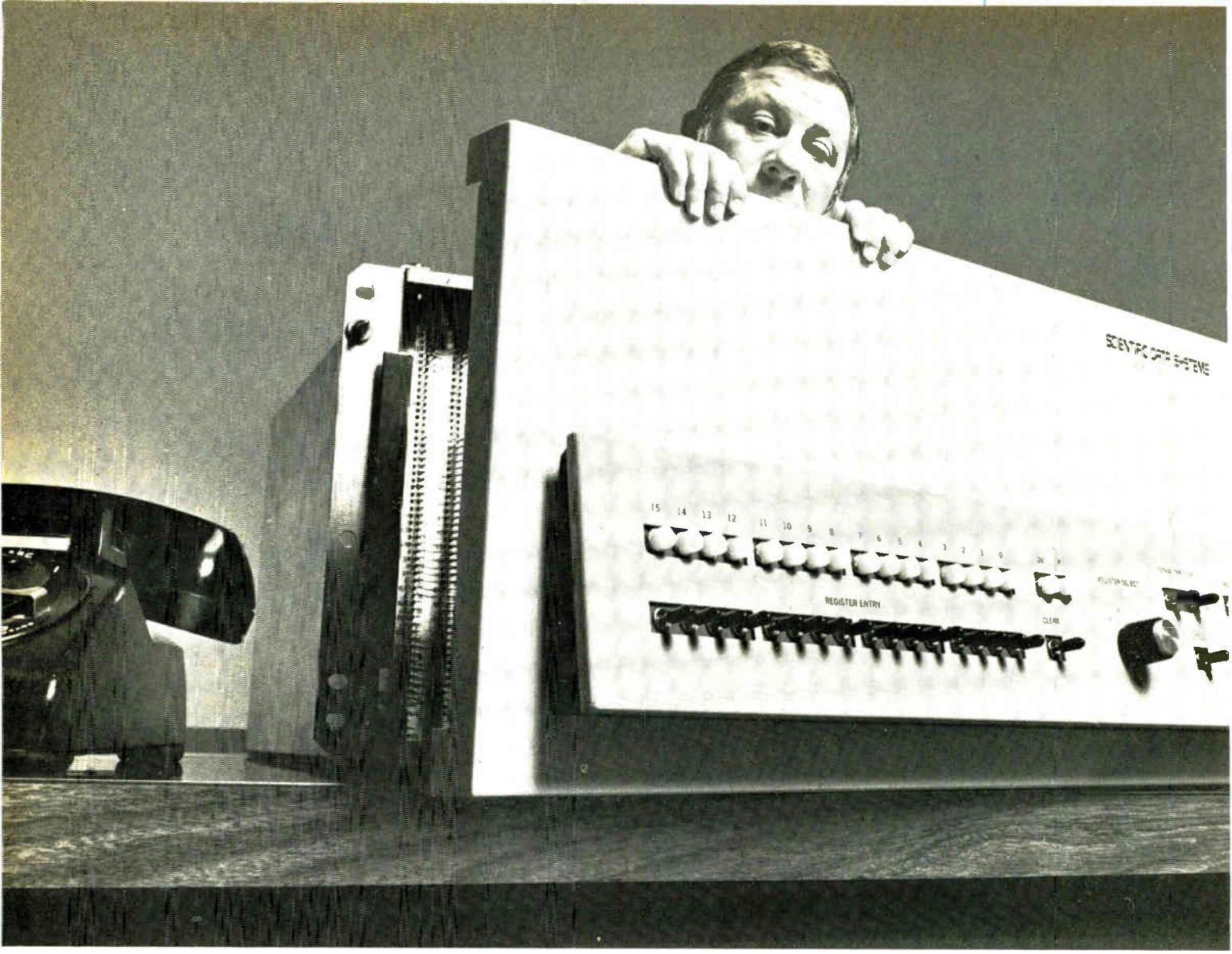

# Our new mini-computers have built-in programmers.

Most small computers are designed for programmers. Ours are designed for people.

Just tell our 16-bit machines what you want done. The CE16 and CF16 will do it, because their "built-in programmers" (a comprehensive set of sophisticated instructions) let any engineer use them with ease. For example, the single instruction "scan memory" makes our machines compare a given number with the contents of the entire memory.

The CE16 and CF16 have 125 other heroic instructions that specify comprehensive maneuvers. So you give fewer instructions and use far less core memory than with any other small computer. Problem run times are shortened and Input/Output operations are simplified.

The CE16 and CF16 are designed to control and exchange information with a large number of external devices while doing related computation. Their "automatic I/O" enables them to talk back and forth between memory and a group of interrupting peripherals, in order of priority, without needing attention from the on-going program.

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:

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- A representative with more information than could fit in a brochure.
- Or a meeting between our sales engineer and one from any competitor you want, at your office. The competition can even bring a programmer along. We won't have to.

SDS

**Scientific Data Systems, El Segundo, California**

Circle 50 on reader service card

# NASA expects GOTS to resolve problems of man-machine interface

Research program will use variety of tactile input-output devices, but personalized high-speed memory core rates high on priority list

Men who work for NASA could soon be on the far side of the moon, just them and their computers. That's why the National Aeronautics and Space Administration, perhaps more than any other agency or organization outside the military, must solve the string of problems that stymies the so-called man-machine interface. To this end, the agency's Electronics Research Center has budgeted $750,000 annually for an open-ended hardware-software program called GOTS (graphically oriented time-sharing system) being cranked up at its Computer Research Laboratory in Cambridge, Mass.

The program will try out a wide range of computer input-output devices, and the GOTS research team will face diverse problems as each device is dovetailed into a time-shared environment. While some of the problems haven't even surfaced yet, they are already coloring GOTS organization.

**Start.** Conceived as modular, GOTS will constantly change its characteristics with the needs of research. What might be called GOTS 1 is about to go on line. It's based on a Honeywell DDP-516 computer with specially developed software, and some reworked hardware. Though the GOTS team hasn't yet begun working with more exotic input-output devices, the setup already includes both monochrome and color crt displays, data-entry tablets, and teletype. Coming up is, for example, a feedback-controlled joystick which could give users tactile or kinesthetic cues. Also, voice input is being studied with the goal of error-free communication despite slurred or mumbled commands.

Sound is often the surest way to communicate with men, so GOTS eventually will have simulated voice outputs. As a spokesman puts it, "You can't avoid seeing a loudspeaker message."

Data-entry tablets for the program soon may be equipped with projection crt's, converting their surfaces into displays. These would serve the same purpose as normal crt displays, but graphic input with a tablet would be many times more accurate than possible with a light pen.

Even artificial arms and hands may find their way into the GOTS scheme. And following the lead of researchers into artificial intelligence and pattern recognition, some of the researchers are thinking about a television input.

**Flux.** But more immediately, they are solving—and trying to anticipate—the continually changing problems of a growing, research-oriented, time-shared computer system. Despite fancy terminals, a GOTS-like system could be a failure if software deficiencies made it slow to respond or hard to use.

One key problem is allocation of high-speed core memory to give each user the illusion of a system dedicated to his terminal alone. And when the time comes to study the human-engineering aspects of new terminal types, the basic hardware-software system can't be allowed to get in the way.

With only 32,000 words in the computer's core stack, GOTS scientists have developed a paged and segmented memory allocation system in which both the supervisory program and the programs and files of individual users are contained in chunks of memory, called pages, typically 256 or 512 words long.

Pages are stored in mass memory on drums or disks and called into core only when needed for computation. For example, even the GOTS system's supervisory software (which, though only three-fifths complete, already needs more than 50,000 words of memory) is stored almost entirely on drum or disk with pages called in as necessary.

With paging alone, each user would have the illusion of 32,000 words all to himself. But segmentation adds even more flexibility and also reduces required memory capacity.

**Togetherness.** In GOTS, segmentation is the separation of a program or routine from the data on which it operates. Thus, a routine can be shared through segmentation without invading the privacy of individual files, or storing it in more than one memory location.

The segmentation feature also is said to make re-entrant processing easier to program and to make data bases easier to organize. And when segmentation is added to paging, the flexibility is such that a user has the illusion of simultaneous access to a number of computers—each with more memory than presently in the DDP-516.

But ingenuity can only extend a system's capabilities so far. Thus, GOTS is already slated to become a multiprocessor, multiple-core memory system sometime in 1970 after adding two DDP-362 computers, one already delivered. Eventually, GOTS will be interfaced with the research center's yet-to-be-installed IBM 360/75 computer complex. In

addition it will supply test facilities for systems like the Exam aerospace multiprocessor [*Electronics*, March 31, p. 50].

## Commercial electronics

### Punchless cards

The punched card is about to lose its holes. The Potter Instrument Co. of Plainview, N.Y., thinks it has a better idea—a developmental magnetic unit record system that uses binary-coded magnetic dots on a standard 7⅜-by-3¼-inch IBM card, and has a new card reader to enter this magnetically coded data into a computer's memory. Any conventional typewriter or line printer can prepare the cards, if it has been provided with special type bars or slugs showing the coded dots; it can print man-readable alphanumerics at the same time.

The new cards will appear with feasibility models of related equipment at the Spring Joint Computer Conference opening this week in Boston. Each card contains 10 lines of up to 70 characters each; the total capacity is almost nine times as much as the 80 columns of punches containing one character each in conventional punched cards.

**Dotty.** The code consists of eight positions, in each of which a black dot may be printed. This corresponds to an eight-bit binary code, with a dot representing a 1 and no dot a 0. Four of the eight positions appear above the alphanumeric character, the other four below. Depending on how the printer is modified, the alphanumeric and binary data may appear on the same side of the card, or one may be printed on the front and the other on the back, by using a reversed carbon paper as part of a snapout form containing the card. Of course, when the binary data is on the back, the code is reversed; but the electronic circuitry that translates this code into signals for the computer can be modified easily to take this reversal into account.

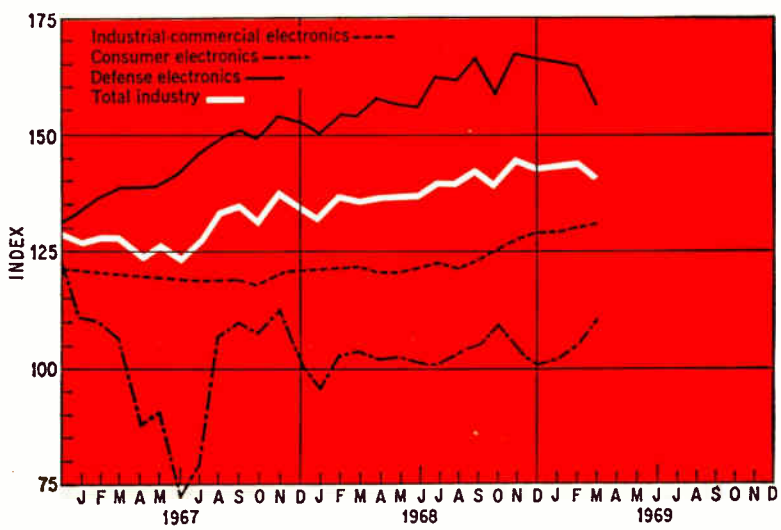
The eight-bit code permits up to 255 different characters to be encoded; the present developmental model uses only 81—which itself is even more than the maximum of 64 provided in a Hollerith code arrangement.

In some ways the new system resembles an experimental unit record system developed last year by the Univac division of the Sperry Rand Corp. [*Electronics*, March 18, 1968, p. 48]. That unit, sponsored by the U.S. Army Electronics Command, could store up to 1,000 characters on a plastic card much smaller than the standard punched card; the unit could also hold man-readable information that wasn't necessarily the same as the magnetically encoded data. Univac also developed a fluidic transport for recording and reading the data. The Army is continuing its evaluation of the Univac unit and another one built by Magnavox; further development will require additional funds under a new contract, but new funds don't appear to be forthcoming.

Potter's new unit record is considerably more flexible than the magnetic-ink character recording that's widely used on bank checks. In the magnetic-ink arrangement, the reader must decode the actual form of the character, which is printed in a special font that's only marginally man-readable, and which is limited to numeric and a few special characters. A Potter spokesman said the system could be compared to optical character-recognition systems, but that it was potentially much less expensive. It's projected selling price is expected to be less than $10,000—compared

## Electronics Index of Activity

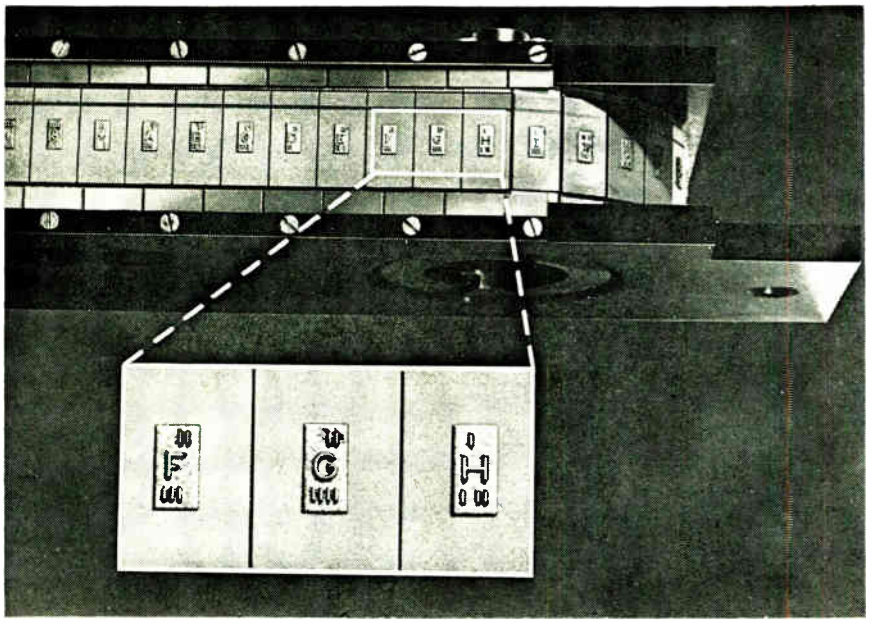
May 12, 1969




| Segment of industry | Mar. 1969 | Feb. 1969* | Mar. 1968 |
|---|---|---|---|
| Consumer electronics | 111.2 | 105.1 | 104.3 |
| Defense electronics | 156.4 | 164.8 | 153.8 |
| Industrial-commercial electronics | 130.7 | 129.9 | 121.7 |
| Total industry | 141.2 | 144.4 | 136.0 |

Electronics production slipped 3.2 index points in March from February's level, though output in two major sectors increased. Consumer electronics made the strongest advance, up 6.1 points to 111.2, while industrial-commercial production inched up 0.8 to 130.7. But an 8.4-point drop in defense output to 156.4 more than offset these gains. The over-all index was still 5.2 points above the year-earlier mark, however.

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



**Hole filler.** Chain module with magnetic character font for Potter printer. System replaces punched cards with man-readable letters.

with amounts approaching or even exceeding six figures for optical character readers.

## Manufacturing

### Two out of three

In recent years NASA technicians have often found that their biggest headaches developed because of prosaic skills and objects: welding techniques, batteries, electrical connectors, and tape recorders among others. As the second decade in space gets moving, these problems become more acute. Components and systems must last for as long as a decade in such proposed programs as the National Space Station.

The peskiest problem is welding connections between electronic systems and subsystems. It's a major source of failure, and the costs of making and testing reliable interconnections eat up a major portion of over-all systems costs. The space agency is now testing a system which during fabrication monitors three critical variables in the welding process. A breadboard model of the system, tested in 50,000 welding operations at NASA's Ames Research Center, proved to the agency's satisfaction that it can detect all bad welds. Two prototype systems are debuting at General Dynamics Pomona and Lockheed Missiles and Space for evaluation on the assembly line. While the Pomona unit isn't into operation yet, the Lockheed system has been working for a few weeks and it already appears that besides obvious advantages of economy and reliability, it doesn't appear to have much effect on the time needed to fabricate.

**Trio.** Basically, NASA has discovered that for the welding of circuit modules the three variables which are most important are weld voltage pulse monitoring, infrared radiation, and setdown measurement. Initially, other variables—including eddy current measurement, weld-joint resistance measurement, and sonic and ultrasonic measurement—were investigated, but it was determined that the first three were most critical. The agency further determined that the use of "two out of three" logic in judging welds made more sense than indications of any one attribute. Instrumentation for determining the three was selected on three criteria: that it did not interfere with normal welding operations, that it had no effect on the characteristics of the weld, and that it was simple. In the prototype equipment a solar cell and oscilloscope control for the i-r variable, electrodes and a voltmeter handle the weld-volt pulse, and a transducer containing four strain gages along with a sensitive digital voltmeter determines and displays setdown.

While the exact criteria undergo change in various applications, limits are programed into the test equipment. When a variable does not meet tolerance, a light on the weld evaluator goes on. If two of the three lights go on the weld is rejected.

## Avionics

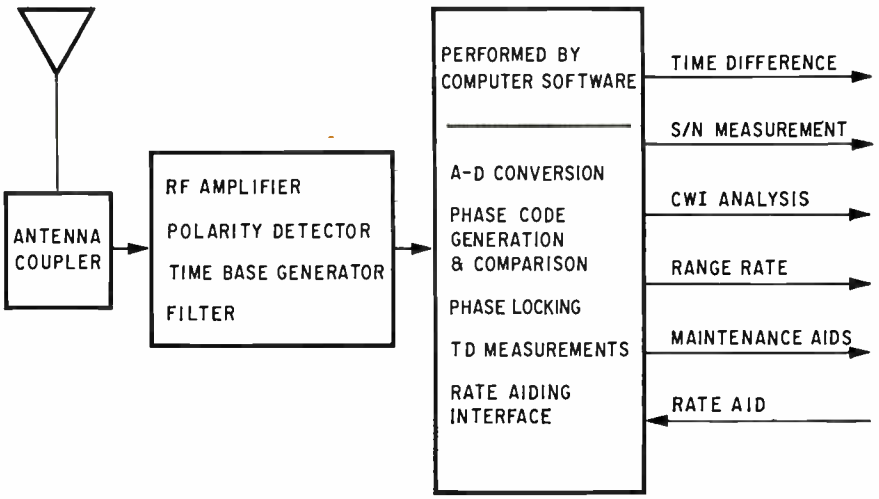
### Little loran

Two years ago, Litton Industries reorganized its Westrex Communications division after the Pentagon canceled a $20 million contract to modernize the Air Force's extensive ground-to-air communications network. The result: a new name (Litcom), a new management, a new plant, a new direction (radio navigation), and now a new product.

Claude Pasquier, the division's director of navigation products, believes that with its new unit, a 6-pound loran receiver, Litcom can challenge the long-standing leaders in the radio navigation field—Sperry, ITT, and Collins Radio.

The total system Litcom is offering—the sensor, a 5-pound Arma Micro D airborne computer, a display unit, an antenna coupler, and interface gear—weighs less than 40 pounds; conventional systems such at ITT's ARN-92 tip the scale at slightly more than 100 pounds.

**Sharing the load.** "When we started designing the system," explains Pasquier, chief architect of the little loran, "we decided to try to remove as much hardware as possible from the sensor by performing many of the loran's conventional functions in the computer." The result is that the Litcom sensor, which measures 3½ by 7⅝ by $12\frac{9}{16}$ inches, contains only an automatic notch filter to reject near-band interference in the 100-kilohertz loran signal, a pream-




**Simplicity itself.** Litcom's 6-pound loran receiver has minimal hardware since most conventional operations are handled by airborne computer.

plifier, an envelope deriver, two hard-limiting amplifiers, and a time-base generator consisting of a 12.8-megahertz temperature-compensated oscillator, squarer, and divider, all of which simply set up the signals for computer analysis. Functions such as phase-code generation and comparison (including phase locking), analog-to-digital conversion, time difference measuring, and rate aiding—operations usually performed by hardware in conventional loran receivers—are included in the computer program.

At the heart of the sensor's miniaturization is the use of the hard-limiting amplifiers. In conventional loran receivers, the gain for each signal must be linearly adjusted to produce signal outputs with constant amplitudes. In the Litcom sensor, the hard-limiting amplifiers clip the positive and negative peaks off the analog signals. Not only are these signals made uniform in amplitude, but they are thus converted into a digital, or square-wave, form that can be changed to binary numbers by the computer. This, of course, eliminates any need for a separate a-d converter.

**Test-runs.** According to Litcom's marketing manager for radio navigation products, Robert J. Vollaro, both the Air Force and the Army have shown interest in the system; the Air Force tested it for three weeks at Eglin AFB in Florida, and the Army tested it briefly in a UH-1D helicopter. "In neither case did the system fail or in any way need modification," says Vollaro.

Currently, Litcom has one contract from its sister division out in Woodland Hills, Calif.—Litton Guidance and Control Systems—to supply the loran receiver for the doppler inertial loran system (DILS), and another from the Coast Guard for a single complete system.

Although the Arma computer in the system performs many of the functions normally done by the loran sensor, the Litcom receiver is still compatible with any airborne computer having adequate reserve processing capacity, says Pasquier. In the DILS program, for instance, Litton will use its own computer. Further, because of this compatibility, the sensor can be used in retrofits, notes Vollaro. The Navy, for example, has asked Litcom to work with both Grumman and LTV Aerospace on the possibility of backfitting the A-6 and A-7 aircraft with the little loran; both of these aircraft now use the IBM 4-pi.

Vollaro estimates the cost of the system with computer at a little less than $50,000. But in quantities of 100 that price could drop to as little as $35,000, he adds.

## Solid high power

When the Navy last year decided it needed a compact, multifunction radar for its aircraft in the late 1970's, the Naval Air Systems Command kicked off its Molecular Airborne Intercept Radar (MAIR) program. The program's goal is a phased-array radar—all solid state, if possible.

Now the Navy, considering MAIR's requirements and those of other systems, is moving to avoid a potential stumbling block to solid state designs by funding separate development of a high-power coherent X-band power source. And it's turning to a second organization—the Naval Electronic Systems Command—to develop a solid state component which will be able to replace such things as traveling wave tubes, klystrons, and crossed-field amplifiers.

**New way.** Development is to take five years or longer, for while the Navy knows exactly what it wants, a lot must be done to get it. The request for proposals for the first development phase, sent out last month, points this out. According to the rfp, "There is no way of stating which of the many known approaches, if any, will be suitable. The program may require new techniques and new devices."

Nonetheless, all of the apparent difficulty has sparked, rather than dampened, contractor interest. Fifteen firms were represented at the prebidders' conference and the Navy expects at least a dozen bids on May 19.

The first two phases of work will be monitored by the Electronics Systems Command. Then they'll be handed back to the Air Systems Command for the finale. Three $30,000 Phase 1 contracts will be awarded in June. The three firms chosen will then have six months to determine the best approaches to developing the hardware. With the program defined, one or more of the firms will push on in Phase 2 to theoretical studies of materials and devices, as well as to the development of experimental hardware. This should take two years. Then if it all works out, the program will go into Phase 3, calling for an operating model.

The ultimate achievement will be the source itself. It will operate at about 10 gigahertz, achieving a

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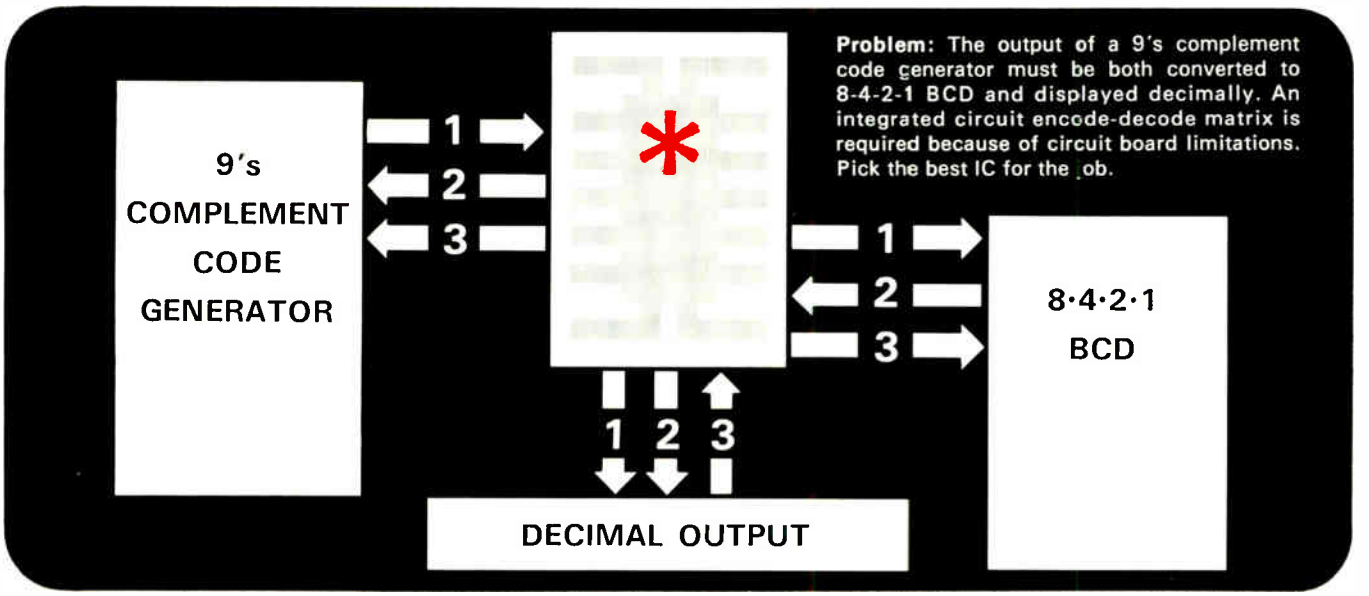


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peak power of 11 kilowatts and a surprisingly high 3.5 kw average. Tuning range will be 20%, d-c to r-f conversion efficiency 25%; the goal for instantaneous bandwidth is 10%. The Navy plans to apply the source initially in an airborne radar transmitter. Goals for this application have also been set. The transmitter will have a mean time between failures of 10,000 hours, take up two cubic feet and weigh less than 150 pounds when combined with power supplies and hooked to the aircraft cooling system.

## Adding dimensions

It's easy enough to determine by radar whether something is orbiting the earth. But it's much harder to tell just what that something looks like.

The picture is likely to get better in about a year when a new millimeter-wave radar goes into operation at the Aerospace Corp., El Segundo, Calif. The company is aiming for a range resolution of 6 inches, compared with the few feet now obtained. Used in conjunction with acquisition and tracking radars, the new radar should be able to give an accurate reading on the size and shape of foreign space vehicles.

The Aerospace Corp. will be using a 94-gigahertz, linearly frequency-modulated (or chirp) radar with bandwidth of 1 gigahertz and a long-duration pulse. This combination is needed because the Aerospace radar has a peak power of only 1 kilowatt. The long-duration pulse puts a lot of energy on the target, and the extremely broad bandwidth with the frequency-modulation signal provides the good resolution.

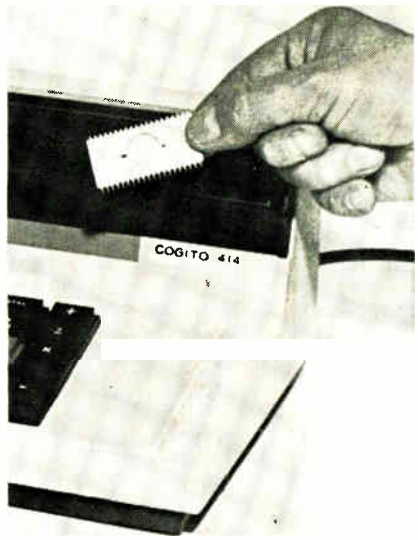
**Major product.** The radar is being designed to sweep the signal so that objects just 6 inches apart on a satellite will appear as separate returns. Engineers at the nonprofit organization say linear f-m is the only practical way to process the extremely large time-bandwidth-product signals. The radar's projected product of 1 million—calculated by multiplying the 1-Ghz bandwidth by the 1-millisecond pulse length—is about 1,000 times larger than the time-bandwidth products of previous linear f-m systems, researchers say.

The frequency versus applied voltage in the radar's backward-wave oscillator is not a linear function. But to make the radar work, the frequency ramp from the oscillator, which drives a 1-kw peak output traveling-wave tube, must be linear over the 1-millisecond sweep duration at 1 gigahertz. This is where Aerospace's specially developed sweep linearizer goes to work. It consists of two 6-inch-diameter dishes and a corner reflector, with the dishes—one receive and one transmit—mounted near the base of the pedestal holding the radar's 15-foot dish.

Part of the energy that would otherwise go to the feed horn of the big antenna is tapped off and radiated from the 6-inch transmit dish to the corner reflector. The reflector's distance from the two small dishes makes for a delay of 860 nanoseconds before the signal gets to the receive dish. But in that time, the bwo has moved some 860 khz, so that the radar's mixer actually sees two signals—one from the bwo and the delayed signal from the linearizer loop—860 khz apart. When the delayed and undelayed signals are compared in the mixer, the result is ideally a difference signal at 860 khz.

**Matchup.** This signal is then compared in phase with an 860-khz signal in a stable crystal-reference oscillator. Any phase difference is converted to an error voltage that modifies the linear voltage ramp modulating the bwo. This composite (the linear voltage ramp plus the error voltage) produces a linear frequency ramp in the bwo and a mixer output, both at 860 khz. The sweep linearizer thus functions as a phase-locked loop to give the linear sweep of 1 khz per nanosecond required to get the desired time-bandwidth product of 1 million.

The system has been tested over a 10-mile range, and Aerospace officials say they're confident of reaching their time-bandwidth-product and resolution goals.




**Handy.** One of eight MOS LSI chips in the Cogito 414.

## Integrated electronics

### Cogito, cogitas, cogitat . . .

When the SCM Corp. unveiled its Cogito 414, an $895 general-purpose desk calculator featuring a large-scale MOS array, top executives spoke glowingly of technological knowhow that had enabled them to put all the machine's circuitry on eight chips. What they didn't say is that the 414 was just the first of several LSI calculators on the way; the next, also MOS, is due in a matter of weeks.

The eight circuits in the new machine were developed at American Micro-systems Inc. by SCM engineers. AMI, which has worked closely with SCM during the 2½ years it has been in business, itself designed the four circuits to be used in the next calculator.

The eight 414 circuits are:

- two control chips containing microprograms;
- a memory chip consisting of three 68-bit shift registers;
- an adder plus a four-bit delay;
- a keyboard buffer (a decoder and a register to handle input signals);
- a transfer chip that's actually an elaborate switch to manipulate signals from the shift register and the arithmetic unit;
- a timing chip, with bit and character counters;

# 4 Amplifier High Gain "Building Block" Array

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The "matched set" of four is the RCA-CA3048. It provides 57 dB (typ.) voltage gain per amplifier or 114 dB (typ.) when two amplifiers are cascaded. Each amplifier features a Noise Figure of 2 dB (typ.) at 1 kHz, −3 dB bandwidth of 300 kHz, and an input resistance of 90 kΩ (typ.).

Ask your local RCA Representative or your RCA Distributor for full details. Or write for technical data to RCA Electronic Components, Commercial Engineering, Sec. ICN5-2, Harrison, N. J. 07029.

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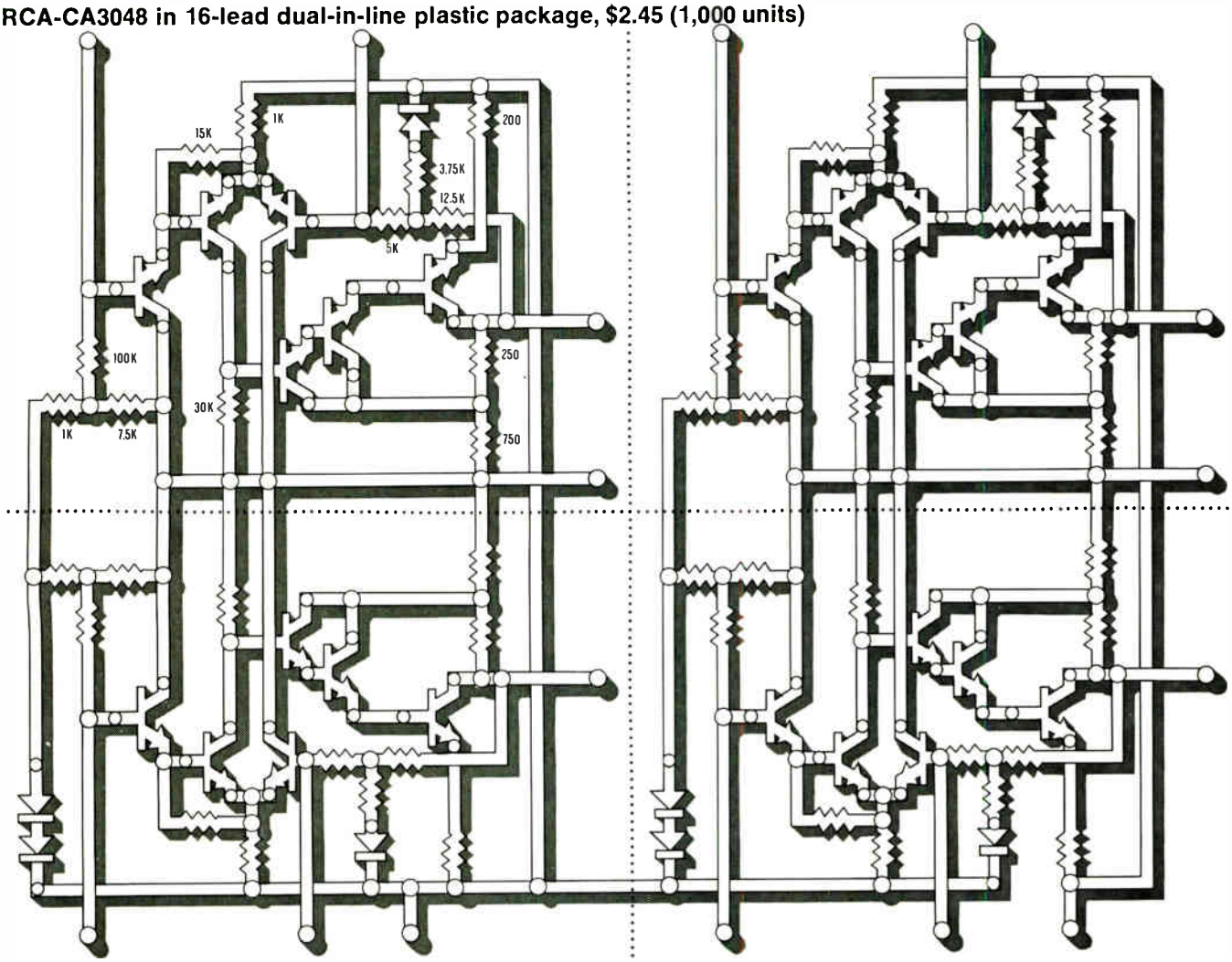
If you need an array with greater bandwidth—check: **RCA-CA3035**—Three individual general-purpose amplifiers with gain-bandwidth externally adjustable. $1.50 (1,000 units)

**RCA-CA3048 in 16-lead dual-in-line plastic package, $2.45 (1,000 units)**



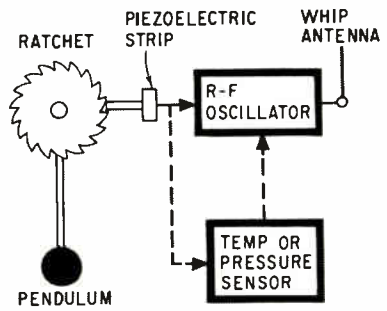

RCA Integrated Circuits

▪ and a display chip to control the drivers for the cold cathodes.

None of the chips is a read-only memory, though SCM says that the decoder and microprograms could take that form.

## Advanced technology

### It's a snap




**Powerful strip.** Piezoelectric strip, activated by ratchet, supplies enough power to drive radio transmitter.

Piezoelectric crystals aren't usually used as sources of electric power. Rather, they convert power, as in a microphone, from one form to another, or they're used in an oscillator to vibrate resonantly and thus help stabilize a circuit's frequency.

But Honig Laboratories of Westbury, N.Y., is using piezoelectric material as the sole source of electric power in a solid state transmitter. The company's goal is to develop a small, low-cost transmitter with an indefinite shelf and operating life, says William Honig, president. Tied into an oceanographic data buoy, the transmitter could send out information on water temperature, atmospheric pressure, or location. In the lifejacket of a pilot downed in the ocean, or thrown overboard from a small boat in trouble, such a transmitter could serve as a beacon for search and rescue craft.

Honig Lab's power source is a strip of piezoelectric material mounted as a cantilevered beam. When the strip is deflected or plucked and then suddenly released, as it would be by the rise and fall of ocean waves, it snaps back and produces a pulse of electrical power. Such pulses have been as strong as 200 milliwatts, over a snap-back interval of about a millisecond, Honig says.

**Mechanics.** In a breadboard model, this power drives a transistor oscillator. A pendulum-and-ratchet mechanism deflects the piezoelectric strip. A similar mechanical arrangement for deflecting the strip could be built into a buoy or a small-boat locator, Honig notes, and sensors in the buoy could also be powered by the device's pulses. Outputs from the sensors could frequency- or amplitude-modulate the r-f pulse, which is delivered to the terminals of a quarter-wave whip antenna.

Honig explains that the total efficiency of converting the mechanical stress energy to r-f power could be as high as 50% because the strip is plucked so that forces are applied along its poling axis—the axis along which a latent electric field is established when the material is heated in an external electric field during processing. The high total efficiency is also a result of the efficient energy-storage circuitry that's used, according to Honig.

Other applications Honig has in mind for his development are guarding industrial plants—the piezoelectric strip would be activated when stepped on by an intruder—and opening garage doors.

## Communications

### One vs. many

It's conceded in Washington that the country will eventually have a domestic communications satellite system, despite efforts to the contrary by established ground-based carriers. But the question has been whether the Federal Communications Commission will decide to go with special purpose or multipurpose satellites.

Now, with the White House believed to be leaning toward the multi-version, the smart money says that the FCC will recommend a pilot multipurpose system. All indicators point to release by the commission within weeks of a statement of policy and operating characteristics for the system. Then the commission will open itself to proposals from potential operators.

**Gap fillers.** The problem was brought into focus earlier this year when the General Electric Co. suggested that the FCC set up a special purpose satellite system to perform jobs not adequately handled by existing carriers. According to GE, those are computer data link, telemail (telegrams to post offices and delivered by postmen), video links for business conferences, and long-haul services for bulk users (such as television networks).

The FCC, hoping to get off the spot on some of the tough questions, was obviously taken by the idea. But the carriers strongly objected to the approach, preferring instead to have the commission grant a go-ahead for a multipurpose system that would act like a cable in space.

### Finding the way

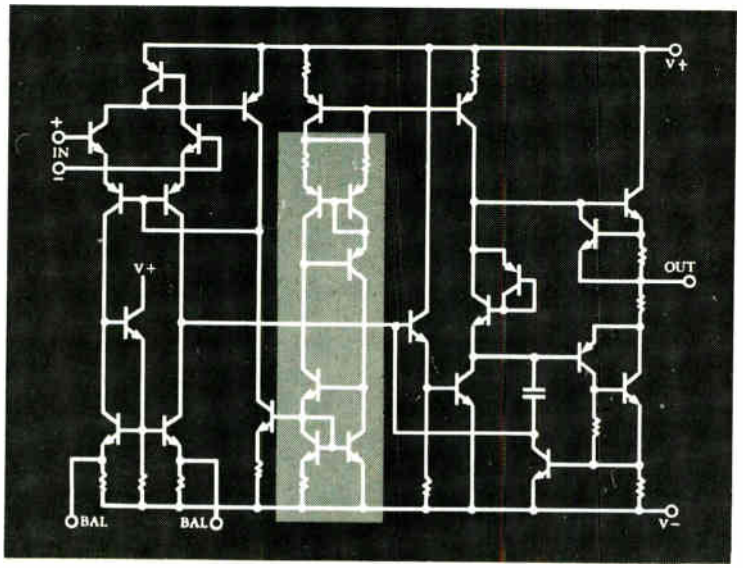
When the Federal Communications Commission last August opened an inquiry into frequency requirements of an urban vehicle locator system, it expected to get some solid suggestions from both industry and users. Now, the replies are in—and the FCC isn't much the wiser.

Only five equipment manufacturers and nine trade associations and users filed replies to the inquiry. There was great disagreement over whether or not enough is known today about urban vehicle locators to allow the FCC to start making rules.

**Wait.** Just how the FCC will handle the issue remains to be seen. But most likely it will postpone action until after September when it will have the results of a study, financed by a $200,000 grant from the Department of Housing and Urban Development, and being conducted by the Institute of Public Administration—a Washington think tank. The study will analyze different configurations for a public urban locator system (Pulse), and

# Op amps, like girls, are pretty much alike.

## Now meet Miss Universe.



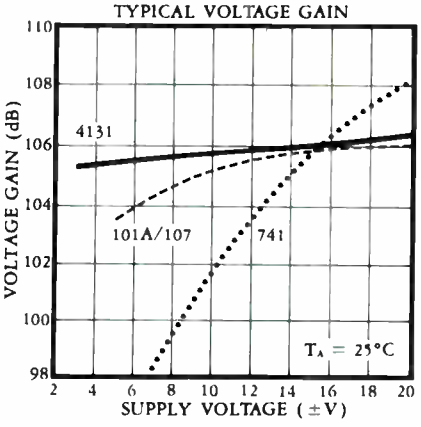

Now, we're not ones to thump the tub much. But this month we're unveiling our RM4131 fully compensated op amp, a pin-for-pin replacement for the good old 709, 101A, 107 and 741, and we felt you ought to know. It's not that the RM 4131 has anything the others don't have. It just has a potfull more of everything.

**Figures don't lie.**
Here are all the significant figures. Read 'em and weep, you other guys. And they don't even mention things like the RM4131 only needs a 10k ohm trim pot for balancing, not a 5 meg pot like some we could name.

| Specification | 741 | 107 | 4131 |
|---|---|---|---|
| Slew rate (v/μs) 2k load | 0.5 | 0.5 | 2.0 |
| Min. voltage gain (dB) @ ±3 volts | 80 | 80 | 94 |
| Typ. bandwidth (MHz) | 0.8 | 0.8 | 4.0 |
| Max. power consumption (mW) @ ±20V, 25°C | 120 | 120 | 64 |
| Max. bias current (nA) @ 25°C | 500 | 75 | 50 |
| Max. offset current (nA) @ −55 to 125°C | 200 | 20 | 20 |
| Max. offset voltage (mV) @ −55 to 125°C | 6.0 | 3.0 | 3.0 |

**Take slew rate.**
Compare our 2.0 v/μs typical slew rate to 0.5 v/μs for the others. And our slew rate is guaranteed 1.5 v/μs minimum across the whole ±3 to ±20-volt supply range, while the others peak sharply at ±15 volts.

**And voltage gain.**
Time now for a graph. Notice that the 107 shows specified gain only down to ±5 volts. At ±3 volts our RM4131 has 94 dB gain, compared to about 80 dB for the others.




**Or bandwidth.**
Naturally, frequency response jumps, too. At 25°C, the RM4131 is down 3 dB at 50 kHz, and hits unity gain at 4 MHz. Compare this to 8 kHz and 800 kHz respectively for 107s and 741s. Need we say more? Well, we will anyway.

**How come?**
Briefly stated, the RM4131 does all these neat things because of (1) that patent-pending current regulator in the gray patch above. It preserves gain at low voltages. And (2) our handy knack with small geometries, which gives frequency response a kick in the back porch. Plus (3) a winning way with latest process technologies, such as our new silicon nitride passivating layer for superb surface stabilities and high-beta transistors.

**And how much.**
Price for 100-999, full military version (−55°C to +125°C) is $20. Commercial versions are also available. So for evaluation quantities of our optimum op amp, see your Raytheon distributor. Or send for data from the company that's delivering the ideas in linear ICs. Raytheon Semiconductor, Mountain View, California. (415) 968-9211.

RAYTHEON

recommend Federal policy. However, the study is already due for some debate: most companies replying strongly suggested that the vehicle locator system, implying only location, should be renamed the automatic vehicle monitoring system, implying two-way command and control.

Wide disagreement exists even as to the future potential market for such a system: Raytheon figured a solid potential of up to 10,000 emergency-vehicle users and 50,000 fleet users such as taxis, while a more optimistic Hazeltine estimated up to 80,000 police and transit candidates and 200,000 fleet users.

Although most companies and associations urged the FCC to put off making rules for the time being, Motorola suggested that now was the time for the agency to make rules and offer assurances that other systems can enter the field as soon as they prove themselves.

The Teledyne Systems Co. more or less agreed. The company plugged for the adoption of its loran C-D receivers. Developed for the military, this system, Teledyne noted, has been well tested and needs no additional development funding.

The Electronic Industries Association, however, stressed the need for "a period of investigation of techniques and methods before direction of rule making can be determined." The EIA suggested the FCC should "with a minimum of regulations and rules," allow this exploration to take place, since standardization of a system based on current technology could hinder development in the future.

## Contracts

### Shorten the overruns

Congressional criticism over burgeoning budgets is forcing the Defense Department to find ways to curb enormous cost overruns on new weapons systems. While the Pentagon hasn't yet devised a broad policy to encounter the problem, it has taken some corrective measures on particular programs.

"Many contractors are so interested in getting the bid, they don't pay too much attention to price because they realize that during the course of the contract there will be so many change orders, that they can make up the differences in the original bid," says Defense Secretary Melvin R. Laird. "We have got to get our contract definition procedures in shape so that we don't get into this business of change too much, whether initiated by the contractor or by the military services."

To illustrate the problem, Laird has already toted up $1.8 billion in cost overruns in current aircraft, ship, and missile programs [*Electronics*, April 14, p. 70].

Laird proposes that before the Pentagon signs a procurement contracts it get into a position to get good bids and hold the contractors to the price they quote, allowing for inflation. To get that position, the Pentagon is considering an emphasis on competitive prototypes in subsystems, and sometimes even in full systems, before production decisions are reached.

**Longer look.** In a corollary move, Laird wants to spend more time in the test and evaluation phase of research and development programs. Too often, the Pentagon has started buying weapons systems before all the development bugs have been worked out. Laird has already delayed buying Boeing's SRAM and Minuteman 3 missiles for this reason.

As part of the new setup, the Navy is being encouraged to farm out ship design to competing individual contractors who can design with the peculiarities of their own shipyards in mind; to award a single multiyear, multiship contract to one yard instead of dividing the order among several yards; and to set up a single project manager for each major ship type so he can watch both cost and change control.

The new emphasis will also be seen in two new major programs, the F-15 fighter and the B-1A strategic bomber. The Air Force will be asked to lay out significant testing milestones that will have to be

Bob Dobkin
National Semiconductor

LINEAR BRIEF 2

# FEEDFORWARD COMPENSATION SPEEDS OP AMP

A feedforward compensation method increases the slew rate of the LM101A from 0.5/μs to 10V/μs as an inverting amplifier. This extends the usefulness of the device to frequencies an order of magnitude higher than the standard compensation network. With this speed improvement, IC op amps may be used in applications that previously required discretes. The compensation is relatively simple and does not change the offset voltage or current of the amplifier.

In order to achieve unconditional closed loop stability for all feedback connections, the gain of an operational amplifier is rolled off at 6 dB per octave, with the accompanying 90 degrees of phase shift, until a gain of unity is reached. The frequency compensation networks shape the open loop response to cross unity gain before the amplifier phase shift exceeds 180 degrees. Unity gain for the LM101A is designed to occur at 1 MHz. The reason for this is the lateral PNP transistors used for level shifting have poor high frequency response and exhibit excess phase shift about 1 MHz. Therefore, the stable closed loop bandwidth is limited to approximately 1 MHz.

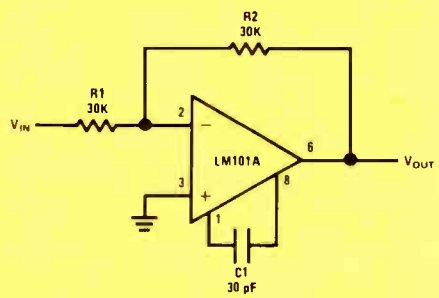



**FIGURE 1. Standard Frequency Compensation**

Usually, the LM101A is frequency compensated by a single 30 pF capacitor between Pins 1 and 8, as shown in Figure 1. This gives a slew rate of 0.5V/μs. The feedforward is achieved by connecting a 150 pF capacitor between the inverting input, Pin 2, and one of the compensation terminals, Pin 1, as shown in Figure 2. This eliminates the lateral PNP's from the signal path at high frequencies. Unity gain bandwidth is 3.5 MHz and the slew rate is 10V/μs. The diode can be added to improve slew with high speed input pulses.

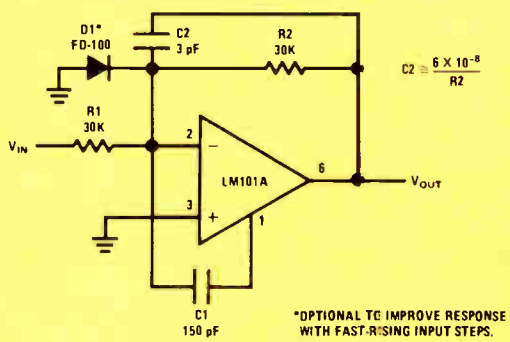



**FIGURE 2. Feedforward Frequency Compensation**

Figure 3 shows the open loop response in the high and low speed configuration. Higher open loop gain is realized with the fast compensation, as the gain rolls off at about 10 dB per octave until a gain of unity is reached at about 3.5 MHz. Figures 4 and 5 show the small signal and large signal transient response. There is a small amount of ringing; however, the amplifier is stable over a −55°C to +125°C temperature range. For comparison, large signal transient response with 30 pF frequency compensation is shown in Figure 6.

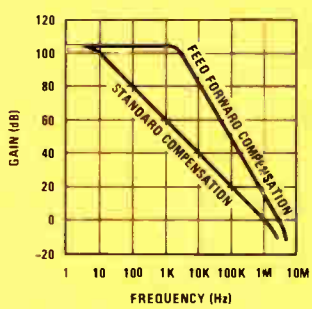



**FIGURE 3. Open Loop Response for Both Frequency Compensation Networks**

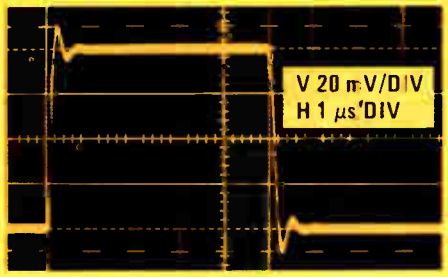



FIGURE 4. Small Signal Transient Response with Feedforward Compensation

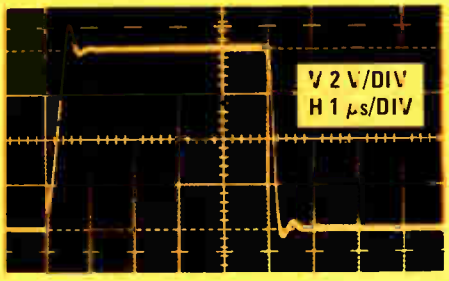



FIGURE 5. Large Signal Transient Response with Feedforward Compensation

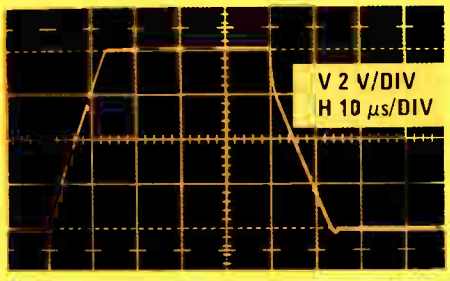



FIGURE 6. Large Signal Transient Response with Standard Compensation

As with all high frequency, high-gain amplifiers, certain precautions should be taken to insure stable operation. The power supplies should be bypassed near the amplifier with .01 μF disc capacitors. Stray capacitance, such as large lands on printed circuit boards, should be avoided at Pins 1, 2, 5, and 8. Load capacitance in excess of 75 pF should be decoupled, as shown in Figure 7; however, 500 pF of load capacitance can be tolerated without decoupling at the expense of bandwidth by the addition of 3 pF between Pins 1 and 8. A small capacitor $C_2$ is needed as a lead across the feedback resistor to insure that the rolloff is less than 12 dB per octave at unity gain. The capacitive reactance of $C_2$ should equal the feedback resistance between 2 and 3 MHz. For integrator applications, the lead capacitor is isolated from the feedback capacitor by a resistor, as shown in Figure 8.

Feedforward compensation offers a marked improvement over standard compensation. In addition to having higher bandwidth and slew, there is vanishingly small gain error from DC to 3 kHz, and less than 1% gain error up to 100 kHz as a unity gain inverter. The power bandwidth is also extended from 6 kHz to 250 kHz. Some applications for this type of amplifier are: fast summing amplifier, pulse amplifier, D/A and A/D systems, and fast integrator.

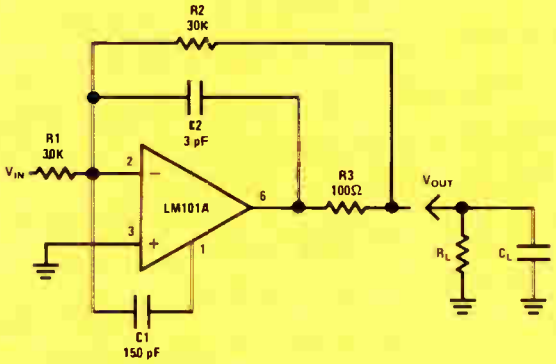



FIGURE 7. Capacitive Load Isolation

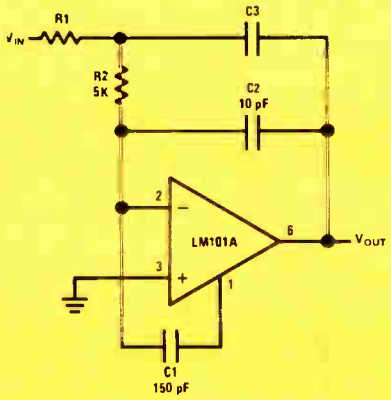



FIGURE 8. Fast Integrator

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reached in the research and development phase. The service will also be made to choose carefully among the weapons it wants to develop, since in the past it has begun more programs than it could finish.

## Components

### Bumping the substrate

The need for inexpensive and reliable integrated-circuit interconnections has led to the development of direct–flip-chip and beam-lead –bonding techniques. In both cases, the bump or beam is attached to the chip so that the chip can be attached to a substrate. Of course, it would be much easier if the bumps could be attached directly to the substrate to accommodate any chip. And a starting point may be the work that T.J. Matcovich and R.L. Coren of C&M Associates are doing for Du Pont, as described at the Electronic Components Conference in Washington earlier this month.

In his paper, Matcovich describes a method for attaching bumps, or pedestals, to a ceramic substrate—a process considered impractical up to now because of the difficulty of making all the bumps the same height so that the chip can be bonded in one step.

Using commercially available Motorola MC-359 IC chips with nine bonding points, Matcovich and Coren attach the bumps in the following manner. After conductive lines are printed and fired on the substrate, the bumps are formed at the nine bonding locations by printing pads (made of a combination of silver and platinum) over the conductive lines. To make bumps uniform in size and height, the researchers press them under a piece of metal slightly larger than the chip and containing nine tapered pits at the key points. This metal form not only shapes the bumps, but mashes down the conductive leads in the area where the chip is to go, eliminating any possibility of the chip's shorting out to the leads. Finally, the chip is ultrasonically bonded to the bumps.

## Displays

### Teacher in a tube

A demonstration random-access teaching system that can provide up to 240 different audio-visual programs simultaneously from its disk storage is being completed at a suburban Chicago high school.

According to its developer, Ampex' Special Products division, installation of the system's video portion will allow students at Oak Park and River Forest High School to select from up to 3,000 still television pictures, either independent of, or synchronized with, any of the school's 224 instructional audio tapes. Any of the images can be viewed on a student's tv monitor with an average waiting time of no more than a second.

The random-access video portion of the system is centered around three magnetic disks, each holding as many as 500 images on a side. Each of the disks has two moveable access heads directed by digital information on the audio tape to synchronize the video and audio. Video information on the master disks are fed to buffer disks, each having 40 stationary heads corresponding to 40 cathode-ray-tube terminals, or student outputs. There can be up to six disks.

**Easy come.** The video portion is analogous to the audio, which has a main bank of tapes. Each tape can be transferred within seconds to a tape recorder at each student's cubicle. With this system, students can begin tapes at irregular intervals; previously they had to be present at a specific time for tape start-up to avoid missing part of the lesson.

Total cost of the system will come to about $1.2 million, of which $400,000 covers the design and installation of the video. The price is high, concedes Weldon Squyres, market-support manager at Ampex, but he feels that one-time-only development and design accounts for a good percentage of that figure. However, any mass market that may develop will probably only be for components of the system, he says. Squyers believes that large university libraries may

# U. S. Reports

install such an audio system so that students, by depositing coins, could record any of thousands of lectures on their own tape cassettes.

## For the record

**Tape deal.** Du Pont's chromium dioxide magnetic tape will be produced in Europe by Philips' Gloeilampenfabrieken, according to a nonexclusive agreement negotiated by the two firms. The tape, called Crolyn and first marketed about two years ago [*Electronics*, June 26, 1967, p. 56], costs more than conventional tape. However, it can record twice as much per inch.

**Disk jockeying.** Information Storage Systems Inc. of Cupertino, Calif., has assigned Telex Computer Products of Tulsa, Okla., exclusive North American marketing and service rights to its newly developed disk pack drives. A source close to the deal says that about 2,400 of the disk drives are involved. Telex plans to market them for around $20,000 apiece. The new devices are said to be fully compatible with the IBM 360 computer line. Information Storage, which was formed by a group of ex-IBM disk-drive people, expects to start deliveries in a month or so.

**New classification?** As a 22-man panel appointed by MIT ponders the university's role in military research (a preliminary report is due May 31 and the final word is to appear Oct. 1), industry leaders and Washington sources don't appear to be overly concerned. Even though MIT president Harold W. Johnson has announced that no new classified projects will be accepted by the Lincoln or Instrumentation Laboratories during the special committee's deliberations, on-going projects such as the Poseidon missile and the Self-Aligned Boost and Reentry System (SAPRE) are unaffected.

Even if MIT should decide to drop all classified programs, the consequences to the nation's technical competence wouldn't be


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| Dual 4-input Complementary Gate | SW1206 | SW1006 |
| Quad 2-input NOR Gate | SW1210 | SW1010 |
| Quad 2-input NOR Gate | SW1211 | SW1011 |
| Quad 2-input NOR Gate | SW1212 | SW1012 |
| 85-MHz AC-Coupled J-K Flip-Flop | SW1213 | SW1013 |
| Dual R-S Flip-Flop (Positive Clock) | SW1214 | SW1014 |
| Dual R-S Flip-Flop (Negative Clock) | SW1215 | SW1015 |
| Dual R-S Flip-Flop (Single Rail, Positive Clock) | SW1216 | SW1016 |
| Translator—ECL to Saturated Logic | SW1218 | SW1018 |
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## U.S. Reports

grave. Just about all of the work, particularly at the Instrumentation Lab, is classified confidential—the lowest security priority. In fact, much of the research and development could be carried out clear of any classification at all. And any classified work remaining would certainly be picked up by companies, according to Alan J. Grant, former president of the Lockheed Electronics Corp. and now a group vice president of Fairchild Camera & Instrument. In 1968, Government projects at both laboratories totaled $116 million, with about half being classified.

**Thin lines.** Fairchild Semiconductor has developed a method calculated to pack more semiconductor chips on a ceramic substrate. Since most of the area is taken up by the printed conductors, Fairchild simply prints them smaller. But it's not really as simple as that.

The limiting factor in printing fine lines, according to William Littell, senior engineer in charge of thick-film process development, is the silk or metal screen. This screen is usually placed under the mask, and the resolution of the printed conductor is determined by the clearance between screen, mask, and substrate. The narrower the clearance, the thinner the lines. Fairchild eliminates the space between screen and mask by combining the two, and the space between mask and substrate by using contact printing.

The combined mask and screen is actually one sheet of metal with the desired pattern etched halfway through on one side, and the grid pattern etched halfway through on the other. Fairchild will employ this technique in the manufacture of custom hybrids—about 80% of its hybrid business is custom. Littell says that besides getting more chips on a substrate, the technique will accommodate flip-chip and beam-lead bonding of very complex chips; as the devices become larger, the space between the bonding pads decreases, and if a conductor network is to align itself with the balls of the flip-chip device, the conductor width must be as small as 2 to 4 mils.

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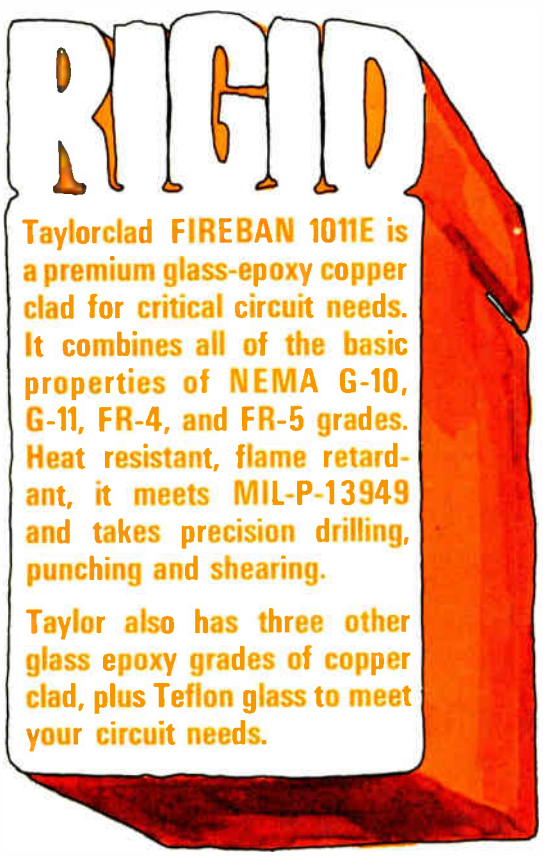

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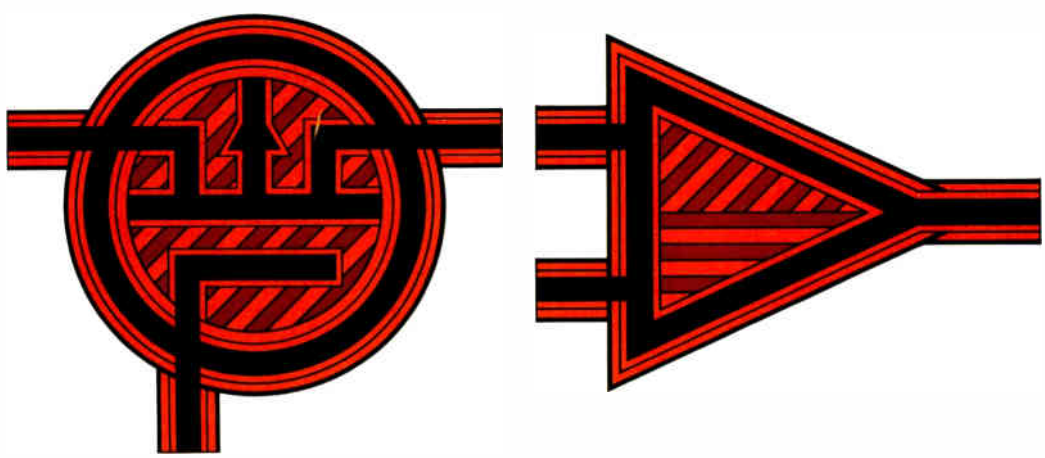
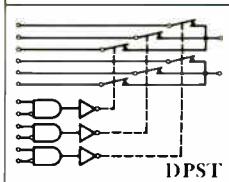
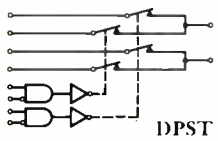
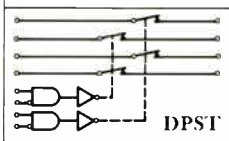
Applications Power *

# more data transmission applications for ANALOG SWITCHES & OP AMPS

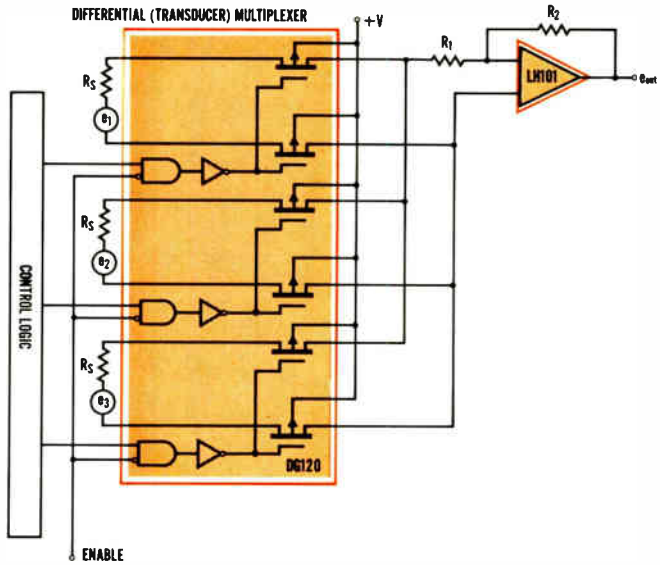


* Applications Power . . . A broad product line, an extensive network of stocking distributors and an experienced applications team waiting to serve you.

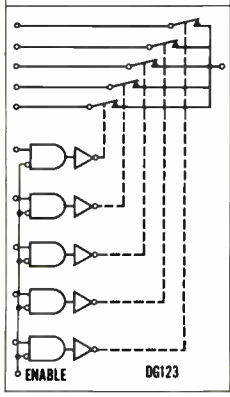
# Here are two more examples that illustrate the versatility of Siliconix driver/FET switch packages in data transmission systems.

| Functional Description | Channels | Type | Max. $r_{DS(ON)}$ (ohms) | Switch Type |
|---|---|---|---|---|
|  DPST | 3 | DG120<br>121 | 600<br>600 | PMOS<br>PMOS |
|  DPST | 2 | DG122<br>132 | 600<br>600 | PMOS<br>PMOS |
|  DPST | 2 | DG126<br>129<br>140 | 80<br>30<br>10 | N<br>N<br>N |

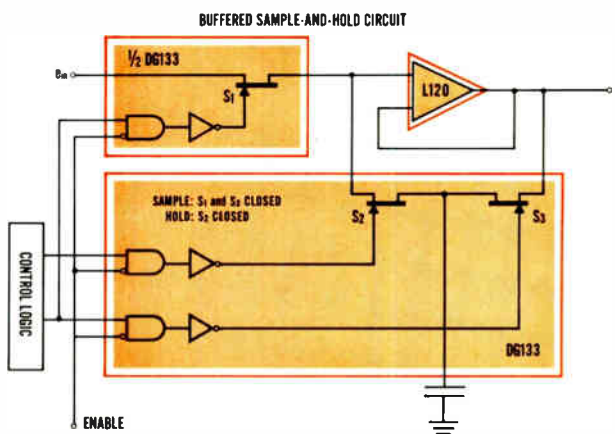
Two and three channel packages are available with various ON resistances to meet your specific requirements. Drivers accept standard DTL, RTL, or TTL logic inputs.



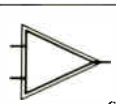
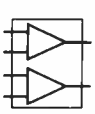

This three channel version of a transducer-multiplexer uses a single DG120 along with an LH101.

| Functional Description | Channels | Type | Max. $r_{DS(ON)}$ (ohms) | Switch Type |
|---|---|---|---|---|
|  ENABLE DG123 | 2 | DG110<br>111<br>112<br>133<br>134<br>141<br>147<br>148 | 600<br>600<br>600<br>30<br>80<br>10<br>600<br>40 | PMOS<br>PMOS<br>PMOS<br>N<br>N<br>N<br>PMOS<br>PMOS |
| | 4 | DG116<br>118 | 600<br>600 | PMOS<br>PMOS |
| | 5 | DG123<br>125 | 600<br>600 | PMOS<br>PMOS |

One of these driver/switch combinations may be used with your sample-and-hold circuit. These switches may also be used to implement your multiplexer/decoding functions.




Low input leakage of the L120 OP AMP makes it ideally suited for sample-and-hold circuits. Two channels of this circuit require only three DG133s and one L120. An alternative approach would require two DG129s and one L120 for two channels.

| 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<br>LH 101 (Internally compensated) | 6 mV | 500 nA | 50K | ±12V | 0.25V/μsec. | • Operation from ±5 to ±20V power supplies<br>• Low current drain<br>• Continuous short circuit protection<br>• Same pin configuration as 709 amplifier |
|  L 120 | 200 mV | 50 pA | 100 | ±12V | 20V/μsec. | • Low input leakage<br>• High slew rate<br>• Unity gain stable<br>• Ideal for sample and hold, integrating and fast voltage comparisons |

*Working on data transmission? Write today for complete data on any or all Siliconix driver/FET switch combinations and OP AMPS.*

***For instant applications assistance, call the number below. Ask for Extension 19.***


**Siliconix incorporated**

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*Telephone (408) 245-1000 • TWX 910-339-9216*

When Jozef Hendriks was a boy, ten-year guarantees were commonplace.

Venray in The Netherlands used to be a no-nonsense town. Like most any town in the States. Inventive genius was governed by a hard morality. You made something new. It worked. You guaranteed it. None of this Oops-Sorry-Back-To-The-Drawing-Board business. The maker, not the user, paid for the maker's mistakes.

Joe Hendriks spent his boyhood in Venray. His budding genius was governed by that hard morality. You made something. It worked. You guaranteed it.

Joe Hendriks now works for Teradyne. He designs instruments to test electronic components. He designs them for such dogged reliability that, you guessed it, Teradyne provides a ten-year guarantee on each instrument's electronic circuitry.

25 or 30 years ago maybe this wasn't such a big deal. Today it's a big big deal. Errors are more expensive than ever. One bad component that gets into an assembly can cost more than the entire lot it came from. And guarantees are fewer and farther between.

With all their esoteric knowledge and capability for flights of fancy, Teradyne designers like Joe Hendriks are as old-fashioned as sin. They wouldn't be caught dead using tubes, stepping switches or conventional relays, or programming equipment that can't be cross-checked.

You get the idea. Teradyne is in the business of designing long-life instruments, not for the laboratory, but for the production line.

If your profits are made by making, distributing or using electronic components, be glad for the Joe Hendrikses in this world of the quick and easy. You need automatic instruments guaranteed to work for the next ten years without adjustment. You can buy them from Teradyne, 183 Essex Street, Boston, Massachusetts 02111.

# Teradyne makes sense.

# What are TI semiconductors doing in department stores?

## (Solving problems like yours)

# In industry after industry, our customers are doing old jobs better and new jobs in new ways.

## In department stores

Digital Data Systems' "Creditmaster" validating system (left) enables retailers to check credit cards in one second from countertop remote terminals. A central processor identifies card as (a) good, (b) good for a limited amount, (c) lost or stolen, or (d) possible counterfeit.

Extensive use of TI medium-scale integration (MSI) and plastic-encapsulated TTL integrated circuits greatly reduced equipment size and design time and cost, while increasing reliability and ease of maintenance.

## In currency changers

Transmarine Corporation uses TI's SN72709N operational amplifier in a currency validating system so fraud-proof no counterfeit bill can beat it.

TI linear integrated circuits enabled Transmarine to reduce d-c amplifier drift from ±50 to ±8 percent. Production time was cut by 25 percent, size by 60 percent, and cost by 50 percent.

## In your broker's office

The VidiQuote display from Trans-Lux Corporation converts stock-market quotations into a continuously updated display.

LSI/MOS 32-bit shift registers maintain the display on the monitor screen for a continuous image. Synchronization signals are provided by Series 74 TTL integrated circuits and TI DTL circuits. The new Trans-Lux system features significant cost savings, plus reduction in size.

## In highway construction

MicroMetric Corporation's 3-axis reversible scaler simplifies translation of data from drawings or photos into computer language for computation of construction problems such as the amount of roadbed fill required. MSI/TTL from TI enabled MicroMetric to cut costs while increasing speed from 30 kHz to 5 MHz and reducing size by two-thirds.

## In power plants

Scam Instrument Corporation developed a new recording annunciator to monitor up to a thousand points in power plants and other industrial systems.

Series 74N MSI/TTL integrated circuits were used, and as a result, logic hardware costs were cut by two-thirds. Monitoring capacity was nearly doubled, resolution was improved from 1250 to 800 microseconds, and overall size was reduced by 80 percent.

In hospitals...chemical plants... machine shops...printing plants... paper mills...water metering... offices...automotive skid controls ...TI is helping customers like you do old jobs better and new things in new ways.

What's *your* problem? Chances are, TI can help with industry's broadest line of semiconductors, advanced custom technologies, and applications assistance. Call your local TI distributor or TI sales engineer.

TEXAS INSTRUMENTS
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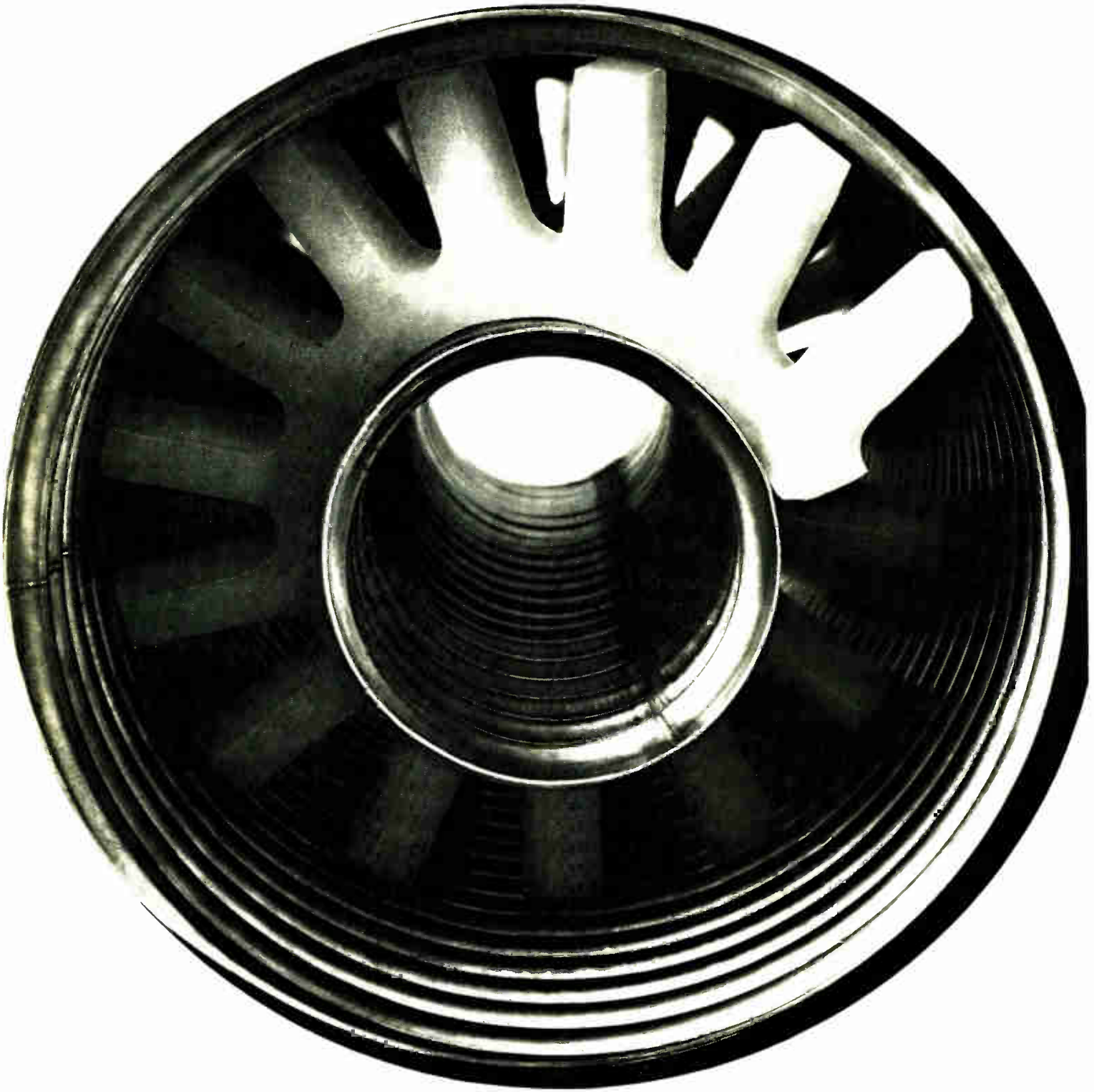

Faced with carrying a couple of hundred RF kilowatts? Need low, low attenuation? Move up to 8" HELIAX® coaxial cable. Big. Semi-flexible. Continuous lengths to 850 feet. Eliminates connector bullets and complicated hangers. Thermal expansion and contraction don't faze it. Power capabilities: 300 kw average at 30 MHz; 58 kw at 600 MHz. Use for HF; Tropo; OTH radar; VHF and UHF-TV. Wouldn't you like to know more? Communicate with Andrew. 11-68

ANDREW

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Circle 74 on reader service card

# Washington Newsletter

May 12, 1969

**Army developers of day-night tv face in-house rivalry . . .**

There may be trouble brewing within the Army Electronics Command over its lagging low-light-level television systems program. Problems still plague the night-vision systems developed around secondary electron conduction (sec) vidicon tubes. And now a competing system, built from off-the-shelf components, has progressed to a point where its developers want to contract for an operational system. However, they worry that the sec researchers may try to delay procurement of the new system until they can improve and justify its own program.

For several years, the Army's night vision laboratory has been spending millions of dollars annually to develop the sec vidicon system. However, the tubes are still very expensive and difficult to build.

Pressed by Vietnam war demands and discouraged by the delays in developing the sec system, the Army more than a year ago asked the Electronic Command's night vision and illumination branch—which usually is concerned only with procurement—to develop a cheaper version.

The branch developed what it calls the day and night television system, or Dants. It is built around such components as a Starlight sniperscope (which uses image-enhancement tubes) connected by fiber optics to a high-resolution Oxicon tube (a U.S. version of the Plumbicon tube).

Developers of the Dants night vision system say it outperforms the sec systems though it costs only a fifth as much. A typical sec system goes for about $75,000.

Preliminary tests show that a 25-millimeter-aperture Dants system can equal the output of an 80-mm-aperture sec tube. Sec systems have produced pictures with a resolution of 600 tv lines at $1 \times 10^{-5}$ foot-candles scene brightness, but an 80-mm Dants tube will give a picture resolution of more than 1,000 tv lines.

**. . . so old rival Navy may buy first units**

The Navy reportedly is very interested in Dants, and could end up buying units before the Army does. In a test in the Atlantic for the Navy, Dants produced a clear picture of a 30-foot gray boat at 1,000 meters during starlight conditions.

Several companies are already involved in the Dants program. General Precision Laboratories built an early model; the General Electrodynamics Corp. has built a prototype using its Oxicon tube; and Autonetics, a relative latecomer to the program, now has a system near the checkout stage. Once requests go out for a Dants system, more companies are expected to join in the competition.

**Pentagon weighs updated versions of airborne CP's**

The current timetable for the expensive updating of the nation's airborne command posts calls for contract definition to begin in fiscal 1971. The Pentagon, now in the design and analysis phase of the program, is weighing many alternatives, including the use of DC-8 or 707 jetliners, C-5A or 747 jumbo jets, or the present EC-135's in refurbished form.

The planes will carry either a modified version of the present communications setup or a more elaborate combination involving satellite communications. Cost of the total system could range from $300 million to as much as $700 million depending on the mix. Research and development alone could cost $100 million if the most complex, or satellite, version is chosen.

# Washington Newsletter

## Safeguard may face software hurdle, too

**While capital controversy currently centers on the technological feasibility of radar and missile hardware for the proposed Safeguard Sentinel antiballistic-missile system, the biggest problem may turn out to be the ABM computer software.**

Insiders say that programing the computer complexes that will monitor and interpret the radar data will be a formidable task. For one thing, the computers, working without complete descriptions of targets picked up, will have to determine whether they're hostile or not. "How do you program computers to distinguish between natural phenomena, such as meteorites, and incoming missiles when their 'signatures' are similar?" asks one insider. And the sheer amount of programing necessary presents an added problem. One major difficulty the Pentagon had with the simpler Sage air-defense system was the system's unwieldy programing.

## House gets bill to curtail FCC's control of CATV

**Congress may finally get around to taking a look at the cable television question and may even provide guidelines to the FCC on how to handle it.**

Rep. Samuel Stratton (D., N.Y.), whose upstate New York district has no broadcast stations but does have cable systems and a large cable components manufacturer, the Taco Co., has introduced a bill limiting the FCC's authority to regulate CATV. Stratton charges that the FCC's Dec. 12 freeze on CATV expansion has started to "strangle" the industry [*Electronics*, Dec. 12, 1968, p. 48]. He revealed that Taco has laid off 400 employees—half its work force—as a result of lack of cable expansion.

**Stratton's bill would require the FCC to set technical standards for CATV and would require that CATV be limited only when a broadcaster could prove economic injury.** CATV interests are currently locked in a battle with broadcasters over such issues as importing distant signals and program origination. Although Stratton admits his bill might not be the best possible solution, it focuses Congressional attention on the issue.

Meanwhile, the House Communications subcommittee, at the urging of Rep. Lionel Van Deerlin (D., Calif.) ranking Democrat on the committee, will probably hold hearings on CATV in May or June.

## Pentagon sees gap in laser research

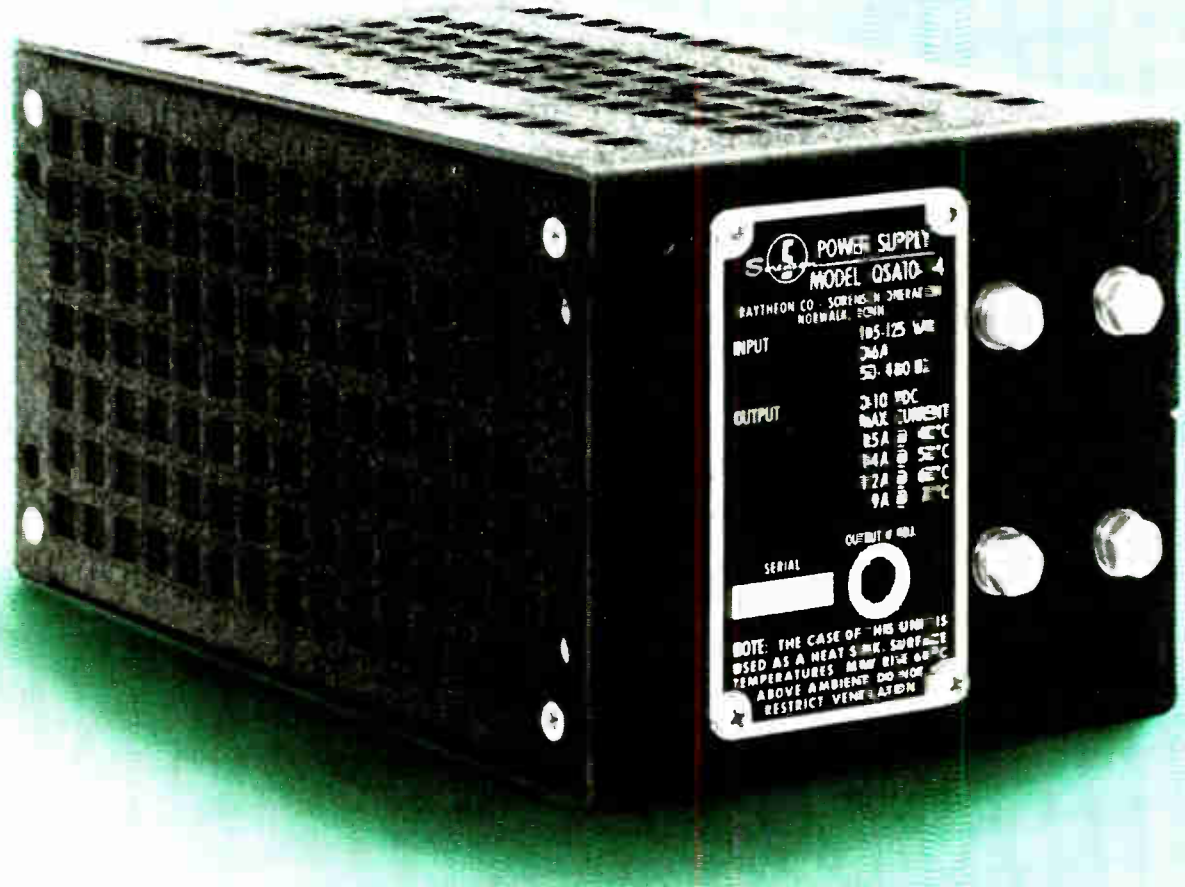
**Soviet advances in the military use of laser, radar, and microwave technology may spur a major push in these areas by the Defense Department.** The Pentagon has revealed that while the Soviet Union appears to be years behind this country in the military use of integrated circuits, Russia may be ahead of the U.S. in the development of high-power solid state lasers. Further, according to Pentagon insiders, **Russia is matching our efforts in the development of microwave antennas as well as large multibeam electronically-steerable phased arrays.**

## Addenda

**The Navy has ordered an investigation into the biological effects of exposure to radar.** In hearings last year on the radiation protection bill, it was pointed out that the Soviet's military has much lower radiation-exposure limits than the American. If the Navy study, to be carried out by the Zaret Foundation Inc., shows there is biological damage from radar, it could require changes in radar designs. . . . **Boeing has been awarded a $350,000 contract by the FAA to study the use of L-band satellite signals for aeronautical services satellites** [*Electronics*, March 31, p. 67]. The contract calls for the establishment of design criteria.

# Sorensen modular power supplies

# ±0.005% regulation $89.00




■ Optional 10μ sec. overvoltage protection. ■ Requires no external heat sink in ambients to 71° C. ■ 29 models—voltages to 330 Vdc at power levels to 300 watts. ■ Remote programming—remote sensing—series/parallel operation. ■ Overload and short circuit protection. ■ Meets military specifications.

Model QSA 10-1.4, shown actual size, illustrates the compactness of the Sorensen QSA Series. These laboratory-grade, precision power sources are designed for OEM or system applications and utilize the latest solid-state regulating technology to provide a high degree of regulation and stability.

Sorensen produces 29 wide-range models, each with optional overvoltage protection. Other manufacturers require more than 100 models to cover the same area. By producing and stocking fewer models, Sorensen is able to provide better specifications, higher reliability, lower prices and "same-day shipments."

For more information contact your local Sorensen representative or; Raytheon Company, Sorensen Operation, Richards Ave., Norwalk, Conn. 06856. Tel.: 203-838-6571; TWX: 710-468-2940; TELEX: 96-5953.

RAYTHEON

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Circle 200 on Inquiry Card

# Let's get specific

## 1. Some manufacturers advertise "broad line"

## TRANSITRON is shipping the following devices:*

### SERIES I INTEGRATED CIRCUITS

| Type No. | Circuit Function | Fan-out | Temp. Range |
|---|---|---|---|
| TG 40 | Dual 4-Input | 15 | M |
| TG 41 | NAND Gate | 7 | M |
| TG 42 | | 12 | I |
| TG 43 | | 6 | I |
| TG 50 | Expandable | 15 | M |
| TG 51 | Quad 2-Input | 7 | M |
| TG 52 | OR Gate | 12 | I |
| TG 53 | | 6 | I |
| TG 60 | Single 8-Input | 15 | M |
| TG 61 | NAND Gate | 7 | M |
| TG 62 | | 12 | I |
| TG 63 | | 6 | I |
| TG 70 | Expandable | 15 | M |
| TG 71 | Dual 2 x 2 | 7 | M |
| TG 72 | Exclusive OR | 12 | I |
| TG 73 | Gate | 6 | I |
| TG 80 | Dual Pulse | 15 | M |
| TG 81 | Shaper/Delay | 7 | M |
| TG 82 | AND Gate | 12 | I |
| TG 83 | | 6 | I |
| TG 90 | Exclusive OR | 15 | M |
| TG 91 | with Comple- | 7 | M |
| TG 92 | ment | 12 | I |
| TG 93 | | 6 | I |
| TG 100 | Expandable | 15 | M |
| TG 101 | Triple 3-Input | 7 | M |
| TG 102 | AND-OR Invert | 12 | I |
| TG 103 | Gate | 6 | I |
| TG 110 | Expandable | 15 | M |
| TG 111 | Dual 4-Input | 7 | M |
| TG 112 | OR Gate | 12 | I |
| TG 113 | | 6 | I |
| TG 120 | Expandable | 15 | M |
| TG 121 | Single 8-Input | 7 | M |
| TG 122 | NAND Gate | 12 | I |
| TG 123 | | 6 | I |
| TG 130 | Dual 4-Input | 30 | M |
| TG 131 | Line Driver | 15 | M |
| TG 132 | | 24 | I |
| TG 133 | | 12 | I |
| TG 140 | Quad 2-Input | 15 | M |
| TG 141 | NAND Gate | 7 | M |
| TG 142 | Quad 2-Input | 12 | I |
| TG 143 | NAND Gate | 6 | I |
| TG 150 | Quad 2-Input | — | M |
| TG 151 | OR Expander | — | M |
| TG 152 | | — | I |
| TG 153 | | — | I |
| TG 160 | Triple 2-Input | 30 | M |
| TG 161 | Bus Driver | 15 | M |
| TG 162 | | 30 | I |
| TG 163 | | 15 | I |
| TG 170 | Dual 4-Input | — | M |
| TG 171 | OR Expander | — | M |
| TG 172 | | — | I |
| TG 173 | | — | I |
| TG 180 | Dual 4-Input | — | M |
| TG 181 | AND Expander | — | M |
| TG 182 | | — | I |
| TG 183 | | — | I |
| TG 190 | Triple 3-Input | 15 | M |
| TG 191 | NAND Gate | 7 | M |
| TG 192 | | 12 | I |
| TG 193 | | 6 | I |
| TF 20 | Two-Phase SR | 15 | M |
| TF 21 | Clocked Flip | 7 | M |
| TF 22 | Flop | 12 | I |
| TF 23 | | 6 | I |
| TF 50 | Charge Stor- | 15 | M |
| TF 51 | age JK Flip | 7 | M |
| TF 52 | Flop (AND | 12 | I |
| TF 53 | Inputs) | 6 | I |
| TF 60 | Charge Stor- | 15 | M |
| TF 61 | age JK Flip | 7 | M |
| TF 62 | Flop (OR | 12 | I |
| TF 63 | Inputs) | 6 | I |
| TF 100 | Dual 35 MHz | 11 | M |
| TF 101 | JK Flip-Flop | 6 | M |
| TF 102 | (Separate | 9 | I |
| TF 103 | Clock) | 5 | I |
| TF 110 | Dual 35 MHz | 11 | M |
| TF 111 | JK Flip-Flop | 6 | M |
| TF 112 | (Common | 9 | I |
| TF 113 | Clock) | 5 | I |

### SERIES II INTEGRATED CIRCUITS

| Type No. | Circuit Function | Fan-out | Temp. Range |
|---|---|---|---|
| TG 200 | Expandable | 11 | M |
| TG 201 | Single 8-Input | 6 | M |
| TG 202 | NAND Gate | 9 | I |
| TG 203 | | 5 | I |
| TG 210 | Expandable | 11 | M |
| TG 211 | Dual 4-Input | 6 | M |
| TG 212 | OR Gate | 9 | I |
| TG 213 | | 5 | I |
| TG 220 | Quad 2-Input | 11 | M |
| TG 221 | NAND Gate | 6 | M |
| TG 222 | | 9 | I |
| TG 223 | | 5 | I |
| TG 230 | Quad 2-Input | — | M |
| TG 231 | OR Expander | — | M |
| TG 232 | | — | I |
| TG 233 | | — | I |
| TG240 | Dual 4-Input | 11 | M |
| TG 241 | NAND Gate | 6 | M |
| TG 242 | | 9 | I |
| TG 243 | | 5 | I |
| TG 250 | Expandable | 11 | M |
| TG 251 | Quad 2-Input | 6 | M |
| TG 252 | OR Gate | 9 | I |
| TG 253 | | 5 | I |
| TG 260 | Single 8-Input | 11 | M |
| TG 261 | NAND Gate | 6 | M |
| TG 262 | | 9 | I |
| TG 263 | | 5 | I |
| TG 270 | Dual 4-Input | — | M |
| TG 271 | OR Expander | — | M |
| TG 272 | | — | I |
| TG 273 | | — | I |
| TG 280 | Expandable | 10 | M |
| TG 281 | Dual 4-Input | 5 | M |
| TG 282 | AND Gate | 8 | I |
| TG 283 | | 4 | I |
| TG 290 | Dual 2 + 3 | — | M |
| TG 291 | Input OR | — | M |
| TG 292 | Expander | — | I |
| TG 293 | | — | I |
| TG 300 | Expandable | 11 | M |
| TG 301 | Triple 3-Input | 6 | M |
| TG 302 | AND-OR Invert | 9 | I |
| TG 303 | Gate | 5 | I |
| TG 310 | Expandable | 11 | M |
| TG 311 | Dual 2 + 2 | 6 | M |
| TG 312 | Exclusive OR | 9 | I |
| TG 313 | Gate | 5 | I |
| TG 320 | Triple 3-Input | 11 | M |
| TG 321 | NAND Gate | 6 | M |
| TG 322 | | 9 | I |
| TG 323 | | 5 | I |
| TG 350 | Quad 2-Input | 22 | M |
| TG 352 | Lamp Driver | 18 | I |
| TF 120 | Dual 50 MHz | 11 | M |
| TF 121 | JK Flip-Flop | 6 | M |
| TF 122 | (Separate | 9 | I |
| TF 123 | Clock) | 5 | I |
| TF 130 | Dual 50 MHz | 11 | M |
| TF 131 | JK Flip-Flop | 6 | M |
| TF 132 | (Common | 9 | I |
| TF 133 | Clock) | 5 | I |
| TF 200 | 50 MHz JK | 11 | M |
| TF 201 | Flip-Flop (AND | 6 | M |
| TF 202 | Inputs) | 9 | I |
| TF 203 | | 5 | I |
| TF 210 | 50 MHz JK | 11 | M |
| TF 211 | Flip-Flop (OR | 6 | M |
| TF 212 | Inputs) | 9 | I |
| TF 213 | | 5 | I |
| TF 250 | Charge Stor- | 11 | M |
| TF 251 | age JK Flip- | 6 | M |
| TF 252 | Flop (AND | 9 | I |
| TF 253 | Inputs) | 5 | I |
| TF 260 | Charge Stor- | 11 | M |
| TF 261 | age JK Flip- | 6 | M |
| TF 262 | Flop (OR | 9 | I |
| TF 263 | Inputs) | 5 | I |

* Electrically and mechanically interchangeable with SUHL I and II.

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# about TTL

## 2. Some manufacturers talk vaguely about MSI availability

## TRANSITRON has the following Series III complex functions available...NOW:

### SERIES III DIGITAL FUNCTIONAL ARRAYS

| Type No. | Circuit Function | Temp. Range |
|---|---|---|
| TA 10 | Full Adder | M |
| TA 11 | | M |
| TA 12 | | I |
| TA 13 | | I |
| TA 20 | Dependent Carry | M |
| TA 21 | Fast Adder | M |
| TA 22 | | I |
| TA 23 | | I |
| TA 30 | Independent Carry | M |
| TA 31 | Fast Adder | M |
| TA 32 | | I |
| TA 33 | | I |

| Type No. | Circuit Function | Temp. Range |
|---|---|---|
| TD 40 | Carry Decoder | M |
| TD 42 | | I |
| TR 60 | 4-Bit Storage | M |
| TR 61 | Register | M |
| TR 62 | | I |
| TR 63 | | I |
| TR 70 | 4-Bit Storage | M |
| TR 71 | Register Bus | M |
| TR 72 | Transfer Output | I |
| TR 73 | | I |
| TM 81 | 16-Bit Memory | M |
| TM 82 | | I |
| TM 83 | | I |

### ...PLUS THESE EXCLUSIVE TRANSITRON SERIES III DEVICES

| Type No. | Circuit Function | Temp. Range |
|---|---|---|
| TC 11 | Binary Ripple Counter | M |
| TC 12 | | I |
| TC 13 | | M |
| TC 14 | | I |
| TC 15 | BCD Ripple Counter | M |
| TC 16 | | I |
| TC 17 | | M |
| TC 18 | | I |

| Type No. | Circuit Function | Temp. Range |
|---|---|---|
| TR 15 | 4-Bit Shift Register | M |
| TR 16 | (Non-resettable) | I |
| TR 17 | | M |
| TR 18 | | I |
| TR 25 | 4-Bit Shift Register | M |
| TR 26 | (Resettable) | I |
| TR 27 | | M |
| TR 28 | | I |

## 3. Some manufacturers talk "fast delivery"

## TRANSITRON can ship most requirements within 24 HOURS of receipt of order

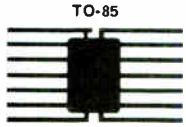
Because we maintain depth stocks of all major active types, Transitron can fill 90% of your TTL requirements off the shelf. This means that, when you have an urgent requirement, we can and will ship within 24 hours of the time we receive your order. If you need one of the few specials which we don't stock, it may take us a little longer . . . but not much.

**GET THE SPECIFICS FROM TRANSITRON . . .** Your broadest industry source for TTL.

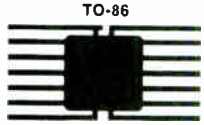
Write for complete specifications and data on any of the types shown here. And if you want TTL in plastic, ask for information on Transitron's 7400/5400 Series.

### TTL PACKAGE OPTIONS

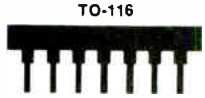
TO-85



TO-86



TO-116



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Orlando, Florida 32806
22 W. Lake Beauty Drive
Suite 201
(305) CHerry 1-4526

**PHILADELPHIA**
King of Prussia, Pa. 19406
580 Shoemaker Road
(215) 242-3995

**PHOENIX**
Scottsdale, Arizona 85251
77 3rd Avenue West
Suite 210
(602) 945-0771

**SAN FRANCISCO**
Palo Alto, California 94303
991 Commercial St.
Room 5
(415) 961-1954

**CANADA**
Toronto 18, Canada
1229 The Queensway
Suite 9
(416) CLifford 9-5461

**Transitron**
electronic corporation
168 Albion Street Wakefield, Massachusetts 01880

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

# "Unbelievable!"

**"Unbelievable!"**

But true.
The new Codex Model AE-96 modulator/demodulator can make 1 leased line do the work of 4, by transmitting and receiving data at 9600 bps over lines previously utilized at 2400 bps or 4800 bps at the most. Accuracy is as good as with 2400 bps equipment.

**"Tell me another"**

It has an Automatic Equalizer ("AE") that conditions the 9600-bit data to travel smoothly on one voice grade Type 3002, C-2 conditioned line. You just push a button for initial equalization, which takes a mere 3½ seconds. The equalizer then monitors and optimizes performance 8 times per second to compensate for line changes. No hours of manual tweaking.

**"You've struck a nerve"**

Codex s 9600 bps Modem is in use and on the production line. It meets RS 232B Interface Standard (full duplex) of EIA, and MIL Std. 188B.

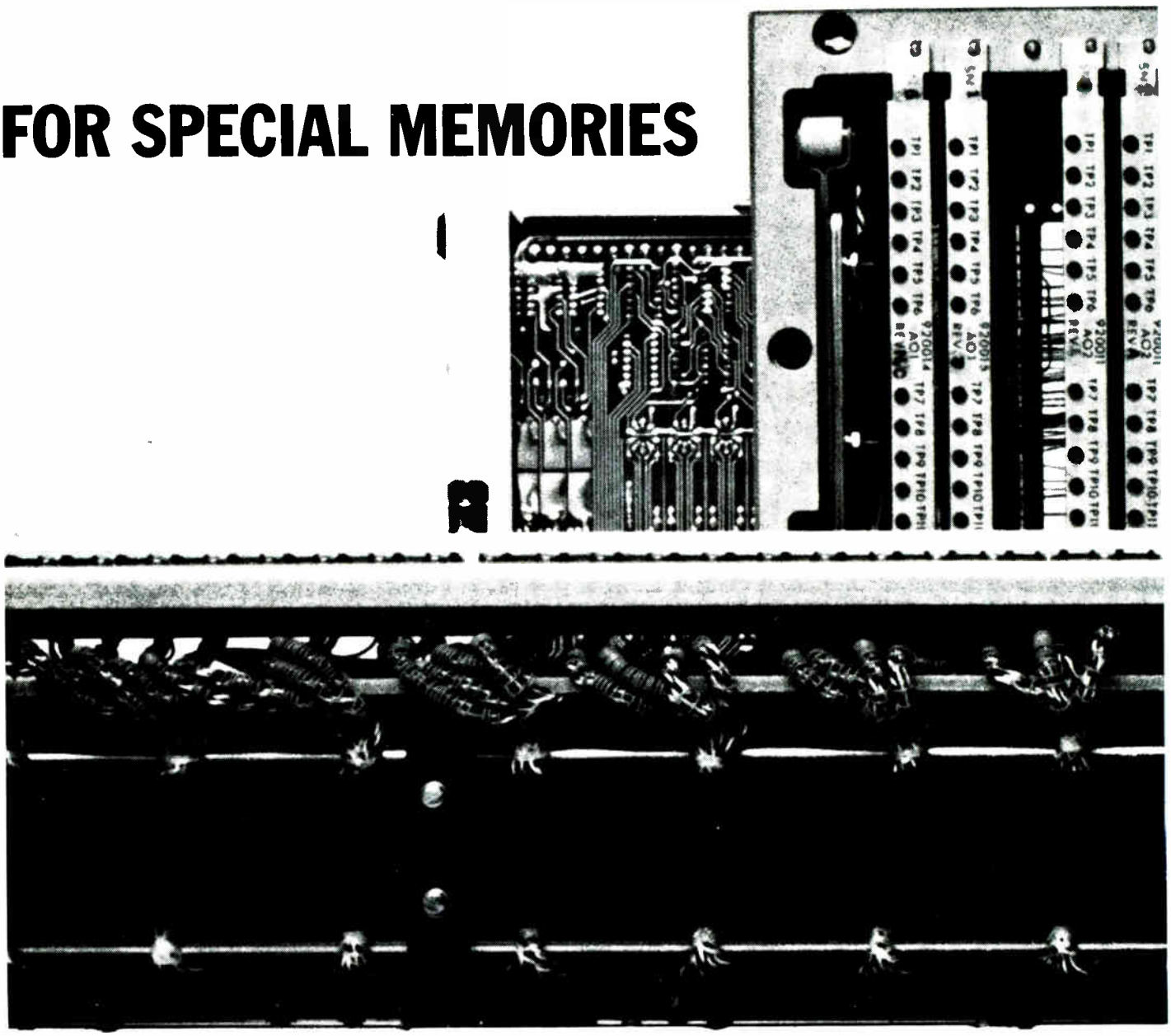
**"O.K. Send me the whole story"**

For literature, test results and full details, contact Richard Young, Marketing Manager, Data Transmission, Codex Corporation, 150 Coolidge Ave., Watertown, Mass. 02172. Phone: (617) 926-3000 TELEX: 922-443.
If you're not familiar with Codex (until now we've concentrated in military markets) . . . we have some real eye-openers to show you!

codex corporation

Circle 81 on reader service card

# FOR SPECIAL MEMORIES



If you're a computer system designer, every one of your systems is special. But that doesn't have to mean costly, custom hardware for implementation. Electronic Memories has the broadest, most versatile memory line in the industry. A complete line of systems, stacks and cores, built for aerospace, military and commercial applications. Chances are good that one of our standard products will fit right into the slot in your system.

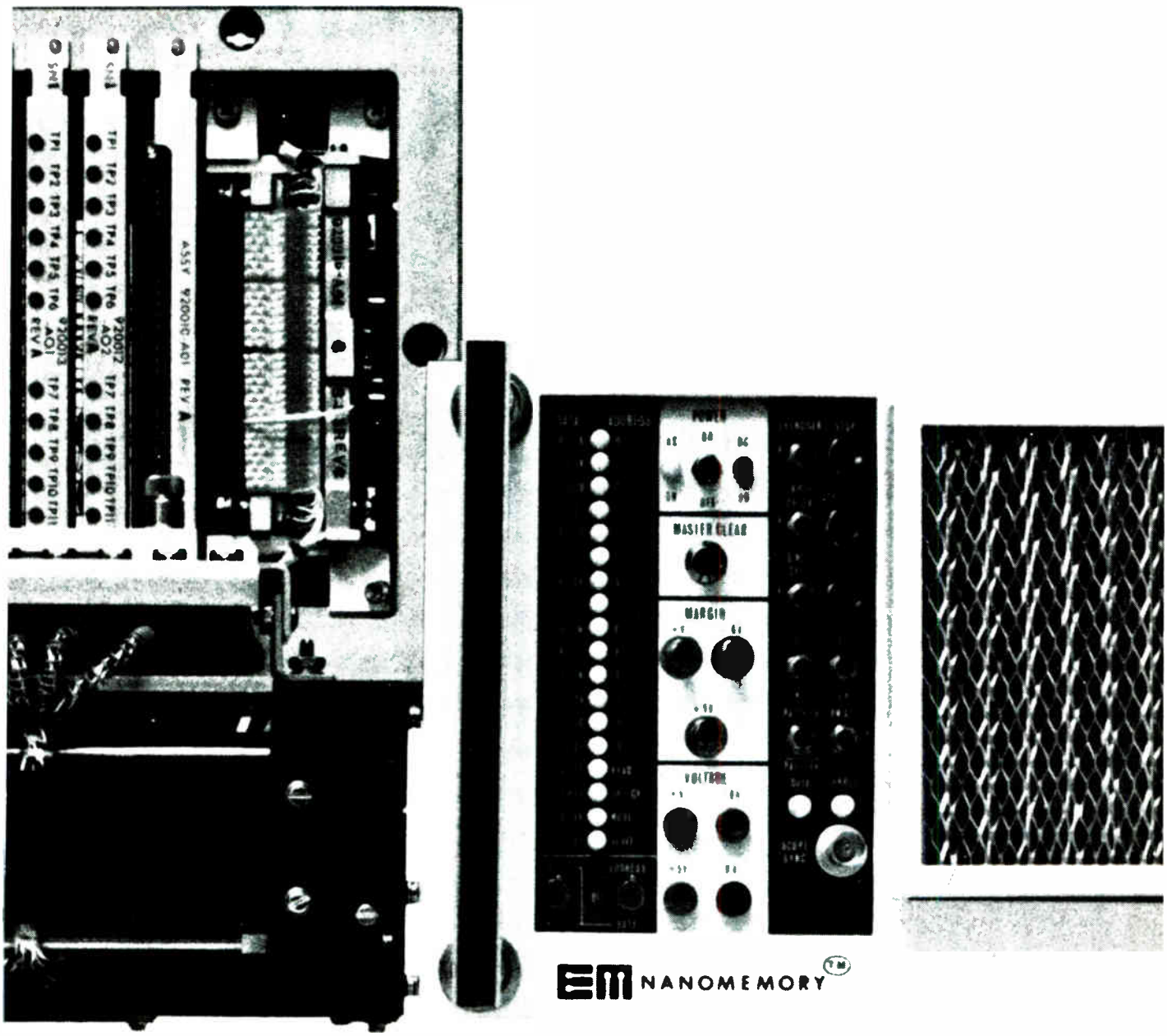
A. There's our SEMS 5, built small and reliable for airborne and satellite computing applications. 131,062 bits with a cycle time of 2$\mu$s in 132 cubic inches. And packaged to meet the applicable portions of MIL-E-5400, MIL-E-4158 and MIL-E-16400.

B. If you need a ground-based militarized system, look at our SEMS 7. It's not as small as the SEMS 5, but has more storage (327,680 bits with a 2$\mu$s cycle time). And it meets all the applicable portions of MIL-E-4158, MIL-E-16400 and SCL-6200.

C. For more speed, there's our NANOMEMORY™ 2650 System. It's built with IC electronics, uses a 2½D drive and stores up to 294,902 bits with a cycle time of 650ns. You can even get it with a built-in self-tester. All in a 2⅝ cubic foot module that does everything bulkier systems do.

D. And for low cost systems, use our MICROMEMORY™ 1000. You get up to 32k bits of storage with a cycle time of 2.5$\mu$s occupying only 400 cubic inches and dissipating 35W. We use a special 3 D technique that both lowers the component count and increases the MTBF. The MICROMEMORY 1000 comes with no case so there are no special cooling requirements, while true random access and a simple I/O interface make for easy integration into your system.

E. If you're starting further back than that, pick one of our stacks. 2½ D or 3 D. Military or commercial. Miniaturized, heated, folded or split into modules. Whatever's exactly right for your application.




F. Or, if you're working right from scratch, we've got cores. 18 to 80 mil magnesium-manganese cores that operate from 0°C to +65°C, with cycle times that range down to less than 600ns. 18 to 30 mil lithium ferrite cores that operate over the full temperature range from −55°C to +125°C. We've made cores for all the major computer programs and most of the satellites. And we're building them for our own systems. Right now and in volume.

If you need more information, circle the reader service number. We'll send a complete collection of our literature. If you need the hardware, call us collect.

## THE MEMORY SQUAD

If you're not at the hardware stage yet, maybe we can help with your design. The group below is our Memory Squad, our senior engineering staff. Write and we'll send you the whole group for a day. They'll give you a one-day seminar on memories in your plant. It will cover everything from cores to memory systems, with the emphasis on the practical aspects of implementing designs. They've designed and built equipment for the full range of applications from satellites to computers to submarines. Write requesting the seminar and get some of their experience into your systems now. They're standing by.

ELECTRONIC MEMORIES INC.
12621 Chadron Avenue
Hawthorne, California 90250
(213) 772-5201 EM



Circle 83 on reader service card 83

# Carte Blanche re-invents the credit card.

The way we look at it, we practically invented the travel and entertainment credit card in the first place. So why shouldn't we *re*-invent it?

We think it's time for some changes because your credit needs today are a lot different from what they used to be. And we think you deserve more when you pay good money for a credit card.

**Relief for Credit card headaches.**

"We're sorry about the mix-up . . . but it's our computer, you know."

We won't give you an answer like that. Because at Carte Blanche, the emphasis is on man, not the machine. Sure, we have the very latest new computers to help with our accounts. And that's just what they do: help.


**Someone to talk to.**

They help the Member Service Representative who's assigned to your account. We even tell you her name. So if you ever have a question on your account, you know exactly who to write or call. And when you do, she'll use our computers and microfilm records to get you an almost instant recap of your account's status.

**Our new service: Cartan Travel.**

When things are running smoothly inside, then there's really no limit to the variety of service you can offer. And we've just added a new one we think our members will appreciate. We've just acquired Cartan Travel, one of the nation's largest travel firms.

You may have heard of the famous Cartan Tours. Well, starting May 1, Carte Blanche members can charge any of them on their Carte Blanche Card. They can charge them at the thousands of travel agencies throughout the United States that handle Cartan Tours. And they can even arrange for convenient extended payment.

**Jet away from it all.**

Speaking of travel, we're honored on virtually every domestic and international airline that goes anywhere worth going. (You can take up to 24 months to pay for your ticket, too, depending on the amount.)

Which brings to mind our many other Carte Blanche services. A superb list of fine restaurants. An impressive list of hotels, motels, and inns. All the major rent-a-cars. More gas stations and brands of gas than any other multipurpose credit card offers. A wonderful selection of specialty shops and liquor merchants.

**Little things mean a lot.**

Of course, not everyone is a would-be world traveler. So we have plenty to keep you happy at home. There's our exclusive, pink Hers Card. It gives her credit for being a woman.

We're the only travel and entertainment card that guarantees your credit at 1,300 hospitals throughout the country. We're also the only card of our kind that offers you a $250,000 accidental death insurance policy. (Not very entertaining ideas, but reassuring ones.)

**A look to the future.**

Now, you might say it sounds like we have a lot going for us. We do. And we have a lot of plans for the future—some of them pretty revolutionary. You'll be hearing about them very soon.

For now, let's just say they'll be bringing Carte Blanche Credit to more people than ever before.

**You shouldn't be without us.**

It all boils down to this: you should make room for us in your wallet—if only for the fact that we promise you the service you pay for. But we've given you all the other reasons. Just pick your own. Or, invent one.

**Tear out.**

At any rate, send us the attached application now. It only takes a minute to fill out. But we think it might bring you years of satisfaction.

Like they say, experience is the best teacher. So see what it's like to say "Carte Blanche!" (kart' blonsh') instead of "Charge it."

# We give you more than credit.

# The Connector Thing

## in which Microdot reveals some of its highly creative thoughts on the care and feeding of engineers.

"Have another helping of Beluga caviar," smiled Ben Effits, Microdot's director of personnel. The young recruit mumbled his thanks and piled some more of the shiny black stuff on a small graham cracker.

"So this is your R&D supper club, eh Mr. Effits?"

"Call me Ben, my boy. Yes, this is the Ivory Tower Room. We believe that one must have the correct environment for creative performance. And this one is it. So exclusive, no sales engineer has ever seen it, let alone been in it."

The young engineer nodded his approval. "And these pictures on the walls?"

"Oils. Originals. Of those stellar people, much like yourself, with the genius, the essence, who have contributed to Microdot technology. Take that lad there," Ben Effits waved toward a striking oil of a mid-thirtyish Ph.D. in shiny blue serge with eyes to match. "That's Marc. One of our most inventive creators. The father of," Ben lowered his head and eyes, "the MARC 53 line of high density, circular multi-pin connectors."

"And they named the creation after him," the recruit breathed.

"That was just a paltry token of what we did for him," Ben Effits raised a finger and a comely damsel undulated in with another bottle of Piper-Heidsick '59.

"One of our R&D secretaries by day," Ben winked and went on. "The MARC 53 is quite a successful line of subminiature connectors. They're the most advanced high density connectors in the business, from seven to sixty-one contact arrangements in under one inch i.d. They feature Posilock®, the only advanced push-pull, lock coupling mechanism that guarantees proper engagement under 'blind matting' conditions. And Posiseal®. That's a sandwich insert that uses silicon interwafer seals. With Posiseal®, there's never been an air void problem or moisture problem between contact."

"Remarkable," incredulously the recruit.

"You bet. High density, circular subminiature connectors were really born and raised at Microdot. We also have a MARC 53 RMD version. Rear-insertable and rear-removable pins and sockets. No tools needed for assembly and disassembly. What does that mean to you?"

"Why, no damage to delicate rubber seals or inserts," replied the recruit. "And it also means that it must be one hundred percent field serviceable."

"Of course. And there are many other features. Scuff-proof contacts, for example. Interchangeable parts so that a cracked insulator or worn plating only means a new part, not a new connector."

"My boy, it is that type of connector technology that is rapidly gaining us our rightful place in the industry as the highest quality full-line producer of ultraminiature and subminiature connectors. Naturally, when you value technological contributions as highly as we do, you run the risk of a somewhat dilettante reputation. For several years, there were those who envisioned us as a sort of connector gourmet organization. Tasting little tidbits of the huge smorgasbord of connector technology, so to speak."

"Understandable," gurgled the young engineer, as he swallowed another spoonful of the caviar.

"But no longer so. From Lepra/Con to Twist/Con to Golden Crimp to MARC 53, our repertoire now extends the full range of subminiature or ultraminiature connector requirements.

"Can I write for the specs for MARC 53?"

"Of course. Anybody can. But if you're coming with us, you'll have your own monogrammed and autographed set."

"Well, that's very nice of you Mister, uh Ben. I'd like to...."

"Fine. It's settled."

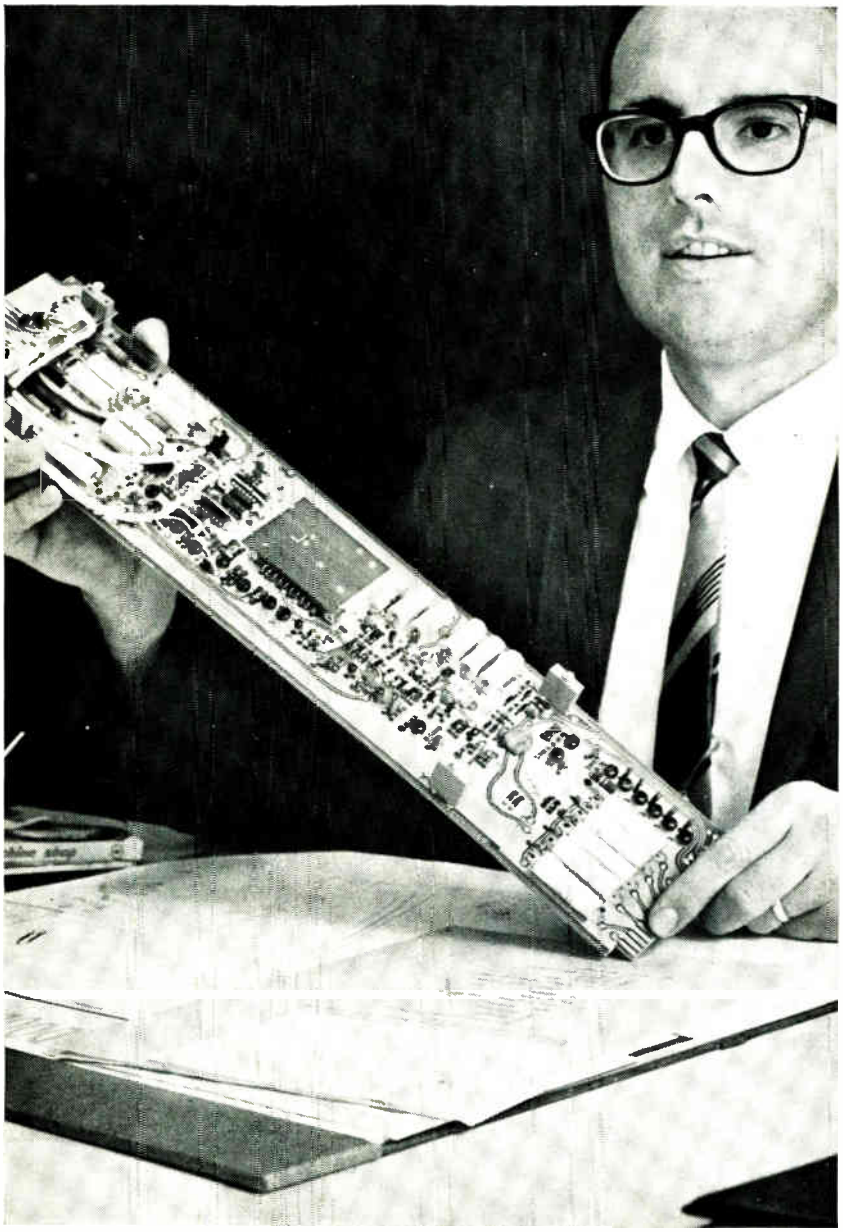
"Now," added Ben, "after you've signed, we can discuss your bonus and then confer with the decorator about your quarters. Oh, waiter, some more Piper-Heidsick '59 and the check please."

MICRODOT INC.

220 Pasadena Ave., South Pasadena, Calif. 91030

# "Freon"® solvents improve reliability and reduce costs.

-Jack L. Steiner, Manager of Assembly Operations, Applied Dynamics, Inc.



Applied Dynamics, Inc., an analog-computer manufacturer in Ann Arbor, Michigan, accomplished more effective cleaning of electronic subassemblies by using "Freon"* solvents. In addition, they improved quality, reliability and reduced costs.

Applied Dynamics uses "Freon" TMC for complete removal of rosin flux after soldering of assembly boards. A two-solvent system, "Freon" T-WD 602 and "Freon" TF, is used for further cleaning of critical modules to completely remove polar soils deposited by plating, handling, etc.

Because of their experience with "Freon" solvent systems, Applied Dynamics is considering additional ones.

Parts are efficiently cleaned in Branson ultrasonic equipment specifically designed for the application and proper handling of "Freon" solvents.

To insure complete cleanliness before the critical modules are inserted into the computer, a three-tank cleaning system is being employed. In the first tank, "Freon" T-WD 602 (a patented emulsion of "Freon" TF, water and detergent), removes foreign matter picked up on the production line. To remove any remaining impurities and detergent residue, boards are then immersed in "Freon" TF. This is followed by a rinse in still a third tank with ultrasonically agitated "Freon" TF.

"These systems insure complete removal of all foreign material and are economical. Since we started this procedure, leakages have been eliminated," says Mr. Steiner.

"Freon" solvents may well be able to do similar things for you, too, if you have difficult cleaning problems to solve.

And it can cut your costs, too—because unlike many other solvents, "Freon" needs no inhibitors. So it is easy to clean and reuse.

Find out what "Freon" can do for you. Write to DuPont Co., Room 7238, Wilmington, Delaware, 19898. (In Europe, write to DuPont de Nemours International, S.A., "Freon" Products Division, 81, Route de l'Aire, CH-1211 Geneva 24, Switzerland.)

*Reg. U.S. Pat. Off. for DuPont's fluorocarbon solvents.

DUPONT FREON® Solvents

# Industry Standards

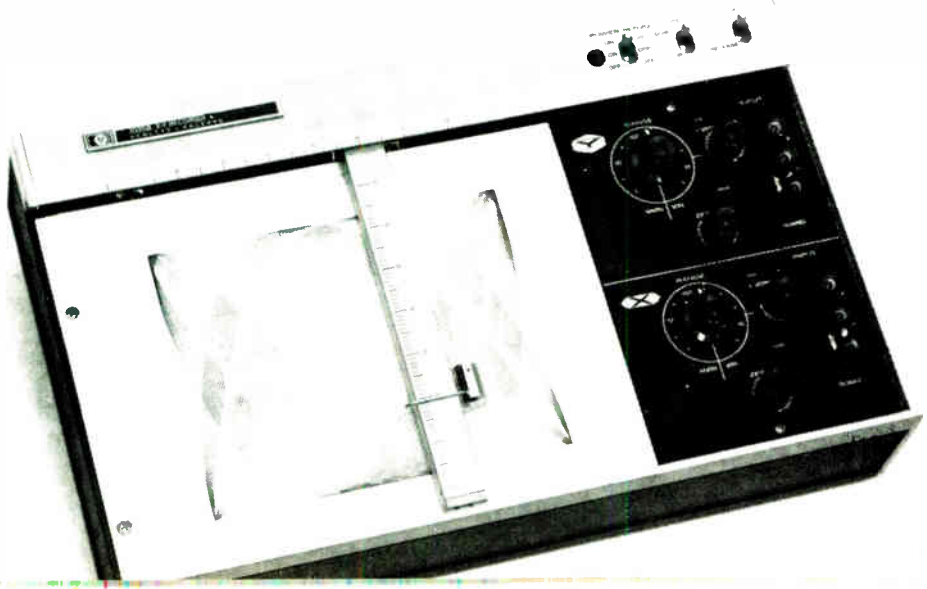
These general-purpose XY recorders set new price/performance standards for users. Bold words, but we can prove them. We call them "general purpose" because they combine features and performance covering a broad range of user needs. And the price is down where everyone serious about recording XY data can afford them.

High performance: On both the 7035B (8½"x 11") and 7005B (11"x 17"), you get 20 in/sec slewing speed, five calibrated input ranges from 1 mv/in. to 10 V/in, with metric calibration optional; one megohm input impedance on all but the two most sensitive ranges; 0.2% accuracy full scale, with 0.1% linearity and resettability. Features: All the time-and field-tested HP features are standard, such as all-solid-state circuitry, exclusive electric paper hold-down, zener reference, electric pen lift, easy-load platen, rack/bench convertability, instant access for adjustment or maintenance. Price: A low $985 (7035B) and $1195 (7005B).

To check on how closely we meet your XY recorder standards, call your local HP field engineer. Or write Hewlett-Packard, Palo Alto, Calif. 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

GRAPHIC RECORDERS

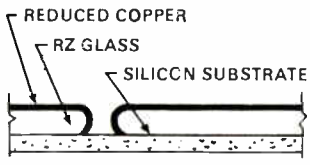



Owens-Illinois RZ Glass Sputtering Target is a NEW copper alumino-silicate glass readily sputtered on a silicon substrate. After sputter deposition, the RZ glass layer is etched to open up contacts to the silicon substrate. A simple oxidation-reduction process then produces *pure* copper conductive layers on the RZ glass, even in etched undercuts.

RZ glasses are ideal for making single or multilayer interconnections in medium or large-scale integrated circuits. The conductive layer is produced uniformly on RZ-coated substrates regardless of surface geometry.

You now have your choice of *three* sputtering targets from Owens-Illinois . . . 1. NEW RZ copper alumino-silicate, silicon-matching, 2. EE-9 alumino-silicate, silicon-matching. 3. EE-10 alumino-silicate, alumina and gallium arsenide matching.

All three are readily deposited at rates of 250 Å/minute with standard R.F. sputtering equipment, followed by simple etch when needed. A new manufacturing process holds the sodium content of these glasses below 20 ppm.




Owens-Illinois can supply targets promptly in lengths, widths, and thicknesses to fit your R.F. set-up and substrate dimensions. We'll work with you on materials to meet your special needs.

Complete data, specifications, and sputtering procedures developed in the Owens-Illinois microelectronics research labs will be sent to you promptly on request. Ask for information on these other O-I electronic materials: package sealants, substrate glazes and insulating films, preform materials, glazed IC packaged parts and substrates. WRITE TO:

THE O-I FAMILY OF WORK-TOGETHER ELECTRONIC MATERIALS.

OWENS-ILLINOIS
ELECTRONIC MATERIALS
Toledo, Ohio 43601


Circle 90 on reader service card

Circle 91 on reader service card →

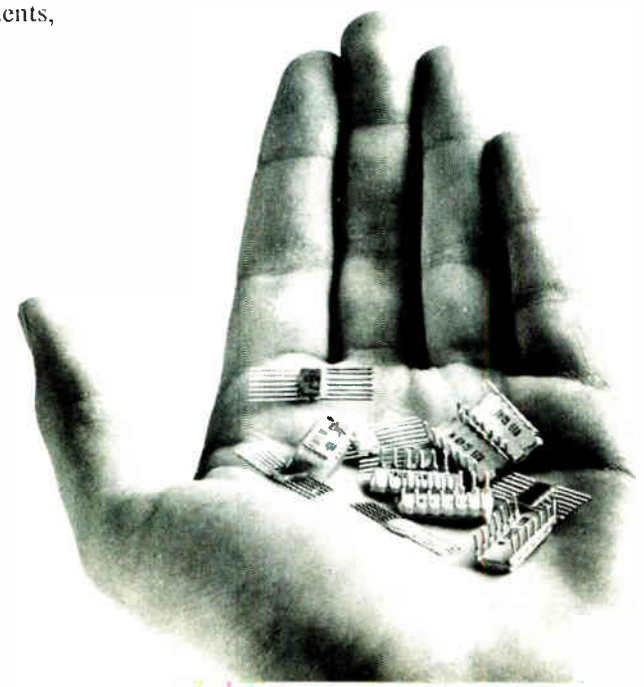
# Sylvania introduces the MSI supermarket.

**FUNCTIONAL ARRAYS, TYPICAL CHARACTERISTICS (+25°C, +5.0 Volts)**

| Function | Type Nos. | $t_{pd}$ (nsec) | Avg. Power (mW) | Noise Immunity +(Volts)– | | Fanout |
|---|---|---|---|---|---|---|
| Full Adder | SM10 Series | Sum 22 Carry 10 | 90 | 1.0 | 1.0 | These arrays are available in fanouts up to 15 and are completely compatible with SUHL I and SUHL II integrated circuits. |
| Dependent Carry Fast Adder | SM20 Series | Sum 22 Carry 10 | 125 | 1.0 | 1.0 | |
| Independent Carry Fast Adder | SM30 Series | Sum 22 Carry 10 | 125 | 1.0 | 1.0 | |
| Carry Decoder | SM40 Series | 2 | 25 | 1.0 | 1.0 | |
| 4-Bit Storage Register | SM60 Series | 20 | 30/bit | 1.0 | 1.0 | |
| Bus Transfer Output 4-Bit Storage Register | SM70 Series | 20 | 30/bit | 1.0 | 1.0 | |
| Cascade Pullup Output 16-Bit Scratch Pad Memory | SM80 Series | 25 | 250 | 1.0 | 1.0 | |
| Decade Frequency Divider | SM90/92 Series<br>SM91/93 Series | 35MHz<br>30MHz | 125<br>85 | 1.0 | 1.0 | |
| 4-Bit Shift Register | SM110 Series | 25MHz | 120 | 1.0 | 1.0 | |
| Parity Generator/Checker | SM120 Series | 22 | 125 | 1.0 | 1.0 | |
| Comparator | SM130 Series | 17 | 120 | 1.0 | 1.0 | |
| Programmable Binary Divider | SM140 Series | 25MHz | 150 | 1.0 | 1.0 | |
| Programmable Decade Divider | SM150 Series | 25MHz | 150 | 1.0 | 1.0 | |
| Binary Counter | SM160 Series | 25MHz | 135 | 1.0 | 1.0 | |
| Decade Counter | SM170 Series | 25MHz | 135 | 1.0 | 1.0 | |
| Binary Up/Down Counter | SM180 Series | 25MHz | 205 | 1.0 | 1.0 | |
| Decade Up/Down Counter | SM190 Series | 25MHz | 205 | 1.0 | 1.0 | |
| BCD to 7-Segment Translator | SM200 Series | 85 | 280 | 1.0 | 1.0 | |
| Dual 4-Bit Multiplexer | SM210 Series | 10-20 | 130 | 1.0 | 1.0 | |
| Demultiplexer | SM220 Series | 9-14 | 225 | 1.0 | 1.0 | |

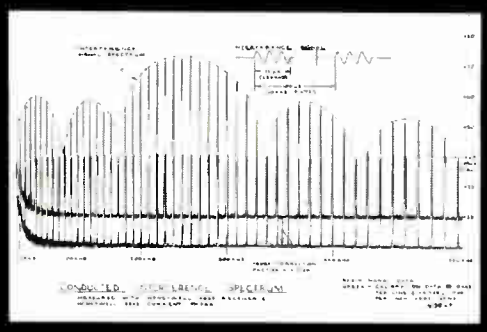
Sylvania Electronic Components,
Semiconductor Division,
Woburn, Mass. 01801

SYLVANIA
GENERAL TELEPHONE & ELECTRONICS



# Cut costs and increase flexibility! Impossible? Not with our 7899 EMI System.

Honeywell's 7899 Automatic Signal Analysis and Display System doubles as a complete frequency domain lab. Individual modules, such as receivers, recorders, generators, display units and sensors, are self-contained and usable independently of the system as laboratory instruments. No additional components needed. No additional expense.



Typical 7899 System X-Y Plot of conducted interference from 250 kHz sinewave pulsed at a 10 kHz for a duration of 12m sec.

As a system, it scans and plots detected signal amplitudes from 3 Hz to 1000 MHz in a time span depending on recording technique and desired frequency resolution. Operator control of frequency, scan rate, narrow or wideband detection, sensor and recording and/or display device is provided by a single panel programmer.

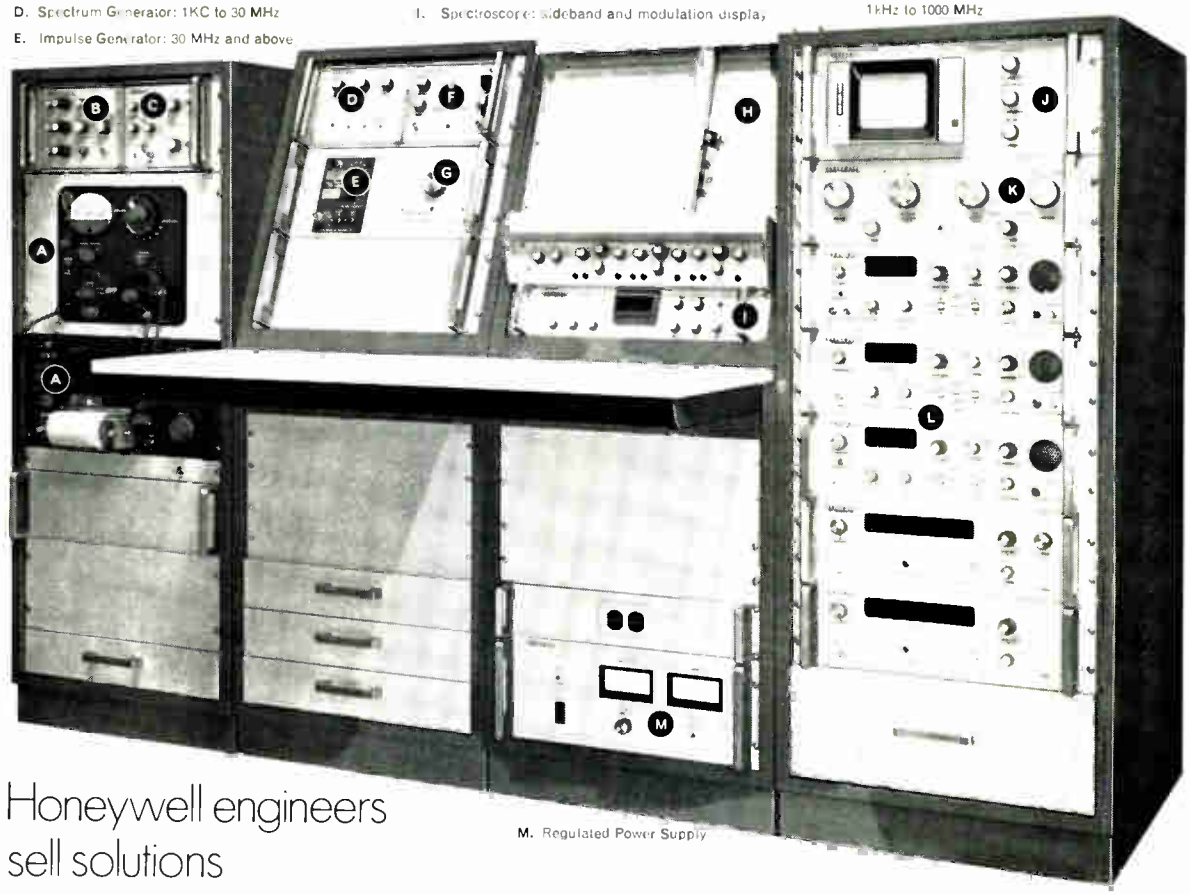
Automatic band-switching and simultaneous plotting of both average and peak output are among optional features available for completely automatic EMI data collection.

The 7899 is the result of Honeywell's more than 20 years' experience in the EMI/RFI field—experience you can rely on for the most practical solution to interference measurement.

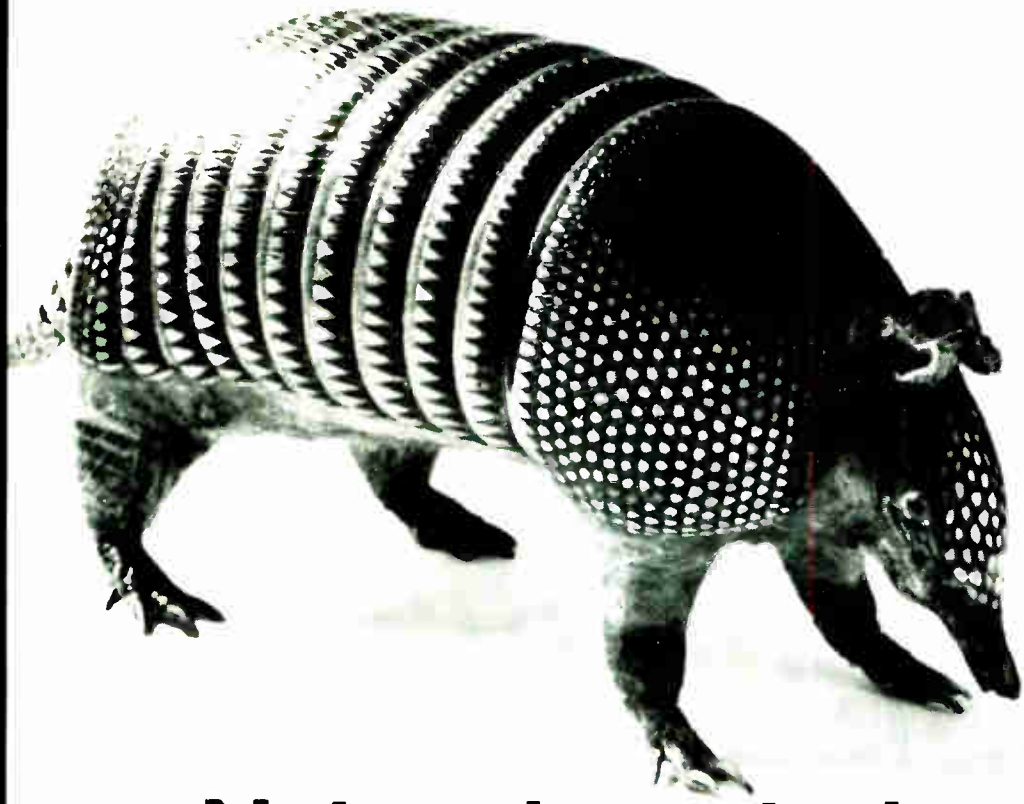
For more complete information, call Bill Mattox (collect) at (301) 263-2661 or write to Manager, RF Products, Honeywell, Test Instruments Division, Box 391, Annapolis, Md. 21404.

**Honeywell**

A. Wave Analyzer System with Level Recorder
B. Sub Audio detection
C. Impulse Generator 120 Hz to 2.5 kHz
D. Spectrum Generator: 1KC to 30 MHz
E. Impulse Generator: 30 MHz and above
F. System Log Converter
G. Pre Amp Control Unit: AW 204–2825
H. X-Y Plotter: graphic spectrum display
I. Spectroscope: sideband and modulation display
J. Storage Scope: spectrum display—high speed
K. Program Control
L. Receivers and Converters: 1kHz to 1000 MHz
M. Regulated Power Supply




Honeywell engineers sell solutions



# Nature invented hard-shell protection.

# We swiped it.

The Armadillo Connector is here.

We take a connector design that's already foolproof, and make sure it'll *stay* that way. By wrapping a coat of stainless steel armor around it to protect it from all abuse in the field.

It's complete protection. For our new D Series connectors that deserve it. For example, they have the Hughes exclusive PolarHex center jackscrew coupling system.

This means polarization every time. Perfect alignment. Easy mating and unmating.

These connectors are fully environmental, too. They come in five shell sizes, with 18 to 138 contacts. They have the famous Hughes crimp snap-in contacts and retention mechanism. And you can use our new Pull-Thru insertion tool with them for faster wiring.

Now the most advanced of all rectangulars come in the most advanced packages. (For example, the shells are mechanically keyed to prevent mismating.)

Another Hughes innovation.

With armadillos, hard-shell protection is very old. But with connectors, it's very new.

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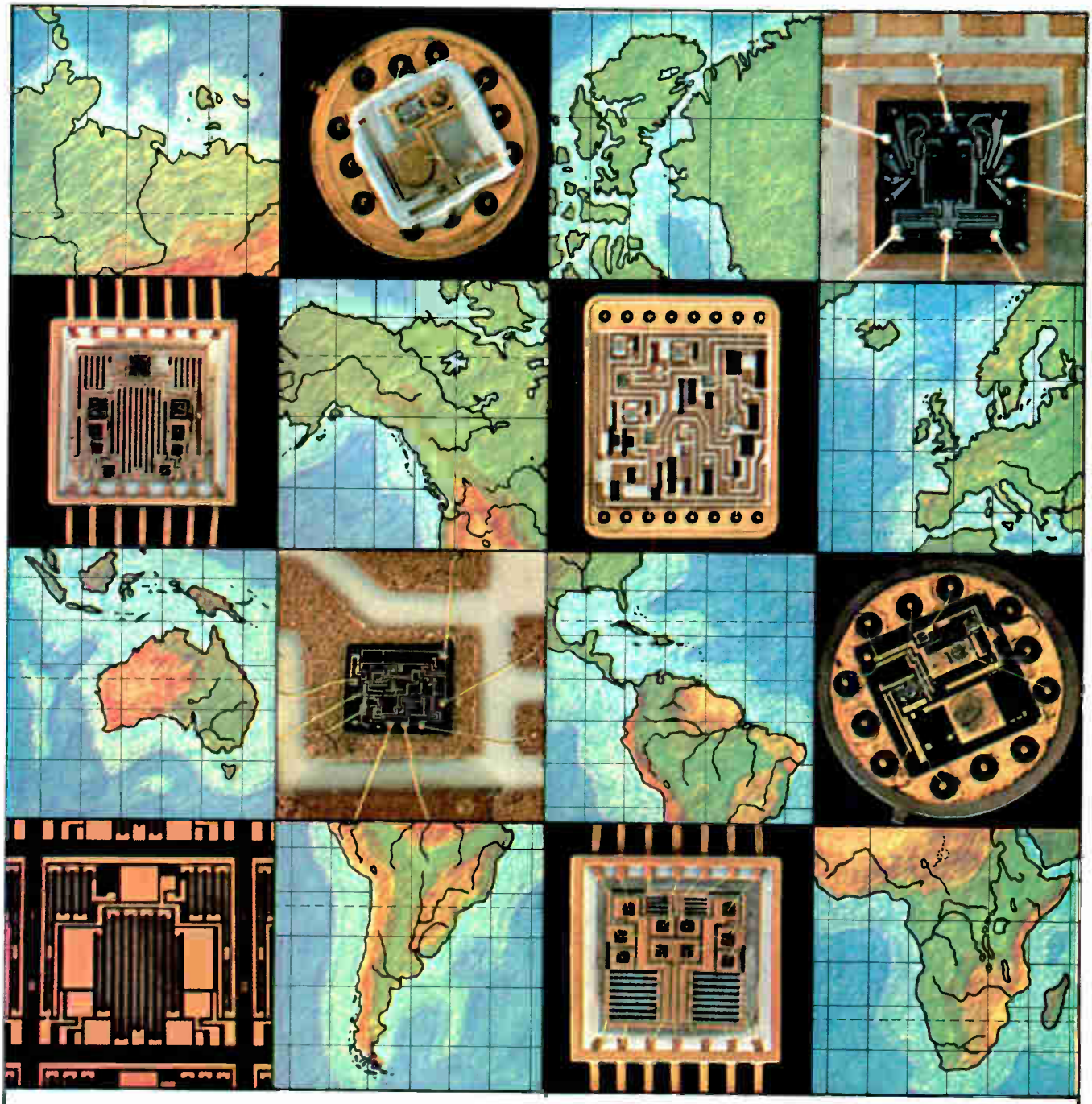

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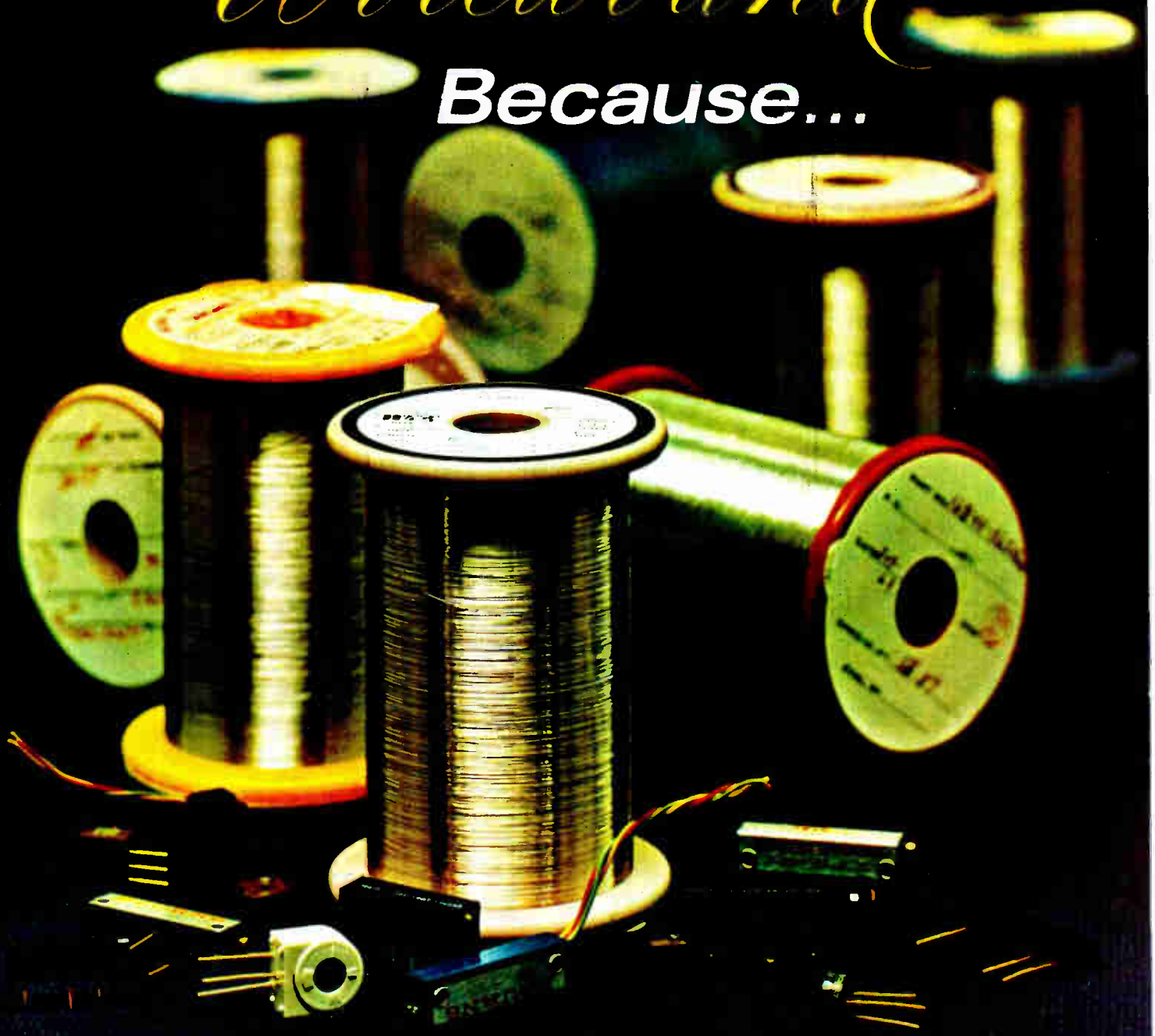

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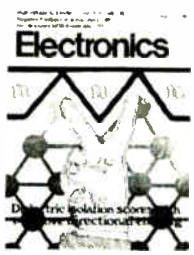
# Technical Articles

**Earth resources technology satellite finally on the way**
page 98

The long-delayed program to keep a running check on the earth's resources with sensors carried aboard orbiting spacecraft is moving into the RFP stage. A full-fledged system could prove well worth the wait, keeping tabs and supplying data on soil, forests, water supplies, mineral deposits, and the like, and providing aerospace contractors with some big, long-term orders.

**New etchant puts dielectric isolation in the groove**
page 112




Applications of dielectric isolation were long limited to radiation-hardened circuits where costs were no particular object. Now, however, it's practical for all linear and high-voltage, as well as certain digital, IC's. The means to this end is an anisotropic etchant that attacks the 100 crystal plane more rapidly than the 111, forming V-shaped isolation grooves. Since etching stops at the tip of the V, the process is easily controlled and valuable semiconductor material is not wasted. Other advantages: more flexible complementary structures and selective gold doping for saturating logic circuits. Art director Gerald Ferguson, whose initials are visible on the cufflink, created the cover.

**Through thick and thin with memory systems**
page 116

The ninth installment of *Electronics*' series on memory technology covers ferroelectric and thin-film units. The former, which work off the piezoelectric properties of certain ceramics, are comparatively slow but rugged enough to withstand punishment that would pulverize most of their counterparts. Thin-film memories have commanded great interest over the years for their potential high-speed, low-cost operation.

**Keeping track of Japan's high-speed passenger trains**
page 124

High-speed passenger trains have been operational in Japan for the past five years on the 320-mile run from Tokyo to Osaka. Planners at the Japanese National Railways are now mapping out expansions and improvements. As a result of the control and safety exigencies raised by the proposed speeds—220 miles per hour against the present 125 mph—these undertakings promise new challenges for electronic technology and techniques. Among the projects under way: highly automated control systems operating on a movable-block principle, as well as new radars and communications nets.

## Coming

**Where it's at with r-f power transistors**

Users of power transistors get a welter of information on d-c parameters from manufacturers, but not much r-f data. This article surveys available and upcoming products and furnishes a roundup of important characteristics.

# At long last, ERTS is on the way

Much-delayed program to keep tabs on the earth's resources with sensors mounted in orbiting satellites is finally reaching the RFP stage, and if it develops into a full-fledged system, it will have been worth the wait

By Alfred Rosenblatt and Paul Dickson

Associate editors

**No space program** proposed in the past several years has attracted so many friends and yet made so little progress as the Earth Resources Technology Satellite. Its friends include the Congress, assorted Government agencies, and the aerospace industry. The opposition: NASA officials, of all people, and a formidable opposition they've been.

But now, after more than five years of study and restudy, justification and rejustification, threat and counterthreat, a request for proposals is finally emerging, one calling for a modest, demonstration ERTS system. But even this emergence has sorely tried the patience of potential bidders. They're certainly used to delays, but this RFP waiting period has become a sort of vigil. NASA first promised to mail the RFP in January, let it slip to February, and then left everyone hanging on a day-to-day basis. One of the stumbling blocks was that the space agency and Government users—the Interior and Agriculture Departments—weren't able to agree on the work statement.

But if there's ever been a space program that justified patience, it's this one. While it will hardly be another Apollo ($30 billion appropriated so far), ERTS is likely to snowball into an operational system of many special-purpose satellites or several big multipurpose craft, as well as a large supporting ground communications setup and a data processing network, by the mid or late 1970's. Recognizing this, several systems houses have had teams of spacecraft, sensor, and data-management experts hard at work for the past few years in anticipation of the request for bids. And they've been spending their own money—with no returns so far.

In its long-delayed RFP, NASA will spell out the functional details of the initial resources-sensing satellites, indicating the types of remote electronic sensors they should carry, the data-gathering and processing problems, and the launch schedule.

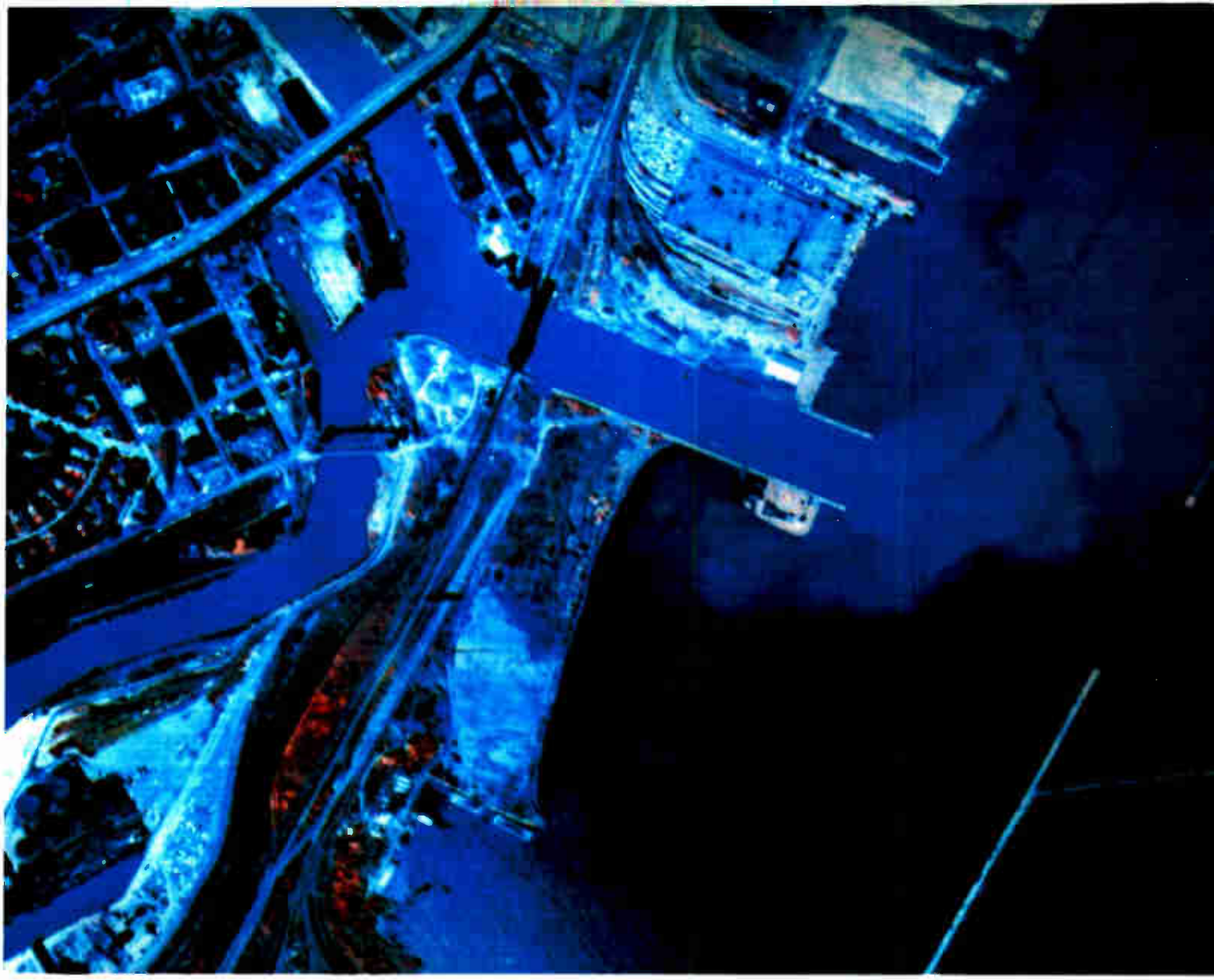
Right now it looks as if NASA plans to orbit one satellite (ERTS A) in late 1971, and a second (ERTS B), with possibly more advanced sensors, a year later.

The two craft would be primarily experimental, according to Leonard Jaffe, director of NASA's space applications programs. But Jaffe is quick to note that just as with the first Tiros, the data collected can be interpreted and put to use as soon as it starts coming back. "We look upon it as an experiment in which we'll find what we can use, how to process data, and how to use the data operationally," he says.

From the information garnered by these initial satellites, NASA will plan an operational earth resources system (ERS). Jaffe does see the possibility of experiments continuing through a few more letters of the alphabet—ERTS C, D, and so on—but he can't say what form the additional spacecraft would take. He also sees the possibility of conducting advanced ERTS experimental work on future manned missions. And he adds that the ERTS program could follow the same route as Nimbus and Tiros, with NASA running the experimental phase and a user agency taking over the operational system.

These latter satellites perform earth-resources-type missions, though their objectives are more limited. Meteorological craft such as Tiros and Nimbus look down upon the earth with television cameras and, relying on the visible light from the sun, take large-scale photographs that are sent back to earth and used to help make long-range weather forecasts.

An earth resources satellite would also look at the earth, but with television cameras, radiometers, and scanners that could distinguish physical details to an extremely fine degree. And most important, the sensors would be able to "see" a whole spectrum of frequencies, ranging from the ultraviolet,



**Laser-beam picture.** Aerial view of Cleveland waterfront was made from a 35 mm color-infrared transparency by RCA's 2-inch return-beam vidicon/laser reproducer system. The vidicon took a separate picture of the transparency through three color filters. Over-all system resolution is 4,500 tv lines and video bandwidth is 4 Mhz. Scan-like lines, caused by jerky movement of film under laser, will be eliminated.

down through the visible and near infrared, and into the microwave. The aim is to keep very exact tabs on the world's crops, forests, geological formations, soil, and water—or whatever else may be of interest to this country.

## First payload

NASA has already made known the proposed sensor payload for the initial satellite, although the RFP will set down the final details.

The primary sensor will be a three-camera, multispectral television system now being developed by RCA and relying on that company's 2-inch return-beam vidicon. The system will be able to operate continuously, providing outputs for immediate real-time transmission to a ground station or a video tape recorder for delayed transmission.

The satellite's secondary sensor could be either of the multispectral scanning cameras being developed by Hughes Aircraft and Hycon under separate NASA contracts.

ERTS A will also have a data-collection system to record the observations or measurements made by remote, unattended sensors on the ground. The information gathered in this way could include surface temperature, soil moisture, snow depth, and ocean salinity. According to Jaffe, this data-collection system will reflect NASA's experience with such programs as the Interrogation, Recording, and Location System (IRLS) now flying aboard Nimbus, and the Omega Positioning and Location Experiment (OPLE) carried by the Advanced Technology Satellites; both systems gather data from either fixed or moving sensors on the ground.

There's no technical obstacle to getting such a system on the satellite, but the number of ground

sensors to be scanned must first be determined. So, too, must the method of obtaining data—either by interrogating the sensor or having it transmit at random. Cost of the sensors' transmitters must be low, because the number of sensors could eventually run into the many thousands.

The satellite will also carry two wideband vtr's to store data, distribution systems to handle power generated by solar cells, S-band communications equipment to send data to ground stations, housekeeping telemetry links, and a ranging transponder to help ground stations track the craft.

"The ERTS B payload depends on our success with A," Jaffe says. "The two launches are a year apart and we could change things. Since we are working on two scanners we may very well send the first on ERTS A and the second on ERTS B. Of course, this isn't definite. Some think it best to have each satellite identical for reasons of scientific comparison."

Phase B and C studies in response to the NASA RFP will run six months, with awards going to two or more companies, Jaffe says. The first-phase feasibility study was handled in-house by NASA, primarily at the Goddard Spaceflight Center, which will manage the program. Hardware procurement in phase D will follow the award of the studies by nine months to a year.

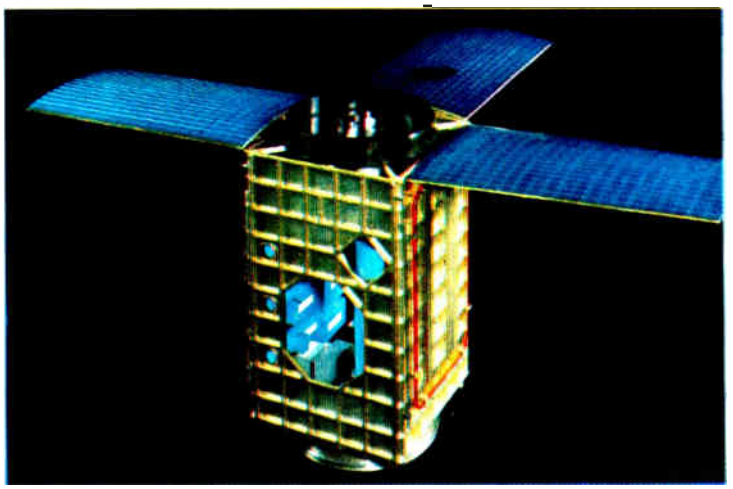
### Whole new ballgame

NASA's decision to allow six months for the studies of spacecraft and sensor designs seems to indicate that the competition for the satellite is wide open. The space agency had earlier said it expected completed studies in three months, leading many potential bidders to assume that only satellites already or soon to be in orbit would be ERTS candidates. Among these are General Electric's Nimbus, RCA's Tiros-M, and TRW's orbiting geophysical observatory (OGO). Defining a new satellite, one built from the ground up, takes longer, obviously, than merely proposing modifications for existing craft.

As for new sensors or experiments, Jaffe says contractors will be free to recommend replacements or additions. However, the Interior Department is opposing any attempt to fly a lot of extra sensors aboard ERTS. According to William A. Fisher, research coordinator of the department's earth resources observation satellite program, vendors may try to add sensors to justify the size of their spacecraft. Interior wants the satellite small and producing practical information.

NASA, Fisher says, may be considering too sophisticated an experimental operation. He sees no need for long, involved experiments, believing the future of ERTS lies in quickly realizing its operational potential. He predicts that Americans will come to expect ERTS data as regularly as their mail delivery.

The ground receiving stations in the system must take each form of data, note at what time it was obtained by the satellite, relate it to map coordinates of earth, and put it into the form each user agency wants.



With windows, RCA's earth resources satellite would be a somewhat larger version of the company's Tiros M weather satellite. The ports in the craft are for the sensors including three 2-inch return-beam vidicons.

Many feel data handling could easily be the pacing item in the program and this probably explains the delayed release of the request for proposals. NASA hadn't originally given much consideration to data handling in the RFP, but Jaffe says "it's now a major portion of the ERTS experiment."

Back in January, Fairchild Space Defense Systems of Syosset, N.Y., received a contract from NASA to study an earth-resources data processing center.

Actually, Interior Department officials aren't at all worried about handling ERTS information, which they calculate will amount, for them, to about 250,000 pictures a year. "We've been using photographic data for a quarter-century," says Fisher, "We now process more than a million pictures a year and Agriculture handles some 3 million. And since the ERTS pictures will be better than many we're now getting, the number processed by our agencies may even decrease."

But others expect sophisticated data processing techniques to provide more information than can be garnered simply by viewing pictures sent back by vidicons. This data, particularly from imaging scanners, which have a more uniform response than vidicons across the spectral bands and across ground-target areas, would lend itself to such techniques as computerized spectral analysis and false color enchancement. The results could be automatic determination of the types of rocks, soil, and vegetation scanned by the satellite.

### Slow motion

In developing the requirements for ERTS, NASA has had to consider the special wants of potential users—the Commerce, Agriculture, and Interior Departments and the Navy. But the problem of coordinating various requirements doesn't alone

explain the slow progress of the program. NASA itself has just not moved.

Rep. Joseph E. Karth (D., Minn.), chairman of the House space science and applications subcommittee, has bluntly accused the space agency of foot-dragging. As long as five years ago, he says, NASA decided to make earth resources experiments part of the manned spaceflight program [*Electronics*, March 17, page 58], automatically relegating ERTS to a back seat behind Apollo.

Of the potential users, the Interior Department has perhaps been the one most dismayed by NASA's inactivity. And on Oct. 21, 1966, it took the most imaginative step to push NASA off dead center. On that day, the then Secretary of the Interior, Stewart L. Udall, announced that his department would embark on an independent Earth Resources Observation Satellite program. Even the program's acronym—EROS—was provocative and calculated to goad the space agency. EROS began as a sort of practical joke, but it has put the Interior Department in a position to tell NASA what should be included on such a satellite. And the program continues—sans satellite.

Although the relationship between Interior and NASA has been running hot and cold for years the current feeling is "relatively friendly," according to Fisher.

"NASA is honestly attempting to get a program going," he says. It's embarked on what Fisher politely calls "a minimal but sincere effort."

Interior would like to take over the operational ERS system in the same way the Weather Bureau relieved NASA of responsibility for the operational meteorological satellites after the first Nimbus.

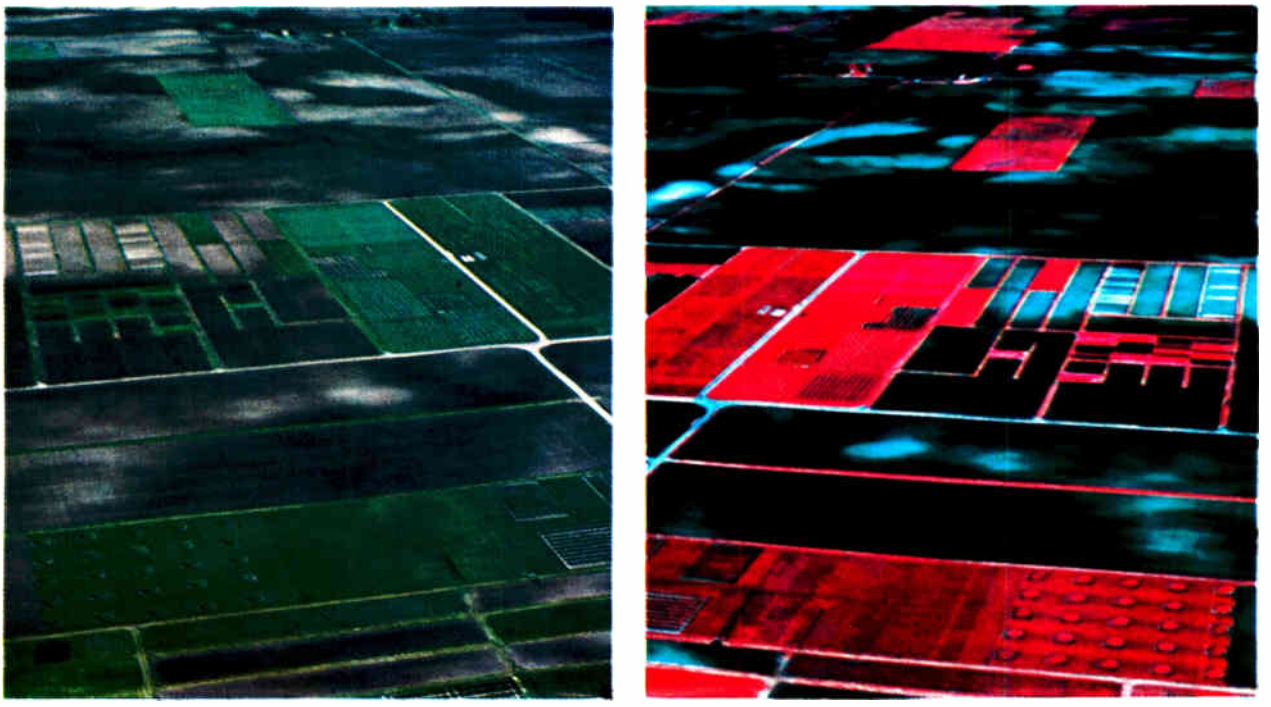
The pictures taken by an earth resources satellite will be very different from those sent back by meteorological satellites. The latter photograph the whole earth with wide-angle-lens cameras. The resources satellite, on the other hand, will take pictures of 100-by-100-mile sections of the earth. Thus the satellite, which will be making a roughly polar orbit, will photograph a 100-mile swath across the earth below. It will make a complete orbit in about 100 minutes and will be up at least a year.

But because the earth rotates beneath the satellite, successive tracks over the ground won't be contiguous. They'll be about 1,500 miles apart, in fact, and it will take about 18 to 20 days to fill in and cover the entire globe with overlapping tracks. The satellite will then be positioned over the first track and will begin sending back a second view of the terrain it has already covered.

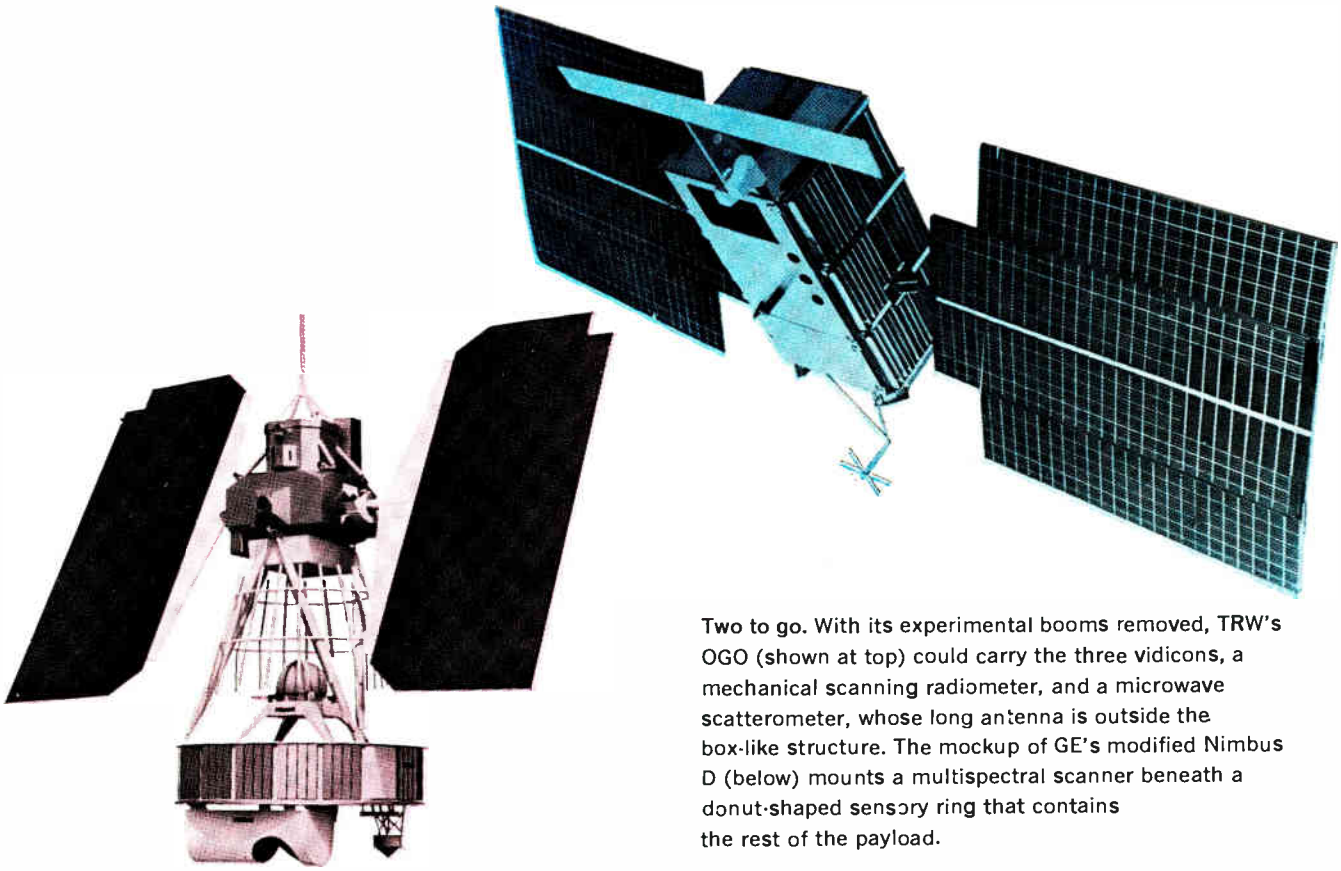
"This calls for a very precise orbit selection and insertion—something like 492 ± 2 nautical miles," says David Keller, earth resources program manager for General Electric's Missile & Space division. "This is much more precise than we can get with a launch vehicle alone, so we'll have to add orbit adjustment nozzles to the craft."

The 500-mile-high orbit represents a compromise between the requirements of the sensors, which should be as close to the earth as possible, and the stability requirements of the spacecraft, which should be out of the atmosphere's drag.

Selecting a sun angle also involved a compromise. Geologists wanted the sun to hang just above the horizon so that shadows would enhance the



**Tell-tale hues.** Color infrared view of fields at Purdue University's agronomy farm shows vegetation in bright red and contains information on the crop spectral characteristics that's not present in the ordinary color photograph.



Two to go. With its experimental booms removed, TRW's OGO (shown at top) could carry the three vidicons, a mechanical scanning radiometer, and a microwave scatterometer, whose long antenna is outside the box-like structure. The mockup of GE's modified Nimbus D (below) mounts a multispectral scanner beneath a donut-shaped sensory ring that contains the rest of the payload.

features of the terrain. The Agriculture Department wanted the sun straight overhead to give maximum illumination to the ground and maximum reflection for the sensors. The compromise, arrived at after studies of the relationship between the satellite's orbit and sensor performance, ranges between 30° and 35°.

Once set, the angle will remain the same; the satellite orbit will be sun-synchronous, meaning that its precession rate will equal the angular rate of the earth's travel about the sun. The 35° angle chosen corresponds to conditions at about 9:30 in the morning.

The prime contract for the satellite itself will, of course, be the most lucrative item in the hardware-procurement phase of the program. According to a report last December by Karth's subcommittee, two satellites could be flown for $45 million; half of this could go to the spacecraft contractor.

At least six companies—GE, RCA, and TRW, who hope to modify existing satellites, and Lockheed, North American Rockwell, and Hughes, who want to design new satellites—may already have submitted unsolicited proposals to NASA. Along with these six, two others may respond to the RFP.

Industry has been so eager to spend its own money on ERTS studies that NASA has been able to sit back and reap a harvest of free information. GE, for example, has submitted three spacecraft systems studies to the space agency, each one unsolicited and quite costly.

GE is probably more aware than most of how lucrative an operational satellite program could be. Total cost of the Nimbus program, which GE became involved with in 1959, will approach some $300 million by the time the E and F models are launched in the 1970's.

Most, if not all, of the ERTS satellites studied could be launched with a relatively low-cost Thor Delta booster.

There is, of course, disagreement over whether NASA should use a modified spacecraft or have one developed from the ground up. "There's no satellite right now that won't have to undergo a rigorous modification to make it suitable for an ERTS application," says W.L. Dowdy, earth resources manager for North American Rockwell. The company, prime contractor for the Apollo spacecraft, has never built an unmanned satellite. But it has built portions of satellites, such as structures and propulsion systems, that others have flown. And it has designed an octagonal-shaped ERTS craft with a large open bottom into which payload packages could easily fit, according to Dowdy.

"The structure is really the easy part—it never fails and it represents only about 5% of the overall program cost," Dowdy says. "The hard part is to design the power-supply and attitude-control systems. These would be the major efforts in any satellite program."

To those companies that have orbited unmanned satellites, this argument is understandable. "If we

didn't have a spacecraft we'd probably say it's just as easy to start one from scratch," says Donald L. Waltz, program manager for earth resources at TRW. "But there's no way to get around the fact that we have people, parts, and facilities for putting this kind of spacecraft together."

## Candidates in orbit

RCA, TRW, and GE claim that they'd save money for NASA if one of them got the award because they've already developed assembly-lines to put together space satellites. An earth resources vehicle would be just another item on the line, they argue, with the same basic structure as the earlier craft. And parts already built but not used in earlier programs could be installed in the ERTS craft.

Further, GE sees no need for any change in the Nimbus power supply, for example, if that craft were modified for ERTS. And on OGO, items such as gyro units, reaction wheels, horizon scanner heads, and sun sensors would hardly have to be changed at all, according to TRW's Waltz. Two more satellites have gone into production than have actually flown, he notes, so that many parts are still on hand.

RCA's candidate for ERTS is a stretched version of its Tiros M. A full load for the Tiros is 700 pounds, but by lengthening the craft's box-like structure, the load could be boosted to 1,200 pounds, estimates Bernard P. Miller, chief of RCA's earth resources development program. He adds that this would mean a 500-pound sensor payload.

If its Tiros M is picked for the ERTS A mission, RCA feels it will be largely because the satellite is assembled with its four sides lying flat on a table. This, says the company, makes it extremely easy to integrate the sensors into the structure—and to add sensors later on.

When almost everything is in place, the sides are folded up to form the box and the last of the components and the wing-like solar paddles are added. For the earth resources mission, the RCA satellite would have the same kind of momentum wheel stabilization and despinning that holds Tiros M steady about its three axes.

GE's design for an earth resources satellite is almost identical to that of its Nimbus D craft, slated for launch in the spring of next year. Nimbus D will carry 1,380 pounds into orbit, but its structure can be beefed up to carry as much as 1,600 pounds, making it the Big Daddy of the proposed satellites. GE doesn't expect an ERTS craft to carry anything near these weights, however.

Should GE get the award, the ERTS craft would share the production line with Nimbus E and F; contracts covering these craft, structurally identical to the D model, are expected to be awarded late this year. It might be hard to tell the satellites apart anyway. GE's approach to ERTS is summed up by a sign on the wall of program manager Keller's office: "Make it exactly like Nimbus."

Attitude control, power-supply, command, and thermal-control systems would all be identical to those on Nimbus D, according to Keller. The addition of a precise orbit adjust system would be the biggest, though still a minor, structural change.

Also new would be the S-band communications links to accommodate the wideband data. ERTS will need two 20-Mhz-wide channels, conjectures Keller, compared with the single 10-Mhz-wide channel on Nimbus. More commands would also probably be incorporated in a Nimbus-ERTS system, but this could be done by simply adding memory modules.

TRW's Waltz sees an OGO-derived earth resources satellite hauling 1,260 pounds into orbit, with nearly 350 pounds of that being payload. With structural modifications, the OGO could be enlarged to a 1,500- pound craft, and its payload to 425 pounds, he estimates. (The sixth OGO, scheduled for launch late this month or early next, will weigh 1,200 pounds).

For the ERTS mission, the booms on which OGO's space physics experiments are carried would be removed and its attitude-control system would be modified to point the spacecraft towards the earth. As now designed, OGO's horizon sensor and star-tracking system don't have any specific pointing direction. TRW would also add a three-axis cold-gas stabilization system, says Waltz. There'd be very little change in the satellite's solar paddles, even though they wouldn't point optimally towards the sun. Changing their position would mean changing the support structure, a complication TRW doesn't want to tackle. Besides, the 600 watts the solar cells can produce is more than enough for an ERTS mission, Waltz declares.

Among the other companies seeking the satellite contract, Lockheed is understood to be working on a modification of its Agena launch vehicle, which has supported payloads in space. And Hughes has studied several systems, one of them barrel-shaped with a solar-cell paddle at one end.

## Sensor array

There are all sorts of sensors that could find some use in an earth resources program. Several have been flown aboard NASA-owned aircraft in tests conducted by the Manned Spacecraft Center in Houston. Until now, NASA's earth resources program has been largely limited to such test flights.

Sensors are also flying in company-owned planes. Those tested include multiband film and television cameras, infrared and ultraviolet scanners, microwave radiometers, and radar scatterometers.

Of particular interest for ERTS are multispectral sensors, basically devices that can be "tuned" to respond to wavelengths in particular bands. Cameras can have this characteristic with combinations of film and optical filters, for instance. It's also possible to set up line scanners, with either optical diffraction grating or prisms, that zero in on wavelengths ranging from the ultraviolet to the thermal infrared.

Active and passive microwave sensors that can operate through heavy cloud cover could prove extremely useful on an ERTS mission. It's been ascer-

tained only recently that much of the earth is covered by heavy clouds for considerable lengths of time. Vidicons or multispectral scanners, which rely on the visible or infrared spectra, are useless under cloudy conditions.

Other sensors under consideration include passive radiometers and radar scatterometers sensitive to particular frequencies, side-looking radars, ultraviolet spectrometers, magnetometers, and gravity gradiometers, although the latter two are probably more useful in airplanes than in an orbiting satellite.

But this is no drawback. Aircraft will undoubtedly always play a role in an operational earth resources system. Besides checking out new sensors, they'll be used to investigate certain regions in detail. And they'll carry such sensors as magnetic anomaly detectors or high-power side-looking radar, which also aren't suited for a high-flying satellite.

Thus far, two important contracts for the initial resources satellites have gone to RCA. The firm's Astro-Electronics division is developing the 2-inch return-beam vidicons, and its Defense Communications Systems division is tackling vtr development. (RCA has also gotten NASA funds to develop a laser-beam reproducer for recreating at a ground station the pictures received from the satellite.)

Optical filters in front of the vidicons will make each of them sensitive to a different spectral band, from the blue-green (0.475 to 0.575 micron), through the yellow-red (0.580 to 0.680), to the photo-infrared (0.690 to 0.830).

RCA actually began developing the vidicons in 1964, when it concluded that an earth resources mission would have to use some sort of television

## Spectral, but not illusory

Photographs and television pictures from aircraft and satellites even now play an important role in surveying the earth and its environment. Stills taken on the Gemini and Apollo flights have proved of great value to, for example, geologists assessing the composition of vast areas of the earth. And television pictures relayed to earth by meteorological satellites make possible accurate long-range weather forecasts.

But such pictures are taken in a rather narrow band of wavelengths—mostly the visible light portion of the electromagnetic spectrum. Now, spaceborne equipment is being developed to produce images at ultraviolet, infrared, and microwave frequencies.

These systems will give scientists new kinds of information about the earth and its resources. Every object on the surface of the earth absorbs, reflects, and emits electromagnetic energy at distinctive wavelengths. Any given object will appear clearly at one frequency but be invisible at another. Each, in other words, has a distinct spectral signature, and it's possible to uncover, by taking simultaneous images in various bands, characteristics not apparent in the visual range alone. Collection and analysis of this data will reveal sharp differences among apparently identical objects. And various things may be learned about chemical and physical properties.

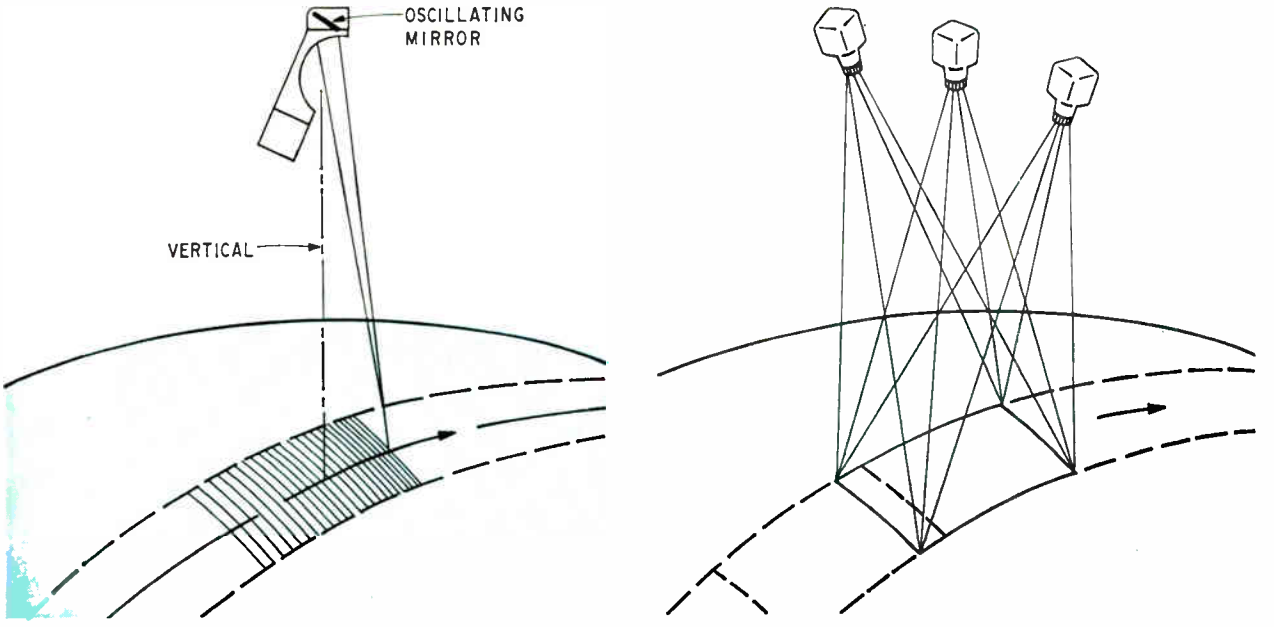
Attempts to make sense of spectral characteristics have been going on for several years, particularly at organizations such as Purdue University's Laboratory for Agricultural Remote Sensing.

It is not a simple task. "Man has had millenia of experience interpreting what he sees with his eyes, but only a few decades of seeing with ultraviolet and infrared," says Michael D. Richter, a senior systems engineer at TRW. "He's only beginning to understand the meaning of what he sees there, to learn how to cope with the extra information these additional wavelengths give." In the infrared wavelengths, for example, healthy vegetation shows up in bright red; blue or green may mean plants are dying.

At the moment, scientists working in five fields are potentially the biggest beneficiaries of data obtained from earth resources satellites:

- **Cartography.** A satellite could map an entire area with a single photograph more accurately than is possible with the perhaps thousands of conventional aerial shots needed to blanket the same area. In addition, repetitive pictures from an orbiting spacecraft such as the proposed ERTS would record landscape changes as they occur.
- **Agriculture and forestry.** Healthy crops and trees could be distinguished from the diseased, and the optimum use of land areas could be determined from soil surveys made by satellite-borne sensors. Different kinds of crops could also be determined automatically, making it possible to predict agricultural yields. Forest fires could also be quickly detected.
- **Oceanography.** The distribution of ice floes, ocean surface temperatures, current patterns, and marine biology data could be monitored via tv and infrared and microwave frequency systems.
- **Geology.** Large-scale — continental — geographic features are best viewed from orbiting spacecraft. Fractures and faults, for example, show up better in radar images than in visual photographs. But both kinds of observation would help in locating petroleum and mineral deposits. Repetitive infrared and visual imaging could be used to indicate geothermal power sources, movements of the earth's crust, and the anomalies that precede such natural disasters as earthquakes, landslides, and volcanic eruptions.
- **Hydrology.** Accumulations of snow and ice could be monitored to get more accurate estimates of potential water runoff. Surface water in lakes, rivers, and ponds could also be surveyed, with flood-control, pollution-control, irrigation, and power programs benefiting immeasurably from such data.

The potential benefits of an earth resources system far outrun the estimated costs of developing and operating it. "In our case studies, the benefits in a number of areas would total approximately $12 billion globally over a 20-year period," declares John E. Naugle, NASA's associate administrator for space science and applications.




**Ground sweep.** The return-beam vidicons would focus on the same part of the ground track beneath this spacecraft, but Hughes' multispectral camera would scan across the track with an oscillating mirror.

system. Resolution of the vidicons, which have an illuminated area of 1 square inch, is 6,000 tv lines, or 36 million picture elements; conventional space vidicon tubes have a resolution of but 1,000 tv lines. Actually, because contrast conditions of the earth photos will be far from ideal, RCA expects to get only about 4,000 lines of resolution in the final photographs from the laser reproducer.

RCA is also developing a 4½-inch return-beam vidicon with an illuminated area 2 inches square; this tube should give resolutions as high as 10,000 lines, the company says.

The three vidicons in the satellite will be carefully synchronized and mechanically aligned to view the same region on the earth. Identical shutters will expose the vidicons simultaneously for several milliseconds to limit blurring from the motion of the satellite.

Pictures will be read out sequentially from the vidicon surfaces. On the ground, a relatively large-scale digital computer will be used to combine the three spectral views into a single color picture. The separate picture elements in the composite will register to within three or four picture elements, well within Interior Department's requirements for mapmaking, notes RCA's Miller. Resolution of features on the ground will range between 100 and 200 feet.

However, registration may prove a difficult problem. The vidicons have a set of inherent electron-tube distortions, and these not only affect registration but could introduce errors into photographs. Thus, the intensity of the scanning spot may vary over the face of the vidicon tube; the photo-emissive material may not be deposited uniformly; and charge buildup in one area—caused by viewing bright clouds over a relatively dark earth, for instance—could cause the beam to diverge from its proper path in the tube.

## Spotters

These registration hangups don't trouble the multispectral scanners being developed by Hughes and Hycon. Instead of separate apertures, the scanners have a single set of optics for all wavelengths. "Our color registration will be excellent because of the common optics," says Steven D. Dorfman, manager of the space applications and exploration lab at Hughes Aircraft's Aerospace group.

The Hughes design, which closely resembles the spin-scan camera the company built for the Advanced Technology Satellites, images a small spot of light, corresponding to a portion of the field of view, onto a light detector. This is a single-point detector—that is, light falling on it cannot be scanned as with a vidicon. Pictures are produced by scanning the image spot with an oscillating mirror. The scan rate will be selected so that the speed of the satellite causes consecutive sweeps to be contiguous. In short, the horizontal dimension of the picture would result from the optical scan, the vertical dimension from the motion of the satellite.

Such a camera system could work in the same spectral bands as the RCA vidicons, or farther out into the infrared. Hughes is developing one scanner with four channels, three mostly in the visible band (0.5 to 0.6, 0.6 to 0.7, and 0.7 to 0.8 micron) and the fourth (0.8 to 1.2 microns) in the near infrared. The company is also developing a channel in the far infrared (10.2 to 12.6 microns) and is considering the possibility of a scanner system with as many as 24 separate channels.

That many channels are possible because the scanner, unlike the return-beam vidicons, does not use a single type of light detector. It employs the most suitable detector for the spectral band being imaged.

The bands are selected by passing the image spot through a refractive prism and spectral filters. The light bands are then conducted by fiber-optic bundles to the detectors—photomultiplier tubes for the visible light, photodiodes for the infrared. In the far infrared, the detectors would have to be cooled to less than 100°K.

Hycon's multispectral scanner is understood to be similar to Hughes' except that it scans with a rotating 24-lens turret instead of an oscillating mirror. The scanner selected for the payload will be the one with the higher signal-to-noise ratio, according to one ERTS designer.

The video tape recorders in the satellite must be extremely wideband to handle the sensor data and must last 1,000 hours—more than three times as long as recorders in broadcast studios.

The vtr's will have a 6-Mhz bandwidth, says RCA, which will supply three developmental models to NASA late this year. An ordinary broadcast video tape recorder has a 4-Mhz bandwidth, but the increased data capability of the RCA unit stands out more sharply when it's compared with the capacity of recorders already in space. When it goes into orbit, Tiros M will record at 500 hertz and play back at 8 kilohertz. Nimbus is a bit faster, recording at 1.6 khz and playing back at 52 khz.

The recorder will have to take in more than just the data from the return-beam vidicons; that could be handled with a 4-Mhz bandwidth. The earth resources satellite's vtr will also have to accommodate the multispectral sensors being considered for the payload, and other sensors that may be included in the future. And all the data recorded must be multiplexed onto a single channel for rebroadcast to the earth.

### Wear and tear

RCA proposes to get the increased bandwith by boosting the head-to-tape speed to just under 2,000 inches per second. The company will use standard 2-inch-wide tape with a four-head transverse scan to record a single wideband track. There may be two narrowband channels included for housekeeping purposes, though.

But increasing the head-to-tape speed increases the wear on the two, and makes it more difficult to achieve the 1,000-hour lifetime. Says F. Donald Kell, manager of RCA's ERTS recording program, "Essentially, most of the technology—the use of integrated circuits and the design of the transport mechanism—already exists. The limit on life is the head and tape wear."

Right now, Kell is evaluating different materials for the construction of the head, plus various tape-binder systems. His group is also studying ways to multiplex the sensor data onto the tape. It could be done by first digitizing the data and then recording it in a pulse-code mode, or by using an analog technique such as time-division multiplexing.

The tape will run reel-to-reel rather than in an endless loop, and will be able to record up to 30 minutes of data. This relatively short time is deemed sufficient because the recorders will be needed only when the satellite is out of range of ground stations. Most of the data will be collected and sent in real time. And recorded data will be sent to the ground as soon as possible.

The recorder's power consumption is set at about 75 watts and its weight at a little more than 45 pounds. The unit will come in two sections, one housing mechanical components and the other the electronics.

### Reception committee

ERTS data will be received at the Stadan (space tracking and data acquisition network) stations at Mojave, Calif., and Rosman, N.C., according to Gerald M. Truszynski, NASA's associate administrator for tracking and data acquisition. The space agency is also considering using the Fairbanks, Alaska, Stadan station.

The stations will be equipped to handle up to 10 Mhz of bandwidth for the first ERTS satellite and eventually 50 Mhz of bandwidth for a fully operational version. And there may someday be stations devoted entirely to handling earth resources information, Truszynski says. Another possibility for the future: satellites at synchronous altitude may be used to relay data from the earth resources satellite. There'd then be no need for tape recorders in the satellite. Data would always be sent, either directly or by relay, to the ground as it was received.

Initial ERTS information will be delivered daily on large reels of magnetic tape to Goddard Spaceflight Center where the photos will be reconstructed.

RCA began developing its laser-beam image reproducer specifically to handle the high-resolution pictures produced by the company's return-beam vidicon. Kinescope tubes, conventionally used to reproduce tv pictures from space, run out of resolution at about 3,000 lines. And it doesn't look as if they'll get much better, says RCA's Miller. The laser unit's resolution is 6,000 lines and it could go higher.

In the image reproducer, the incoming video signal intensity-modulates the beam of a helium-neon laser. This beam is optically focused to form a 0.8-mil spot, and a high-speed scanning mirror then deflects the spot horizontally across film, producing a final hard copy of the picture. Vertical scan is obtained by moving the table on which the film is fastened. The light energy can be modulated at extremely high rates, according to RCA, so that bandwidths may exceed 100 Mhz.

Besides this RCA reproducer, designs in which electron beams write across film in a vacuum are being considered. ■

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# Designer's casebook

## IC circuit measures speed of switches

By Remult Iltis

American Laundry Machinery Industries, Cincinnati, Ohio

In electromechanical systems, it is often important to know the response time of a switch. Since this time is in the order of milliseconds, it is difficult to make accurate measurements of the switching time. The circuit shown measures switching times using 3 microcircuits, an oscillator, and a counter.

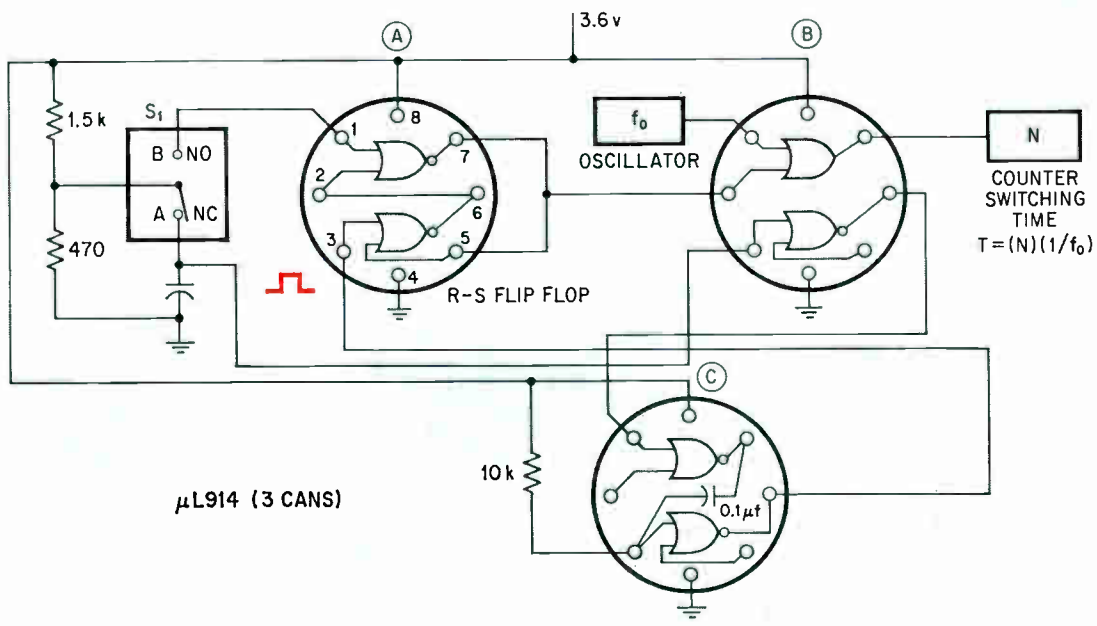
$S_1$ is a single-pole, double-throw microswitch the switching time of which is to be measured. A signal, $f_o$, from the oscillator, feeds NOR gate B the output of which is connected to a counter. When the switch is in the normally closed position, gate A, which is an R-S flip flop, is at logic 1 inhibiting B from transmitting the signal to the counter.

When the switch is activated, contact a opens before b closes. Gate C's output switches to logic 1 and sets the flip flop output to logic 0. This activates gate B which transmits the oscillator's signal to the counter. When contact b closes, the flip flop is reset inhibiting B and blocking the signal from reaching the counter.

The switching time is $T = (1/f_o)N$ where N is the number of counts registered by the counter, $f_o$ is the frequency of the oscillator in hertz, and T is in seconds.

Increasing the frequency of the oscillator, leads to greater precision in measuring switching time. 100 kilohertz is an adequate signal to measure switching times of a few milliseconds.

Using a 10-Mhz oscillator, switching times in hundreds of nanoseconds can be measured.




**Count down.** When contact a of the switch opens, the flip flop is set and gate B delivers the signal from the oscillator to the counter. Counting continues until contact b closes, at which time the flip flop resets, inhibiting the gate from delivering signals to the counter.

# Op amps replace transformer in phase detector circuit

By Anthony F. Gangi

Texas A&M University, College Station

Synchronous phase detectors which are wideband and have single-ended inputs are useful as tracking filters, phase-lock frequency-modulation discriminators, and synchronous detectors. But single-ended inputs are generally obtained with transformers whose characteristics limit the bandwidth of the detector. This problem can be eliminated by using an operational amplifier scheme instead of the common transformer-coupled, balanced-phase detector.

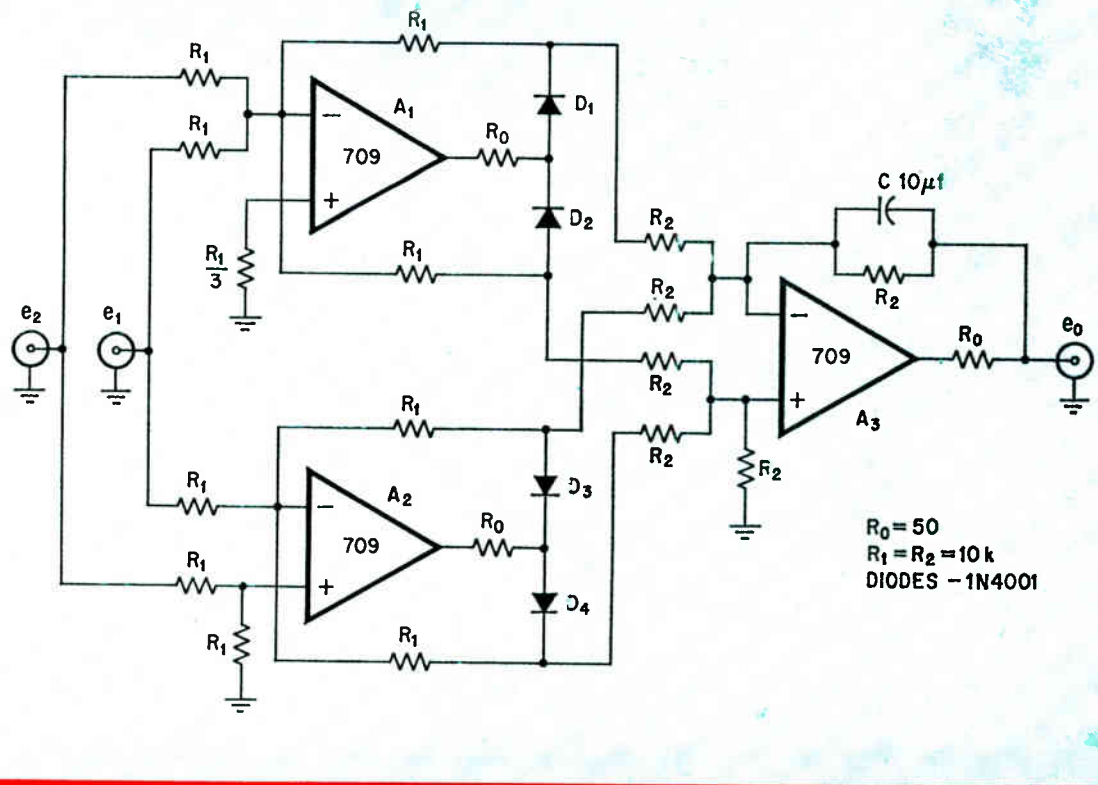
The circuit consists of three operational amplifiers—two used as small signal rectifiers ($A_1$ and $A_2$), and the third as both a difference amplifier and a low-pass filter.

The two input voltages are given by the following equation:

$$e_1(t) = E_1 \cos\omega t$$
$$e_2(t) = E_2(t)\cos[\omega t + \phi(t)]$$

where $E_2(t)$ and $\phi(t)$ are slowly varying relative to $\omega$, and $E_1$ is a constant. The output of the third operational amplifier is the low-pass (or averaged) value of the outputs generated from the first two op amps. If $E_1 >> E_2$, this output voltage becomes $e_o \approx (2/\pi)E_2\cos\phi$. If $\phi = 0$, the circuit is a phase sensitive synchronous detector whose output is independent of the reference voltage amplitude $E_1$ (as long as $E_1 > E_2$). If $E_2$ is held constant (and $E_1 > E_2$) and $\phi = (\pi/2 + \psi)$, the circuit acts as a phase detector with its output proportional to the sine of the phase difference $\psi$.

The circuit operates satisfactorily for frequencies from below 10 hertz to frequencies above 10 kilohertz. The high frequency limitation is set by the frequency response of the op amps (at low voltage levels), by the frequency dependence of the op amp common-mode rejection ratio, and by stray capacitance. With more expensive op amps having broader frequency responses and higher slewing rates, the circuit can respond to frequencies from 1 hz to over 1 Mhz.




**Wideband.** The wideband, phase sensitive, synchronous detector uses operational amplifiers to increase the bandwidth over that of conventional detectors which use transformers. Op amps $A_1$ and $A_2$ function as small signal rectifiers while the third amplifier is used as a lowpass filter.

# Signals shifted 180° as amplitude remains constant

By Joseph J. Shin

Loyola College, Montreal

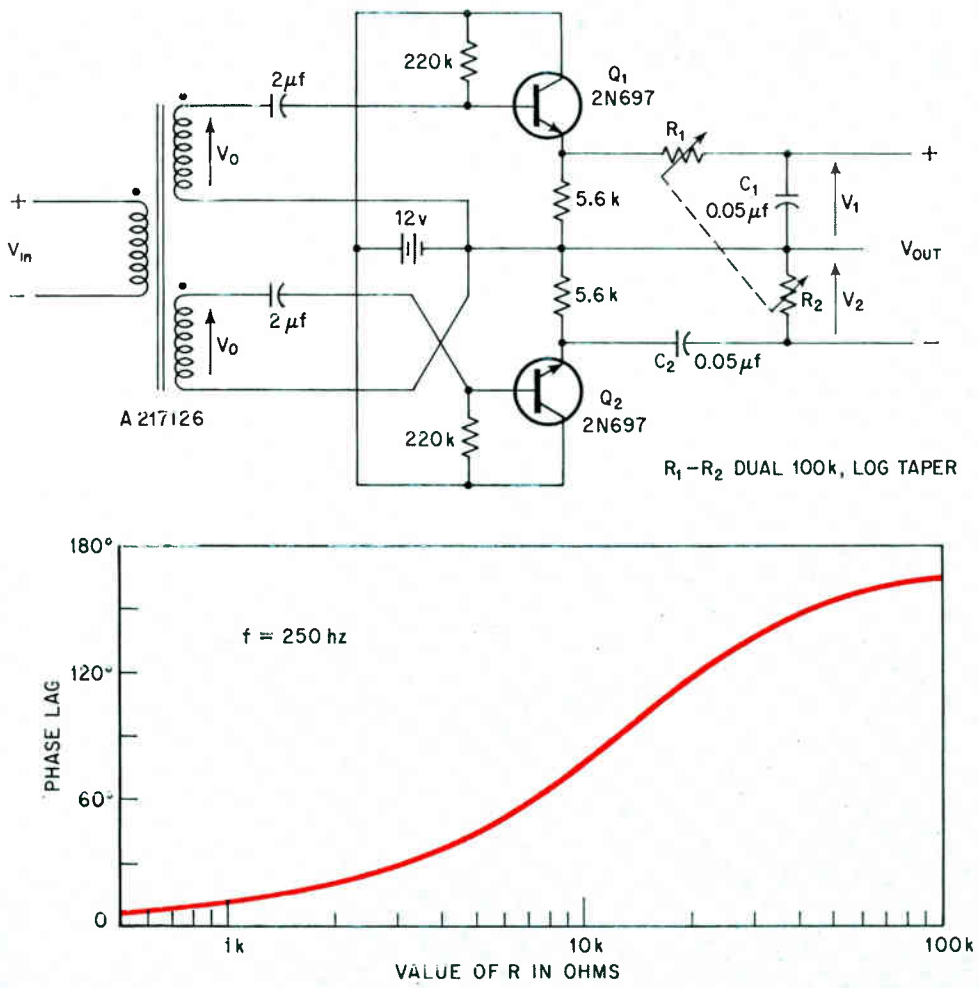
A useful procedure in phase-locking amplifiers is to shift a sinusoidal signal over a 180° range. This circuit operates over any frequency range and by adjusting the RC time constants, shifts a signal up to 180°, while maintaining a constant output amplitude and low output impedance.

$R_1C_1$ provides a 0° to 90° phase lag, while $R_2C_2$ provides a 0° to 90° phase lead. By arranging the secondary windings of the transformer as shown, the phase shift of the output voltage becomes 0° to −180°.

If $R_1 = R_2 = R$, the output voltage and phase angle is given by $V_{out} = V_o \angle -\beta$ where $\beta = \tan^{-1}[2\omega RC/(1-\omega^2R^2C^2)]$.

Emitter followers $Q_1$ and $Q_2$, by presenting a high input impedance to the signal source, prevent a short-circuit by $C_1$ and $C_2$ if $R_1$ and $R_2$ are set at low values.

Reversing the input leads provides an additional 180° phase shift: $\beta = 0°$ to $+180°$. When $R_1C_1 = R_2C_2 = 1/\omega$, $\beta = -90°$. For the given values, the frequency is about 1 khz.




**Lagging.** This circuit's continuously variable phase shift, constant output voltage, and low output impedance makes it useful in analog computers. The phase lag of $R_1C_1$ combined with the phase lead of $R_2C_2$ provides a constant output voltage.

# Zener circuit detects transients in power lines

By Octavius Pitzalis Jr.

U. S. Army Electronics Command, Fort Monmouth, N.J.

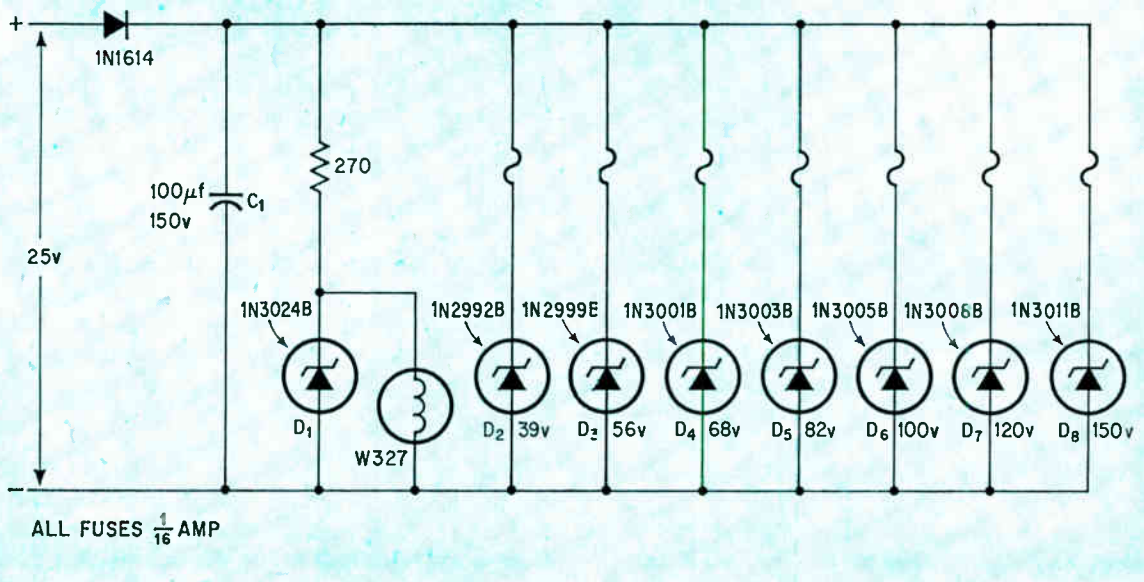
Large spikes in power lines can damage and even destroy electronic equipment. A detector that constantly monitors power lines and stores the approximate voltage magnitude of the largest spike can quickly determine if a supply line spike is responsible and indicate the magnitude of the disturbance. Although a technician using an oscilloscope could get more precise waveform information, the detector offers the advantage of continuous surveillance of the supply buses. Installation of the detector permits recording of otherwise elusive transients occurring at any time during equipment operation.

The detector is designed for a 28-volt d-c electrical supply source. The detection is done by the parallel group of zener diodes, $D_2$ through $D_8$, each of which is in series with a very sensitive $\frac{1}{16}$-amp, 10-ohm instrument fuse. Each zener-fuse combination corresponds to a detected voltage level about 5 volts greater than the breakdown voltage of the zener. Therefore, voltages of 44, 61, 73, 87, 105, 125, and 155 are the approximate detection levels for the zeners indicated. The 100-microfarad capacitor, $C_1$, is used to absorb transients of less than 1 millisecond. The zener voltages chosen and the number of zeners used are determined by the range and accuracy of the voltage spikes to be monitored.

Assume a 37-volt transient spike exceeding 1 msec in duration is present on the 28-volt supply bus. This means the total peak voltage is 65 volts. Zener diodes $D_2$ and $D_3$ avalanche into conduction, and the fuse in series with each opens. $D_4$ through $D_8$ don't avalanche for this transient, and their fuses remain undisturbed. Examination of the fuses for failures readily indicates a spike in excess of the level determined by $D_3$, the 61-volt level, but less than the level required to destroy the fuse in series with $D_4$, the 73-volt level. The spike is therefore greater than 61 volts and less than 73 volts.

The input diode serves to prevent fuse damage should the detector be connected with incorrect polarity. The lamp glows only for correct polarity connection to the live 28-volt line. The series resistor $R_1$ and the 15-volt zener, $D_1$, parallel the lamp to protect it from incoming voltage spikes.

This detector can similarly detect peak positive voltages developed on a-c supply lines. A second detector installed with reversed supply connections can monitor the a-c line for peak negative voltages. With simple modifications of the capacitor, $C_1$, and the zener diodes, this type of detector can be altered to monitor transients of other peak values and minimum durations on any supply line.




**Continuous surveillance.** To determine whether any dangerous transient voltage spikes exist on a power bus, this detector is connected in series with the supply line. Determining which fuse has blown yields an estimate of the amplitude of the spike.

# New etchant puts dielectric isolation in the groove

This process is now competitive in cost with junction isolation thanks to an anisotropic etchant that forms v-shaped areas, making possible higher component packing densities and improved production yields.

By David F. Allison, Albert P. Youmans, and Thomas H. Wong

Signetics Corporation, Sunnyvale, California

**Once restricted** to expensive radiation-hardened circuits, dielectric isolation is now being used in linear, high-voltage, and some digital circuits. The needed shot in the arm—a directional etchant—gives this process the edge over junction isolation in many cases.

Space savings and higher yields derive from the nature of the etching process, which proceeds 30 times more rapidly along the 100 crystal plane—where atoms are less densely packed—than it does along the 111 plane. Thus, the etchant forms a v-shaped groove the depth of which depends only on the width of the photolithographically-produced isolation mask. Since etching virtually stops when the 100 plane is no longer exposed—that is, when the tip of the v is reached—the process is easily controlled.

Once isolation grooves have been made, they're coated with silicon dioxide and filled with polycrystalline silicon. Then, the entire structure is turned over and lapped until the deepest isolation groove appears. Since the depth of the grooves can be predicted exactly from the width of the isolation masks, the appearance of the deepest groove acts as a signal and makes it possible to adjust lapping exactly for less deep grooves.

Conventional, as opposed to directional, etchants attack the crystal equally in all directions, producing grooves at least twice as wide as they are deep. Therefore, components have to be spaced far apart. Even more serious, dimensions of the isolation grooves can't be controlled precisely because they depend on the length of time of etching, the etchant's temperature, and on other variables. Thus, grooves sometimes aren't deep enough and some of the devices short each other. Often grooves are too deep, leaving little room for devices. This low yield, in the past, has limited dielectric isolation to only the most expensive applications.

However, now that these drawbacks have been overcome the process as a whole offers a number of advantages both for low and high voltage IC's. For high voltage circuits it permits much higher bias voltages because the collector is formed in high-resistivity grown silicon rather than in an epitaxial layer. It's difficult to grow a high resistivity epitaxial layer. Moreover, epitaxial layers generally have more defects than the original substrate.

To achieve a high breakdown voltage, the high resistivity collector region must be about 40-microns thick at 300 volts. In junction isolated circuits, isolation diffusions take at least one day to penetrate this layer, tieing up equipment and resulting in very wide strips. For example, in a 300-volt circuit these regions take up 80% of the total semiconductor area. On the other hand, in dielectric isolation an anisotropic etchant takes only minutes to form grooves and allows components to be spaced only 10 microns apart.

## Winning way

Thus, because of the economical advantages in yield and high packing density, dielectric isolation is being looked at for other applications. For example, it makes possible the fabrication of complementary bipolar transistors that have a high $f_T$ and, at the same time, can be used in a variety of circuit designs.

Commercially available junction isolated ICs with complementary transistors use either lateral or substrate pnp's. The lateral type consists of two

## V for economy

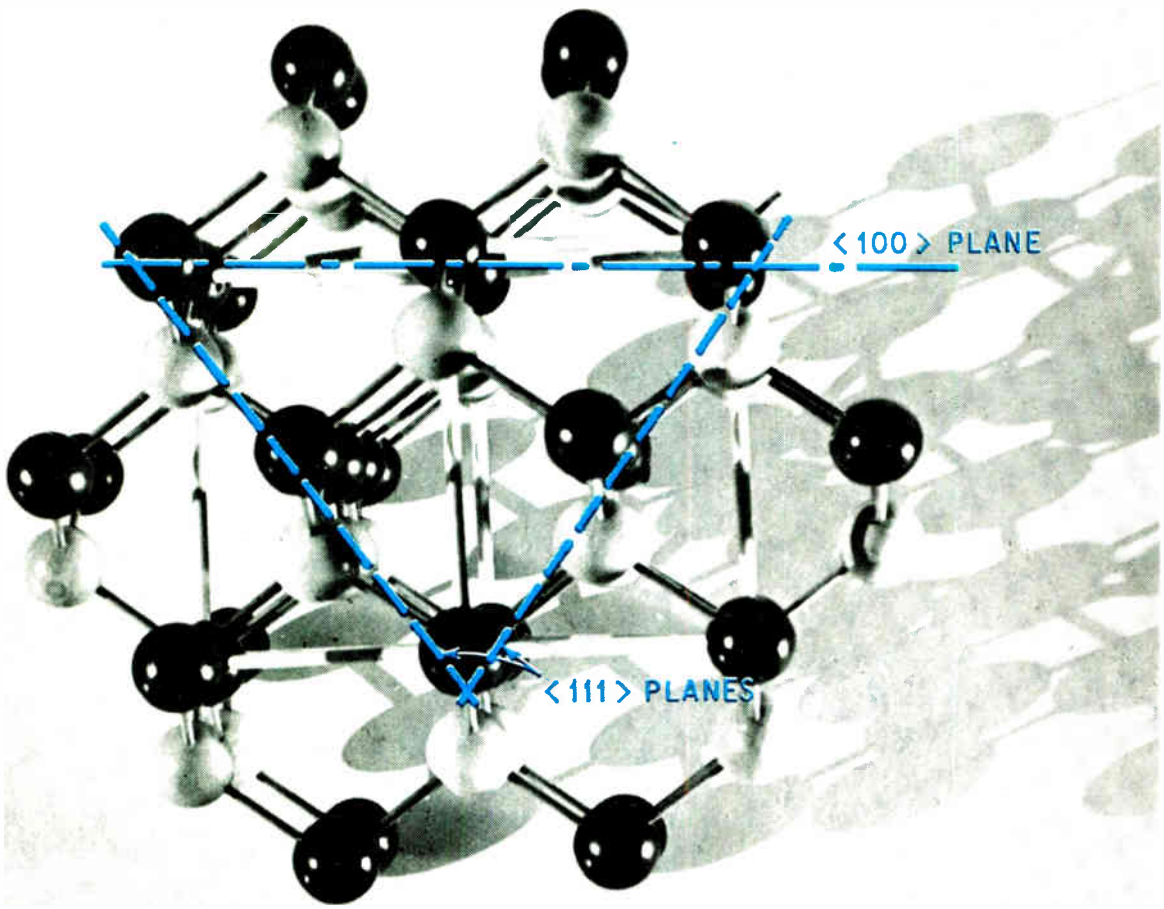
Silicon's crystalline structure can be visualized as a number of perfectly stacked cubes, each containing four atoms inside, six in the walls, and eight in the corners. The index numbers describing the various planes that intersect such a cube are reciprocals of the intersection in the x, y, and z directions. For example, the 100 plane intersects the x direction at 1, and the x and y direction at infinity.

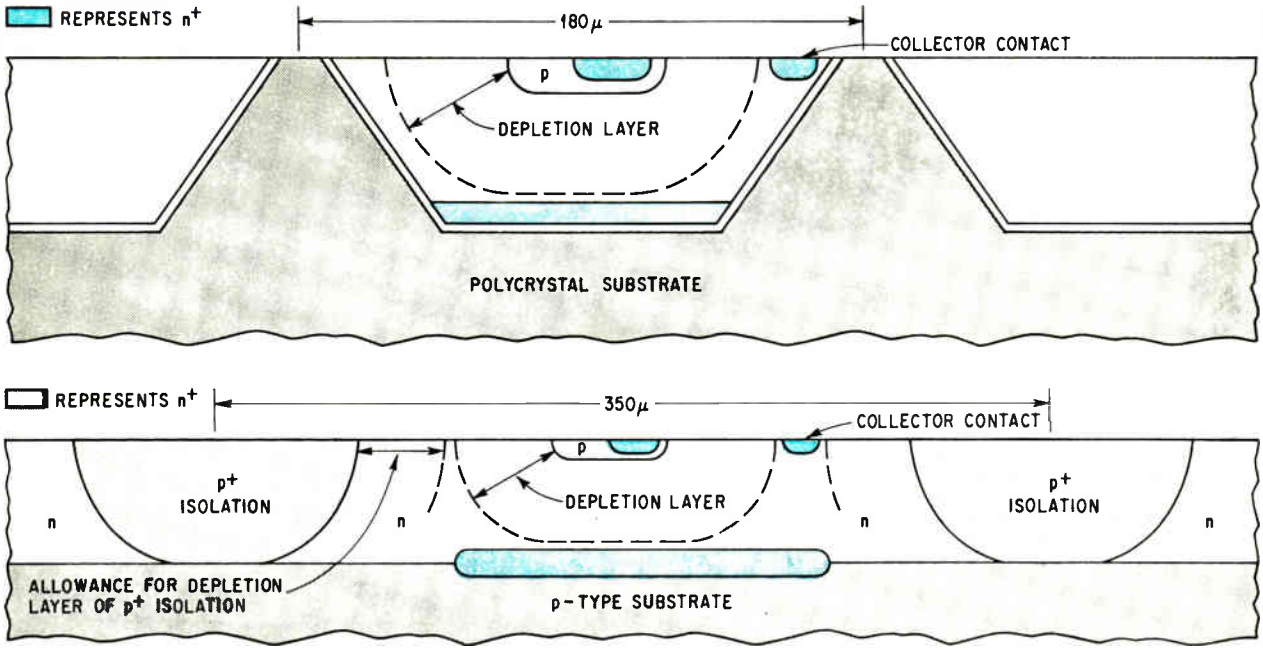
Because the basic cube can be oriented in six different ways, the various planes appear in six directions. Thus, every 100 plane, for example, is intersected by several 111 planes. Because the structure is that of a single crystal, angles between these planes are very precise.

**Atomic density.** Laboratory models of single crystals show how atomic density varies with the angle of observation. For example, head on the 111 plane has many atoms while the 100 plane has few.

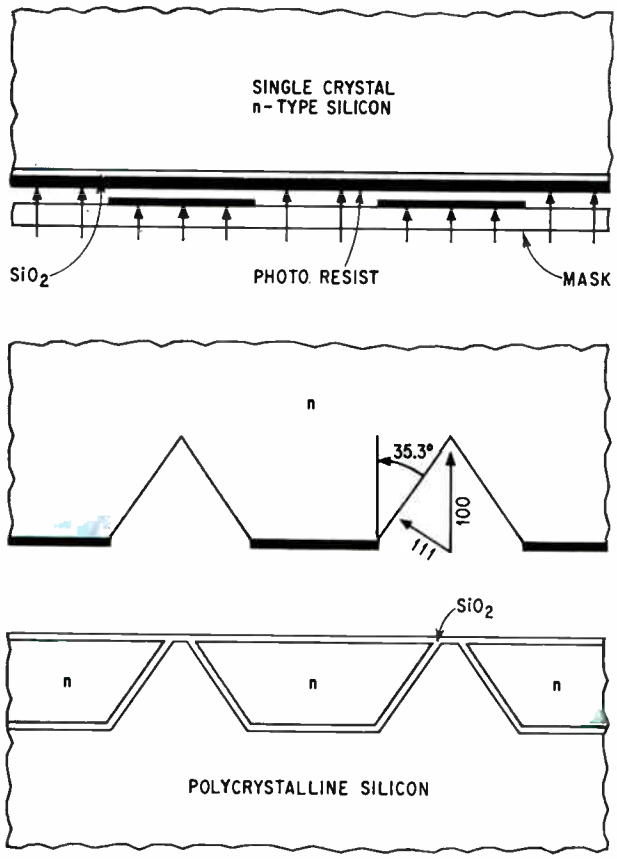
The anisotropic etchant attacks the silicon 100 plane until it reaches the 111 planes which extend down from the edge of the silicon dioxide window and meet to form a V.

It's relatively unimportant which crystal plane is used in bipolar ics although until recently it was easier to grow silicon with the 111 plane perpendicular to the axis of the bar; this plane is still preferred for MOS devices because it results in higher mobility. However, 100 silicon is now available in production quantities and, as a result, the economic advantage of using the anisotropic etchant is no longer offset somewhat by the extra expense of the semiconductor material.






**Making room.** Big advantage of dielectric isolation with anisotropic etch is that many components can be packed on IC. Dielectrically isolated device (above) and p-n junction isolated device (below) are contrasted.




**Isolation steps.** Pattern is exposed to back side of silicon slice during dielectric isolation. Then unexposed regions are etched with anisotropic etchant, which forms v-shaped groove. $SiO_2$ dielectric coats single crystal; polycrystalline silicon backfills grooves, and silicon is lapped from top to expose grooves.

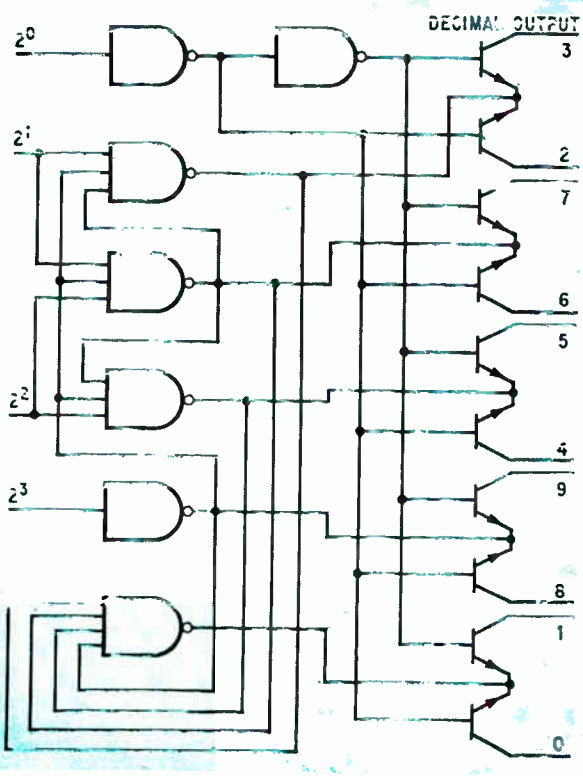
p beds that are simultaneously diffused into the n-epitaxial layer. Fabrication is easy but current gain and $f_T$ are low. By contrast, the substrate type, consisting of a p-diffused emitter and a p collector formed on the substrate, gives slightly better current gain and higher $f_T$. (The p diffusion also forms the base of the complementary transistor.) Since all the pnp's in one such circuit have a common collector, the number of possible circuit designs is limited.

More sophisticated complementary structures required very complex processing sequences because it's extremely difficult to control epitaxial growth and multiple diffusion. Furthermore, p-n junctions sometimes break down, especially at local imperfections in the crystal.

Dielectric isolation eliminates these problems and also eliminates unwanted transistor action due to pnp structures throughout the wafer. Even more important, resistivities in isolated islands can be changed by long diffusions without having to worry about back diffusion from p-isolation areas. In fact, complementary pairs of transistors can be made in only six diffusion steps. In one such pair fabricated at Signetics, the $f_T$ of the pnp device was 100 megahertz while that of the npn was 350 Mhz.

## Gold diffusion

Another application of dielectric isolation is in saturating logic circuits. Gold is normally diffused into these type circuits to reduce the lifetime of minority carriers. However, gold has such a high diffusion constant that it penetrates through all components in p-n junction-isolated circuits. This doesn't affect performance in the majority of




| INPUT | | | | OUTPUT ON |
|---|---|---|---|---|
| $2^3$ | $2^2$ | $2^1$ | $2^0$ | |
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 1 |
| 0 | 0 | 1 | 0 | 2 |
| 0 | 0 | 1 | 1 | 3 |
| 0 | 1 | 0 | 0 | 4 |
| 0 | 1 | 0 | 1 | 5 |
| 0 | 1 | 1 | 0 | 6 |
| 0 | 1 | 1 | 1 | 7 |
| 1 | 0 | 0 | 0 | 8 |
| 1 | 0 | 0 | 1 | 9 |
| 1 | 0 | 1 | 0 | 8 |
| 1 | 0 | 1 | 1 | 9 |
| 1 | 1 | 0 | 0 | 8 |
| 1 | 1 | 0 | 1 | 9 |
| 1 | 1 | 1 | 0 | 8 |
| 1 | 1 | 1 | 1 | 9 |

**Layout.** Decoding is done using the $2^0$ bit to determine whether decimal number is odd or even in dielectrically isolated Nixie tube driver IC. This bit goes into two inverting buffers in series, and outputs of buffers become the even or odd lines to drive output-transistor bases. Five gates decode the five states of the 10 outputs from $2^1$, $2^2$ and $2^3$ inputs. These states are decimal 0 and 1, 2 and 3, 4 and 5, 6 and 7, and 8 and 9. Gate outputs go to emitters of five pairs of output transistors. Only one output of these five gates can be low at one time, at which point it goes to a diode and a $V_{CE(sat)}$ above ground (above 1.0 volt). Decoding technique assures that all unselected output transistors can't be forced into an $LV_{CEO}$ latch-back breakdown.

saturating logic circuits, but there are many cases where gold doping of individual components is a must.

Oxide isolation, however, prevents gold from diffusing into other components. Signetics has taken advantage of this in a Nixie tube driver IC where input logic circuitry uses low voltage, high-speed saturating transistors doped with gold. The output high-voltage driver transistors, which have high-resistivity collectors, are gold free. To fabricate this circuit, islands containing the input transistors were selectively doped with high-concentration phosphorus to reduce resistivity. Then gold was diffused in through oxide windows.

## Close together

Advantages of this circuit over junction-isolated versions are a high enough breakdown voltage (170 volts) to accommodate any Nixie tube, a high-current sinking capability, a reverse bias on unselected outputs to avoid latch-back type breakdown, and a high yield because all of the components are formed in the grown single-crystal material rather than in an epitaxial layer.

Dielectric isolation also permits many unique structures, especially when the anisotropic etchant is used. For example, etching a groove that reaches close to the top surface of the collector region appreciably reduces collector-series resistance in transistors. Also, high voltage pinched resistors can be formed. In addition, these resistors can also serve as field effect transistors if the p gate is disconnected from the source. Furthermore, structures for improving lateral current gains and FET performance have been made.

Another important plus is the reduction of parasitic capacitances by the oxide dielectric. This should result in high speed for linear and digital circuits. Finally, the cost of radiation-hardened circuits—where dielectric isolation has been used for some time—should be reduced thanks to the new isolation technology. ■

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Memories XIX

# Ferroelectric memories for special applications

By Alvin B. Kaufman

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**For certain applications,** polycrystalline ferroelectric materials promise a high-performance memory at a very low cost. These applications include frequency control and the identification of persons seeking access to secured areas. Such memories are amenable to batch processing, capable of high storage density, and resistant to nuclear radiation. Moreover, they produce signals many orders of magnitude larger than those generated with solid state magnetic memory devices.

Ferroelectric memories are well suited for immediate use in certain industrial jobs where only a single word—without addressing logic—is required for a control process. For example, they can be employed in remote meter-reading schemes or in multichannel radio receivers, where linear-select memories can act as a binary code to control a precise frequency and thus to select the individual channels.

To write data in a ferroelectric memory requires the application of a 75-to-150-volt signal for as much as a millisecond—somewhat less for higher voltages. The pulse establishes oriented domains within the ferroelectric material in somewhat the same way that a current pulse polarizes (magnetizes) a ferromagnetic material. Several differently polarized regions can exist in the same device, storing several independent bits.

Two different approaches have been taken to data retrieval. In one of these, application of an interrogating voltage pulse generates another pulse of the same or opposite polarity depending on the polarity of the ferroelectric material; the output voltage pulse can be used directly with MOS or converted to a current pulse to drive bipolar semiconductor circuits.

In the other approach, a ferroelectric wafer's opacity, which depends on its domain orientation, permits data to be read out with a beam of light impinging on an array of photodetectors behind the wafer.

With either retrieval method, the ceramic's piezoelectric and optical characteristics depend on the properties of the orientable domains. And since this orientation is essentially permanent and needn't be disturbed by reading, the ferroelectric memory has a nondestructive readout capability at speeds greater than a megahertz. Once established by a writing signal, the orientation stays put regardless of environmental change or power failures.

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

These memories aren't in wide use at present, however, and for several reasons. First, many potential users consider ferroelectric devices to be unproven. Second, since the ferroelectric device is voltage-sensitive, it cannot easily take the place of a current-sensitive magnetic memory. It's also quite slow to write. Further, the logic that decodes addresses for a ferroelectric array is expensive because it requires diode or transistor isolation to decouple the elements from one another. And finally, the basic memory element looks like a three-port device; its implementation in an array thus appears easier than it really is.

## Taking the wrong path

Another factor to be considered: ferroelectric memory elements are capacitive both with respect to each other in an array and with respect to the printed-circuit wiring associated with the array. This capacitance sets up paths through which unaddressed bits may appear at the output, creating errors or uncertainty in the addressed data. And the isolation needed to block these second-order paths is likely to be expensive.

In a ferroelectric memory from which data is retrieved optically, similar second-order paths are likely to exist in the write circuits, so that data can sometimes be loaded in the wrong place. Also the read circuits, which use a light source and an array of photocells, are likely to be complex.

These considerations make the future of ferroelectric memories in computers rather bleak. Large-scale integrated decoding circuits might overcome

some of the problems, but the use of LSI in this sphere seems unlikely in the immediate future. Electrically alterable read-only memories remain an attractive application, but magnetic memories have a big head start here.

The most useful form of ferroelectric memory is the piezoelectric bender, shown below. This device consists of two pieces of ferroelectric material bonded to the opposite sides of a thin metal plate and containing a pattern of electrodes on their outer surfaces. Because the material is piezoelectric, a voltage applied to one of the electrodes causes the entire device to deform physically; this deformation, in turn, generates output voltages at the other electrodes, again as a result of the piezoelectric property.

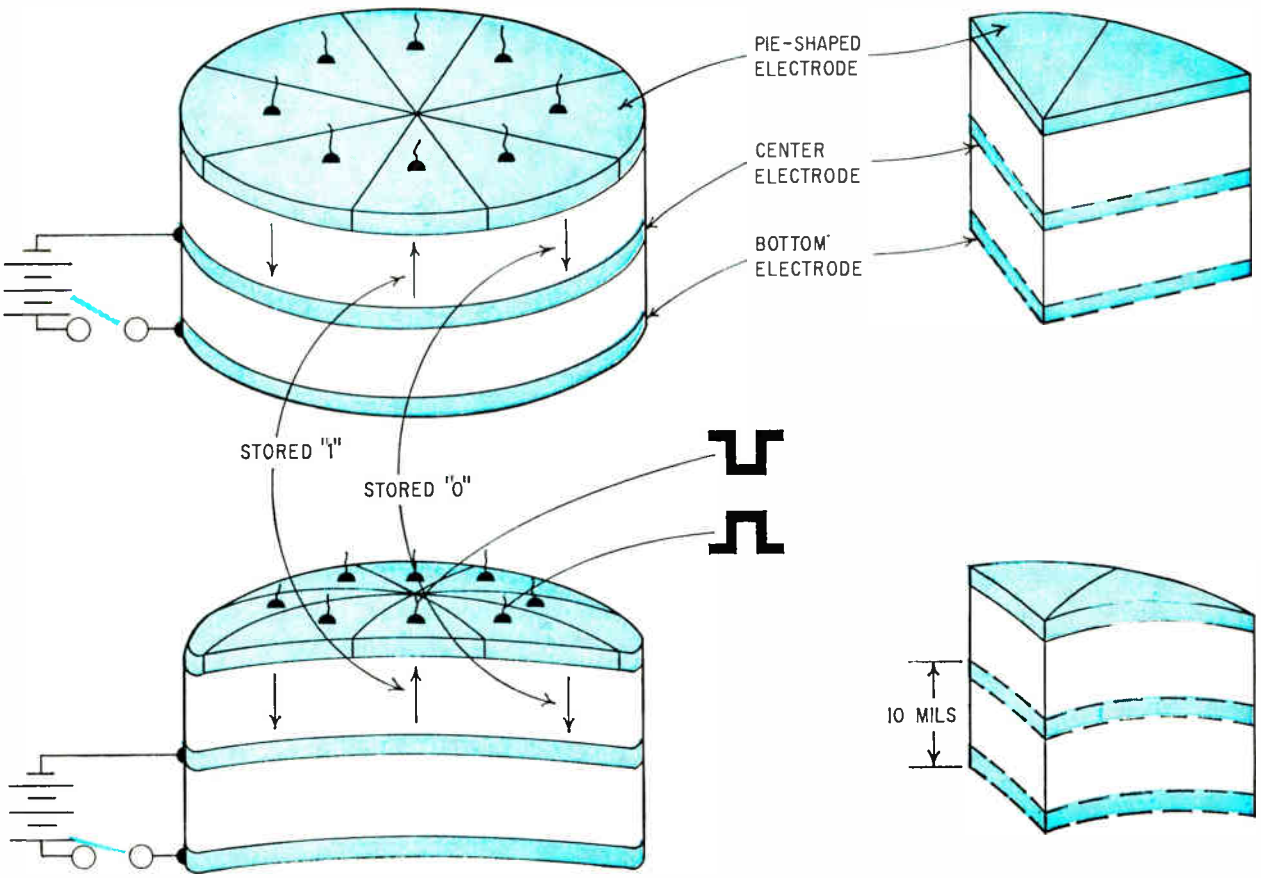
The polarity of the output voltage depends on how the material under each electrode was polarized during a previous writing operation. This memory can produce several volts in its output signal and can drive bipolar, metal oxide semiconductor, and silicon controlled rectifier circuits directly.

In one recent application developed at Diginetics Corp., a small ferroelectric memory was embedded in a printed-circuit board, as shown on page 118, to make a kind of electronic key. When the fully-assembled key, encapsulated in an opaque dyed epoxy, is inserted in a readout device, it generates a combination of voltage signals that are compared with a preset combination in the reader. If the combinations match, the reader produces a signal that could be used for credit identification or to provide access to restricted areas. The combination stored in any particular key can be easily changed by an encoder device, but is, according to Diginetics, extremely difficult or even impossible to duplicate.

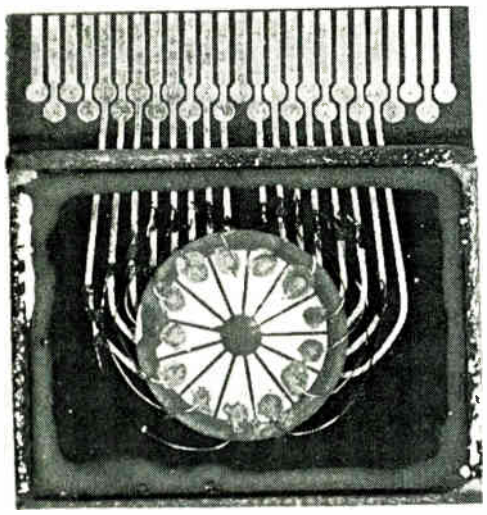
The photograph shows a 13-bit memory capable of 8,192 different combinations. However, a 20-bit memory, of the same physical size, could provide more than a million different combinations.

These keys have a number of advantages over the magnetically encoded cards now used in similar applications, the most important being the fact that it's hard to alter data stored in the ferroelectric device. The magnetic code, on the other hand, can be easily changed, deliberately or accidentally. Furthermore, the ferroelectric data isn't as readily ascertained as the magnetic, even if there's no intent to alter it.

Today's most commonly used ferroelectric material is a lead-zirconate-titanate composition, sometimes doped with bismuth or niobate. This material's principal disadvantage is its high writing voltage; if a material could be developed with a




**Bender.** A voltage applied to the bottom layer of this $1 piezoelectric wafer bends it; because both layers are bonded to the center electrode, the top layer also bends, producing output voltage signals.



**Two keys.** The ferroelectric wafer, when embedded in opaque epoxy, makes a key that's much harder to duplicate than the old-fashioned variety.

voltage in line with a computer's normal d-c power supplies, computer applications might suddenly seem more attractive.

Also such transparent ferroelectric materials as bismuth oxide and niobate glass-ceramic are being considered for use in certain types of displays. ■

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Memories XX

# Coupling sets thin magnetic films on closed flux path


By Hsu Chang

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**Placed face to face,** pairs of thin-film memory elements, sandwiching striplines, form coupled magnetic films in which the flux lines of their magnetic fields are almost wholly contained in magnetic material. The films therefore operate with large disturb margins and produce relatively large output signals but require only small input currents. These advantages follow from the device's structure, which is at least as important as the film's intrinsic magnetic properties.

Flux closure is the key to thin-film memory performance, in terms of high speed, large capacity, and low cost. All of these parameters can be improved if the memory elements are made smaller; but only when the flux lines close in a magnetic material can miniaturization without demagnetization occur. One reason for the outstanding success of the ferrite core over the years is that its toroidal shape intrinsically offers a closed path for flux.

Miniaturized closed-flux devices such as coupled films require demanding techniques for depositing integrated multilayer structures, in which magnetic films are deposited on top of other conducting or insulating films. These techniques include controlling the properties of these films, etching the layers at various stages, maintaining the closed-flux pattern at the edges of etched lines, and adding high-permeability keepers. As a result, although the feasibility of coupled film memories has been clearly demonstrated, progress in their development has been rather slow.

At present, memory planes with storage density of 9,000 bits per square inch have been built. This density is higher than that of any other magnetic memory, but it's still far short of that attainable by present-day fabrication technology. These planes

are suitable as building blocks for million-bit memories that cycle in less than 100 nanoseconds,[1] or for much larger memories with longer cycle times. These memories operate at or near a limit imposed by thermal noise in the amplifier, indicating that further development in detection techniques should be undertaken to keep pace with coupled-film structure miniaturization.

Thin films have a number of intrinsic properties that aren't found in bulk material. Of the intrinsic properties, one of the most important in connection with memories is the film's magnetic anisotropy—the variation of its magnetic properties as a function of orientation relative to a crystalline axis.

Anisotropy in general, and uniaxial anisotropy in particular, is important because it permits thin films to be magnetized in either of two opposite directions along the easy axis; these two remanent states correspond to the binary 0's and 1's characteristic of most data storage units.

In general, if a single-crystal film is deposited in the absence of a magnetic field, it will have at least two axes of symmetry, and perhaps more. The number and angle of these axes depend on the film's atomic structure. For example, a single crystal of iron has a cubic structure, and therefore is biaxial—it has two axes at right angles to one another parallel to the film plane. When such a film has been magnetized, much energy is required to reverse or alter the magnetic state, because the anisotropy is strong.

On the other hand, in a polycrystalline film of permalloy, the individual crystals, or crystallites, are randomly oriented. If the film is deposited in a magnetic field, the field creates an artificial anisotropy, called magnetization-induced anisotropy. It's this artificial anisotropy that offers the two stable quiescent states required in a memory.

This magnetization-induced anisotropy in polycrystalline permalloy is about two orders of magnitude smaller than the material's intrinsic crystalline anisotropy. This permits the word field—perpendicular to the easy axis—to be only a few oersteds, and the bit field, parallel to the easy axis, a few tenths of an oersted, if the film's easy axis orientation is sufficiently uniform. Furthermore, a drive field parallel to the hard axis could cause the magnetization in the film to rotate sufficiently to switch the material in only a few nanoseconds, with very little energy dissipated in the material.

Another manifestation of the uniaxial anisotropy is the astroidal rotational threshold curve.[2] This is a plot of the switching threshold in the hard direction versus that in the easy direction, in four quadrants; it resembles a four-pointed star with the tips on the coordinate axes. It's an important property because in an array of thin-film elements data is stored by applying a relatively strong word field at right angles to the easy axis and a weaker bit field parallel to the easy axis; the bit field's direction is defined by the bit to be stored. If the word field is turned on alone, it twists the film's magnetization out of the easy axis. The bit field then biases the magnetization one way or the other. Toward the end of the cycle, the word field turns off before the bit field, which ensures that the magnetization returns to the easy axis in the proper direction.

Because of the astroidal threshold, the word and bit fields when applied together are substantially greater than the minimum total field required to switch the film, yet when applied separately are substantially less than the field that would disturb the film without switching it. Because the fields are usually created by currents in perpendicular conductors, each field exists alone at many points in an array of film elements. The magnitude of each separate field must be kept well within the threshold limits to avoid disturbing the film at these points. Because they add vectorially, both fields together can cause the film to switch even if their scalar sum is less than the magnitude that one field must have to switch the film alone. As a result, the four-quadrant plot resembles the four-pointed star.

Permalloy also has a smaller magnetostrictive effect than iron—that is, its magnetic properties are not as strongly affected by physical deformation. Therefore it can be packaged with less emphasis on protecting it from mechanical forces. This is another reason why permalloy is preferred as a material for thin films.

## Open and closed

However, these desirable characteristics aren't sufficient to realize a workable memory in open-flux devices—that is, devices in which a substantial part of the magnetic flux lines lie outside the magnetic material itself. (All flux lines, of course, are closed; the distinction between the two kinds of devices discussed here is essentially the same as the distinction between a single bar magnet—open flux—and a pair of bar magnets with opposite poles adjacent—closed flux.) The limitations are in phenomena of arrays of film elements, as opposed to intrinsic properties of the film itself.[3,4]

Open-flux single films in an array environment require stronger drive fields for several reasons: the films tend to demagnetize themselves; the magnetization has a tendency to spread; the switching action is retarded by an opposing magnetic field created by the motion of flux lines through nearby conductors; and the ground current tends to spread through the ground plane. These effects are more pronounced in miniaturized elements, so much so that the stronger fields far exceed the levels that the film's intrinsic magnetic properties would otherwise require. In fact the bit field must even be made almost strong enough to switch the film by itself, thus impairing the stored data's stability.

The flux lines associated with an open-flux film element close outside the element. In so doing they interact with adjacent elements. The open-flux element also sustains an internal demagnetizing field opposing its magnetization. Only if the film's coercive force is sufficiently high will it retain its magnetic state in the presence of this demagnetizing field, which is proportional to the film's thickness

and also increases, but not proportionally, as the ratio of the film's width to its length increases. Thinner and narrower film elements are thus less likely to demagnetize themselves, but they also produce smaller output signals that are harder to distinguish from noise; longer film elements don't lend themselves to densely packed memories. Thus to produce an adequate output signal from a miniaturized element that doesn't demagnetize, a structure that closes the flux lines in magnetic material is a necessity.

On continuous films, which are easier to fabricate than arrays of discrete film spots, the storage elements can be defined by drive line intersections. But with permalloy's high permeability, the amount of film affected by the demagnetizing field around a particular intersection is much larger than the area immediately under the intersection.[5] This spreading problem is particularly serious in miniaturized arrays, because the spreading effect can sometimes generate a spurious output from an unaddressed bit, and if a particular bit is addressed over and over again the gradual spreading, like an oil slick on water, can actually destroy adjacent stored data. There are only two ways to prevent it—using discrete spots, or closed-flux elements.

In most thin-film designs, the word and bit currents share a common return through a ground plane. Because this return current is widely diffused instead of concentrated in a narrow conductor, it contributes little to the drive field, and its contribution is likely to be different at different points in the array. To reduce both the magnetization spread and this ground-current spread, a layer of magnetic material over the word and bit lines provides a low-reluctance path around them.

In the quiescent state, if the flux lines from a single open-flux element pass through nearby conductors such as the ground plane, they tend to hold back the element's switching action. This action occurs because the applied field from the drive lines, in altering the magnetic state of the element, moves these flux lines; their motion through a conductor generates eddy currents, which in turn create opposing magnetic fields that retard the principal switching action. This effect is called flux trapping; it can be overcome in open-flux devices only by increasing the applied field. It's not a problem in closed-flux devices because little or no flux exists outside the element itself.

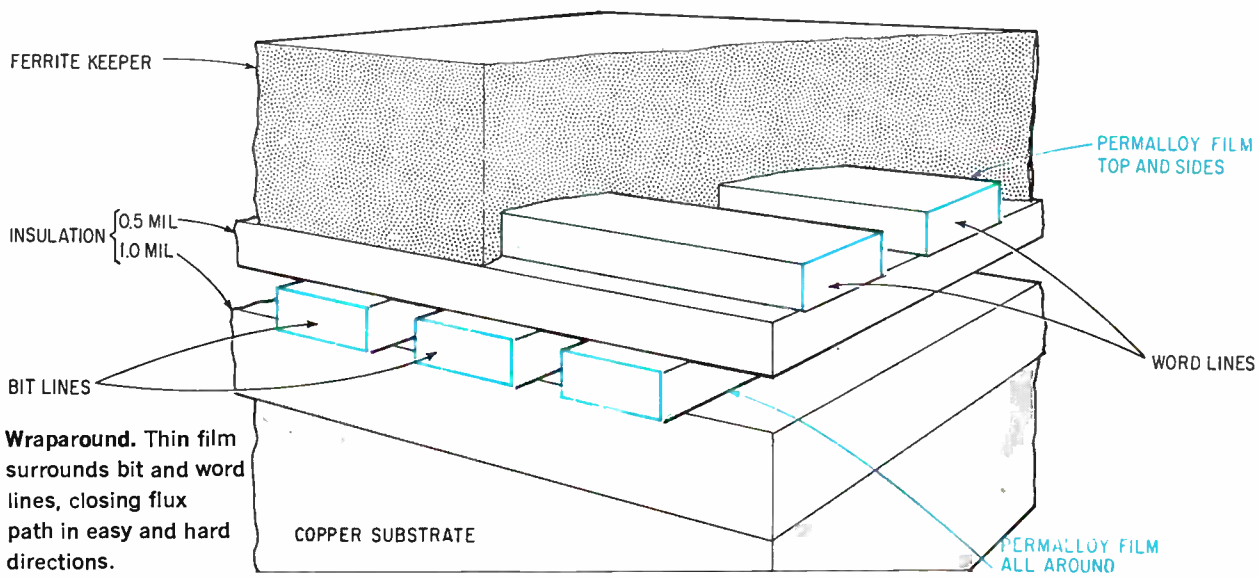
Only through closed-flux devices, such as coupled films, can magnetic materials that switch quickly when driven by a small applied field be made into stable low-current devices with adequate output signals.

## Memory performance

Two good ways to indicate memory cost, at least relative to other designs, are to specify the storage density on a substrate, which also affects the memory's speed and storage capacity as well as its cost, and to specify the utilization of peripheral circuits —measured, for example, by the ratio of memory elements to peripheral circuits.

Because coupled film elements permit greater miniaturization than other elements, their storage density can be made large. Also the number of elements on a substrate of reasonable size can be made large, leading to a large element/peripheral ratio. Thus the coupled film configuration offers an excellent potential for both high speed and large capacity at low cost.[6]

A magnetic film memory's cycle time is the sum of three components. The first of these, the memory elements' switching time, is almost negligible. Transmission delays in the drive and sense lines are obviously reduced by miniaturization and the consequent shortening of drive lines. And finally propagation delays in the drive circuits and sense amplifiers, particularly when these are made of high-speed integrated circuits, are very small, but these circuits for the most part can handle only




**Wraparound.** Thin film surrounds bit and word lines, closing flux path in easy and hard directions.

## Comparing memories

| | Chain store[13] | Mated films[14] | Plated wires[15] | Planar films[4] (IBM) | Planar films[16] (MIT) | Coupled films[1,9] |
|---|---|---|---|---|---|---|
| Density, bits/in² | 400 | 200 | 1,000 | 610 | 12,500 | 12,000 |
| Word current, ma | 800 | 700 | 900 | 510 | 500 | 200 |
| Bit current, ma | 400 | 50 | 20 | 100 | 190 | 15 |
| Switching signal | | | | | | |
| Amplitude, mv | 10 | 3 | 10 | 3.8 | 0.13 | 2 |
| Width, nsec | 90 | 15 | 15 | 8 | 30 | 5 |
| Flux, volt-sec x $10^{-12}$ | 900 | 45 | 150 | 30 | 4 | 10 |
| Drive voltage | 60 | 15 | 20 | 10 | 10 | 5 |
| Module size | | | | | | |
| Words | 2,048 | 4,096 | 2,048 | 819 | 1,024 | 2,048 |
| Bits/word | 72 | 68 | 128 | 72 | 64 to 352 | 64 to 512 |
| Power, watts | — | 250 | 200 | — | 200 | 50 |
| Cycle time, nsec | 500 | 200 | 200 | 120 | 1,000 | 60 |

limited current and power. Since miniaturization, low current, and low power are all characteristics of coupled film elements, it follows that this technology is ideal for large fast memories; indeed, megabit modules with 50-nanosecond cycle times aren't unreasonable at today's state of the art.

Memories of large capacity require long drive and sense lines that can maintain adequate signal-to-noise ratios over many bits.[7] And they must be batch-fabricated. Since flux closure permits thicker films to be used, even in miniaturized devices, without danger of demagnetization, it also produces larger signals, thus improving the signal-to-noise ratio. Furthermore, if the thicknesses for both conductors and insulators are maintained, while the planar dimensions are reduced, the total impedance increases but the resistance per bit remains constant; therefore the attenuation per bit is decreased. Already 10-million-bit storage modules have been built with plated wires;[8] comparable or larger capacity is expected with coupled films, but with much lower word current requirements.

### To make a film

In one coupled-film design, shown opposite, the storage elements consist of two layers of permalloy 1,000 angstroms thick deposited on both sides of a thin copper bit line.[9] The easy axis of the permalloy films is across the bit line, and parallel to the word lines just above. Flux closure in the easy-axis direction is through additional permalloy plated at the edges of the three-layer bit lines. The word lines are plain strips of copper with a 3,000-angstrom permalloy keeper on top and down the sides; flux closure in the hard-axis direction is through this permalloy and also through a ferrite keeper on top of the whole assembly. The bit lines are 4 mils wide on 6 mil centers; the word lines are 6 mils wide on 14 mil centers. Both are 0.5 mil thick. The storage flux is $10^{-11}$ volt-second, switched with a word current of 200 milliamperes and bit current of 15 ma. All the dimensions can vary over a considerable range; different working models have been built with different dimensions.

In this design, the choice of materials and dimensions is largely determined by electromagnetic requirements and materials compatibility. Between the bit lines and the copper substrate is a layer of insulation thick enough to establish a reasonably large characteristic impedance; the insulation between the bit lines and the word lines is thinner, to minimize the magnetic reluctance in the hard direction, but not so thin that capacitive loading between the two sets of conductors would be a problem. The copper conductors themselves are thick enough to have low resistance but, like the insulation, not so thick that they hinder hard-direction flux closure.

The ferrite keeper is the best way to limit current spreading in the ground plane, but it doesn't work very well at high frequencies because its permeability decreases as frequency increases. A permalloy keeper is good at all frequencies, but is effective only when the width of the word lines is much greater than the word line-bit line separation.

In addition to the general requirements for any multilayer structure—good adhesion, chemical stability, and matched thermal expansion coefficients—magnetic coupled film structures have special requirements of their own.[10, 11] For example, the electrical insulation is better if it's put down in several thin layers instead of one thick layer, because there's less probability of pinholes. It must be smooth and clean if the metallic film deposited on

top of it is to have satisfactory properties. To insure this smoothness a thin layer of silicon oxide is deposited on the copper before the top permalloy layer goes down. Because the metallic layers are composites of different materials, their etching into lines requires special care.

## The competition

Coupled films aren't the only structures that have closed flux paths, but they're best. Other approaches include for example, flat films with keepers, chain stores, mated films, and plated wires. But each of these other forms has disadvantages.

To speak of complete flux closure around both word and bit lines is more topological semantics than physical reality. No design provides completely closed paths in magnetic material for all the flux in both hard and easy directions. Two designs that come close are chain stores[12, 13] and mated films. Both of these use magnetic and conductive materials in intricate shapes; conductors pass through holes in magnetic material, or magnetic material is wrapped around a conductor, or both. But some of the flux has to pass through a conductor rather than exclusively through magnetic material, so the path isn't wholly closed. Also, either the flux path around one or both conductors has a nonuniform cross-section, or the film has a nonuniform thickness. The former quality increases the path's reluctance and may make some flux "leak" into the surrounding medium; the latter quality is difficult to implement, especially in small sizes. Furthermore, these three-dimensional configurations are very difficult to fabricate in batches.

Both the plated wires and the coupled films obtain complete flux closure around only one conductor. Partial closure around the other conductor is achieved with a keeper; it's partial because the insulating layer and the first conductor are in the way. This nonmagnetic gap is minimized best with flat geometry, which obviously favors coupled films and their associated striplines, rather than wires.

Nevertheless the fact that these different designs exist, as summarized in the table on page 121, demonstrates their viability. But the combined advantages of high density, low currents, low power, and short cycle time are realized only in coupled films. This clearly demonstrates that performance optimization can be achieved only through both miniaturization and flux closure.

Further development of film memory optimization through miniaturization and flux closure will be aided by advances in interconnection methods, sensing techniques, and memory organization.

Presently available interconnection techniques are the limiting factor to storage density; fabrication techniques are capable of producing integrated structures with much higher densities than anybody knows how to interconnect today.

Miniaturized memory elements always generate smaller output signals, and therefore require more sophisticated detector and amplifier designs. These are highly optimized in a planar film memory built at the MIT Lincoln Laboratory, and are approaching a physical limit imposed by thermal noise. This implies that further miniaturization, and therefore further reduction in sense signal level, is possible only with innovations in detection techniques.

Film switching dissipates so little energy that very long word lines compared to those used in ferrite core memories would be expected. However, the long word lines imply many bit/sense lines, and thus many expensive sense amplifiers. An alternative is to devise novel memory organizations, such as the 2½-D selection already proposed for plated-wire memories,[15] to reduce the number of sense amplifiers. Once the interconnection problem is overcome, even higher-density arrays will become practical, making optimum utilization through novel organization even more urgent. ■

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# Keeping track of Japan's high-speed passenger trains

Speeds of 125 mph are now common on the Tokyo-Osaka line, but runs of 220 mph are planned; as a result, the national railroad is working to replace fixed-block control with automatic movable-block operation

**High-speed passenger trains,** barely out of the talking stage in the U.S., have been an operational reality in Japan for the better part of five years. And planners at the Japanese National Railways (JNR) are even now mapping expansions and improvements. As a result of control and safety exigencies, these extensions promise new challenges for electronic technology and techniques. Among the projects under way: highly automated control systems, operating on movable-block principles, as well as sophisticated new radars and communications set-ups.

So far, the New Tokaido Line (NTL)—a 320-mile, double-track railway linking Tokyo and Osaka—is the only high-speed line in JNR's network. Opened in 1964, it serves a corridor on the island of Honshu, which encompasses close to 50% of the country's population and 75% of its industrial capacity. Twice-as-fast service—the trains, high-balling along at a top speed of about 125 miles per hour and averaging more than 100 mph with stops along the way, make the run in just over three hours—appeals to travelers in Japan. On an average day, the two-way traffic is about 180,000 passengers and 170 trains—nearly triple the levels of 1964, when service was provided by regular-speed trains that took over six hours for the trip. Carrying only passengers, the NTL has freed the Old Tokaido Line, a narrow-gauge system, to haul an increased volume of freight around the industrial heartland.

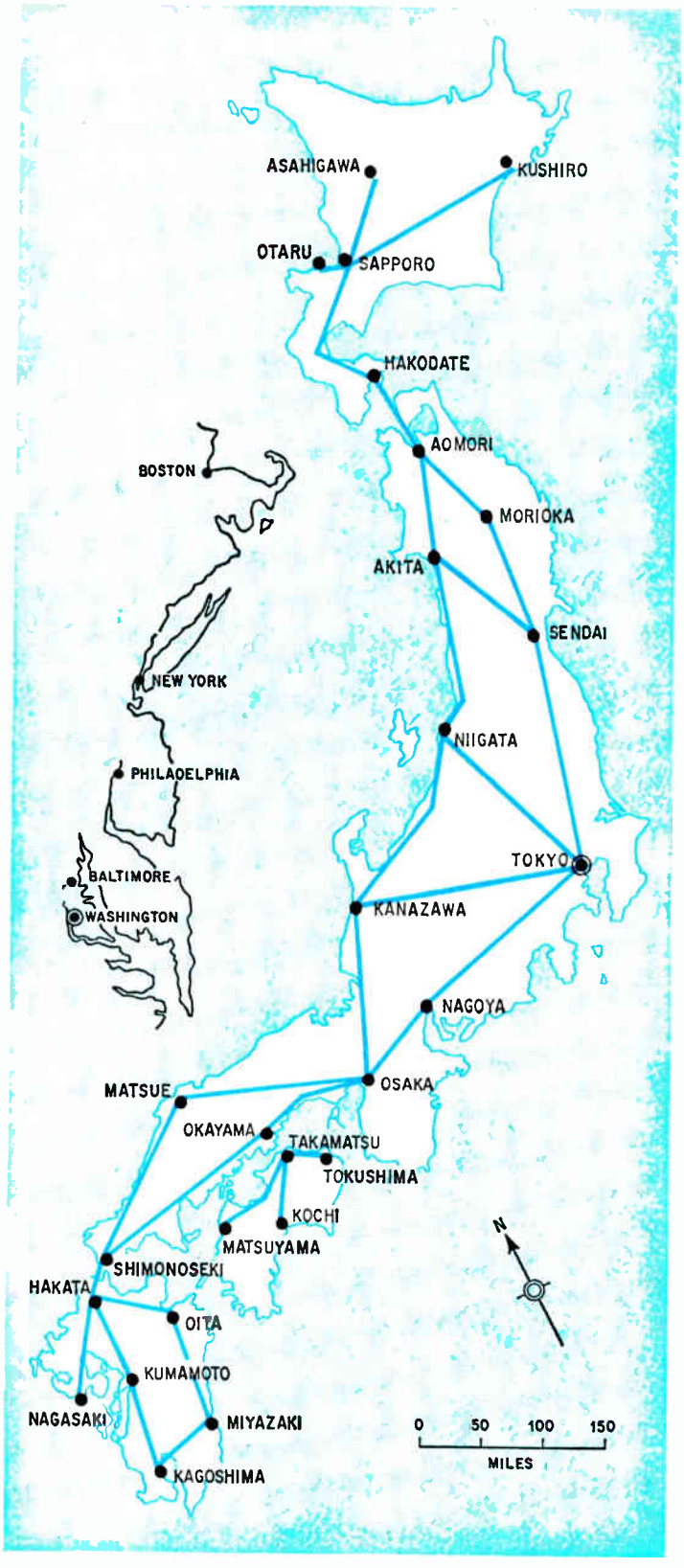
The next link in the high-speed rail chain is already being forged—a westward extension from Osaka across the narrows of the Kanmon Straits to Hakata on Kyushu, southernmost of the four principal islands in the Japanese archipelago. This project, scheduled for completion in 1975, is part of a 20-year master plan drawn up in 1967 by the JNR for a 2,500-mile, high-speed grid connecting all of Japan's industrial cities with populations of 100,000 or more. In addition, it's probable that the NTL system will be outfitted with a new set of double tracks for superexpress trains operating at up to 220 mph to accommodate the needs of the mushrooming Tokaido megalopolis.

The high speeds and close headways at which NTL trains were designed to operate have necessitated highly automated safety control systems. In conventional rapid-transit setups, trains are kept apart by means of fixed-block techniques. The entire track is divided into sectors, and only one train at a time is allowed to enter a given block. Wayside signals inform motormen whether or not there's anything in the sector ahead.

This sort of arrangement is impractical for the NTL since motormen are humanly fallible and can't be depended upon for the split-second reaction times required with a high-speed system. Accordingly, the block signals were taken from the trackside and installed in the cab, where they give visual and aural warnings and, when necessary, automatically trigger the brakes to bring speeds down to predetermined levels.

But though the system currently used on the New Tokaido Line is called automatic train control (ATC), it falls a good way short of being fully automatic, coming into play only when speeds exceed the limits for a given section of track. Acceleration, operation at constant speed, coasting, braking, and station stops are under the full control of motormen. Moreover, the fixed-block system, while satisfactory from a safety standpoint, lacks flexibility, particularly in maximum density, high-speed operations where it's desirable to keep train headways at minimum levels. As a result, the JNR is now working on a movable-block, automatic train operation (ATO) system that will provide full station-to-station control.

There are two kinds of ATO system: centralized and decentralized. In the latter, control equipment is installed alongside the tracks and aboard the trains; decisions are essentially reactive—made in response to local conditions. In the former, control




**Training ground.** The Japanese National Railways system has been operating high-speed trains through a 320-mile corridor linking Tokyo and Osaka since 1964; a westward extension from Osaka to Hakata is scheduled for service by 1975. Both lines are part of a long-range master plan to tie all of Japan's major industrial and population centers together in a 2,500-mile high-speed rail grid. Inset of Northeast corridor in U.S. is to scale.

centers house most of the equipment, and decisions are made on the basis of systemwide traffic conditions. Centralized systems have the edge on lines where traffic density is high, since the outlying local-control apparatus can be largely replaced by a computer. On short, local commuter lines, communications costs are low. The principal drawback is the possibility of systemwide disruptions resulting from individual equipment breakdowns. Failures in decentralized setups are, of course, local propositions.

The new ATO system now being developed includes features of both systems. Both the local-control and centralized subsystems work off a parallel, twin-wire transmission line between the rails. Loop antennas installed in the train's undercarriage have close inductive coupling to the line.

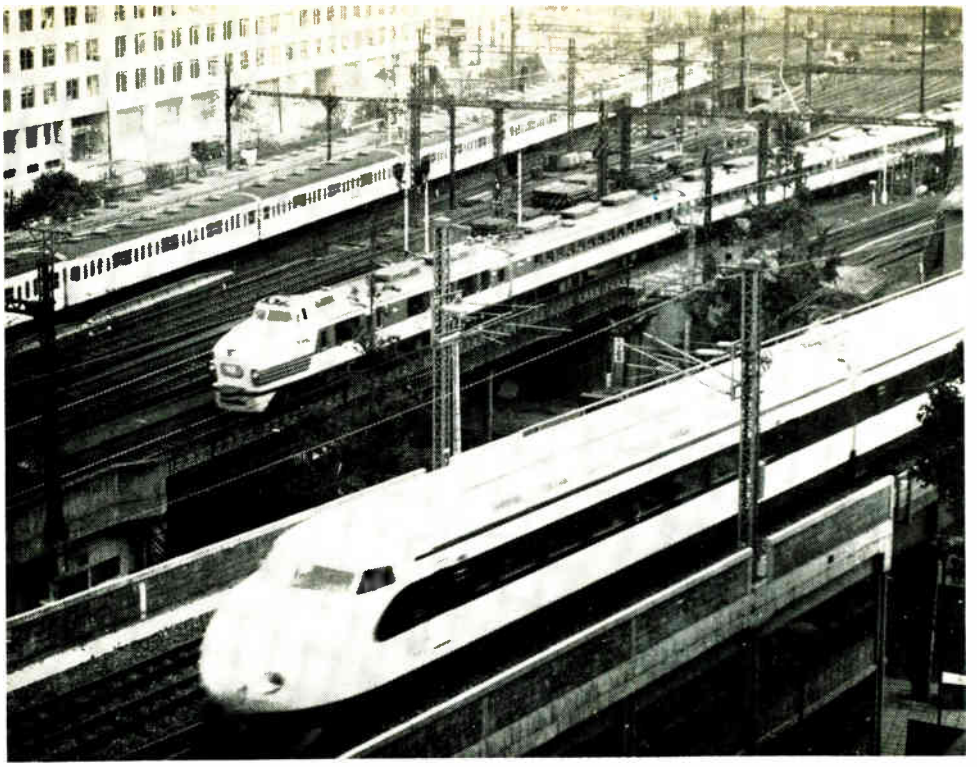
The twin wire is divided into block sections about 1,640 feet long by high-pass filters with a cutoff frequency of 50 kilohertz. As a result, each section is an independent loop with respect to the band below 50 khz, and all sections are common with respect to a high-frequency band. The band below 50 khz is for the local control subsystem, while frequencies from 50 to 250 khz have been allocated to the centralized control subsystem.

The twin-wire arrangement in the proposed high-frequency centralized subsystem has a relay station every six miles or so. Communication between the relay stations and the control center are handled via coaxial cable. A hundred two-way code communication channels, with a modulation rate of 50 bauds, plus three voice channels, are available in the 50-to-250-khz band to shuttle information between trains and the control center. In theory at least, it should be possible to control up to 100 trains on a line with a single central processor.

At fixed time intervals, each train transmits the distance covered during the preceding time unit. The central computer then calculates each train's position, speed, headway, referring to timetables, track-condition data, and related information stored in its memories to come up with individual orders.

Development of the ATO's centralized control subsystem has been under way since 1964; a successful field test was conducted in 1965 on the mile-long loop track at the JNR's Railway Technical Research Institute. During the course of the study, parallel twin-wire and leaky waveguide systems were used alternately as the transmission paths between test trains and the computer. The latter operates at 7.5 gigahertz, so electrical noise is no particular problem. However, this system is far more expensive than its twin-wire counterpart, which is affected by electrical noise. Since the institute's campus-like environment has fewer high-tension lines and less noisy heavy electrical equipment than a trunk line with heavy train traffic, a more realistic field test was successfully run off in 1967, using only the parallel twin-wire transmission line.

The ATO's local-control subsystem is designed to assume the functions now handled by the automatic train control system as a back-up to ensure



**Generation gap.** Three trains around Tokyo station illustrate Japan's progress in high-speed transport. In foreground is the New Tokaido Line; system it succeeded is in middle; and almost out of the picture is an intraurban feeder line.

safe operation in the event of a failure in the centralized subsystem. As a rule, an ATC system like the one now used on the New Tokaido Line has a circuit to detect the presence or absence of a train in a given block section and then transmit the limit-speed signal. This type of system has the virtues of being time-tested, relatively simple, highly precise, and reliable.

In the low-frequency segment of the new ATO system, each train is equipped with a modulated transmitter whose signal is used for train detection. Limit-speed signals are transmitted from trackside equipment to trains with a two-out-of-five frequency code. The parallel twin wire setup in the local-control subsystem is especially attractive because of its ability to transmit a far greater volume of information than the track circuits used in the ATC arrangement.

Local subsystems apparatus installed on the train includes the train signal transmitter and the limit-speed signal receiver; along the track, a train-detection signal receiver, logic, and a limit-speed transmitter for each block are group-housed in signal cabins. At the boundary between each pair of blocks there are high- and low-pass filters that divide the loop line for the local-control subsystem while maintaining a single circuit for the centralized system. The output from the low-pass filters is routed to the signal cabins by cable.

The detection signal transmitted from a preceding train is fed into block-logic circuits, jogging the system's memory and triggering ATC signals to a following train. This block signal set-up is primarily designed to be dependable and fail-safe whether or not there are equipment failures on the train or at trackside. Train detection is continuous, and block clear-up is allowed only when a train passes the boundary into another sector.

The big disadvantage of the system, at least in its present state of development, is its inability to perform non-block operation when there's a switchover to the local system as a result of a failure in the central subsystem. (This problem does not occur when the central subsystem is operative since this set-up continuously updates train positions in its memory and controls track movements without reference to fixed blocks.) In other words, a following train could not be allowed to enter a block still occupied by a train up ahead. In the present track-circuit type of ATC system like the one used on the NTL, a following train somehow in the same block with a preceding train receives no ATC signal since it's been shorted out by the axles of the preceding train. There's an unambiguous indication that high-speed operation is not permitted.

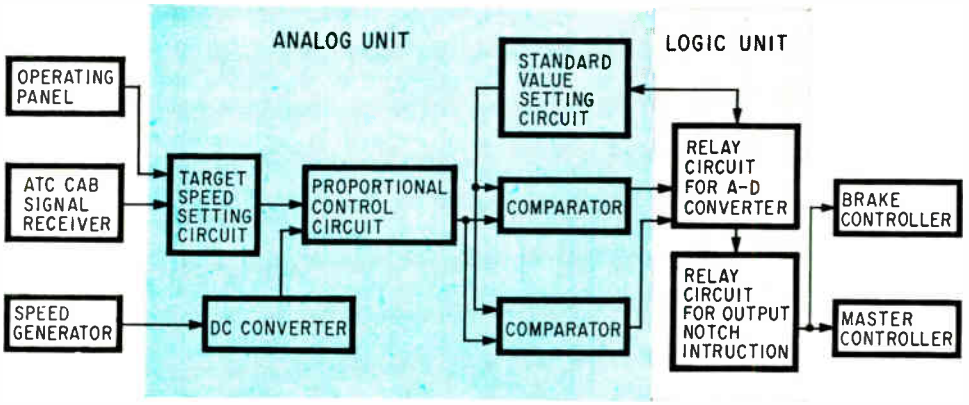
But in the ATO local subsystem, a following train entering an occupied block would receive the same speed indication as the preceding train. A special circuit can be used to maintain the stop signal received before a train enters, but it's not fail-safe.

## Throttling back

Normally, the train detection transmitter puts out a continuous signal to the ground loop from an antenna at the rear of the train. Transmitter output averages 3 watts. The carrier frequency is 24.4 khz, amplitude-modulated by a 36-hertz signal that eliminates power-line or other interference. Malfunctions would be likely if an unmodulated signal were used since there could be spurious indications of a train's presence in vacant block sections.

The train detection output passes through a low-pass filter, traveling down the cable to the signal cabin's receiver. This unit rejects the limit-speed signal and noise induced by the current drawn by the train, amplifying and detecting input. The receiver output operates the train detection relays.

The design of the system has to be such that




**Autopilot.** This block diagram outlines a proportional control system for automatic constant train speed proposed for new links in Japan's growing chain of high-speed railroads.

data on the presence of a train stored in the memory will not be erased even if the detection unit aboard the train fails. If the memory indication were erased, the proceed signal sent to the following train would probably result in a tailend crash.

To prevent this, a detection signal, once received is stored and not erased until a given train is detected in the next section down the tracks. To this end, designers have capitalized on the dynamic time-delay characteristic of the train detection storage relay used in the logic; they use this time delay to erase the memory when a train passes the boundary between two loops.

The limit-speed transmitter uses two of five frequencies—33.2, 33.6, 34.0, 34.4, and 34.8 khz. This affords control with up to nine signal aspects, against seven in the currently operational system on the NTL. Peak transmitting power is 4 watts, and the cross-modulation product of the two signals is suppressed by more than 30 db.

In the limit-speed receiver aboard the train, a band-pass filter is used to reject interference signals from higher harmonics of the train current, and mechanical filters are used to select the signal frequencies. If only one—or three or more—signal(s) are received, a failure indicator is activated.

### When and if

Tests along a trunk line in 1967 furnished a lot of valuable operational data on the proposed ATO system. For example, when the output of the train detection transmitter is 26 dbm, the ground detector receiver input is —35 dbm, making the transmission loss 61 db. When the ATC transmitter's output is 24 dbm, the train's receiver input has a minimum value of —36 dbm, making the transmission loss 60 db.

The loop line has a wire diameter of 3.2 millimeters and a wire-to-wire spacing of 20 centimeters. At frequencies in the 20-to-40-khz range, the characteristic impedance is 500 ohms and the attenuation constant is on the order of 0.2 to 0.3 db per five-eighths of a mile.

The limit-speed receiver's mechanical filter has a minimum signal-to-noise ratio of 21 db when the transmitter output is 24 dbm. The train detection receiver has a larger signal-to-noise ratio—a minimum value of 38 db when the transmitter power output is 26 dbm.

Tests have shown that the ground block logic circuits function properly even when a train passes the block at speeds as low as 3 mph. Operation at slower train speeds is difficult, however, because of the dynamic relay characteristics that protect against failure to detect a train's presence.

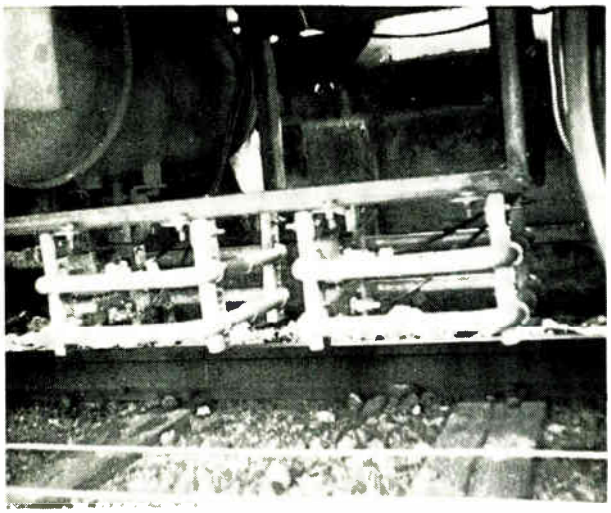
The lengthy braking distances required by high-speed trains make the development of systems to

### No hands

The ATC system, which is distinct from the proposed ATO set-up and originally designed for automatic retardation, can still be fairly easily rigged for complete, start-to-stop control. On the New Tokaido Line, trains often are operated at a constant speed only a bit lower than the ATC limit. To automatically maintain a speed constant, the JNR devised a system with a controller similar to those used in process application.

With a target speed slightly below the ATC limit, the system detects the difference between the target and actual speed, effecting control on the basis of this value. As the difference becomes larger, the acceleration notch is automatically advanced, and vice versa. If need be, the brake control can be used to arrest the train.

The system's performance has been determined superior to manual operation by a motorman. A system of this type has been installed on the prototype train slated for duty on the high-speed line connecting Osaka and Hakata. If all goes well in tests, scheduled for this summer, they'll be installed on production models. Next year, apparatus to automatically stop trains at fixed station points will be checked, and it could also be installed on production models. The effect will be to further automate the Osaka-Hakata run, which will operate at higher speeds than the New Tokaido Line. Although the NTL uses conventional notch techniques for speed control, it is planned that the new line will have thyristor phase-shift control. The motorman will simply set the system to operate at a speed below the ATC limit, and the machinery will take over.



**Upgrading.** JNR is seeking to improve the close-coupled inductive radio system that works off two parallel wires laid between the rails and train-mounted loop coils.

detect out-of-sight obstacles along the tracks desirable. The Japanese National Railways has been doing considerable research in this area, but costs are high and progress has been relatively limited. So far, no operational systems have been put into service.

Perhaps the biggest difficulty with most types of detectors is that objects lying just beside the road bed are often hidden in the shadows thrown by the rails. Such objects could lead to disasters if the train's wheel flanges were to ride up on them, leaving the tracks.

Because the waves transmitted by ordinary radars spread out with distance, such systems aren't suitable for high-speed train applications where the big idea is precise determination of obstacles on the road bed. The JNR is therefore investigating surface-wave radar, which works off track-mounted waveguide that radiates only moderately. The system's transmitter and receiver are installed on the train; the operator simply checks the scope for obstacles on or between the tracks.

### Narrow view

At its Railway Technical Research Institute, the JNR has rigged up a metal, surface-wave transmission line between the rails. The attenuation constant of this guide at 940 megahertz is 20 db per five-eighths of a mile. Calculations show that with a 50-kilowatt-peak-power transmitter, an obstacle can be detected up to two miles ahead of the train.

The disadvantage of surface-wave radar is that the detection range to the right and left of the waveguide is extremely narrow. As a result, a prototype leaky-wave pseudoradar system has been developed and tested at the institute. Sending leaky waveguide is installed on one side and receiving leaky waveguide on opposite sides of the two rails of a single track. A pulse-modulated wave is sent through the sending waveguide from a transmitter at one end; the wave leaks slightly through slots while it advances down the guide, crosses the two rails, and is picked up by the receiving leaky waveguide—through which it returns to the receiver. Planar reflectors, or helix winding inside the waveguide, is necessary to assure that energy in the second waveguide propagates back in an opposite direction from that in the first. If there's an obstacle, the leaked wave is blocked and doesn't reach the receiving waveguide. At the receiver, output for the time corresponding to the point of the obstacle falls markedly.

When operated at 9 Ghz, the attenuation constant along the waveguide is 6 db per five-eighths of a mile and coupling loss is about 76 db a yard. When the sending guide is fed from a transmitter with a peak power output of 50 kw, an object of about 50 cubic centimeters between the two waveguides can be detected at up to 3 miles.

The leaky-wave pseudoradar system is superior to the others from a detection standpoint, but its cost of installation is high. As a less expensive alternative, an electromagnetic-beam wave radar system has been proposed. In this setup, elliptical reflectors with common focuses are installed on both sides of the rail. The wave transmitted from the train is reflected by the reflectors while traveling forward, and reflected waves from obstacles travel back along the same route to be received by the train's antenna.

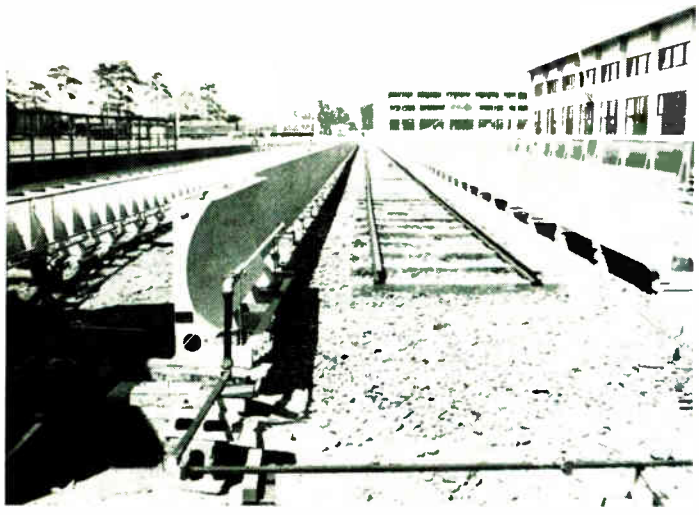
Reflectors 70 centimeters high and operated at a frequency of 9 Ghz have an attenuation constant of 10 db per five-eighths of a mile. An object with a volume of about 50 cc could be detected at a distance of about 3 miles when a transmitter with a peak output of 50 kw is used.

### Attenuating circumstances

For data communications among stations and trains in transit, the Japanese National Railways has been using spatially propagated and inductively coupled radio systems. Applied separately or in concert, such arrangements afford reasonably good coverage over both flat and rugged terrain. On a continuing basis, however, the JNR conducts research and development programs on new techniques and equipment—particularly anything that looks as if it can be integrated into automatic train operation systems.

Among the current projects is an upgrading of the close-coupled inductive radio system, which works off two parallel wires installed between the rails. A high-frequency carrier-current signal of approximately 200 khz is sent from wayside stations through these wires to train-mounted loop coils.

Moreover, the signal level drops at the points every 820 feet or so where the two wires cross over each other to reduce noise, as well as at other points along the line where feeders or filters are installed. Dips in signal strength at these points may be as large as 20 to 25 db, greatly increasing the likelihood of errors during pulse transmission.



**Test case.** At its Railway Technical Institute, the JNR has rigged up an experimental leaky-wave pseudoradar system to improve on surface-wave-set-ups.

**Alternative.** Though leaky-wave pseudoradar has superior detection features, its cost comes high. As a result, the JNR is investigating electromagnetic-beam wave systems.

A twisted-pair, two-wire cable has been proposed to eliminate these disadvantages, and feasibility studies are under way. The between-the-rails installation of the wires for a close-coupled inductive system creates a serious problem for track maintenance personnel.

On the New Tokaido Line spatially propagated radio is used for voice communications, but it cannot provide reliable service in long tunnels. In those along the right of way, a two-wire overhead feeder system is installed along the walls as guides for a 400-Mhz band current, the same frequency used for spatial propagation. At first glance this arrangement appears to be an attractive method to remove the ATO communications system from between the rails. But the attenuation of the parallel-wire line is sizable, as is the level of the received signal.

A leaky coaxial cable system has been tunnel-tested to see if it could overcome these difficulties. But one experiment in which a cable with a leakage slot in the outer conductor was operated at 450 Mhz indicated an average attenuation constant of about 25 db per five-eighths of a mile; such a large level would cause excessive variations in signal strength over the contemplated repeater spans.

As a result, stepped leakage slots, increasing in size with distance from the transmitter, are now being tried out along the line to decrease coupling loss at far-out points and maintain almost constant received signal strength. For this transmission line, coupling loss at points along the cable near the transmitter is around 80 db; variations in received signal strength are kept to within about 10 db.

When operated at low frequencies, this kind of leaky coaxial cable has almost no leakage and should prove useful for communications between fixed wayside stations. Moreover, if installed on existing overhead poles that support traction current wires, it would cause no inconvenience to track maintenance personnel.

In yet another communications system under study, a low-loss, circular, microwave waveguide with leak design features is installed in parallel alongside the track. A signal is transmitted through the guide from a station, and the leaked signal is picked up by train-mounted antennas. An elliptical reflector, with the leakage slot of the waveguide at one focus and the train antenna at the other, is mounted aboard the train to improve signal pickup. The system is designed to minimize variations in received signal level caused by the rolling motion of the train.

In a test in which a circular aluminum waveguide was operated at 7.5 Ghz, the attenuation constant was found to be 4 db per five-eighths of a mile. Minimum coupling loss between the waveguide and the train antenna was about 30 db. A smaller coupling slot—with high coupling loss—was used in portions of the waveguide near the transmitter.

As with the other system, researchers are trying stepped slots to provide progressively smaller coupling losses as the distance from the transmitter increases, the aim being to keep received signal strength constant along the six-mile spans between repeaters. (Specifications call for a +10 dbm level at the transmitter, and a −80 dbm level at the receiver.) Variation in signal level during tests with this arrangement was about ±2 db.

In one test in which $10^7$ coded characters were transmitted from wayside station to a moving train at a transmission modulation rate of 2,000 bauds, the number of errors was nil. Multiplex operation with about 400 voice or data channels appears feasible with this system; each train would be assigned its own frequency.

However, while the leaky waveguide can provide a large number of channels, its cost is still extremely high.■

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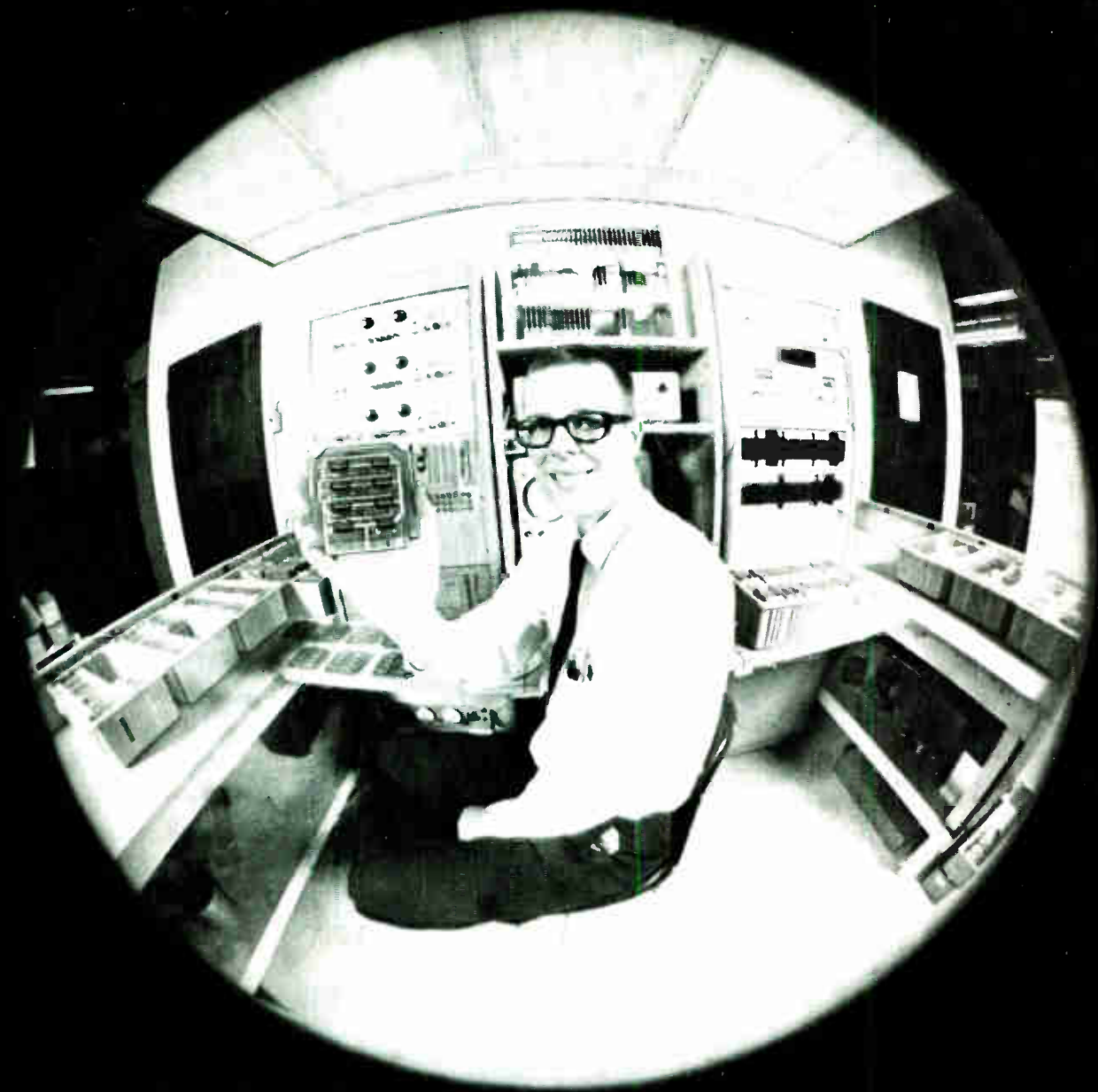

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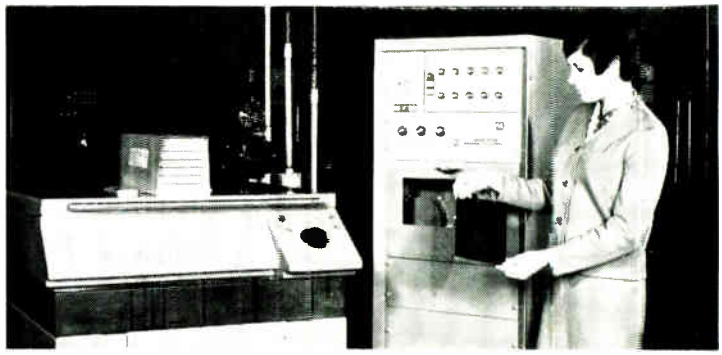

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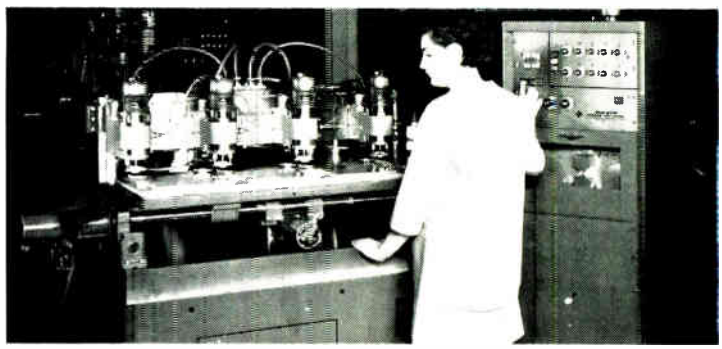

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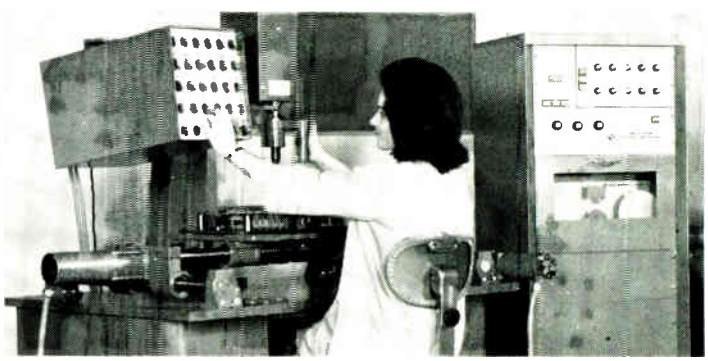

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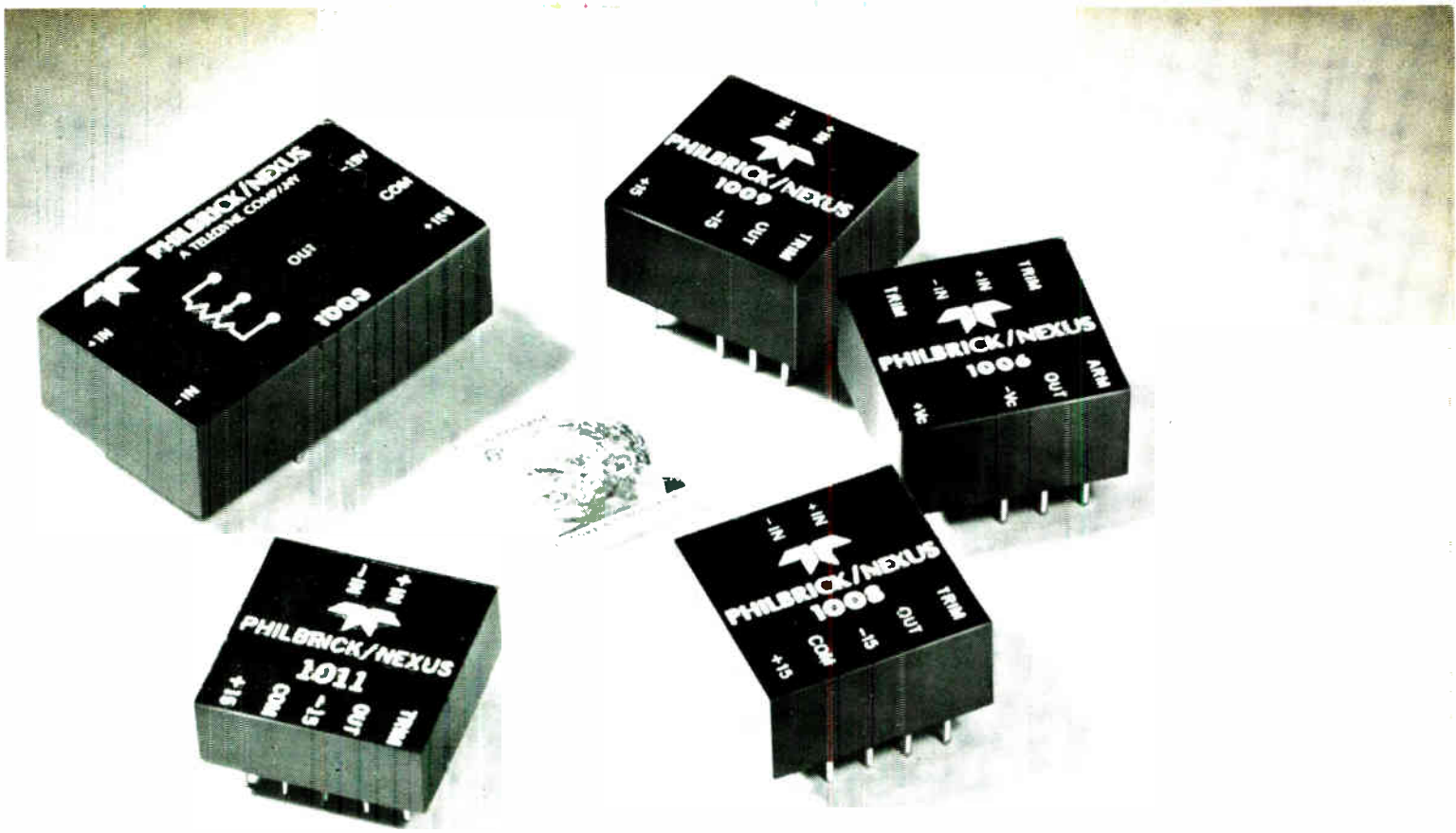


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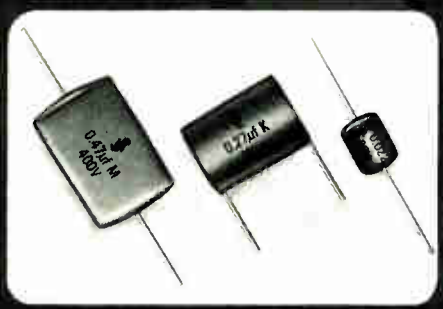

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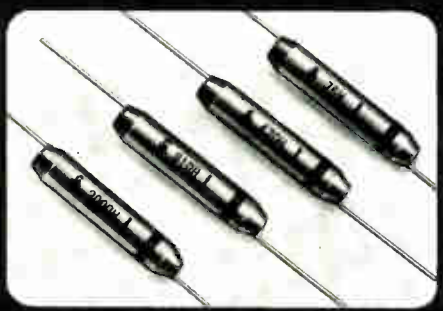
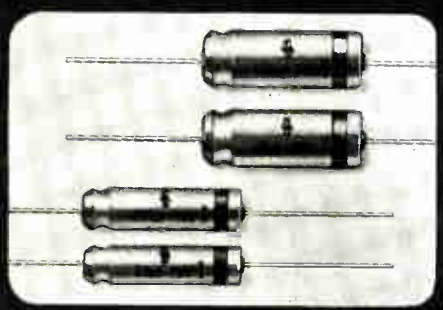


POLYSTYRENE—33-630 V d.c., 1-25,000 pF



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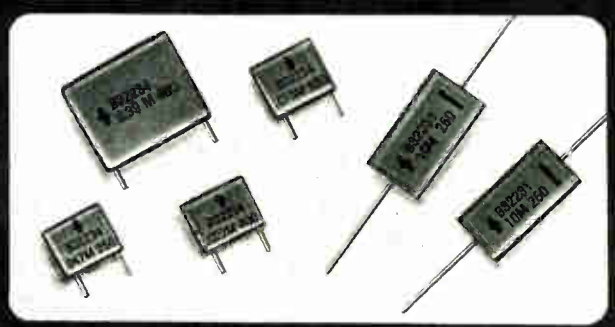

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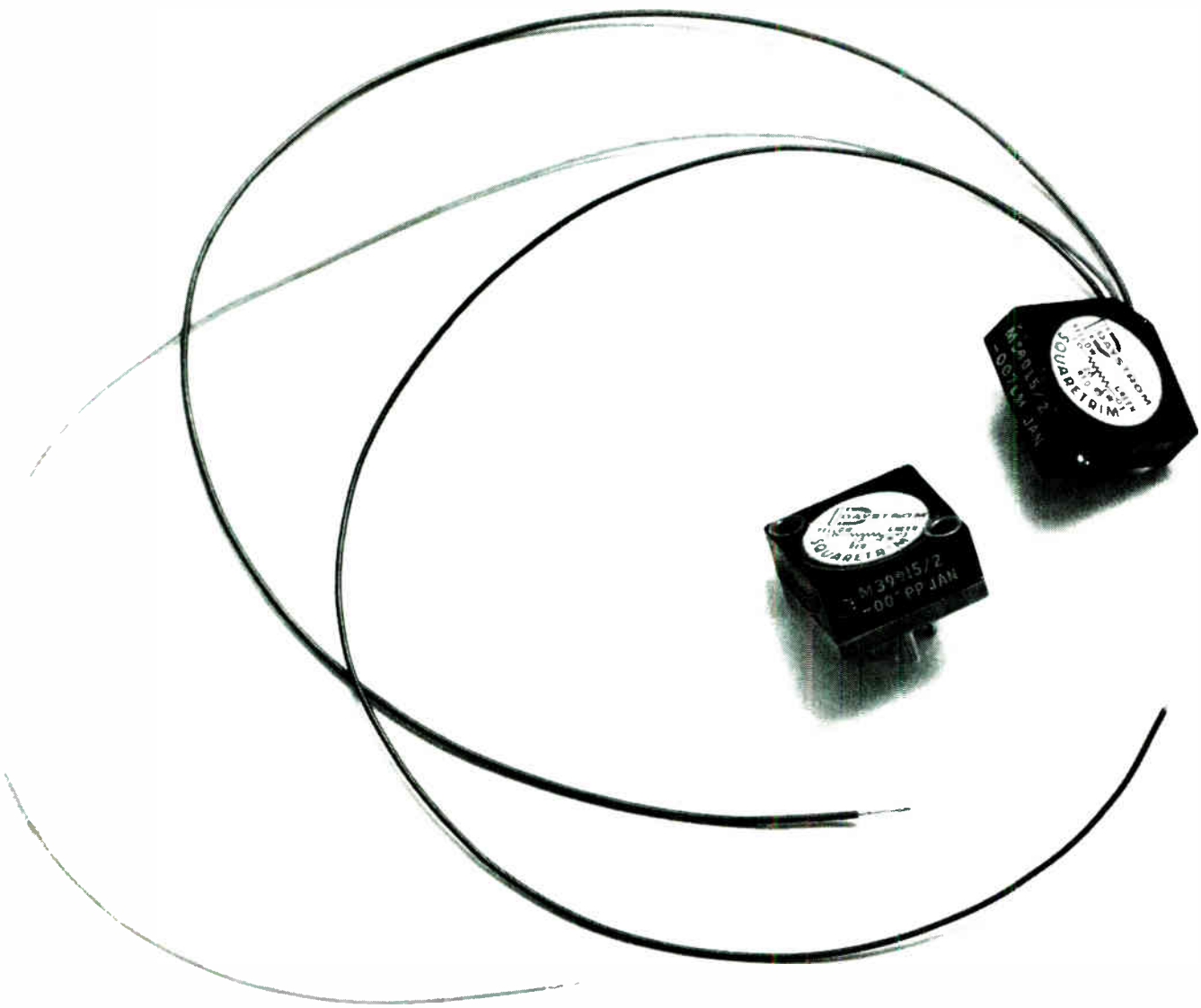

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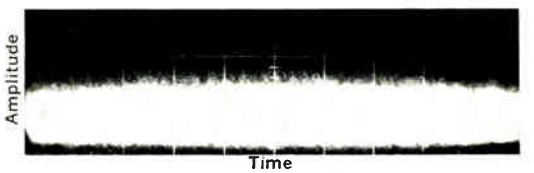

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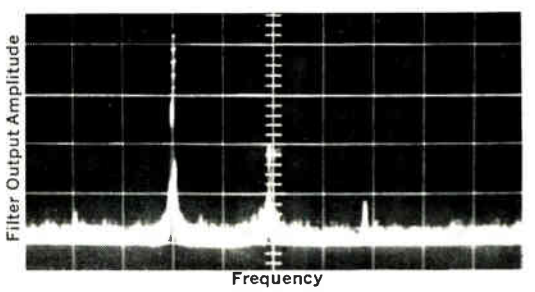

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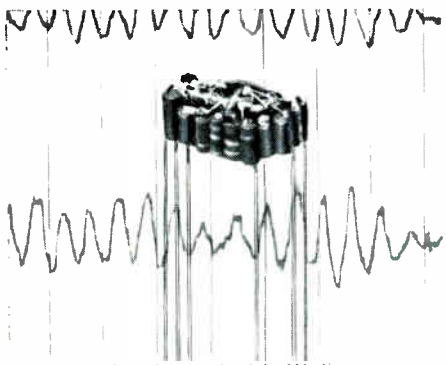

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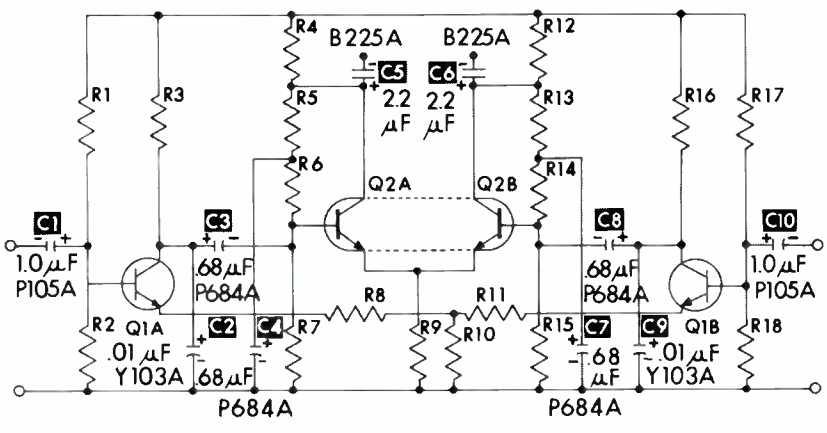


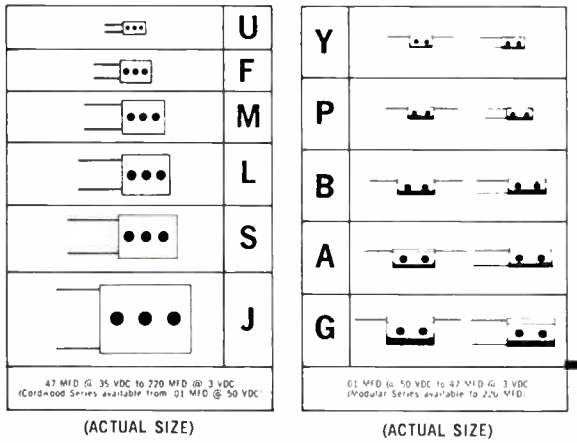


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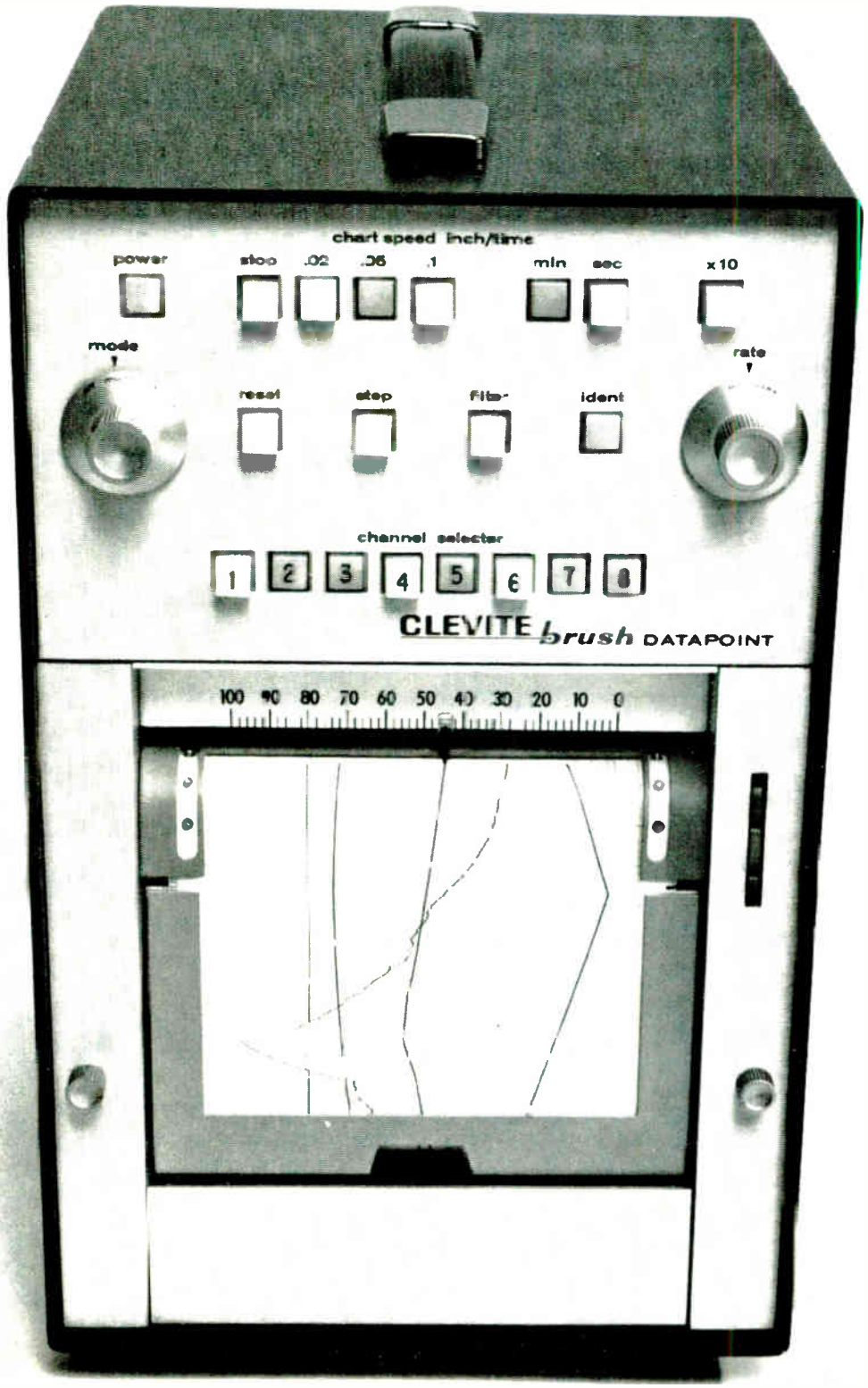


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product report

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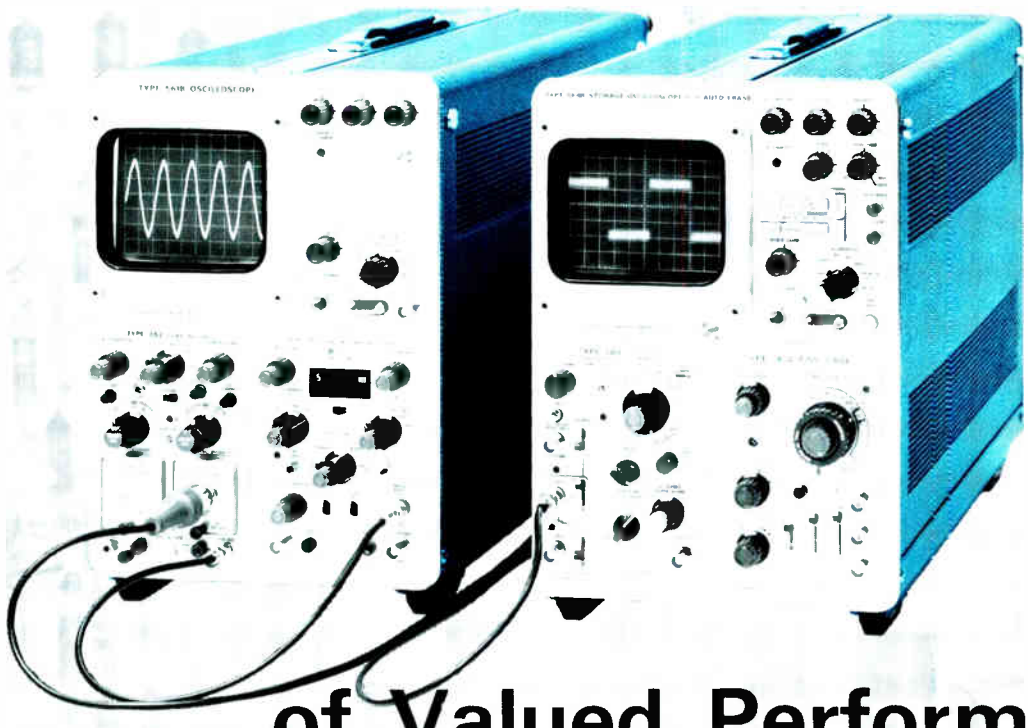

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Solid-state, large screen (8 x 10 cm), internal graticule, dual plug-in oscilloscope defines the new Type 561B. Use of solid-state components throughout offers low-heat dissipation for reliable operation to further expand the performance capabilities of this oscilloscope. Short-proof circuitry has been designed into all low-level power supplies, providing lower output impedance and minimum signal crosstalk. The addition of a quick-change line voltage selector permits operation from any of the following voltage ranges: 90 to 110 V, 104 to 126 V, 112 to 136 V, 180 to 220 V, 208 to 252 V, or 224 to 272 V over a line frequency range from 48 Hz to 440 Hz. The Type 561B calibrator accuracy has been significantly improved in both frequency and amplitude. The 1-kHz frequency is held to ±1%, while the amplitude is maintained at ±1½%.

Total measurement capabilities, through the use of more than 25 different plug-in units, offer the user complete versatility in measurement applications. The dual plug-in unit feature allows conventional displays or X-Y displays with either single-trace, dual-trace or four-trace units. Sampling displays, as well as spectrum analysis and raster generation, are also possible with the Type 561B.

The Type 564B offers all the advantages of the Type 561B, plus an added split-screen storage feature. Greater versatility is thus provided in that either half of the 8 x 10 cm display can be independently controlled, allowing stored or conventional displays on either the upper or lower half. The contrast ratio and brightness of the stored displays are constant and independent of viewing time, writing and sweep rates, or signal repetition rates.

Automatic erasure, after a preselected viewing time of 1 to 12 seconds, is added to the Type 564B MOD 121N. Also incorporated is a SAVE mode which interrupts the automatic erase cycle and preserves the stored information. Remote operation of the erase function is also possible with the Type 564B MOD 121N.

Both the Type 561B and Type 564B have rack-mounted counterparts that occupy only seven inches of rack height.

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|---|---|
| Type 561B | $ 560 |
| Type 564B | $ 995 |
| Type 564B Mod 121N | $1150 |

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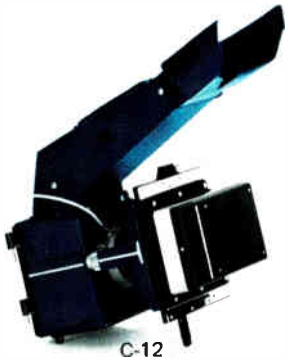
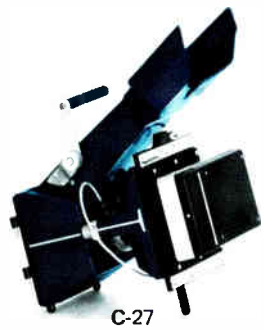

C-12


C-27

## CAMERAS

The C-12 and C-27 general purpose trace recording cameras are suitable for use with the Tektronix 560 series oscilloscopes. Both cameras feature lift-on mounting, swing-away hinging, comfortable binocular viewing, easily-accessible controls, and lens and back options. A special beam-splitting mirror in the C-12 reflects a portion of the image up through the viewing tunnel, giving the viewer the impression of a straight-on view of the CRT. This no-parallax binocular viewing is especially desirable when the oscilloscope has an external graticule.

C-12 . . . . . $460
C-27 . . . . . $430

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An Electric Shutter/Speed Computer is available for both the C-12 and C-27 cameras, permitting remote actuation of the camera. It is intended for use in areas where a large number of cameras need to be remotely controlled or when there is limited access to the oscilloscope and camera at the time of use.

C-12-E Electric Shutter Camera . . . . . $665
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Type 201-1 . . . . . $130
Type 201-2 . . . . . $140

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201-2

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Tektronix offers a choice of voltage and current probes designed to be compatible with circuit measurement requirements. The probes are designed to monitor the signal source with minimum circuit loading while maintaining waveform fidelity.

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P6021/134 . . . . . $295


P6042

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P6042 DC Current Probe . . . . . $625

To help you select the right probe for your application, please consult Tektronix Catalog #28 or call your Tektronix Field Engineer.

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

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# Plastic IC's demand new physical

The military remains dubious about their reliability, but two programs sponsored by RADC may provide the basic data for more realistic tests

By Lawrence Curran
Associate editor

**One sure way** to start an argument between buyers and sellers of high-reliability integrated circuits is to ask whether plastic-packaged assemblies qualify for military use. Vendors will vigorously contend that their devices are ready now for at least certain military applications, while users will cite eye-popping failure rates for plastic IC's in hostile environments—particularly conditions of high moisture. One possible way to start a riot is to ask what constitutes a realistic test of plastic-packaged IC's for military duty. Nonetheless, it's apparent that an answer is needed as suppliers press to enlist their plastic-encapsulated output in the services, an untapped market.

Stephen L. Levy, vice president and general manager of Motorola's Semiconductor Products division, sizes up the situation this way: "I don't see any strong desire on the part of the military to use plastics. The pressure is coming from people designing equipment, people who would like to see them used in certain cases."

On the other side of the fence are the military reliability specialists. Alfred Tamburrino, head of the device analysis group at the Air Force's Rome (N.Y.) Air Development Center's reliability physics section, says the vendors can point to many applications in which plastics can be used with safety in benign environments. "But every time we build equipment to be used in a lab," he says, "someone drags it outside into the cruel world. The military viewpoint is that we should have one specification for a given part and not different ones for a variety of applications."

However, Seymour Schwartz, chief of the failure mechanisms branch of NASA's Electronics Research Center, joins suppliers of plastic IC's in favoring tests that reflect each circuit's actual conditions of use. "I would try to test IC's under actual or only slightly stressed conditions," he says. "There are too many variables in the situation for me to fully trust greatly accelerated tests. Plastic-packaged IC's should be matched to a particular application. You have to realistically test for performance in that environment, and specify with such tests in mind."

**Worst cases.** The problem here, according to Tamburrino, is in deciding what the actual conditions of use are. The same kind of circuit, he says, may have to operate in crusty salt layers on shipboard and in corrosive rat urine in Greece. Neither condition is typical, of course, but both are actual environments. "There isn't any single actual-use condition," Tamburrino maintains. "We need tests that will cover many conditions."

Regarding the military's attitude toward developing tests to qualify plastics, Tamburrino says that "though this may hasten the development of decent plastics, there are plenty of hermetics available at good prices from a number of manufacturers, so there's no real urgency from an economic standpoint. It's the vendors who see it as an urgent problem."

But Mick Carrier, product marketing engineer at Texas Instruments' Semiconductor Circuits division and an authority on plastic packaging, counters: "The military people are trying to play down the urgency of coming up with qualification tests for plastic-packaged IC's until they can get more answers as to the capability of plastics. These devices are being used in products in the field, but no screens have been established and the military feels exposed without them."

There are programs afoot, particularly at the Rome Air Development Center (RADC) to gather basic data for tests tailored to plastics. For one thing, Tamburrino's group has distributed a strictly unofficial test program proposal to IC makers. Intended to gather information on the capacities of plastics to withstand certain tests, it seeks detailed failure analyses from vendors so that failure modes can be determined. The program, though started at the behest of suppliers, aims to come up with standard screens rather than a welter of test data based on individual vendors' procedures. RADC officials are quick to point out that compliance with the program is strictly voluntary. The tests are to be performed on parts that have already been screened using four methods specified in Military Standard 883, the "holy writ" for testing hermetic IC's.

Officials at Rome stress that though the program asks for relative humidity tests with reverse bias for 7,500 hours, this doesn't imply that plastic IC's would have to survive that long to qualify for military use. "It's primarily an information-gathering program sub-

jecting a significant number of parts to failure to determine where the end points lie," says Joseph Brauer, who heads the solid state applications group at Rome. He reports, however, that the response from vendors has been meager since the program was circulated last June.

Signetics, however, appears to be sticking pretty close to the test procedures Tamburrino has suggested and should have preliminary results to show within two months. TI officials, notably Carrier, have visited RADC, but while they indicate that they're conducting an extensive program reflecting the philosophy outlined at Rome, they're departing somewhat from the precise test matrix. "They seem to be taking the program quite seriously, though," Brauer observes.

**Holdout.** But Motorola takes exception to the 100% burn-in called for before a device gets the prescribed short-term sequential high-stress tests and long-term combined environment check. The company says it's setting up an evaluation program that emphasizes standard methods—and doesn't include 100% burn-in.

Brauer believes the main consideration in testing plastics is economics. "Let's look at the economics of buying a particular plastic device and putting on an additional 100% screening to raise the quality to military levels to see if we've still got a bargain," he says. "If the plastic still appears economical, it's time to consider how to qualify it for military use. If not, forget it."

He gets strong support in this from at least one IC vendor. Ben Anixter, director of product marketing at Fairchild Semiconductor, asks: "What incentive do military and space users of IC's have to go to plastics? Where the cost differential between plastic and ceramic can amount to only a nickel, the cost of burn-in may run anywhere from 50 cents to $5. Even if that were cut in half, as it may be next year, you'd still have to add a minimum of 25 cents to the cost of plastic IC's to get them to meet MIL-STD 883. Gross and fine leak tests will run the cost even higher, and you find that you're adding between $3 and $10 to the price of each circuit.

"The military really doesn't seem that hot for plastic IC's," Anixter continues. "It's the manufacturers with products to sell who insist that the military look at plastics." As it happens, Fairchild is not one of those manufacturers.

In Brauer's opinion, there are two big problems with plastic IC's —aside from costs—that will have to be solved before the units are generally accepted for military equipment. One is the intermittent connections made when internal leads are broken by the expansion and contraction of the plastic with temperature changes. The other is the lack of a moisture-proof seal. "I'm quite convinced," Brauer asserts, "that there is no effective moisture seal created by the molded plastic package." The reason is that the plastic contains a release agent "to make sure the thing pops out of the mold," he says. "If the release prevents the plastic from sticking to the mold, it also keeps it from sticking to the lead frame." These drawbacks, he adds, manifest themselves in significantly higher failure rates for plastic IC's than for hermetic units over the long term—even in protected environments.

### A modest proposal

E. David Metz, assistant director of Motorola's central research labs, is among the most vociferous advocates of plastics for military applications. "I'm not claiming that present plastics are ready for the military," he says. "I'm just asking them to tell us what tests we have to pass. We'll make the devices to do it. If we know what they're going to do with a part, the risks are no greater with plastic than they are with metal."

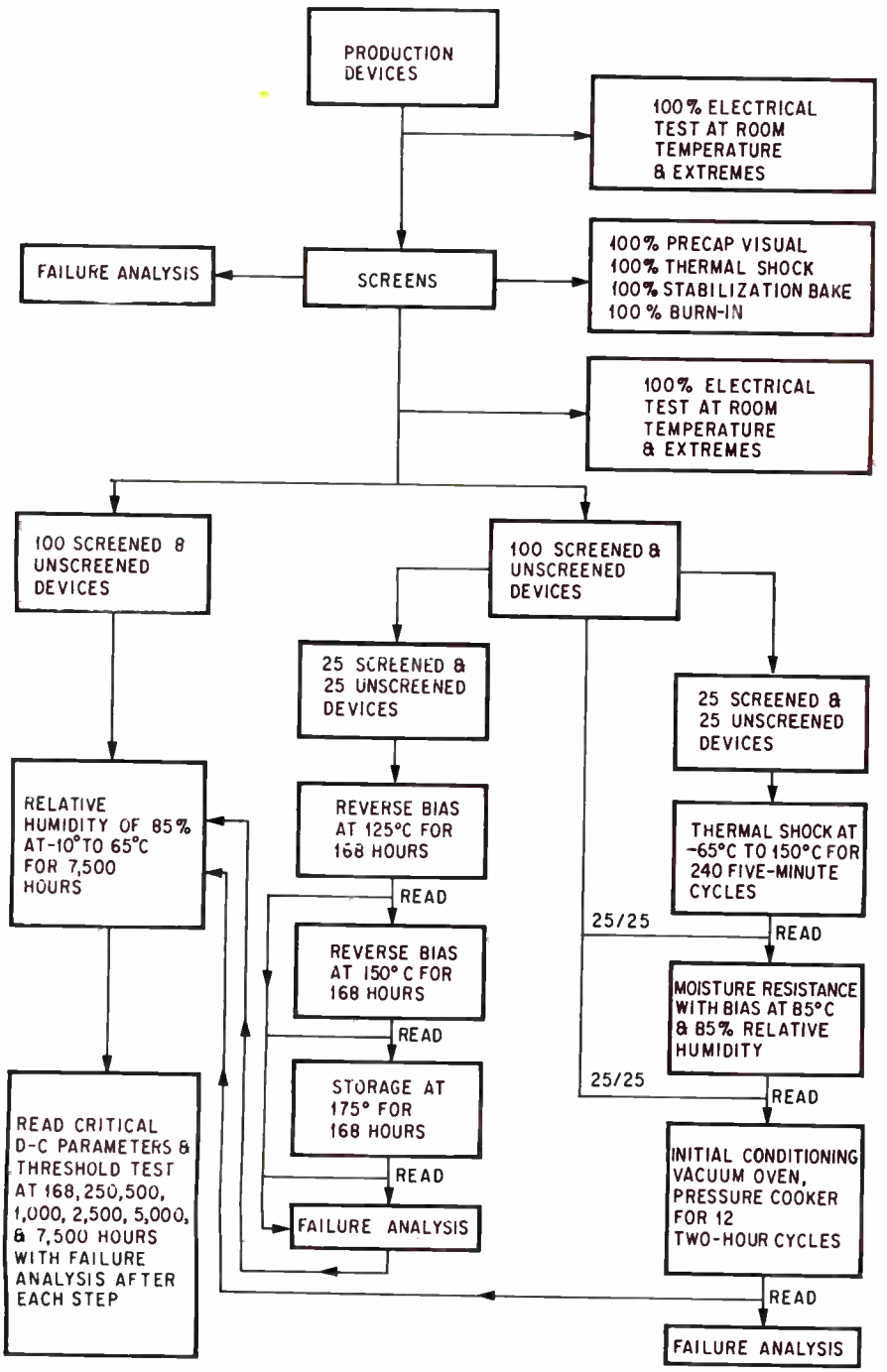
What really irks Metz is the seemingly open-ended requirements imposed on plastic-packaged IC's—particularly in moisture testing. "The military has no complaint regarding shock and vibration. They want moisture data. But if the devices pass, say, 500 hours at 85°C and 85% relative humidity without signs of moisture getting in, the high-reliability users say, 'We know moisture is getting in, so let's go to 1,000 hours or boost the temperature.'"

Metz suggests the following checks to screen plastics for most military applications:

- A 10-day moisture-humidity cycle based on MIL-STD 202,

method 106, but to include bias to simulate the normal temperature and humidity extremes a plastic-packaged IC would undergo in operation.

- Use of a short-term—less than 100 days—accelerating factor, such as pressure-cooker or boiling-water tests, to produce temperatures of 115° to 125°C. Metz suggests this be a lot-sampling check with "some failures tolerated."
- Thermal shock testing, cycling from 0° to 100°C, "but not for 1,000 cycles."
- Materials quality testing, including analysis of the plastic to determine the purity of raw and




**Proposition.** The test program proposed to makers of plastic-encapsulated IC's by the Rome Air Development Center is designed to produce data on failure modes for such devices. Assemblies will be put through four screens before they're run through the program, which is sequential. The way the checks are set up, a total of 100 screened and unscreened parts, stressed three ways, are subjected to a final 7,500-hour series of tests.

cured materials and to pinpoint the presence of ionic contaminants.

Metz observes little inclination among Government reliability specialists "to decide to use plastics. They risk their reputations if they go on record for their use, but they don't risk anything if they recommend against."

RADC reliability specialists would like to see devices pass the moisture-resistance tests prescribed for hermetically sealed devices in MIL-STD 883 and Air Force Change Notice No. 1. Motorola's Joseph Flood, director of reliability and quality assurance, claims plastics can pass this test (10 days with temperature variations from +25° to +65°C, and relative humidities from 90% to 98%) as he puts it, "with no sweat." But he adds: "The question is whether this check is adequate. Most of the tests for hermetic devices have been related to known failure modes in the devices. We don't have the same experience with plastics. We need a new group of tests that will accelerate the failure modes."

## All wet?

At TI, the feeling is that too much emphasis is being placed on the susceptibility of plastic-packaged IC's to moisture penetration. Carrier says the company hasn't had a plastic device rejected for this reason in the three years it's been selling them. He lists workmanship defects—for example, wire bonds not properly oriented on the bonding pads—as the most frequent agents of failure. Next come thermal stresses—such as wires pulling loose from bonding pads as device temperatures rise—stemming from the differing thermal coefficients of expansion for gold wire and plastic materials.

Failures caused by moisture penetration are a distant third in TI's experience. Carrier believes MIL-STD 883 is a good starting point for developing realistic tests, but maintains that an extra set of checks for plastics wouldn't make sense. "Substitute tests have to be developed or the economic advantages of plastics will be wiped out," he declares. For example, no plastic-housed devices can be put to the hermeticity tests prescribed in Standard 883 because there's no cavity to absorb gas.

**Light exercise.** Like Flood, Carrier advocates test programs that pinpoint the failure modes peculiar to plastic-packaged parts. And he backs monitored temperature cycling as one method of screening out thermal stress problems—particularly intermittents. One TI customer tests IC's by having them drive lamps. If there are bad wire bonds or thermal-coefficient-of-expansion problems that could cause intermittent contact between the wire and the bonding pad, the wire will pull loose as the temperature in the test chamber rises and the lamp will go out. Then, as the chamber temperature is lowered, material contraction will bring the wire and bonding pad back together, thereby causing the lamp to light.

"This isn't as simple as normal temperature-cycle chamber tests," Carrier admits, "but we use this type of monitored temperature cycling as part of our reliability evaluation program as well." RADC's Tamburrino agrees that monitored thermal cycling—from −55° to +125°C—is the only way to test for intermittents. "But this is the most costly check there is," he adds. Carrier concedes it's costly but believes it must be done. He says, however, that 10 cycles might be enough to get effective "infant mortality rates" after longer monitored tests have established baseline failure rates.

Returning to the subject of moisture resistance, Carrier says: "I don't feel any tests of this kind today can pinpoint device lifetimes in equipment. There's no curve that can correlate temperature-humidity tests and failure rates."

**Correlation gap.** Carrier doesn't think the 10-day moisture-humidity cycle with biasing proposed by Motorola's Metz is stringent enough, even when augmented by a pressure cooker or immersion in boiling water. "We're not pushing the pressure cooker as a test customers should use for qualification," he says. "We don't think there's a good correlation between it and some longer-term tests in indicating failure modes."

Richard McCoy, director of reliability programs at Signetics, would like to see the military develop "environmental matrix testing" for plastics—in other words,

checks that vary in severity depending on the specific circuit's intended environment. "Once we've determined what environment we're trying to meet," he says, "we should develop correlation tests." The idea would be to establish whether 50 hours of pressure-cooker testing is equivalent to perhaps 2,000 hours' exposure to moisture. McCoy agrees that a 10-day test isn't sufficient to guarantee performance in, say, Vietnam; he suggests that the military demand 2,500 hours of moisture checks and insist that all devices pass.

### All roads lead to Rome

McCoy isn't overly concerned about the military's delay in accepting plastics. He expects RADC to have the last word on how plastics are tested and qualified, and he's probably right; MIL-STD 883 originated there, and though not intended to cover plastics, this standard will be used as a departure point. Says Tamburrino: "The question becomes what additions or deletions will be needed. We don't have absolute standards. These are just tests that we know through experience will get us reliable parts.

"Even though a plastic IC might pass all the qualification tests for hermetics, there's still no assurance it's reliable," Tamburrino adds, citing moisture resistance as a good example of this. Method 1004 of MIL-STD 883 specifies that a hermetic IC withstand cycling between −10° and +65°C at 95% relative humidity for 10 days. It's been determined that if the leads don't corrode in that time, the device will survive. There won't be moisture penetration to the interior of the package because this has been ruled out in previous leak testing.

But Tamburrino says that in a plastic IC, moisture can penetrate along the leads, although this condition may not appear for 500 or 1,000 hours. "Our first efforts, then, will be to compare available plastics with hermetics when they're driven hard, see where plastics fall down, and determine how important the failure is," he says. "We'll try to shake down the parts by overstressing them. This is how we learned to test hermetics."

**Qualifier.** RADC's suggested cycled humidity tests for 7,500 hours from +65°C to room ambient are

being applied in a one-year program being conducted under an RADC contract at the Delco Radio division of General Motors' analytical services group. And John R. "Dick" Bevington, the group's supervisor, notes that reverse bias is part of the testing, which began about mid-April. Delco will check plastic materials from four suppliers and plastic-packaged IC's from four device makers, performing seven or eight different sequences on the devices.

"The severity of these tests will result in high failure rates," Bevington says. This, he points out, is by design because it's the only way to determine the plastics' capability. "By the time we're finished, we should have a pretty thorough evaluation of the existing screening and have come up with some answers."

Because hermeticity tests for hermetically sealed IC's won't do for plastics, and because a valid moisture-resistance test would take at least several hundred hours, there's no convenient, generally accepted method to test for moisture resistance in plastics. This is why new —and controversial—qualification checks like pressure-cooker tests are being examined. "What we'd like to have is a test to indicate whether failures can be made to happen much sooner than 500 or 1,000 hours," explains Tamburrino.

### Show me

"Some people have observed a correlation between the pressure-cooker and the standard moisture-resistance test, but we're not convinced yet," Tamburrino says. Another possibility for screening is the 85/85 test—85°C and 85% relative humidity with reverse bias. This, Tamburrino feels, may prove a more accelerated method than the one in MIL-STD 883, although the temperature isn't cycled. But again, correlation of the test with failures is a problem.

Part of Delco's job will be to determine the relationship between moisture-resistance tests and other stress factors. The firm is to report its findings in June 1970, with the hope of establishing generally acceptable qualification and 100% screening tests. Although Tamburrino realizes the Delco program won't provide final answers, he believes it could well prove a mile-

stone. It should at least answer some vendors' questions about how good their plastics have to be before they're endorsed by the military, he believes.

Tamburrino, like Carrier, doesn't buy the 10-day moisture humidity cycle based on MIL-STD 19500 proposed by Motorola's Metz. "The median failure of epoxy devices tested at 85/85 is 900 hours," he says, "and 10 days is just 240 hours. These are use conditions only and don't account for the extremes the device is likely to encounter." As for augmenting this test with pressure-cooker or boiling-water tests, as Metz suggests, Tamburrino again cites the fact that correlation between pressure-cooker and longer-term moisture-resistance tests hasn't been established.

**Devil's advocates.** Despite the slim amount of reliability data on plastics compiled at RADC, both Brauer and Tamburrino are working to qualify these circuits for military use. Brauer is chairman of a group composed of NASA, Army, Navy, and Air Force representatives considering test methods and procedures for plastic-encapsulated semiconductors. The group set up shop a year ago when, in Brauer's words, "there was quite a campaign by semiconductor manufacturers to sell plastics to the military." At the time, RADC engineers felt they couldn't back plastics because the test data they were getting from manufacturers was inadequate.

The group has met three times to hear representatives report on efforts to develop test methods for plastics. And these reports indicate some progress. "It seems that plastics are getting a little better," Brauer says. "There still aren't any that can take a reasonable salt-spray exposure, but some are proving more effective under temperature-humidity-bias conditions." But there's still a long way to go; Brauer finds that instead of 100% failures, "we're only getting significant percentages."

Brauer also notes what he construes as an improvement in the vendors' attitude: "We've reached a point of greater enlightenment among vendors and users. I think the major accomplishment has been to take this thing out of the public relations realm and put it into the scientific."

# German car market opening up

Paced by Bosch's success with electronically controlled fuel injection system, outlets shows real promise; wipers, lights, and gearshifts on the prospect list

By John Gosch
Associate editor

**West German automakers,** like their Detroit counterparts, are on the point of going for electronic controls in a big way. As is the case in the U.S., the day when electronics will handle all the jobs of which it is capable is still a few years off. Nonetheless, automotive outlets are taking definite shape. "It could well prove the fastest growing sector of the industry within a short time," says Fritz Hoehne, marketing director at Texas Instruments Deutschland GmbH.

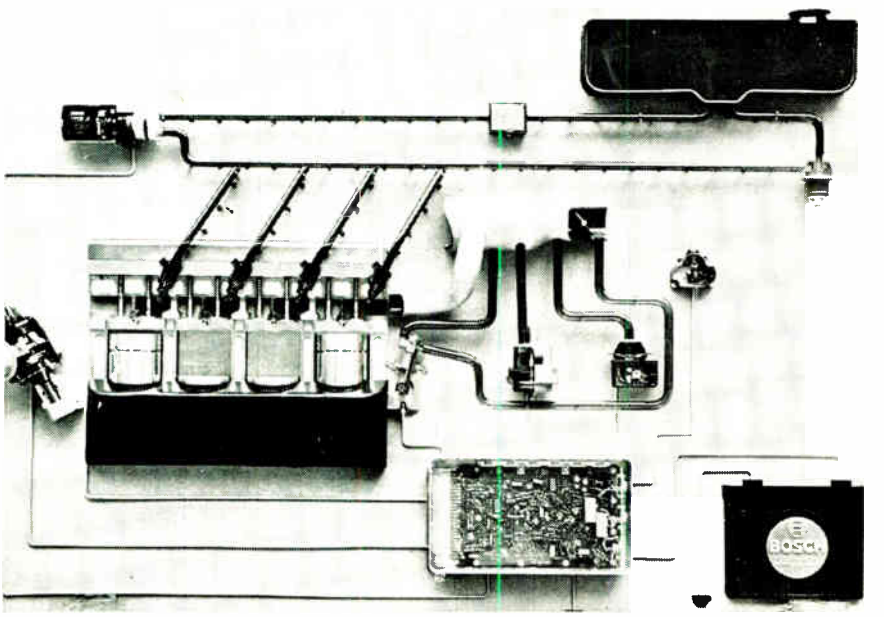
The road still promises to be a bit bumpy in spots. For one thing, the severe environment of a motor vehicle is a testing application for precision components. For another, innately conservative car manufacturers are in no particular hurry to incur the risks involved in a wholesale shift from electromechanical components to electronic circuitry. What's more, they're extremely cost-conscious.

Nonetheless, a combination of circumstances is brightening the overall outlook:

- The Bonn government is pushing through a number of tough, new antipollution and safety laws covering motor vehicles.
- The affluent West German motoring public is now willing to pay a modest premium for features that will make driving more comfortable and safer. "When drivers appreciate the benefits, they don't mind spending a little extra for electronics," says a dealer.
- West Germany's passenger vehicle population is growing by leaps and bounds; it's expected to total 19 million by 1980, 78% ahead of current levels.
- Market-minded parts and accessory houses have launched a merchandising push the last few years that's just now beginning to pay off.

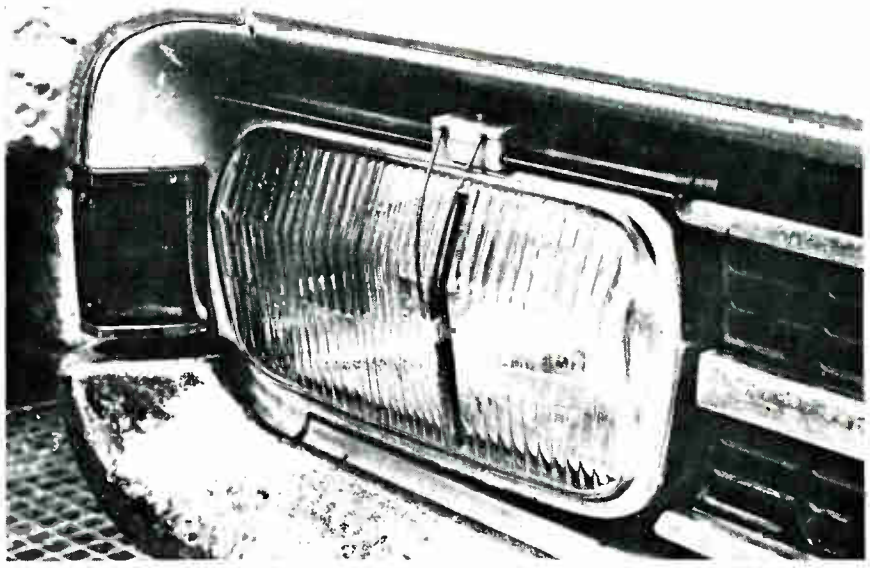
At the moment, the sales volume for all kinds of active and passive devices, excluding radio componentry, amounts to only $10 million or so. "From here on out, it's anybody's guess. But we expect big things," says a source at SGS, a leading European semiconductor firm. Sales are expected to triple by 1970, and Peter Schulte, a marketing official with Motorola Halbleiter GmbH thinks an annual growth rate of 30% is sustainable from that point.

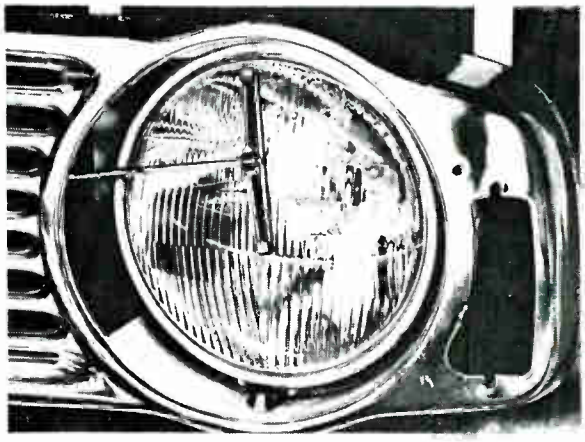
Throughout the industry there's a consensus that the market track will be up, but there's no general agreement about the angle of ascent. "It could well depend on one big auto company with an annual output of several hundred thousand cars or more," says an industry official. "If such a firm decided to install, say, an anti-skid system on a fast-selling model, the market would soar beyond expectations." But others believe component sales will incline more toward chain reaction, rather than explosive, growth. Such an effect is already discernible. After Volkswagenwerk AG, Germany's largest auto manufacturer, installed an electronically controlled fuel injection system in one model, Daimler-



**Around the loop.** Fuel injection system, with control circuitry from Bosch, improves engine performance, lowers gas consumption, and reduces emission of exhaust contaminants to levels lower than are possible with carburetors.

## For the car that has everything . . .

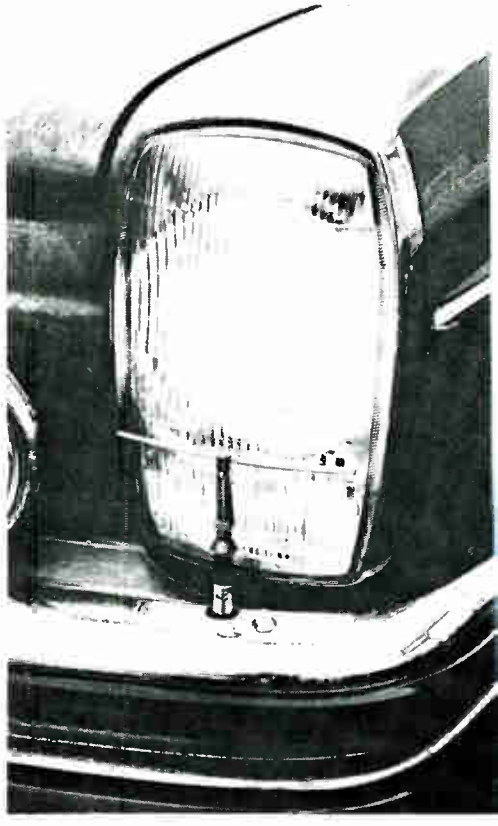




Bosch is readying a line of electronically controlled wiper systems for headlights and taillights. The units, designed for luxury models, will be on the market later in the year.

Benz AG, which produces the Mercedes lines, followed suit. And this year, other manufacturers are expected to fall into line.

Component makers have long been ready for a booming future. Some have had standard circuit designs on their back burners, literally for years, waiting for the car industry to shed its inhibitions about advanced technology. And even now, many auto makers are still concerned about losing their reputation should an electronic system fail. Had it not been for such conservatism, Motorola's Schulte asserts, this year's sales could be five times higher than what they actually will be.



### Number one

What's good for component firms in automotive outlets is, of course, better for accessory makers—the direct suppliers of the car industry. Among the half a dozen or so West

German companies producing electrical-electronic equipment for auto makers, Robert Bosch GmbH stands out. The Stuttgart-based firm, with a worldwide network of manufacturing and sales facilities, was among the first in the country to become aware of what electronics could do in motor vehicles. In September of this year the firm will open a new facility near Stuttgart which will centralize its efforts in automotive electronics. The long-range plan is to become less dependent on component suppliers; Bosch is now stepping up its own production of semiconductor devices at its Nuremberg plant.

So far, Bosch's most spectacular componentry application is its electronically controlled fuel injection system. The control unit of the basic version uses 220 components including 25 transistors and 35 diodes. A recently developed version has 270 components, including 30 transistors and 45 diodes—not much less than some black-and-white television receivers.

Electronic fuel injection control affords better engine performance, lower fuel consumption, and reduced emission of air contaminants in the exhaust than is possible with carburetor-equipped engines. An almost unlimited number of correction factors for particular operating conditions can be fed into the cigar-box-sized control unit, which can be installed almost anywhere in the car.

Volkswagenwerk, fearful that its lucrative export business would suffer unless it complied with U.S. antipollution laws, began installing the system on export models of the VW 1600 about a year and a half ago [*Electronics*, March 17, p. 84]. Since then, the company has sold more than 150,000 such cars in the United States alone. In Europe, where anti-pollution regulations haven't yet been enforced, customers pay the price—an extra $145—for electronic fuel injection primarily because of the system's fuel-saving feature. So far, around 13,000 units have been sold outside the U.S.

**New start.** Last month, Mercedes hit the market with a car featuring the Bosch control system—the Mercedes-Coupe CE. The $4,425 vehicle is designed mainly for those who want better engine perfor-

mance. The system will also be an option on Volkswagen's new VW 411. "And later this year a few more automobile companies will install our system," a Bosch engineer confides.

The domestic market for the system could skyrocket when the Bonn government enforces regulations that limit air contaminants in exhaust gases. One, which will apply to all new cars sold after July 1, limits carbon monoxide content in the exhaust to 4.5% by volume. The other, to go into effect a year from October, sets minimum limits on hydrocarbon particles in the exhaust.

Bosch was in no particular hurry to go the integrated circuit route with its system. But the situation may change soon now that Siemens AG, West Germany's leading electronics house, has started development work. Engineers there believe two or three IC's could be used to replace most of the more than 200 discrete devices now used. Moreover, a source at General Instruments in the U.S. reports his company is working on MOS circuitry for a new model of the control section in Bosch's system.

Bosch is already using IC's in voltage regulators for car alternators. The firm will start selling these units later this year. Marketing men think that in three to five years all cars in Western Europe

**Inputs.** Bosch is now mass producing alternators with IC voltage regulators.

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will have IC's in their voltage regulators. The West German market for semiconductors, including IC's used in regulators, is expected to be close to $4 million within five years.

### Easy riders

In Germany, Bosch has pioneered the application of semiconductors in a gear shift system. Electronically controlled automatic gear shifting was introduced in mid-1966 as an optional feature on the Glas 1700 passenger cars manufactured by Hans Glas GmbH. In the system, shifting is initiated electronically and accomplished hydromechanically. The kingpin item is a transistorized, book-sized control unit mounted under the dashboard. The unit's main inputs are vehicle speed and gas pedal position information. Speed data is derived from a small generator driven by the engine's drive shaft. The generator produces a voltage proportional to car speed. Gas pedal position data comes from a pot mounted on the engine.

Using these inputs, the control unit calculates the optimum gear setting and compares it with the actual. If the two don't jibe, the unit produces an output which is amplified and then fed to electromagnetic valves. These, in turn, control electrically driven hydraulic cylinders for operating the clutch and shifting the gears.

Among the other subassemblies that have gone electronic at Bosch are windshield wiper control systems that allow intermittent as well as continuous wiper blade operation. The former is handy for driving through light rain or fog.

A small dashboard-mounted pulse generator—basically a two-transistor multivibrator – sends short pulses to the wiper motor, each pulse causing one sweep of the blade across the windshield. The interval between sweeps is adjustable between two and 25 seconds. The generator will be a standard item on a Wankel engine-equipped passenger car made by NSU Motorenwerke AG.

Using similar control principles is a Bosch system that combines both windshield washing and wiping operations. When the panel switch for squirting water onto the windshield is operated, the blades automatically start sweeping.

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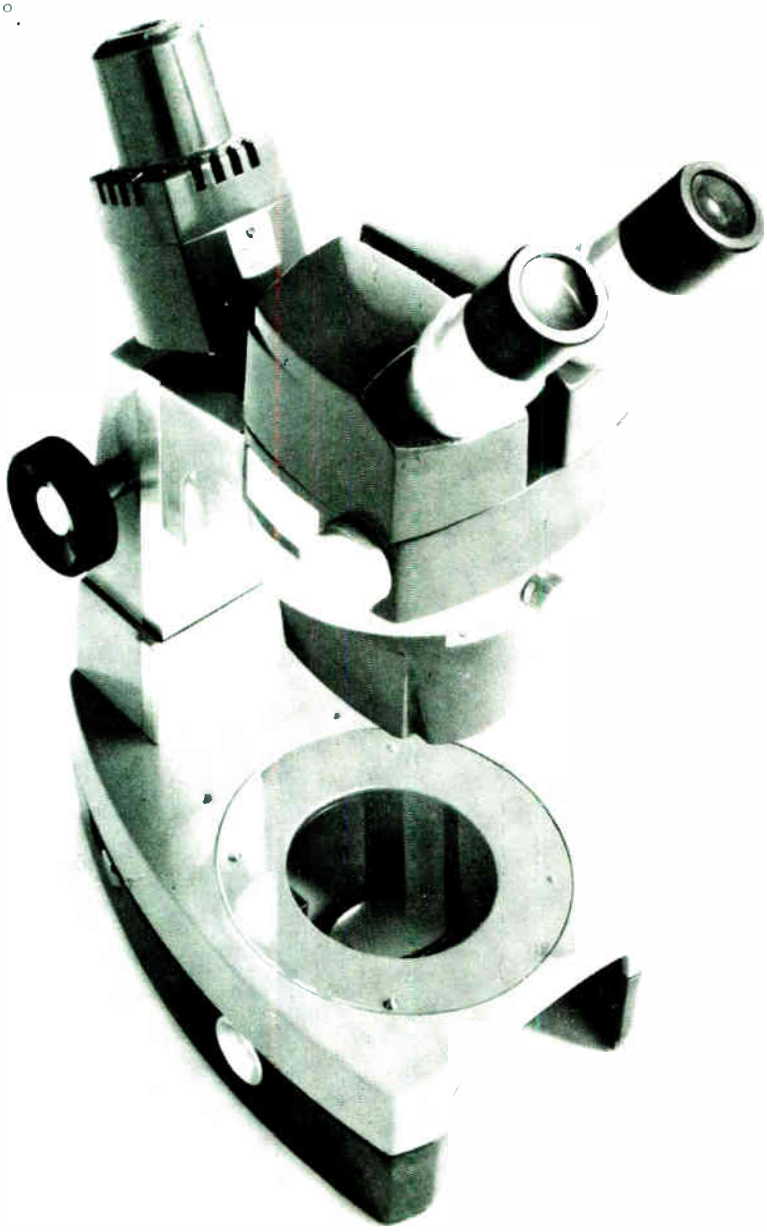



Circle 161 on reader service card

**Light touch.** Electronic control is also a feature of the wiper systems Bosch is developing for headlights and rear lights. In the case of rectangular lights, the blade sweeps across the glass surface either horizontally or vertically with the blade being moved by a telescopic rod or from a small guide rail mounted next to the light. With round lights, the blade moves across the glass in elliptical fashion. These electronically controlled wiper systems, intended primarily for luxury cars, will hit the market in mid-1969.

Another example of what Bosch has up its sleeve is an electronically controlled headlight illumination regulator, a unit that helps prevent drivers in oncoming cars from being blinded when the light beam is too high—a situation that occurs when vehicles are loaded down too heavily in the back.

**Precursor.** The firm has already developed an electromechanical system for light beam correction, intended primarily for trucks. In this set-up, data corresponding to truck load is picked off a switch mounted somewhere between the rear axle and the chassis. Its output is fed to each headlight where it is used to adjust the position of the reflector. The reflector is adjusted so that no matter where the load on the vehicle is located, the headlights will always beam at the proper angle.

Bosch is now readying a system in which load information is produced in an electronic unit whose output will continuously adjust the headlight reflectors. The firm believes automatic headlight control might someday be required by law even for passenger vehicles.

Soon to be enforced is a German regulation which requires all new cars to have a system of four outside-mounted lights for warning purposes. These lights—they go on and off simultaneously at specific intervals—must be in operation when the driver is stuck along the road to flash a warning to other approaching cars. Bosch, like other accessory makers, already has on the market low-cost blinking systems in which intervals are controlled by a two-transistor multivibrator circuit. Enforcement of the regulation on January 1, 1970 is expected to boost component makers' sales.

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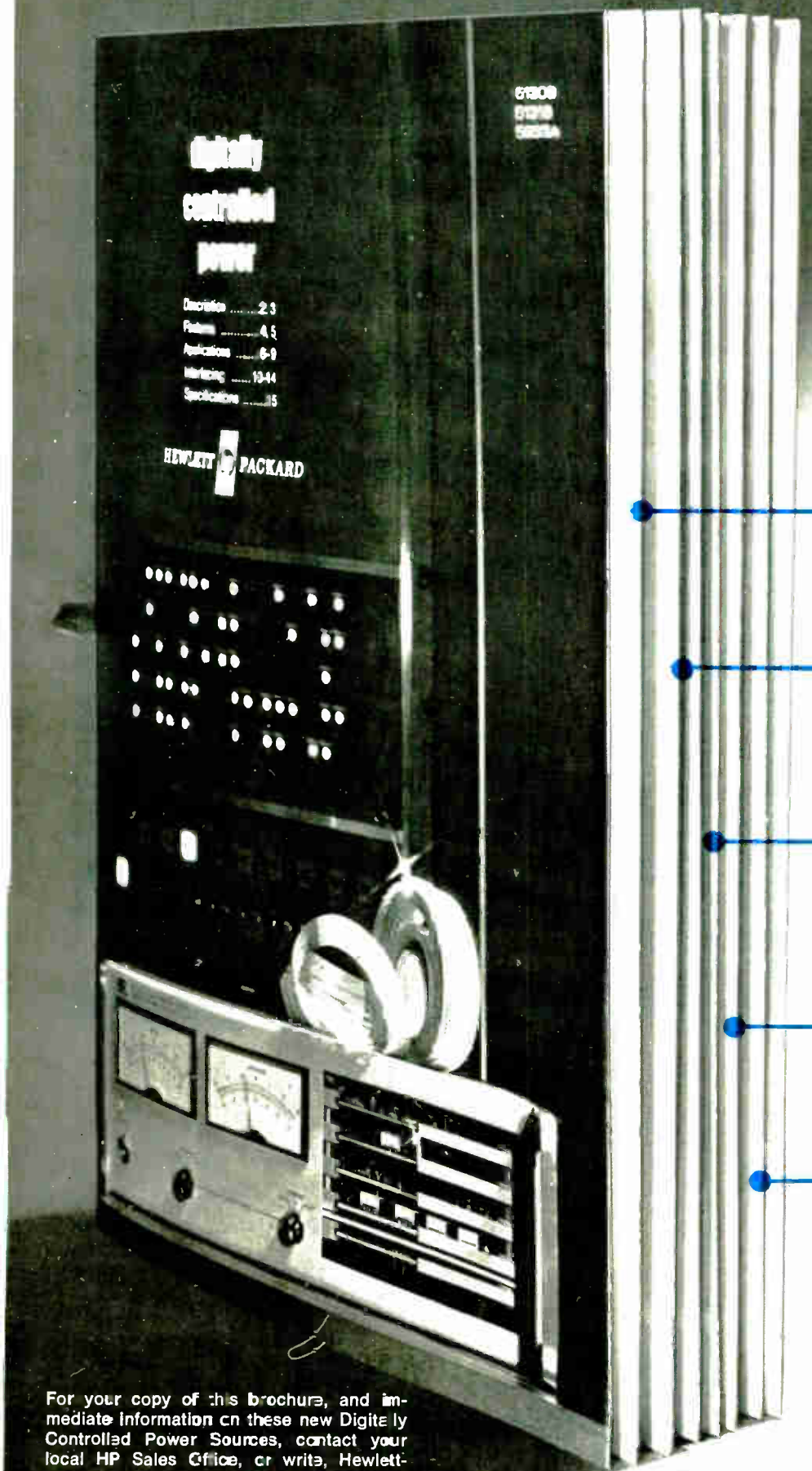


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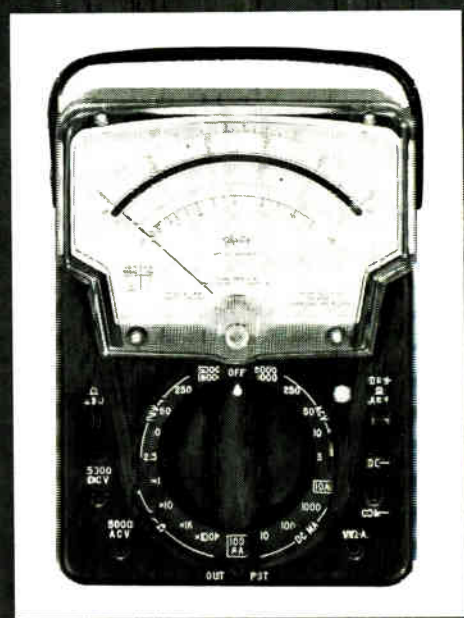

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|---|---|---|
| Specific gravity | 1.36-1.38 | D 792 |
| Molding shrinkage, in./in.: | | |
| Compression | 0.006-0.008 | D 955 |
| Transfer | 0.009-0.011 | D 955 |
| Water absorption, % | 0.6 max. | D 570 |
| Impact, Izod, ft. lb./in. | 0.35 min. | D 256 |

| Durez 11540 Black Phenolic Material | Value | ASTM Method |
|---|---|---|
| Flexural strength, psi | 10,500 min. | D 790 |
| Tensile strength, psi | 7,000 min. | D 638 |
| Compressive strength, psi | 30,000 min. | D 695 |
| Defl. temp., °F., 264 psi | 330 min. | D 648 |
| Modulus in tension, psi | $1.2 \times 10^6$ avg. | D 638 |
| Hardness, Rockwell. E scale | 85 avg. | D 785 |

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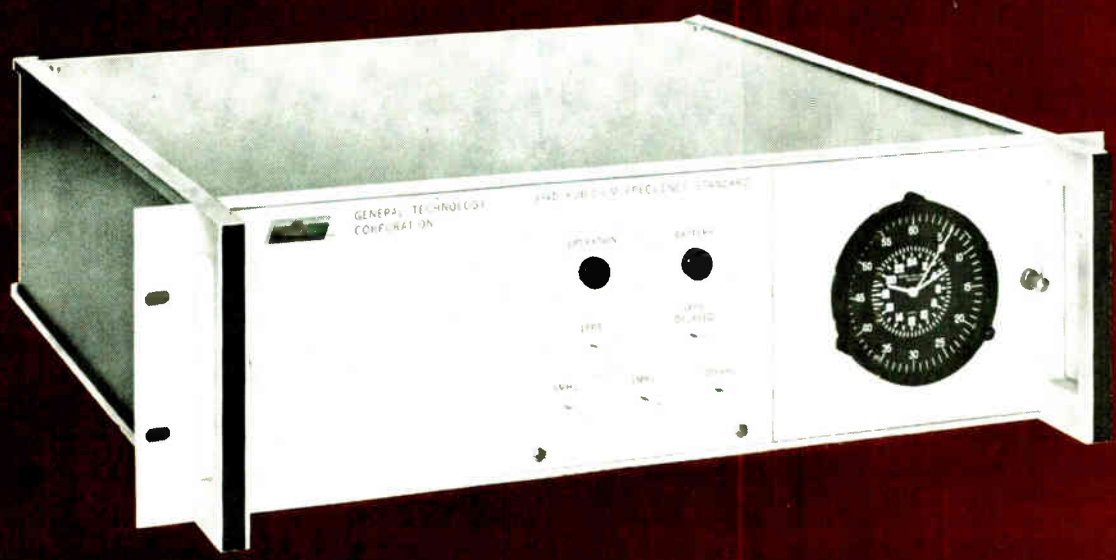

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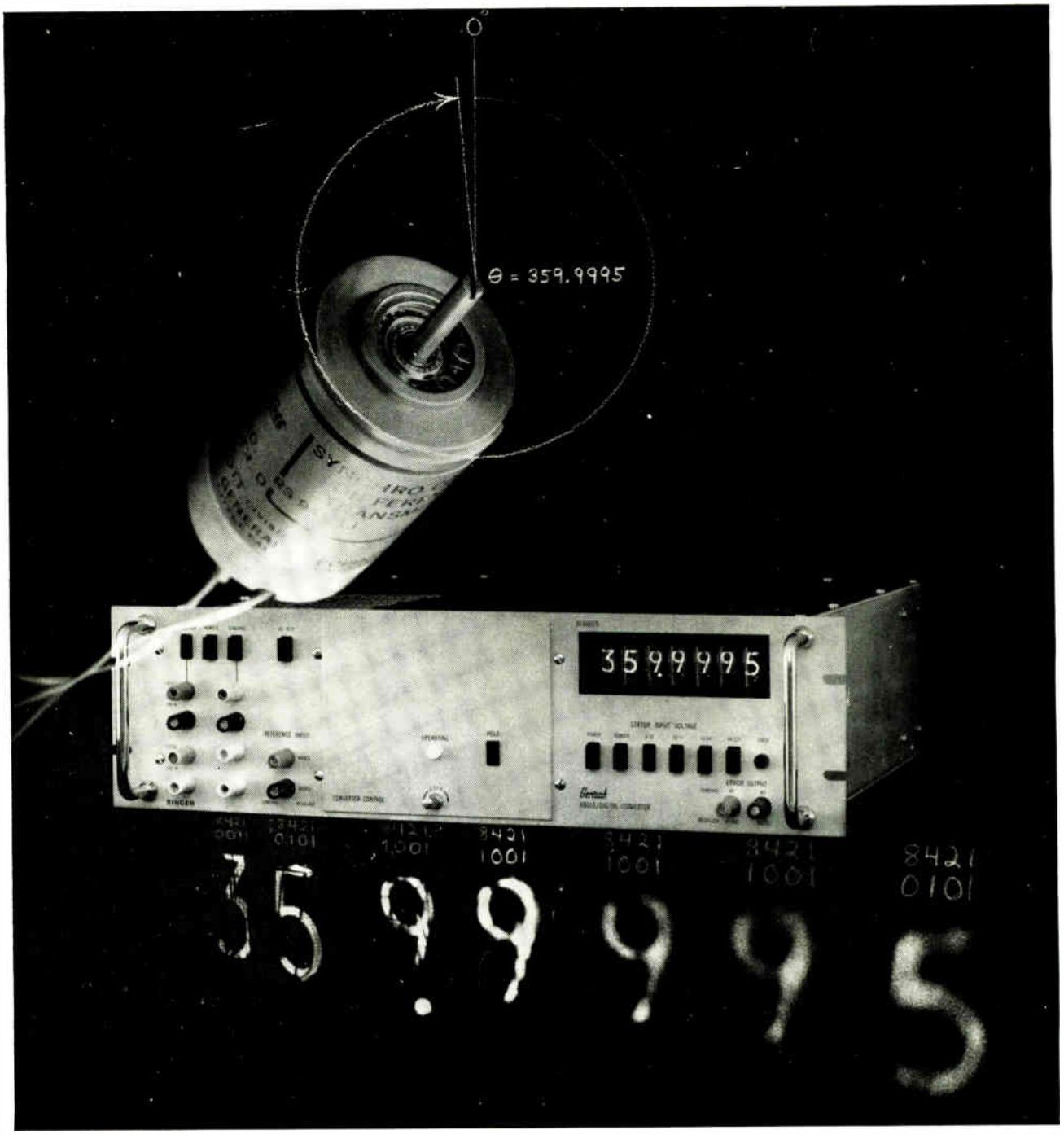
IA-124



Circle 167 on reader service card 167

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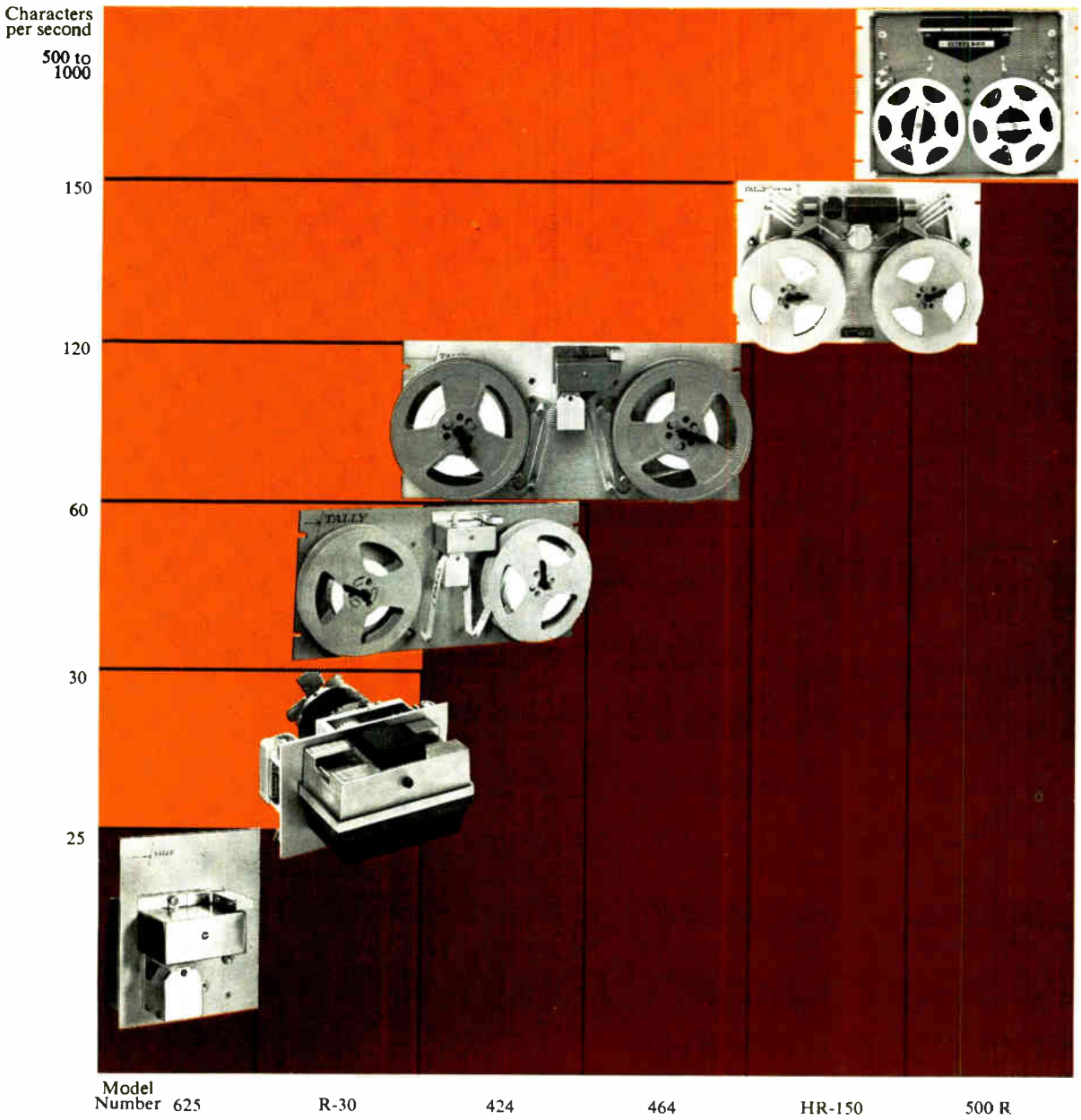


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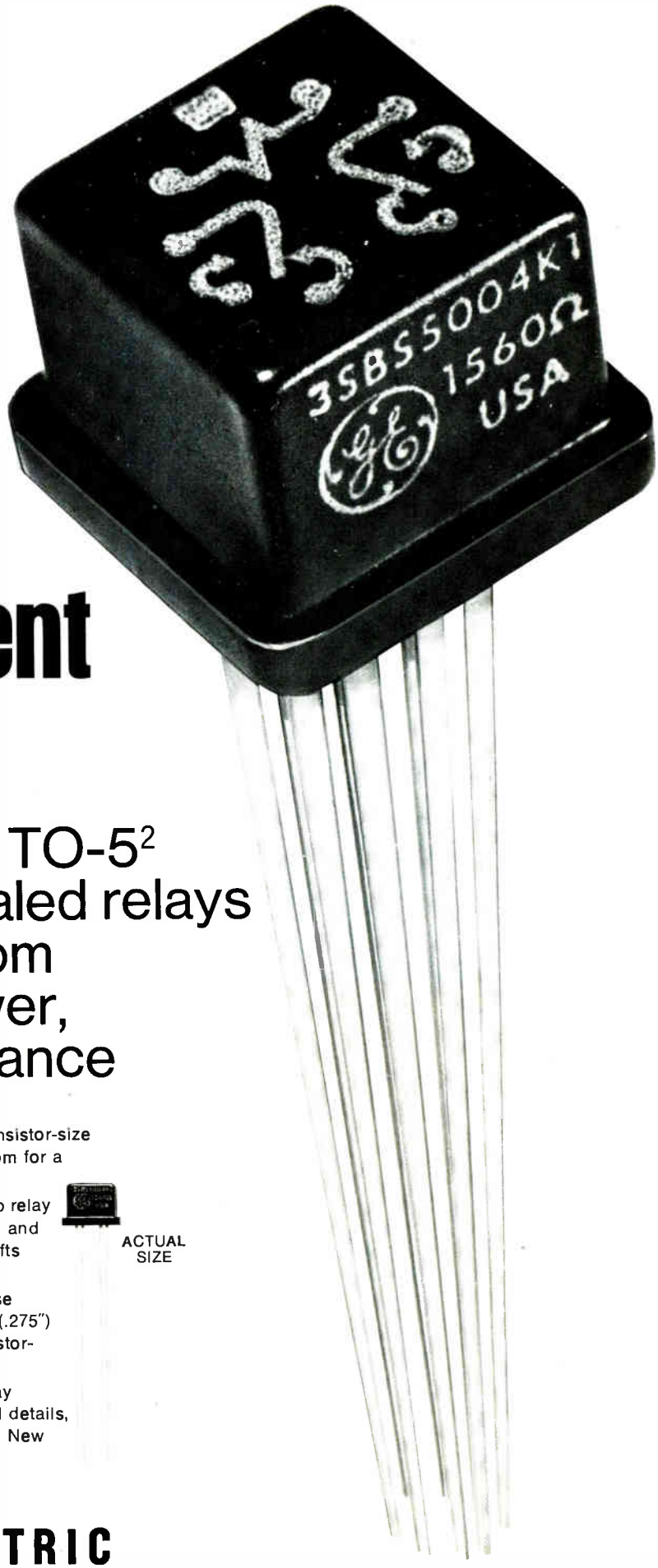
Circle 169 on reader service card

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*actual size*

Reeves® INSTRUMENT DIVISION
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Circle 171 on reader service card


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| 10 | 0.937 | 1.7 | 25 |
| 11 | 1.062 | 3.2 | 29 |
| 15 | 1.437 | 4.7 | 24 |
| 22 | 2.161 | 18 | 5 |

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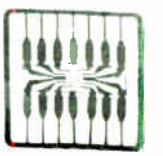

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Circle 173 on reader service card


Circle 174 on reader service card

# Core memory tester has low price tag

Basic machine for probing planes and stacks sells for $25,000; modular design permits addition of plug-in electronics for each type of stringing

By James Brinton
Associate editor

**The middle route** is the choice made by a new company in building a machine to do the complex and demanding job of testing computer memory cores as inexpensively as possible.

The first product of the Heidelex Corp. has a basic price of $25,000. The machine, designated the CMA-101, is for use on production lines to test memory planes and stacks before the addition of read-write electronics.

What makes the job of core testing a very demanding one is the variety of core stringings now in use (3-wire, 3-D; 3-wire, 2½-D; 4-wire, 3-D, and others), the difficulty is compounded by specialized sense and inhibit wiring, segmentation of planes into discrete areas, and other tricks done for the sake of fast, efficient data processing.

Heretofore some makers of memory testers have made their testers so flexible that they could nearly accommodate any kind of stringing. This makes for a costly tester, and a $100,000 unit is about par. On the other hand, some have designed their testers on a custom basis—making them capable of testing one or at best a limited range of memory types. This sacrifice of flexibility allows the price to fall below $50,000.

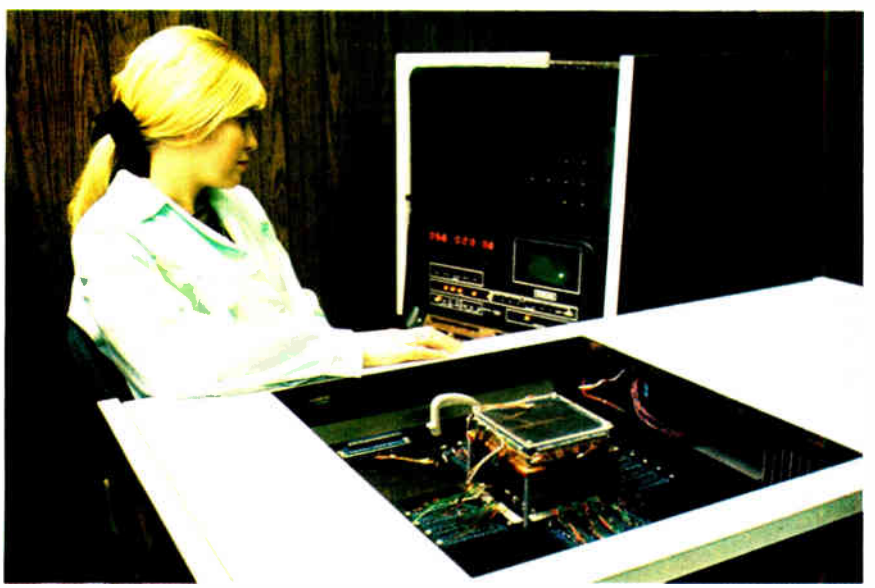
Heidelex aimed for a synthesis and made the CMA101 modular, providing in the main frame the basic electronics needed to control the test process and to display core plane faults. The specific electronics needed to exercise and analyze a given memory type are contained in plug-in modules.

The potential saving to the user is great. Even custom-made memory testers cost approximately $35,000 each when purchased in lots of about four. After buying a CMA101 for about $25,000, a user can equip it to test additional types of memory planes for about $1,000 per type—the price of plug-ins.

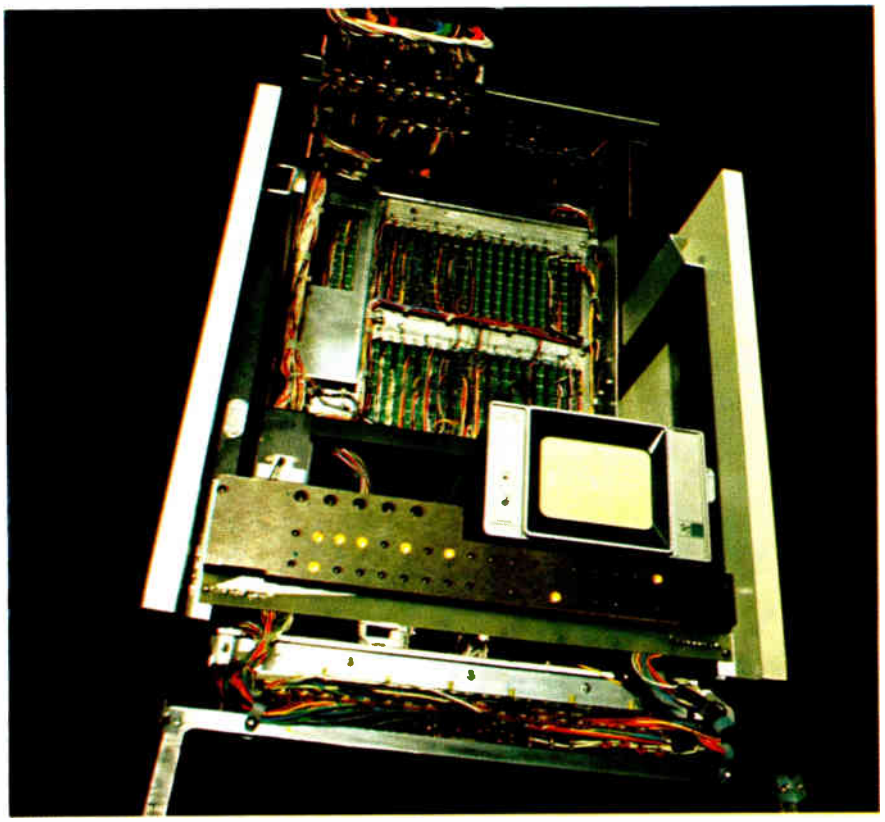
Heidelex president Lewis Illingworth says that the tester easily can hold enough modules to test two or three types of planes, though more would require complex controls which might offset some of the tester's cost advantages.

**A simple worker.** The tester is designed for high volume quality control or acceptance testing, and so it's been built to work simply, with the operator making as few adjustments as possible. A dark Plexiglas cover shields fine adjustments for drive amplitude, timing, sense level, and scan size. The operator needn't touch them.

Since all adjustments are either



**Test station.** Core memory on the fixture in the foreground is checked, and error location pinpointed by numerical readout and cathode-ray-tube display. The station can also include printer output of type of error and its location.



**Modular.** The electronics needed to exercise specific types of core memory is contained in plug-in modules for the test station. The basic system includes circuitry that controls the testing process and displays faults. The CMA 101 requires a minimum of "tuning" and is suited to high-volume operations.

"installed" with the module or made and checked prior to the beginning of a day's testing, the operator need only place a memory plane or stack in the test fixture and start the machine. Each core location is checked while three Nixie tube readouts simultaneously display x-, y-, and z-axis coordinates of tested cores.

If the tester spots a flaw, it halts and the Nixies show the location while a cathode-ray-tube display indicates the location graphically with a bright dot. The CMA101 either stops at a flaw, or pauses momentarily while the operator records the flaw location. It also can provide a printer output for automatic recording of flaw type and location. The hard copy output is an extra.

Plug-in modules for the CMA101 contain the program, test pattern, and timing circuitry needed to check a given memory series. Individual interchangeable switching systems also are supplied by Heidelex Corp. for each memory series to be tested.

**Better emulation.** The CMA101 uses voltage drivers, rather than current drivers, which are said to be more common, and to have higher construction costs. Illingworth states that voltage drive not only better emulates the drive found in computers but also allows easier, closer control of individual drive signal amplitudes and waveforms.

Voltage drive, he adds, also aids in test of 2½-D or 3-D memories with integral diode matrixes by helping to charge, or "pull up" the diodes quickly to avoid a slowly rising pulse. Slow charging could slow the test of diode-equipped core memories about in proportion to the increase in the rise time of the pulses.

However, the CMA101 has an address to address cycle time of about a microsecond, and because testers need not be as fast as the memories they test, according to Illingworth, the CMA101 would seem to be about as quick as necessary.

## Test pattern

For each test, the plug-in control unit generates a test pattern and sets up programs for both the switching network and the system of sensing circuits which monitor the memory's output. The outputs of core locations being tested are routed via the switching system to a group of sensing amps after which the outputs are compared in a strobing unit to precise, programed voltage levels. They are then checked against expected outputs previously synthesized by the control unit, and the errors noted.

The system is also capable of catching flaws in the often complex array of sense and inhibit (or digit) lines used in many of today's memories.

"Not only does one need to know the x, y, and z coordinates of a flaw," says Illingworth, "but also the particular sense line, its polarity, and the particular inhibit line involved. We solve this by wiring each pattern generator individually to cope with the particular sense-inhibit scheme it must deal with."

**Flexible.** For users with a variety of memory types to check (long runs of a single type are the rule), the CMA101 not only can be equipped with several memory test modules, but also adapted to computer control, according to Illingworth. Address and sense data already are buffered for printer output, and conversion to computer access is simple. The computer also would program the various drive and sense characteristics required when switching among tests of several memories.

The company quotes 60-day delivery for the CMA101.

Heidelex Corp., Stuart Rd., Alpha Industrial Park, Chelmsford, Mass. 01824 [338]

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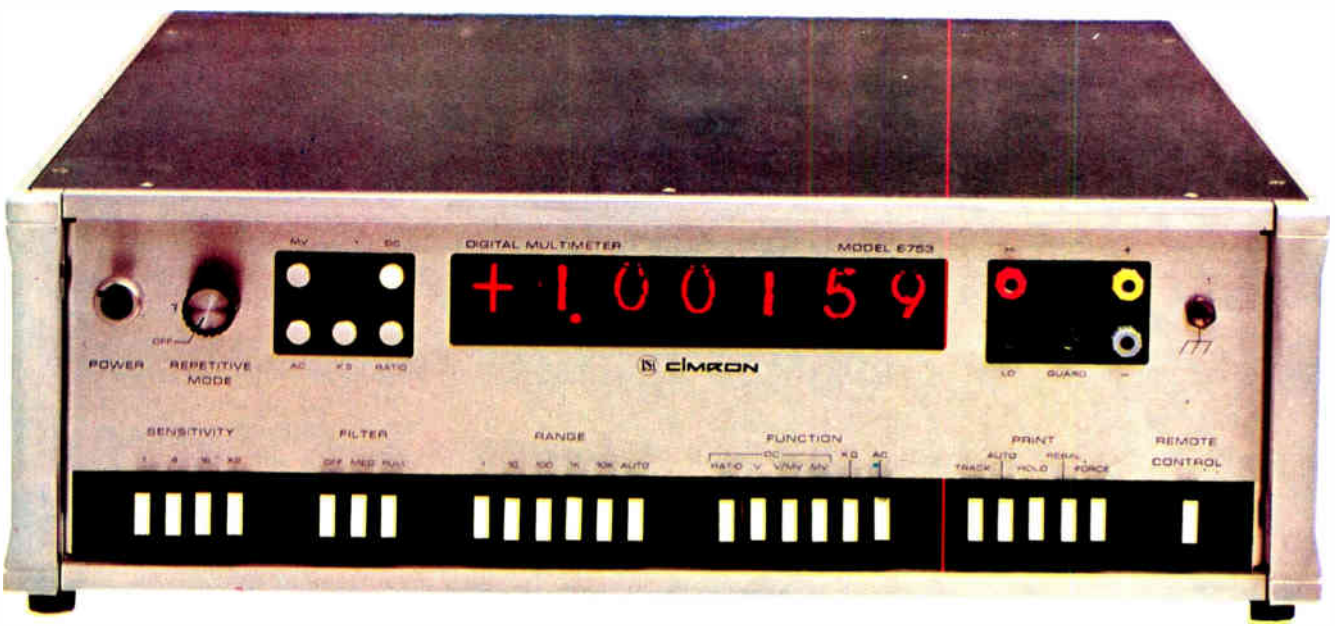
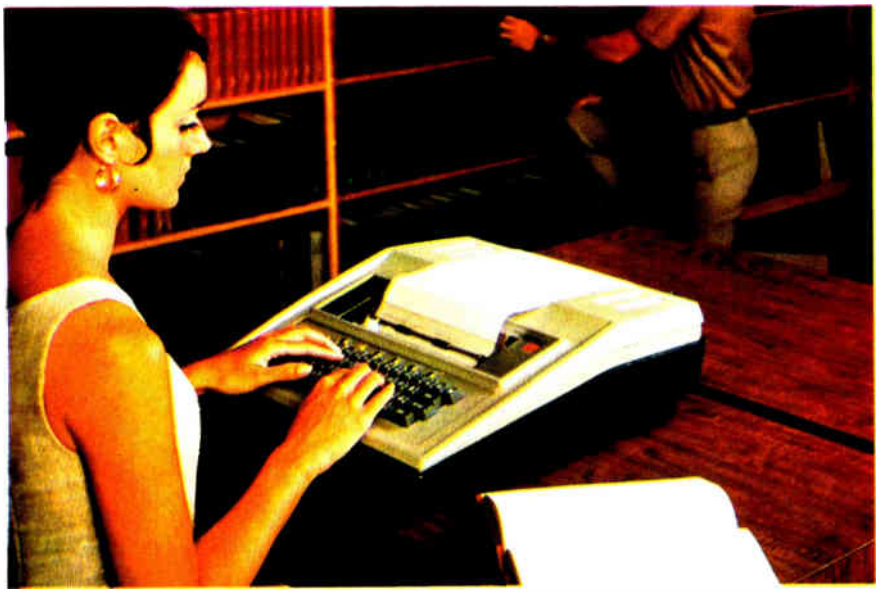





Circle 177 on reader service card 177

# Printer with burning prose

Mesa-shaped silicon elements can develop characters on thermographic paper at rate of 40 per second



**Hot printer.** New data terminal from Texas Instruments has matrix of silicon heating elements that develop characters on heat-sensitive paper.

**Hard on the heels** of Clevite Corp.'s fast electrostatic printer [*Electronics*, April 28, p. 119] comes a data terminal from Texas Instruments Incorporated that literally burns its way across the paper. It has a solid-state printing head that develops characters on thermal-sensitive paper at a 40-per-second clip. Unlike the Clevite machine, which prints a line at a time, the TI printer works with one character at a time, and is intended to replace conventional teleprinters on transmission lines or as computer input/output devices. The unit will be displayed at the Spring Joint Computer Conference.

Because the new terminal uses a heating process and special paper, it's quiet and isn't subject to as much wear and tear as conventional impact printers; and its printing speed is nearly three times as fast.

The machine prints with a tiny chip of silicon whose working surface measures 0.1 by 0.08 inch. The chip itself is mounted on the left-hand edge of a much larger aluminum heat sink which presses it against the paper. Within the working area are 25 printing elements in a $5 \times 5$ matrix. Each element is a silicon mesa made in somewhat the same way as the old-fashioned mesa transistors, with a resistor diffused into its top and a conductor path leading to the mesa from an edge pad. Electronic decoding circuitry selects several of these 25 elements for each individual character and directs an electric current through it to the silicon base, which serves as a common return for all the elements. The current heats the printing element to 250°C, which is hot enough to darken the thermographic paper in a few milliseconds. The current lasts only momentarily; the elements are allowed to cool, and a stepping motor moves the printing head, which remains in contact with the paper, one space to the right to print the next character—all in 25 milliseconds. Because the printing head is mounted on the left edge of the heat sink, each character is visible immediately after it's printed.

Individual characters are printed under direct control of the keyboard —from key to decoder to print-head —unlike some terminals that print a character only after it's been transmitted to a computer and back again. But the terminal also contains a buffer that stores the characters from the keyboard and transmits them in a burst to the computer, thus making more efficient use of the transmission line and permitting more terminals to be connected to a single line without interfering with one another. When the computer transmits data to the printer, it bypasses the buffer and goes directly to the printing head. The buffer, which comes in a standard size of 50 eight-bit characters, is also available with capacities of 25, 32, or 100 characters; it's a set of eight static shift registers of the appropriate size operating in parallel. These shift registers are off-the-shelf MOS units manufactured by TI.

Electronics in the terminal include a translator from the keyboard code to the code used on the transmission line—either ASCII or PTT/6 code—and another translator from the transmission code to the print-head code. Each translator is on its own single LSI chip; the transmission code can be changed simply by changing the card holding these chips.

The entire printer, complete with all its electronic circuits and a 450-foot roll of paper, weighs 38 pounds and measures 17 by 18 by 6 inches. Its price is $4,950; deliveries will begin late this year.

Industrial Products Division, Texas Instruments Incorporated, P.O. Box 66027, Houston 77006 [339]

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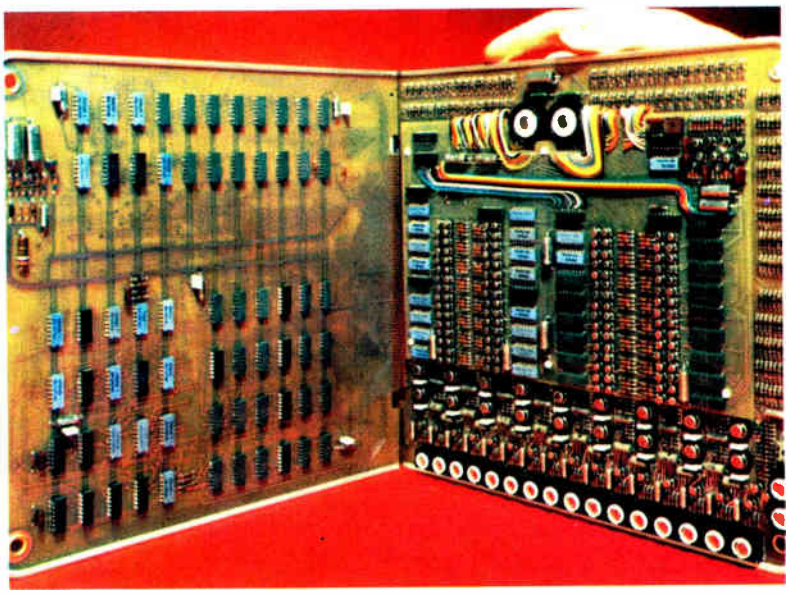
Circle 179 on reader service card

# A memory to build on

4,096-word core module on two printed-circuit boards can be expanded without disturbing data already stored



**Two to get started.** No additional drive or sense electronics is needed when a user decides to add cards and expand the basic memory.

**A good way to sell** something is to save your customer some money, and this is what Sanders Associates Inc. claims to do with its new Memcard 418. According to Burton C. Winkler, manager of memory products for Sanders, "We found out about the possible savings as we worked on one of our own data processors: features contained in the 418 made it possible for us to omit about 150 IC's and the consequent assembly and checkout costs from our production scheme. We figure the saving is in the neighborhood of $300 to $400 per computer." The 418 sells for $1,900.

It is a coincident current, three wire, 3-D random-access memory module, with 4,096 words of 18 bits each and all input-output and data storage electronics on two printed circuit boards. The I-O board is capable of handling data from 4K up to 32K words from the memory. Thus, while the standard Memcard 418 is a 4K-word store, it can be expanded simply by adding memory in 4K-word increments—and no change to existing core or to the computer mainframe is required. "It's not even necessary to tweak up drive current, timing, rise times, etc. Only logic signals travel between the Memcard boards—no drive or sense signals as with other expandable schemes," says Winkler.

Winkler adds that when most competing memory assemblies are expanded, the user must at best exchange his former core stack for another, or at worst take a loss on it and simply buy another larger one. "We think we have the only system that expands without disturbing memory already in use."

The 418 has a 450 nanosecond access time and a 1.5 microsecond worst-case cycle time. Three cycling modes are available with the 418, and it's here that most of the

savings are realized.

**Offers hybrid.** Like most available memory assemblies, the 418 offers both "full" (read-restore and clear-write) and "split" (read-modify-write) cycling. It departs from the norm in offering a "hybrid" cycle—something usually realized only in mainframe hardware.

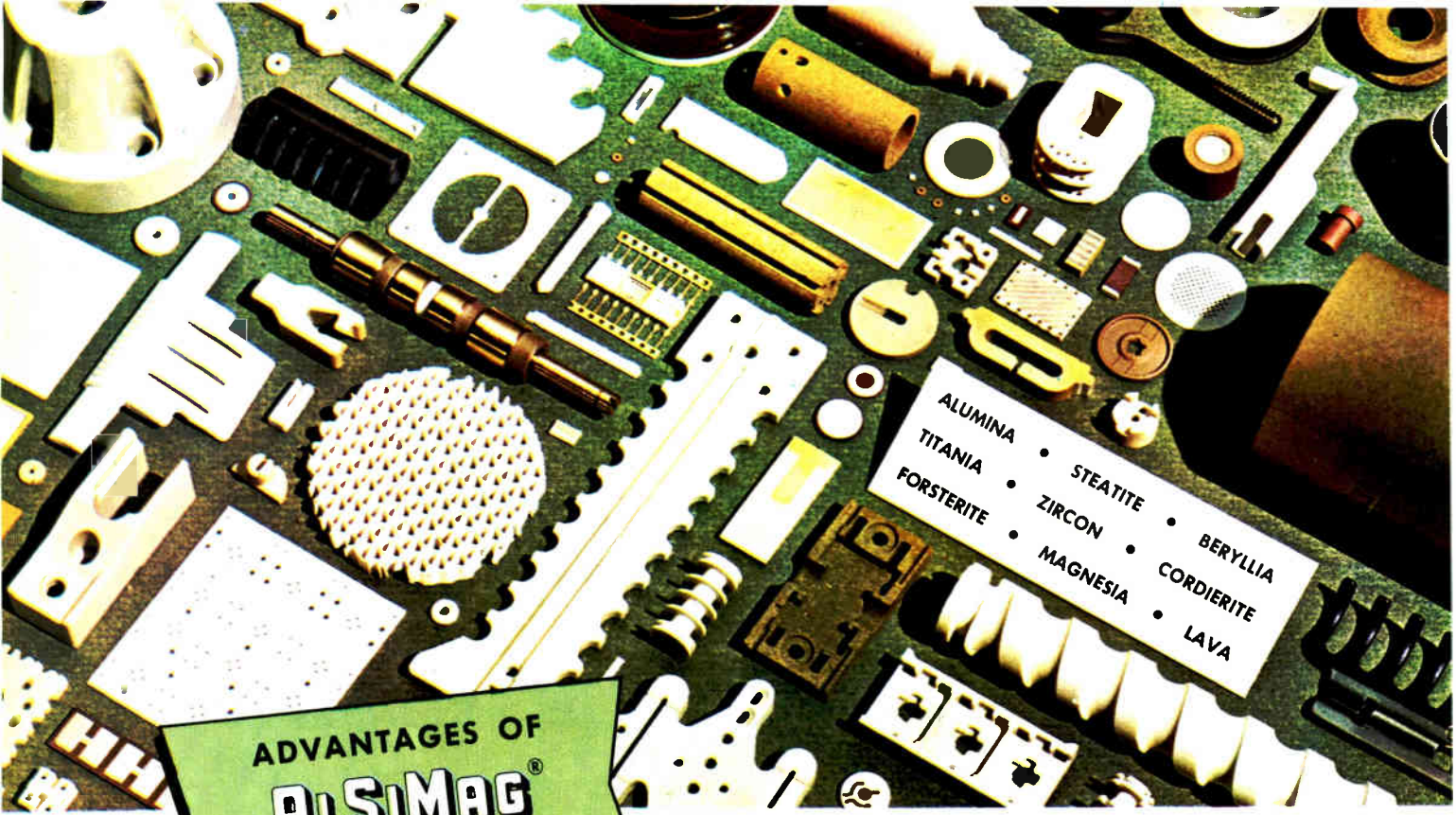
In the 418's hybrid mode, it's possible to read-restore, and read-write on selected bits within the same 1.5 microsecond cycle through something Sanders calls "bit-masking." Normally this takes two full cycles. But the Sanders system uses a sort of small scale "slosh" effect, reading a word into its main I-O register and restoring it while at the same time applying current to a so-called mask input line—one of which intersects each of the word's 18 bits. During the restore process the new data is automatically entered—the appropriate cores now reading 0 rather than 1, or vice versa.

To alter the usual memory's content it is necessary to store the word between cycles. This requires a so-called machine register and the extra associated gating to get the data back into the proper location. The Memcard 418 stores output data only during a single read-write cycle, and doesn't therefore need the extra register electronics. "And that's where the bulk of the savings come from," says Winkler.

Sanders plans to add to the line of Memcard products as rapidly as manpower and markets appear. Already on the stock shelves is a 1024-word model [*Electronics*, Dec. 9, 1968, p. 144]. In the wings are read-only memories, non-destructive read-out devices, electronically-alterable read-only memories, a power supply module, a 1K by 9 bit memory, and eventually Memcards able to expand in word length (as well as word capacity) to 36 bits. All will use a common 12 by 11.5 inch board size.

Price of the Memcard 418 is $1,900 in lots of 100. Expansion modules containing 4K of memory are $1,500 each. First deliveries are due in May, with Winkler quoting "worst case" deliveries of 30 days thereafter, and adding, "We hope to deliver off the shelf by July."

Sanders Associates Inc., Daniel Webster Hwy. South, Nashua, N.H. 03060 **[340]**

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## MORE PROCESSES

American Lava offers the broadest processing capabilities in the industry. These include forming ceramics by all modern methods including pressing, extrusion, injection molding, isostatic pressing, plus metallization, plating, chemical milling, machining, grinding, lapping, and hermetic bonding.

Many of these processes were pioneered by American Lava. Examples are (1) the ability to produce certain as-fired ceramics to precision tolerances and (2) the proprietary AlSiBase process for producing thin flat ceramics.

## MORE SPECIALIZED ENGINEERING TALENT

American Lava, built on engineering ability, has demonstrated that it is the best source for any problem involving technical ceramics.

## GREATER PRECISION

Technical ceramics play an increasingly important part in American industry because they can meet especially demanding requirements. American Lava has the experience, know-how and facilities to produce ceramics to the closest tolerances, and to measure and inspect them by agreed means.

## MORE MODERN DESIGNS

Technical leadership at American Lava Corporation is based on working with its customers to give them what they want. This currently involves work on composite substrates, composite packages, buried metal patterns, super-smooth and flat substrates, special temperature compensating dielectrics, ceramic capacitors and new ceramic coatings for metal and low expansion glass.

## VOLUME PRODUCTION

American Lava has the resources, know-how and the desire to make commitments required to meet volume requirements of its customers. A long parade of firsts in new manufacturing capabilities have allowed American Lava to keep pace with the ever changing need for technical ceramics in volume.

## EXPEDITED PROTOTYPES

Special procedures speed the production of prototypes for your evaluation. A chart giving the characteristics of our most frequently used AlSiMag ceramic compositions will be sent on request. Suggestions are available from our specialized engineering staff.

CODE IDENT. NO. 70371

**American Lava Corporation**

A SUBSIDIARY OF 3M COMPANY

PHONE 615 265-3411 • CHATTANOOGA, TENNESSEE 37405, U.S.A.

*68th YEAR OF CERAMIC LEADERSHIP*

**For service, contact American Lava representatives in Offices of Minnesota Mining and Manufacturing Company in these cities (see your local telephone directory):** Boston: Needham Heights, Mass. • Chagrin Falls, Ohio • Chicago: Elmhurst, Ill. • Dallas, Tex. Indianapolis, Ind. • Laurens, S. C. • Los Angeles, Calif. • Metropolitan New York: Ridgefield, N. J. • Up-State New York and Canada: Phoenix, New York • Orange, Conn. • Philadelphia, Penna. • Roanoke, Virginia • St. Louis: Lee's Summit, Mo. South San Francisco, Calif. • International: c/o American Lava Corporation, Chattanooga, Tenn. 37405, U.S.A., TELEX 558432.

# Hybrid ladder networks aimed at low-cost jobs

## Thick-film units in one-inch-square flatpacks have accuracy of eight bits, with matched resistance values built in

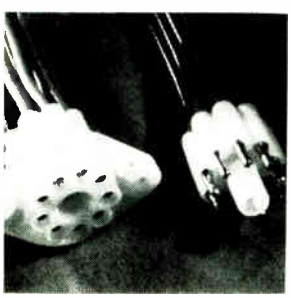
**When low cost** is a must and eight-bit accuracy in a binary ladder network is sufficient, it is no longer necessary to sort through a pile of discrete resistors to build up a matched set.

Beckman Instruments' Helipot division has developed a pre-tested eight-bit thick-film divider network with built in application resistors, which are used for feedback, interfacing, and attenuation.

The model 815 costs the same as or less than discrete networks with the same characteristics, according to Lyle F. Pittroff, applications engineer, who also says the product is pointed specifically toward the low-accuracy military and commercial market. Prices run at $6.95 per unit to $4.70 in lots of 1,000.

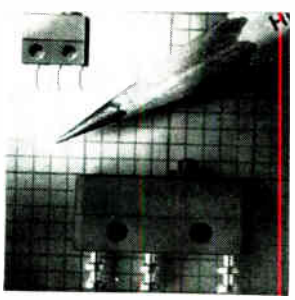
A cermet thick-film process with air abrasive tailoring produces a unit that is stable from −55°C to +125°C, has a ladder attenuation ratio accuracy of 1,952 parts per million, and has a 2:1:2 ratio for the application resistances. Settling time for the network is within 100 nanoseconds.

Pittroff says the focus of the component's design is on the out-

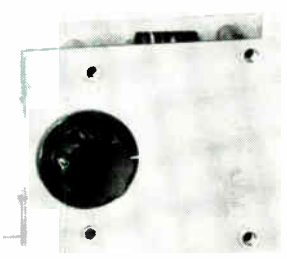


Type 1664-9 plug, used with the 1412 socket, makes a dependable circular connector. Male terminals snap-lock into their nylon housing but can be easily removed with a simple tool. The socket housing can be screw mounted or can be provided with integrally-molded mounting ears for fast snap-in chassis assembly. Molex Products Co., Downers Grove, Ill. [341]

Ten-turn wirewound precision pot model 532 is ⅞ inch in diameter It features a molded housing and lid, with a ¼-in.-diameter passivated stainless steel shaft, and dual slip-ring contacts. Resistance range is 15 ohms to 180 kilohms, with resistance tolerance ±5%. Independent linearity is ±0.25%. Spectrol Electronics Corp., 17070 E. Gale Ave., City of Industry, Calif. [342]

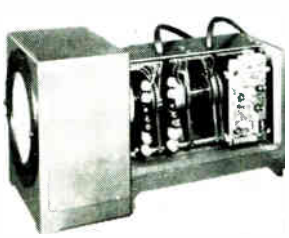


Precision, snap-action switches measure only 0.3 x 0.2 x 0.1 in. exclusive of terminals. They are rated at 1 amp resistive at 28 v d-c or 115/250v a-c, with an electrical life of 100,000 cycles and a mechanical life of 500,000 cycles minimum. Operating temperature range is from −100° to +250° F. Hi-Tek Corp., 2220 S. Anne St., Santa Ana, Calif. 92704. [343]

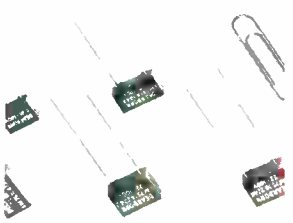


Time delay relay series 1600 is a solid state replacement for motor-driven timers. It comes in fixed and adjustable models, in input voltages of 230, 115, and 24 v a-c and 115 and 24 v d-c. Units feature 3 amp contacts and 0.250 push-on terminals for electrical connection. Hundred lot prices range from $12.04 to $13.98. Meson Electronics Co., Box 4105, Rochester, N.Y. [344]

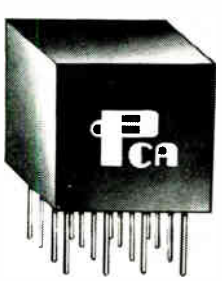

Solid state remote switches designated Minitactor models 701 and 702 can be activated by low-level d-c or digital output voltages. Units will switch up to 300 v rms or d-c (model 701 is a-c output, 702 is d-c output) at 1 amp without external power sources. Model 701 costs $13.50 and 702, $16.50 in small lots. E.D.C. Data Components Corp., Box 279, Massapequa, N.Y. 11758. [345]



Crt mount is precisely fabricated to accomplish the accurate alignment required in high resolution work with 10 in. flat face crt's. For maximum rigidity, the mount is constructed of heavy-duty cast aluminum. Complete magnetic shielding of crt and magnetic components is achieved by a 3-layer shield assembly. Syntronic Instruments Inc., Inlustrial Road, Addison, Ill. [346]



Polyester-film capacitors in the type LM7S series come in rectangular epoxy-case construction. They are dual rated for both a-c and d-c operation. Units are available in values ranging from 0.047 to 5.6 μf at 50 wvdc, 0.01 to 5.6 μf at 100 wvdc, 0.01 to 3 μf at 200 wvdc, and 0.01 to 1.5 μf at 400 wvdc. Dearborn Electronics Inc., P.O. Box 530, Orlando, Fla. 32802. [347]




Broad-band transformers are designed for low impedance operation on transmission lines, balanced to unbalanced. Only 0.650 in. long, 0.500 in. wide and 0.700 in. high, these balun transformers have an open circuit inductance of 350 μh minimum, and a low leakage inductance of 0.5 μh max. PCA Electronics Inc., 16799 Schoenborn St., Sepulveda, Calif. 91343. [348]

←Circle 182 on reader service card

put characteristics of the device rather than on the individual resistances involved. Matched capability of the resistances in the network is assured since all come from the same film batch laid on the same substrate. Standard value resistance for the network is 10 kilohms ±5%.

One of the application resistors is permanently joined to the ladder's output terminals. If this resistor is then connected to an external reference power supply, the network can be operated as a bipolar ladder with the most significant bit becoming the polarity bit, Pittroff points out. Two other application resistors can serve as feedback resistances with operation amplifiers or as network attenuators.

**Yield is key.** Refinements in production techniques developed over Helipot's 14 years in the thick-film business have made such low cost items possible—high production yields are the key. Pittroff says an even simpler eight-bit divider is in the works and will be available as soon as new production machinery is operating.

The model 815 is packaged in a 1 by 1 inch, 14 lead flat pack which will fit the same space used by Helipot's 12-bit and 14-bit higher accuracy dividers so that customers who have been modifying the larger networks for 8-bit use will have no problems, Pittroff says.

Beckman Instruments Inc., Helipot Division, 8475 Artesia Ave., Buena Park, Calif. [349]

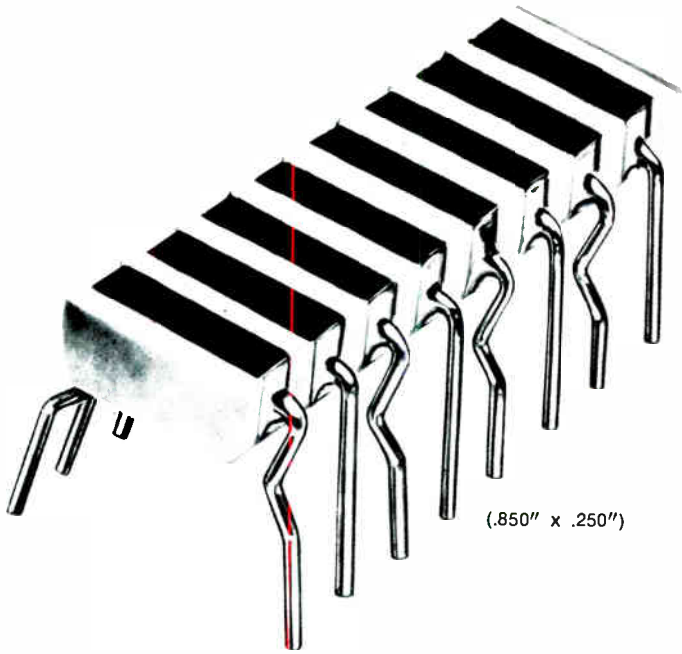
New components

## Switch protects uhf transmitters

Safety cutoff device uses beryllia can to detect overheating

**High thermal conductivity** and the high dielectric properties of beryllia are put to work in a switch developed by the National Beryllia Corporation to protect ultrahigh-

# CTS cermet resistor networks ...with NEW 16-lead dual-in-line package




■ Add more circuitry...up to 16-lead dual-in-line packages...with these new CTS space-saver cermet resistor networks. Specifically designed to simplify automatic insertion and reduce your assembly costs. Easy to hand mount, too.

**Series 760 DIP Resistor Networks** provide ...14 or 16 lead packages...up to 15 resistors per module with an infinite number of circuit combinations...extremely good environmental specifications...5 lbs. pull strength on leads. A natural to combine with active devices to form hybrid circuits. .100″ lead spacing.

**Series 750 Cermet Resistor Networks** offer ...three basic sizes and an infinite number of circuit combinations...excellent environmental characteristics...5 lbs. pull strength on leads...and are available with or without active devices...lead spacing, .125″.

**Check CTS low prices and fast delivery schedule**...2 weeks for prototypes; 4-6 weeks for production quantities. See the prices listed below!

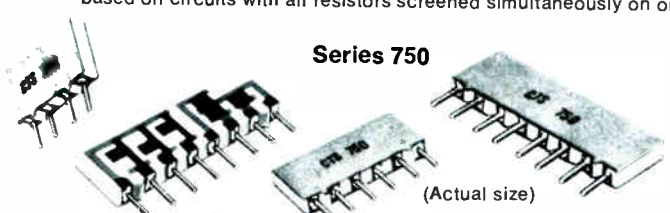
**More flexibility**...CTS packages can be delivered without organic cover coat. You trim for circuit balance in your plant.

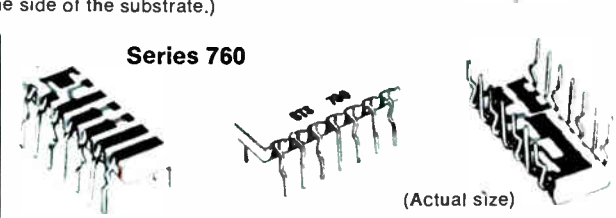
Ask your CTS sales engineer for data. Or write CTS of Berne, Inc., Berne, Indiana, 46711. Phone: (219) 389-3111.

**CTS CORPORATION**
*Elkhart, Indiana*

| Quantity | SERIES 750 | | | SERIES 760 | | | |
|---|---|---|---|---|---|---|---|
| | 4-pin 3 resistors | 6-pin 5 resistors | 8-pin 7 resistors | 9 resistors (14 pin module) | 11 resistors (14 pin module) | 13 resistors (14 pin module) | 15 resistors (16 pin module) |
| 10,000 piece price | 14.4¢ ea. (4.8¢/ resistor) | 19.5¢ ea. (3.9¢/ resistor) | 24.5¢ ea. (3.5¢/ resistor) | 41¢ ea. (4.5¢/ resistor) | 43¢ ea. (4¢/resistor) | 45¢ ea. (3.5¢/ resistor) | 55¢ ea. (3.7¢/ resistor) |
| 1,000 piece price | 28.8¢ ea. | 39.0¢ ea. | 49.0¢ ea. | 82¢ ea. | 86¢ ea. | 90¢ ea. | $1.10 ea. |

Prices shown are ±2½% tolerance, ±250 ppm/°C from 50 ohms through 1 megohm standard TC. (Also based on circuits with all resistors screened simultaneously on one side of the substrate.)





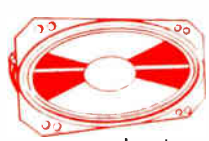
Microelectronic Circuitry


Selector Switches


Trimmers


Potentiometers


Crystals, Oscillators, and Filters

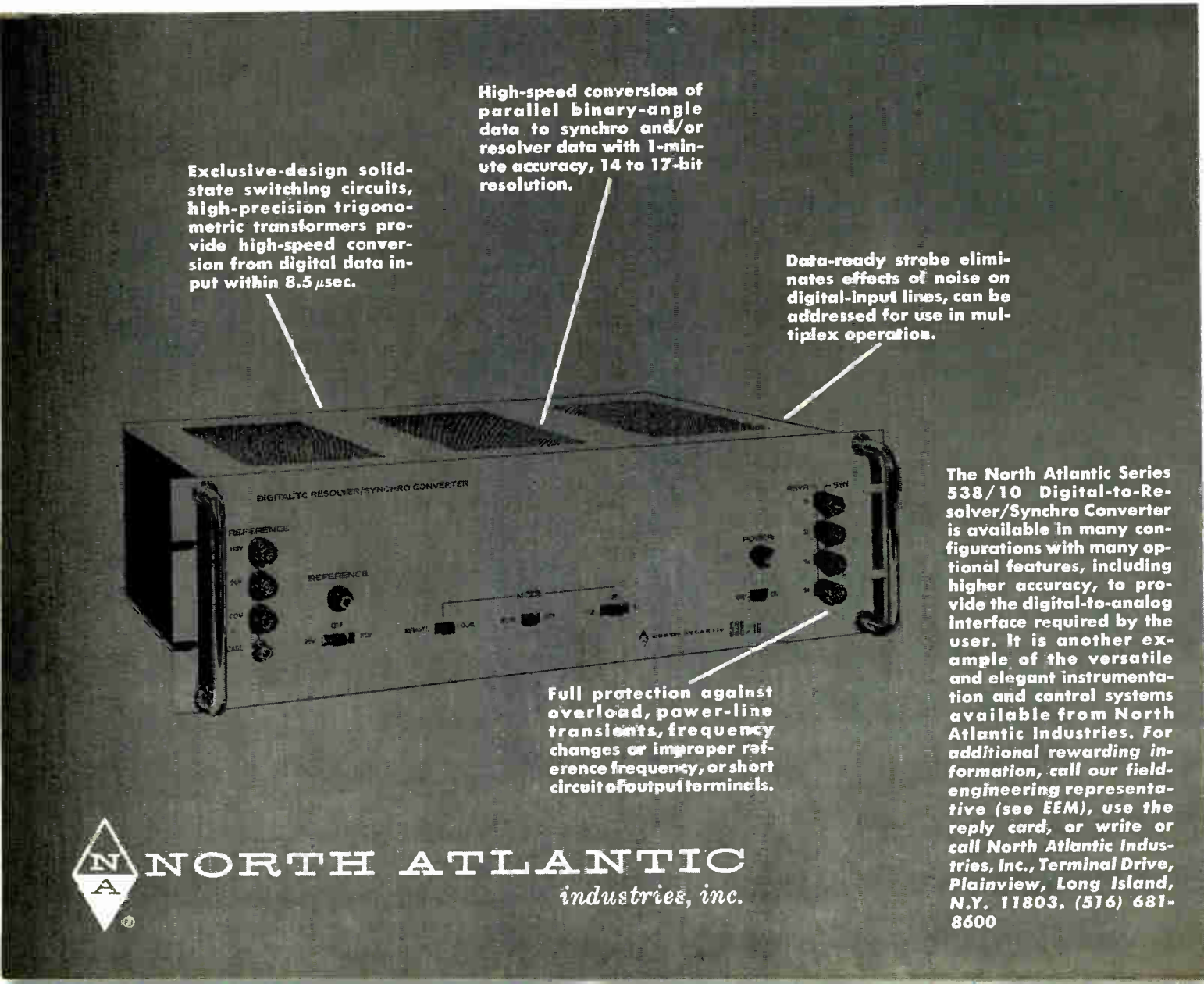

Loudspeakers



Circle 185 on reader service card

# Only one man in a thousand needs this kind of performance in a digital-to-synchro converter...

## (the other 999 heave a sigh of relief knowing it's there)




The North Atlantic Series 538/10 Digital-to-Resolver/Synchro Converter is available in many configurations with many optional features, including higher accuracy, to provide the digital-to-analog interface required by the user. It is another example of the versatile and elegant instrumentation and control systems available from North Atlantic Industries. *For additional rewarding information, call our field-engineering representative (see EEM), use the reply card, or write or call North Atlantic Industries, Inc., Terminal Drive, Plainview, Long Island, N.Y. 11803. (516) 681-8600*

NORTH ATLANTIC
*industries, inc.*

frequency radio transmitters.

Under some operating conditions, improperly tuned transmitters overheat. This causes critical components to burn up and results in a delay while maintenance crews get the transmitter back on.

The thermally operated switch in a beryllia container solves the problem by turning off the transmitter before damage can be caused.

When a radio transmitter overheats, the part that burns out is the final stage, containing a tetrode, an external-anode electron tube and an integrally mounted variable capacitor. The frequency range of the transmitter makes it necessary to locate these parts in close proximity. The thermally operated switch is mounted on the heat sink of the tetrode tube. There it senses the overheating and turns off the equipment. An operator can then let the unit cool down and retune the transmitter to bring it within specified range.

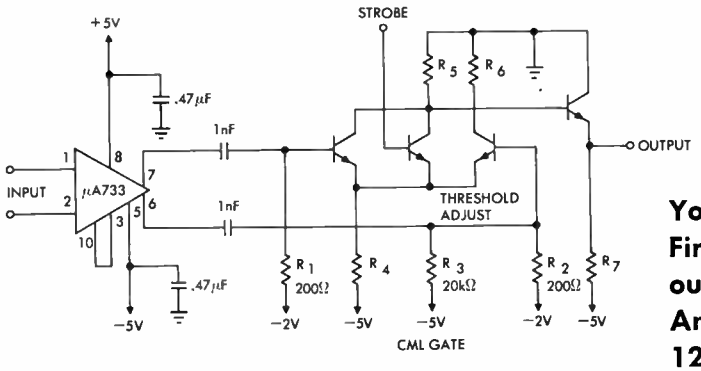
**Safeguard.** Switch is mounted in a container made of beryllia—a heat-conductive electrical insulator.

The function of the beryllia "can" is to transmit the heat from the tube to the switch and to isolate the tube's magnetic field from the switch. This isolation is important because the tubes used in transmitters are sensitive to magnetic fields, and the cases of such tubes are operated at a very high electrical potential.

National Beryllia Corp., Greenwood Ave., Haskell, N.J. [350]

# Hold off on that video amplifier you've been working on.

**FILM MEMORY SENSE AMPLIFIER**




**Delay Time:** 12ns
**Overdrive Recovery Time:** 45ns

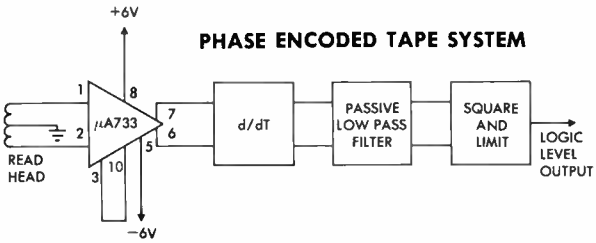
You might not have to build it after all. First check out the Fairchild μA733, our latest wideband Differential Video Amplifier. The 3dB bandwidth is 120MHz at a closed-loop gain of 10 (90MHz at a gain of 100). Input impedance is 25kΩ, phase linearity is 2° at 5MHz and pulse response time is typically 5ns. And noise is a low 25μV rms for a bandwidth of 50MHz because every transistor in the amplifier is made with our special low-noise processing and has an $f_T$ of 1.2GHz.

The μA733 is another of our Second Generation Linears, and the price/performance ratio shows it. Use the μA733 in any application that calls for wide bandwidth, low phase shift and good gain stability at a low price. Here's how:

Write for more specs and detailed application notes. Or just pick up as many devices as you need from your stocking Fairchild distributor.

To order the μA733, ask for:

**PHASE ENCODED TAPE SYSTEM**




**Phase Linearity:** ±2° from 2 to 5 MHz
**Input Resistance:** 25kΩ
**Input Capacity:** 2pF
**Fixed Gain:** 100

| PART NUMBER | PACKAGE | TEMPERATURE RANGE | PRICES 1-24 | 25-99 | 100-999 |
|---|---|---|---|---|---|
| U5F7733312 | TO-5 | −55°C to +125°C | $20.00 | $16.00 | $13.20 |
| U5F7733393 | TO-5 | 0°C to + 70°C | 10.00 | 8.00 | 6.60 |

FAIRCHILD SEMICONDUCTOR

FAIRCHILD SEMICONDUCTOR A Division of Fairchild Camera and Instrument Corporation Mountain View, California 94040, (415) 962-5011 TWX: 910-379-6435

# Meter divides or subtracts a-c and d-c

## Since it can calculate the ratio of or difference between two inputs, instrument can measure gain or turns ratio

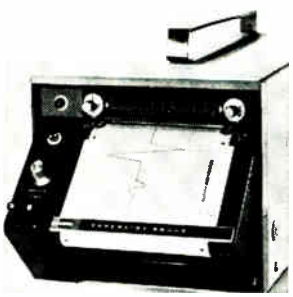
**"What's the difference?"** is just one question that a new ratiometer from Non-Linear Systems Inc. answers. The instrument tells also what the ratio is and what the deviation is between two signals.

Priced at $7,500, the ratiometer consists of a digital voltmeter, which can measure resistance, and a control unit that works the dvm and calculates.

The whole instrument is 17 by 5¼ by 21 inches. On its front panel are two sets of input terminals, marked A and B. Each time the ratiometer makes a calculation, its dvm first measures input A, then digitizes the signal and sends it to the control unit. After storing A, the control unit commands the dvm to look at B.

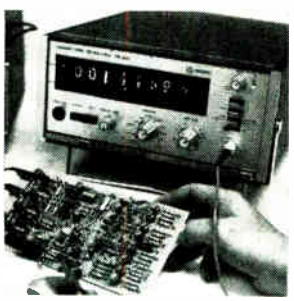
After receiving the digitized version of B, the control unit performs one of three calculations: subtract B from A, divide B into A, or subtract B from A, dividing the difference by B, i.e. (A-B)/B. Its choice depends on the setting of a front-panel switch. Whatever the calculation, the result goes back to the dvm for display.

The readout has seven tubes, one for each of the six significant fig-



**High** input impedance d-c millivolt recorder has a solid state operational amplifier which may never need recalibration. Its measuring element is a permanent-magnet moving coil. Its potentiometric performance includes ranges as low as 10 mv d-c, accuracy of 1%, ½ sec full scale response, and 10 megohm input impedance. Esterline Angus, P.O. 24000, Indianapolis [361]

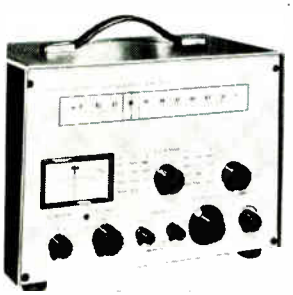
**Frequency** response analyzer 911A measures phase and amplitude vs frequency over the range of 0.01 to 10,000 hz with a high rejection of noise and harmonics in the return signal. It performs with an over-all accuracy of ±1° in phase measurement, and ±1% in amplitude, with greater than 40 db of harmonic and noise rejection. Bafco Inc., 80 Second St. Pike, Southampton, Pa. [362]



**Digital** counter PM-6630 is a 160-Mhz unit that measures pulse width and delay, as well as frequency to 10 nsec resolution. It allows users to select digit and stability options that tailor the unit's performance to their specific application or budget. Price of the 8-digit version is $2,795; the 6-digit costs $2,20. Philips Electronic Instruments, S. Fulton Ave., Mt. Vernon, N.Y. [363]

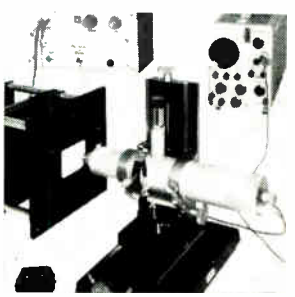
**Log** amplifier model 6001 accepts any r-f input from 400 khz to 130 Mhz with a power range of −70 dbm to +20 dbm. It provides a linear detected output for oscilloscope, voltmeter, or graphic recorder presentation. The output is accurate to ±3 db. Packaged in a half-rack cabinet, the unit measures 8½ 7 x 12¼ in. Telonic Instruments, 60 N. First Ave., Beech Grove, Ind. [364]

**Portable** electronic galvanometer type E11.501 incorporates stable solid state circuitry in a highly sensitive (10 μv/div.) device with a 3 second response time. Unit features a common mode rejection of greater than 140 db at d-c, 50/60 hz, and an input resistance of approximately 9 kilohms. Price is $135. Voltron Products Inc., 403 S. Raymond Ave., Pasadena, Calif. 91101. [365]



**Precision** bridge model 2785 is for measuring capacitance, inductance, resistance and Q. A built-in generator provides all the voltages needed. The instrument is accurate to within ±1% on most resistance and capacitance ranges and to within ±1.5% on most inductance ranges. Q measurements have a maximum error of ±5%. Simpson Electric Co., 5200 W. Kinzie St., Chicago 60644. [366]

**Digital** frequency meter 107 is both a frequency meter and a signal generator. It has a dual power supply, either 12 v d-c or 115 v a-c at option. Accuracy is ample for the newest 0.00025% transmitter tolerances. The generated frequency can be varied in calibrated amounts about center frequency, up to ±50 ppm. Lampkin Laboratories Inc., 8400 9th Ave. NW., Bradenton, Fla. [367]



**Microspot** crt analyzer MA100 is rugged, and suitable for either laboratory or production quality control use. Resolution measuring methods include spatial frequency, two slit, light intensity distribution, and half power line width. A change in the graticule is all that is needed to shift from one method to another. Ferranti Electric Inc., E. Bethpage Rd., Plainview, N.Y. [368]

**Over the range.** The ratiometer measures up to 350 volts, a-c and d-c, and up to 12 megohms.

ures in the instrument's range and one for overranging. The ratiometer switches ranges automatically, so it continuously measures and displays ratios from 0.000001 to 1,000,000.

The input ranges are 0 to 1,000 millivolts d-c, 0 to 350 volts d-c, 0 to 350 volts a-c, and 0 to 12 megohms.

Accuracy varies from range to range, but is around 0.01% of the reading for d-c measurements and better than 0.3% for a-c readings up to 30 kilohertz.

The ratiometer takes 1 second to measure two d-c voltages, make a calculation, and display the result. With a-c inputs, the process takes around 3 seconds, and for resistance measurements the instrument takes 2 seconds.

Range changing adds another second.

This is all very slow, particularly for an instrument such as the ratiometer that's built with TTL integrated circuits. The designers sacrificed speed so that they could build the instrument with one dvm instead of two. This keeps both the ratiometer's size and price down.

Extensive use of IC's in its control unit means also a smaller ratiometer. All calculations are done by NAND gates on a single 4-by-7-inch printed-circuit card. Subtraction of B from A is done directly, and division is done as a repetitive subtraction.

The ratiometer's memory is a bank of 56 flip-flops, two for each of the 28 bits that can be stored.

The company traded off speed to also gain more reliability. The ratiometer uses two shift registers every time it moves a string of digits. For example, if the contents of one register are to be shifted over one position, the entire con-

tent of that register is read into a second register, and then read back into the first with each digit moved up one position. This technique, says the company, precludes reading of a new digit into a flip-flop before the old digit has been read out, which would destroy a bit.

Non-Linear Systems hopes that potential customers are more impressed by reliability and size than by speed. The company expects to sell the ratiometer to engineers who measure such things as amplifier gain, transformer turns ratio, and potentiometer specifications.

Non-Linear Systems Inc., Box N, Del Mar, Calif. 92014 **[369]**

New instruments

## Gaussmeter priced for repair shop

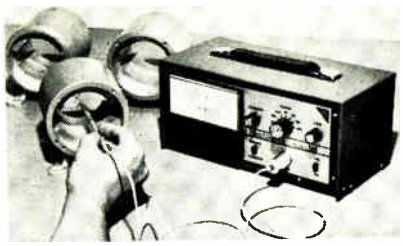
Accuracy of $275 instrument is 3%; full-scale ranges run from 5 to 50,000 gauss

**Trade accuracy** for price; that's what engineers at RFL Industries Inc. did when they designed the Model 505 gaussmeter. All the other RFL gaussmeters have an accuracy of 1% or better, and sell for $600 and up. The 505 measures flux density to within only 3% of the full scale reading, but its price —probe included—is just $275.

According to Vincent Saponar, an assistant marketing manager at RFL, the 505 is for the small laboratory and the repair shop. It's suitable for troubleshooting or monitoring the magnets in such things as motors, accelerometers, and magnetrons.

**Shoebox size.** The 505 is the size of a shoebox and runs off either a battery or a standard outlet. And it has a self-calibration circuit, so there's no need for the operator to carry around reference magnets.

The 505's ranges are 50, 100, 500, 1,000, 5,000, 10,000, and 50,000 gauss full scale. The zero-reading can also be placed in the center of



**Finding flux.** The 505, a portable instrument, can be used to check out the permanent magnets in motors.

the scale; this way the 505's ranges run from —25-to-+25 gauss to —25,000-to-+25,000 gauss.

**Well integrated.** Most of the 505's circuits are built with IC's. A constant current source, controlled by an attenuator, drives a Hall-effect probe. Magnetic flux passing through the detector generates a signal which is amplified and displayed on a 4½-inch taut-band meter. The signal also goes to an output jack for driving a recorder or an oscilloscope.

The probe has an indium-arsenide detector, covered by Fiberglas, and comes in either an axial or a flat shape. Additional probes cost $65 each.

RFL Industries Inc., Boonton, N.J. 07005 [370]

New instruments

## Core memory speeds IC tests

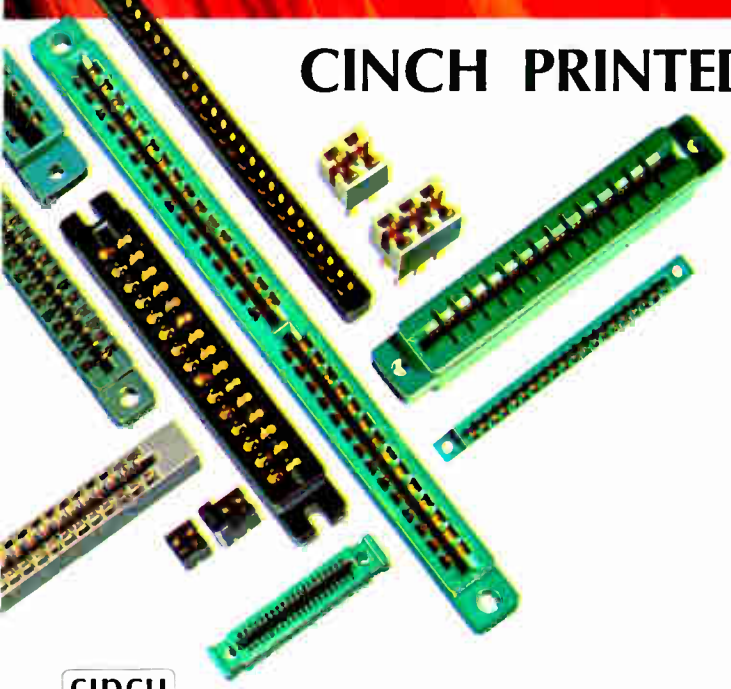
### Disk storage eliminated in instrument redesigned around a computer

**The disk memory** that controls test programs in Fairchild's series 5000 integrated-circuit tester causes a lot of unwanted delay. So engineers at Fairchild's Instrunentation division have taken the disk out and redesigned the tester around a Hewlett-Packard 2114A computer —which has a core memory.

One example of the slowdown caused by the disk memory is that the tester's wafer probe has to wait for a disk to complete a revolution

# YOUR COMPETITIVE EDGE

# CINCH PRINTED CIRCUIT CONNECTORS



Improved performance and lower cost are the best competition beaters . . . and you get either or both with Cinch PC connectors.

There are 22 basic designs described in the new Cinch PC Connector catalog. If the one you need isn't there, Cinch can develop a special connector for your application.

It can incorporate any of six methods of gold deposition (including two selective plating techniques), eight types of contacts, eight types of terminations and six insulator materials . . . whatever best gives you your competitive edge. The resulting product can be produced in quantity in a surprisingly short time.

Write for the Cinch Printed Circuit Connector catalog to Cinch Manufacturing Company, 1501 Morse Avenue, Elk Grove Village, Illinois 60007.

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—8 milliseconds on the average—before it can pass from one sequence to the next. Another example: a sequence designed to select high-grade circuits must be run all the way through even if a circuit fails the first test.

In the new testers, called the 5000C series, the delay is 2 microseconds, the access time of the computer; in the older testers, delay is measured in milliseconds.

Equally as important, a 5000C tester is completely under the control of the computer, and so is more versatile. The 5000C performs multiple tests on over 10,000 devices per hour, about double the rate of the 5000.

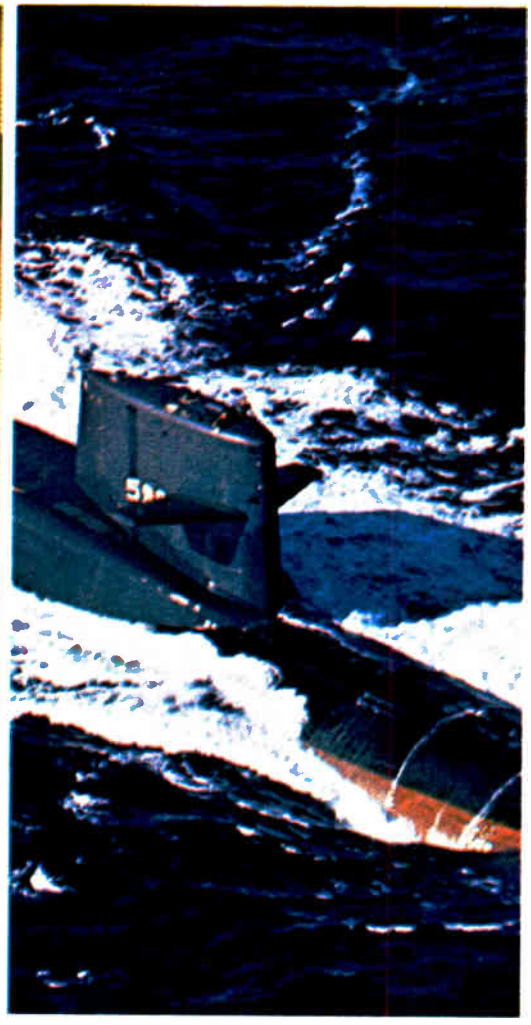
Like the 5000, the 5000C does d-c, a-c, and functional tests, and, with a 5300 module, linear tests.

Prices run from $60,000, for a d-c system, to almost as much as the buyer wants to spend. The 5000C will be Fairchild's big-ticket item for semiconductor manufacturers, large IC users, and anyone else who needs to test circuits in large volumes. As an option, buyers can get H-P's top-of-the-line 2116B computer, which has a 32,000-bit memory and an access time of 1.6 μsec.

Unique to the 5000C among computer-controlled test systems is the use of a high-speed analog-to-digital converter in the d-c test subsystem. Most systems, says applications manager Gordon Padwick, derive a digital value from a series of converging limits; to get an actual number for data logging many tests have to be made. The 5000C uses a 100-microsecond a-d converter built by the Preston Scientific Co. to turn the analog value of the voltage at a given pin into a 14-bit number. The computer makes a go/no-go decision on the basis of this number, and the computer can store the number as well. So, says Padwick, the system can perform 100% data logging at go/no-go test rates.

Another thing the 5000C does is accumulate distribution data from wafer probing, and print out this date on command a couple of times a day. This information enables a manufacturer to determine if critical parameters are getting near their limits.

The 5000C is easier on the programer too. Since the test programs



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## . . . 5000C stamps out drift when testing linear IC's . . .

are under computer control, the programer need not leave extra time to allow for switching the d-c matrix. Most tests take from 1 to 5 milliseconds, says Padwick, and if the programer doesn't know whether the next test will be made from a different pin, he has to leave 2 msec to allow for switching. Since the 5000C's computer does "know" whether a change is necessary or not, it allots switching time only when necessary.

The d-c test system accepts circuits with up to 100 pins; the dynamic test system, which is basically the same as that of the 5000, comes in a 20-pin and a 60-pin version.

The 5300 subsystem, which isn't yet ready for delivery, uses an a-c synchronous detector technique for measuring the performance of linear circuits instead of the normal d-c technique. Input offset voltage drifts with temperature, and temperature increases as power is applied; so d-c methods, which depend on separate measurements at different voltage levels, have built-in inaccuracies, Fairchild feels. In the synchronous detector technique, a feedback loop detects the change in input necessary to support a forced output, and calculates gain from that measurement.

The 5300C is compatible with the old series 4000 as well as with the 5000 and the 5000C.

Functional tests are done at 10 kilohertz, which isn't an especially fast rate. Fairchild explains that the functional-test subsystem is intended mainly for wafer probing, and also that with the 10-khz rate the tester doesn't require the complex and expensive test heads and performance boards needed for high-speed operation.

All subsystems of the 5000C can operate simultaneously, and new programs can be edited while the system is doing tests. In addition to the H-P software, Fairchild adds its own special test software for test programing and for translating from test programs that were used on other Fairchild systems.

Fairchild Instrumentation, 974 E. Arques, Sunnyvale, Calif. 94086 [371]

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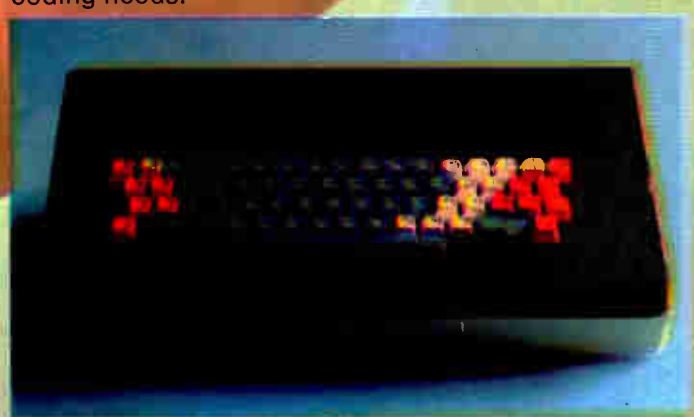

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New microwave

# Receiver/transmitter aimed at 960-Mhz band

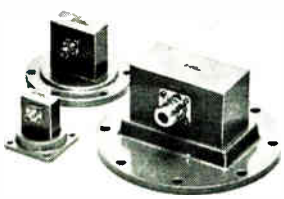
## Terminal for 1970's market to be offered in 60-, 5-channel models; power consumption of 45 watts expected to broaden applications

**Early in 1970,** the Federal Communications Commission will require most users of point-to-point communications to move up to 960 megahertz from the presently used 450-Mhz band. The lower frequency will be reserved for mobile equipment.

To fill the needs of what will probably be an expanded market, Granger Associates has developed a receiver/transmitter terminal for the 960 Mhz band.

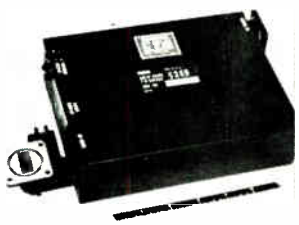
The expanded domestic market, combined with the foreign forecast for equipment in this frequency band is, according to sales manager Charles Novik, expected to reach the 26,000 mark within several years. It is hoped that successful sales in this area, will do much to help the company recuperate from a two and one-half year period of declining profits and considerable after-tax losses and to continue the profits realized in the second quarter of fiscal 1969.

The solid state combination receiver/transmitter terminal will be available in a 60-channel version (3 decibel r-f bandwidth, 4 Mhz) which will meet the Bell system and the International Radio Con-

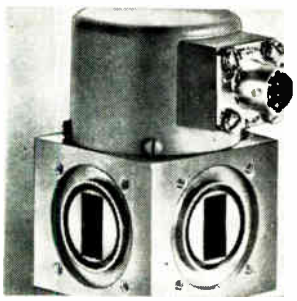


Waveguide-to-coaxial adapters series WCA feature zero transition loss from rectangular to coaxial connectors of "N" to 3 mm (SMA) types. Also featured is low vswr of 1.25 over the waveguide frequency ranges of 2.60 to 18.0 Ghz. The series is available in 18 different models covering 6 frequency ranges and 3 connector types. I-Tel Inc., 10504 Wheatley St., Kensington, Md. [401]

L- and S-band multicouplers series HFM feature a high dynamic range. Noise figures are as low as 4.5 db. Output power is as high as 0 dbm for 1 db compression. The input intercept point is as high as +16 dbm. Individual models operate in 4 ranges: 1,435 to 2,300; 1,435 to 1,540; 1,700 to 1,850; and 2,200 to 2,300 Mhz. Applied Research Inc., Port Washington, N.Y. [402]



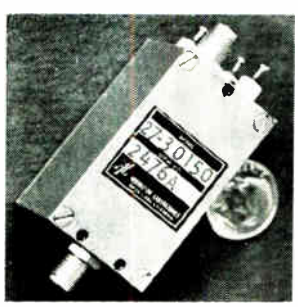
Solid state TR switch S255 is used with a fixed circulator in pulsed radars to alternately connect the transmitter and the receiver to the antenna. Switching time is less than 0.5 μsec; switching energy required, 30 microjoules. Unit handles 10 kw peak continuously and up to 100 kw for short durations. RCA/Electronic Components, 1000 S. Seconc St., Harrison, N.J. 07029. [403]



Ku-band, 3-port waveguide switch model NMC-5071 offers greater than 90 db isolation and measures only 2.75 in. in height. The unit has a low insertion loss of 0.2 db, and a low vswr of 1.10. It is available in 2-, 3-, and 4-port design. The switch measures 1.750 x 1.750 x 2.75 in. and weighs 14 oz maixmum. Neico Microwave Co., 211 Second Ave., Waltham, Mass. 02154. [404]

Attenuating adapter model AH-E01 is essentially an adapter from type N to 3 mm with a built-in 10 db attenuator. It reduces hardware in a circuit by combining two elements, thus eliminating a source of error or instability. Unit operates from d-c to 4 Ghz and is available in attenuation values to 20 db. Price is $50. Microlab/FXR, Ten Microlab Road, Livingston, N.J. [405]


Solid state switch model DS-982 is capable of switching 3.5 kw of peak power at speeds of 50 nsec with less than 2 db loss in the operating range of 1 to 6 Ghz. Featuring a 25 db minimum isolation and a typical vswr of 2.5:1, its operating range is —55° to 100° C. The unit weighs 80 grams and measures 1¾ x 1¾ x ¾ in. Sanders Associates Inc., Ledge St., Nashua, N.H. 03060. [406]



Octave band tunable, solid state source model 67-30150 is suited for wideband receiver, transmitter and test equipment applications. Frequency range is 1 to 2 Ghz; output power, 100 mw minimum; tuning voltage, 0 to —50 v d-c; primary power, —20 v d-c at 200 ma maximum. Size is 1 x 1 x 1¾ in. Addington Laboratories Inc., 1043 DiGiulio Ave., Santa Clara, Calif. 95050. [407]

Waveguide-to-coaxial adapter called Flatback is available in ranges from 1.12 to 40 Ghz, with a maximum vswr of 1.25 for frequencies up to 18 Ghz. Miniature, subminiature, and type N coax connectors are standard. Depth of the 12.40 to 18 Ghz unit is only ½ in. All units meet MIL-E-16400E. Sonoma Engineering and Research Inc., 760 Montecito Center, Santa Rosa, Calif. [408]

←Circle 198 on reader service card

## . . . use of IC's and other solid state components cuts the 6010's power needs and its size . . .

sultative Committee (CCIR) message circuit toll transmission requirements for at least 15 tandem hops; a five-channel model (3 db r-f bandwidth, 100 kilohertz) designed for use in FCC-controlled areas will also be offered. Both terminals are frequency modulated with demodulating repeaters operating in the 790-960 Mhz tunable radio-carrier-frequency band; both are specified for a minimum of 3 watts out of the transmitter. Power consumption is rated at 45 watts for the transmitter/receiver/power supply combination.

According to R.P. Lewis, engineering manager for the model 6010, the 45-watt power-consumption figure represents a 50% reduction from competitive instruments' requirements. "The significantly lower power figure," says Lewis, "permits the system a great deal of flexibility in terms of power and, hence, in applications."

A frequency application for the terminals may be as repeaters located in isolated areas where power will be derived from thermoelectric generators using propane or natural gas as fuel.

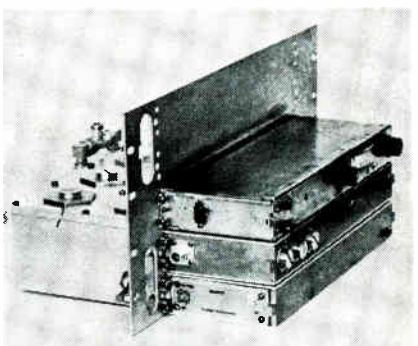
For a repeater, two terminals are required. The receiver of the terminal connected to one antenna is coupled to the transmitter of the other terminal, and vice versa. Says Harold Haug, development engineer: "Usually, such equipment would require two power supplies, one for each terminal. Two Granger terminals operating back-to-back as a repeater will require only one power supply unless a standby is needed."

The need for standby batteries, says Lewis, is reduced to less than one-tenth that of other microwave systems claiming comparable performance; the terminal will operate for more than 30 hours on a single 50-ampere-hour battery. The power requirements for the model 6010, he adds, have been cut by the use of solid state components; power transistors and varactor diodes for frequency multiplication have replaced the klystron tube, and integrated circuits have been used extensively.

**Portable.** The use of solid state components has also permitted a considerable reduction in size, making the equipment marketable for portable emergency conditions. For more conventional use, Novik says, the model 6010 can be used as private or party-line telephone circuits, for data telemetry, remote control of vhf base stations, railway switching and automatic car identification. The model 6010 receiver/transmitter unit in a back-to-back configuration can be operated as an unattended station for transmission of a variety in industrial applications of which pumping stations would be an example.

Summing up, Lewis says the terminal has applications in any area that requires, domestically, five channels or, abroad, 60 channels over distances not greater than 500 miles.

Cost of the terminal, according to Novik, will be in the neighborhood of $3,200 without a multiplexer; delivery in "limited quantities" will begin in November. Size of the transmitter is 1¾ by 14 by 4½ inches; the receiver is the same size and offers a noise figure of 9 db maximum. Radio frequency input levels are rated nominal: —45 dbm, maximum: —35 dbm. The unit can be operated from a variety of power sources: 24 volts d-c, 48 volts d-c, and 117/220 volts a-c, 50/60 hertz.



**Ready.** Model 6010 communications system, shown including diplexer, is designed for 960-Mhz market.

Granger Associates, 1601 California Ave., Palo Alto, Calif. **[409]**

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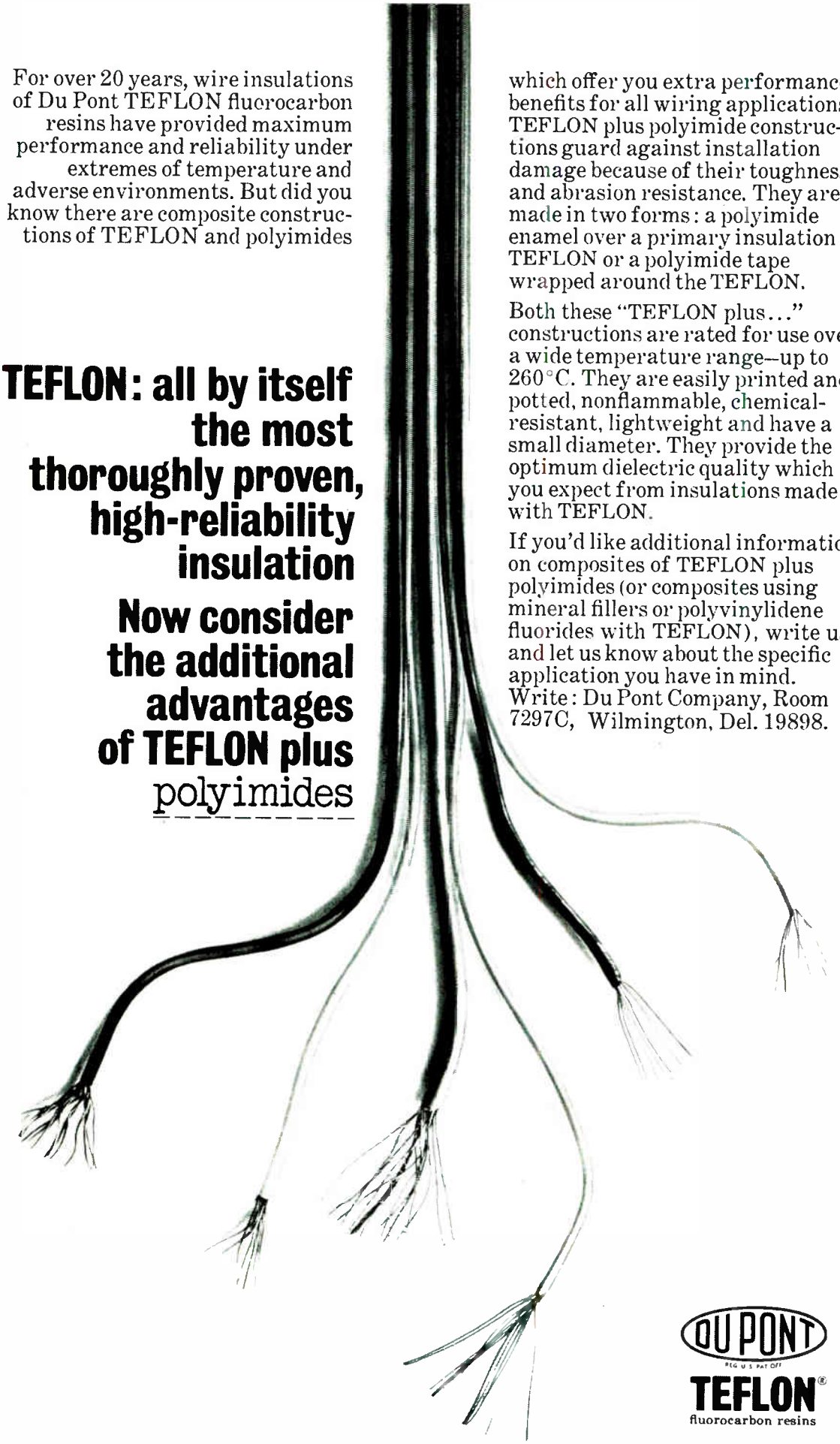

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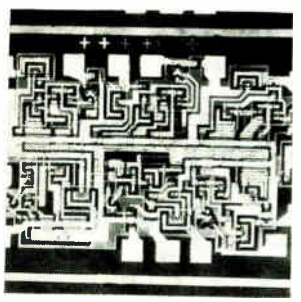
# Switch and trigger functions built into one chip

## Integrated design approach applied first to SCR's and triacs; technique expected to cut cost of phase and power control devices

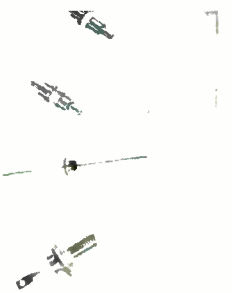
**A single chip** does the work of two in a device approach developed by Hutson Industries, a young Texas electronics company. The technique for combining a switch and its trigger on a single chip within the pellet is being applied first to silicon-controlled recifiers and triac-type devices. Jerry Hutson, president, says the company can deliver the SCR's immediately and will be shipping triac-type units by mid-year.

"Ours is a totally integrated functional device," says Hutson. "The separate trigger chip is eliminated, and this greatly increases the cost advantage over two-chip units." Other companies, he says, are using two chips and thick-film techniques within a single package, but this is the first time that a single chip has successfully been made to perform what has previously been two functions.

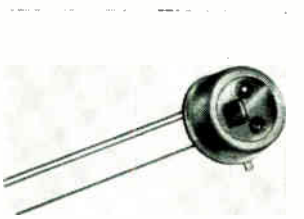
Hutson says he found it basically impractical, if not impossible, to integrate the two separate devices into one pellet. So he took the approach that, given a set of electrical parameters, a functional device can be created that is neither switch nor trigger but appears to



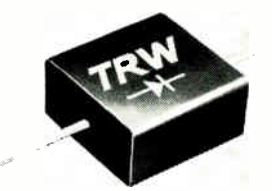
Hex 1-input inverters have been added to the SUHL I and II IC lines. The SG370 circuits operate at 12 nsec typical propagation delay and 22 mw power dissipation per gate function. The SG380's are rated at 6 nsec delay and 22 mw power dissipation. Units come in 14-lead hermetic flatpack or dual-in line ceramic packages. Sylvania Electric Products Inc., Woburn, Mass. [436]



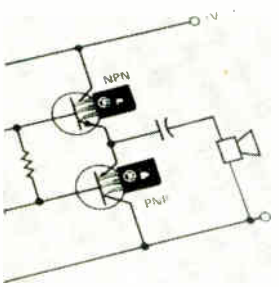
Varactor diodes can be used as harmonic generators, up-converters, tuning devices, or paramps. They are usable for frequency multiplication as doublers, (outputs between 250 and 4,000 Mhz), as triplers (multiplying to 450 to 9,000 Mhz), as quadruplers (outputs of 240 to 1,000 Mhz), and as high-order multipliers (outputs between 400 and 6400 Mhz). ITT Corp., Easton, Pa. [437]



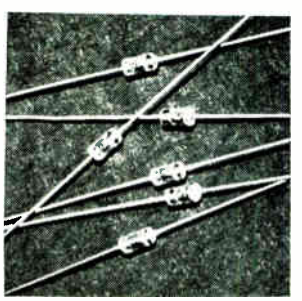
Silicon photodiodes come in 2 types. Type 720, for industrial control use, offers a minimum light current of 90 μa at 500 footcandles 2800°K, maximum reverse dark current of 1μa at −1 v. The 820 is for low noise and faster response uses. Both have a peak spectral response at 8,500 A. Price ranges from 69 cents to $2. National Semiconductors Ltd., Plattsburgh, N.Y. [438]



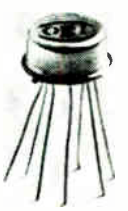

Varicap diodes are designed for use in low-frequency circuits. Type PQ2150 has a capacitance of 150 pf; type PQ2300, 300 pf, and type PQ2500, 500 pf. The single chip devices have less than 1 μa leakage, Q factor greater than 150 and 90 v breakdown. The flat encapsulated package measures 0.320 in. sq. x 0.165 in. TRW Inc., 1100 Glendon Ave., Los Angeles 90024. [439]




Plastic transistors for 20 and 35 w complementary audio amplifiers measure 5/8 x 1/2 x 1/8 in. The npn MJE205 and pnp MJE105 are 5 amp units with a $V_{CEO}$ of 50 v, power dissipation of 65 w. The npn MJE2801 and pnp MJE2901 are 10 amp units with a $V_{CEO}$ of 60 v, $P_D$ of 90 w. Prices range from $1.25 to $1.95. Motorola Semiconductor Products Inc., Box 20924, Phoenix 85036. [440]



Picosecond pulse switching diodes MA4-B200 are epitaxial devices using surface passivation and junction profile control. Minimum breakdown voltage is 70 v, and capacitance range is 3 to 5 pf. Typical turn-on and turn-off times are 500 psec and 75 psec respectively. Price in lots of 1 to 99 is $5.90. Microwave Associates (West) Inc., 999 E. Arques Ave., Sunnyvale, Calif. [441]



Monolithic four-quadrant analog multiplier 5507 is a 7-lead, TO-78 packaged circuit. Features include: 10 mv maximum input sensitivity, 0.8% linearity, 5 Mhz bandwidth, ±3 to ±20 v power supplies, and a full operating temperature range of −55° to +125° C. Price (1-9) is $25 each, (100-299) is $16 each. Optical Electronics Inc., P.O. Box 11140, Tucson 85706. [442]

Radiation-resistant reference diodes encompass nominal voltage ranges of 6.2, 8.4 and 9 v; temperature compensated zeners from 0.01% to 0.0005%; temperature coefficients from −50° to +100° C. Units are available in 0.085 in. maximum diameter x 0.160 in. body size with 0.020 in. nominal gold plated leads. MicroSemiconductor Corp., 11250 Playa Court, Culver City, Calif. [443]

## . . . the chip becomes a more valuable worker . . .

act like both of these devices.

"You cannot say that one area of the pellet is exactly one thing," says Hutson. "It may be one thing before conduction starts, and another thing afterwards."

Hutson says his approach involves meshing the trigger devices and switch on a functional pellet. Furthermore, the pellet eleminates inductors, capacitors, and other components that are required in phase control circuits. "The chip itself becomes a more valuable worker," he says.

**Three types.** Basically, Hutson uses a combination of three types of passivation to achieve the meshing of units on the single device. The surface is first doped, and then second and third layers are applied to prevent it from changing.

"The significant thing about our functional approach," says Hutson, "is that up to now, two units—a diac and triac or a diac and an SCR—have been required to do the same job. With two devices you have to consider their relationship to each other." Even when the characteristics of the units are known, he says, portions of their operation may be bad.

Hutson says his first units will sell for from $5 to $10 each; but with increased production, one pellet with both switch and trigger will cost "the same or less than the two it replaces."

"Units of this type are applicable wherever you need phase control," says Hutson. "We are looking now at parts of the phase market such as fan speed and small motor controls. But it is potentially much wider. We are really aiming at power control which we estimate to be about $25 million a year." The units have a blocking voltage of from 50 to 800 volts, and have a current rating of 3, 5, 8, 10, 15, or 25 amps.

The devices are also available as cell assemblies in which the pellet is mounted on a silver-plated copper disk. Silver-plated leads are attached with high temperature solder, but the cell can be mounted with low temperature solder.

Hutson Industries, 2919 West Valley View Lane, Dallas, Texas **[444]**

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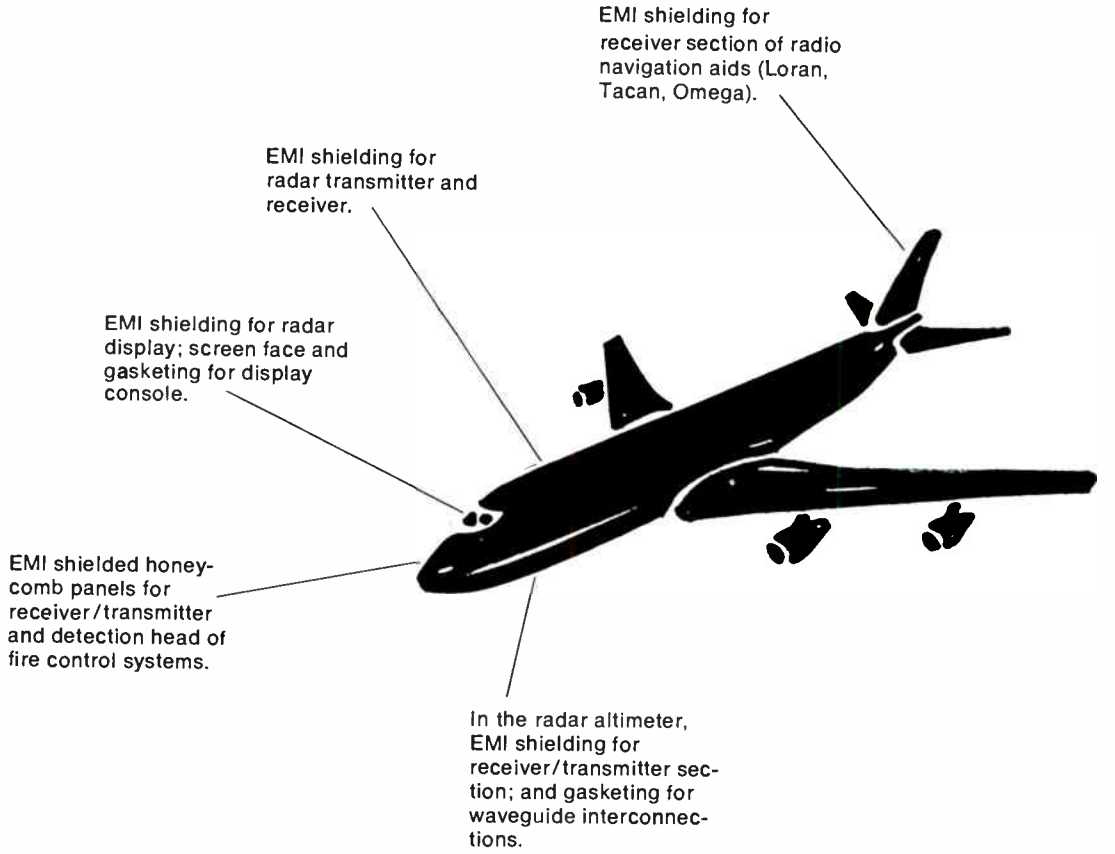


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132



Circle 205 on reader service card **205**

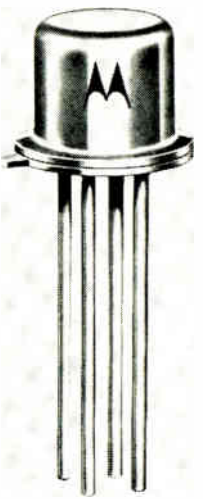
# MOS FET's switch in 3 nsecs

## N-channel devices have low thresholds, high resistance to spikes

**N-channel** metal oxide semiconductor devices can deliver better speed than p-channel units, but the positive gate voltage required to activate them creates instability, driving ionic contaminants through the silicon dioxide insulator and the gate.

However, silicon nitride passivation tames the instability, and Motorola's Semiconductor Products division has been using nitride passivation on all its discrete MOS FET's since November, 1967 [*Electronics*, May 27, 1968, p. 46].

That's one reason the firm is able to introduce what field-effect-transistor product manager Michael Kersey believes is the fastest-switching low-threshold MOS FET on the market—the 3N169.



**Four leads.** N-channel MOS FET switch has external connections for gate, source, drain, and substrate.

It has a threshold of 0.5 to 1.5 volts, a feature that circuit designers are looking for increasingly so that the devices can be directly

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GE Type 29F non-polar tantalum foil is about half the case size of an equivalent solid, yet accepts voltage and current variations in either direction. And from one small, single roll that in no way impairs the inherent reliability characteristics of tantalum foil. (Totally unlike its bulky solid counterpart that requires two slugs connected back-to-back and, in most cases, within a single case.)

The difference doesn't end with just size and reliability. Consider microfarads. GE tantalum foil delivers 50 percent more microfarads per case size, in practically all cases, when compared with solid tantalum.

So for your next non-polar application, contact your General E ectric Sales Representative and ask to see the Type 29F tantalum foil capacitor. It could make a big difference. In size. In reliability. In microfarads.

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linked to bipolar logic, with its low thresholds. Two companion devices, the 3N170 and 3N171 have thresholds of 1.0 to 2.0 volts and 1.5 to 3.0 volts, respectively. Up until now, Motorola sources say, the normal threshold levels for MOS FET's have been 3.5 volts or higher, complicating interfacing between the devices and diode-transistor or transistor-transistor logic integrated circuits.

The second part of the Motorola parlay is speed. All three of the new devices have turn-on delays of just three nanoseconds, rise times of 10 nanoseconds, turn-off delays of three nanoseconds, and fall times of 15 nanoseconds. "As far as we know," Kersey says, "there are no comparable devices available in n-channel with the same low thresholds and fast switching speeds." Total on-time equals turn-on delay plus rise time, or 13 nsec; and total off-time is turn-off delay plus fall time, or 18 nsec.

**Added bonus.** Another feature made possible by silicon nitride passivation is the transistors' high transient breakdown voltage rating. Motorola will guarantee ±150 volts on the gate, which Kersey says is 25 volts higher than the best previous specification he's seen from one other manufacturer and is far above the more usual 10 to 15 volts associated with MOS FET's.

The transistors also have a low drain resistance (200 ohms maximum). Kersey says they will be useful in basic industrial chopper applications in which a fast switch is needed.

Like many other MOS FET's, there are four leads to the transistor package. In addition to connections to the gate, source, and drain, there's a fourth connection to the substrate. Internally, the substrate is connected to the package.

The 3N169 will sell for $4.90 in quantities of 1,000 to 4,999. The 3N170 price is $4.20 for the same quantities, and the 3N171 costs $3.55. All three are housed in TO-72 metal cans.

Motorola Semiconductor Products Inc., Box 955, Phoenix, Ariz. 85001 **[445]**

New semiconductors

# Microwave line from MERA project

## TI products include low-noise transistors, complex modules, one IC

**Two years after** the first MERA modules were demonstrated, Texas Instruments has announced the commercial availability of a line of solid state microwave devices.

Designed to cover the range from 100 megahertz to 4 gigahertz, the transistors are available in several stripline packages, including a ceramic C-band package 0.075 inch square for microstrip applications.

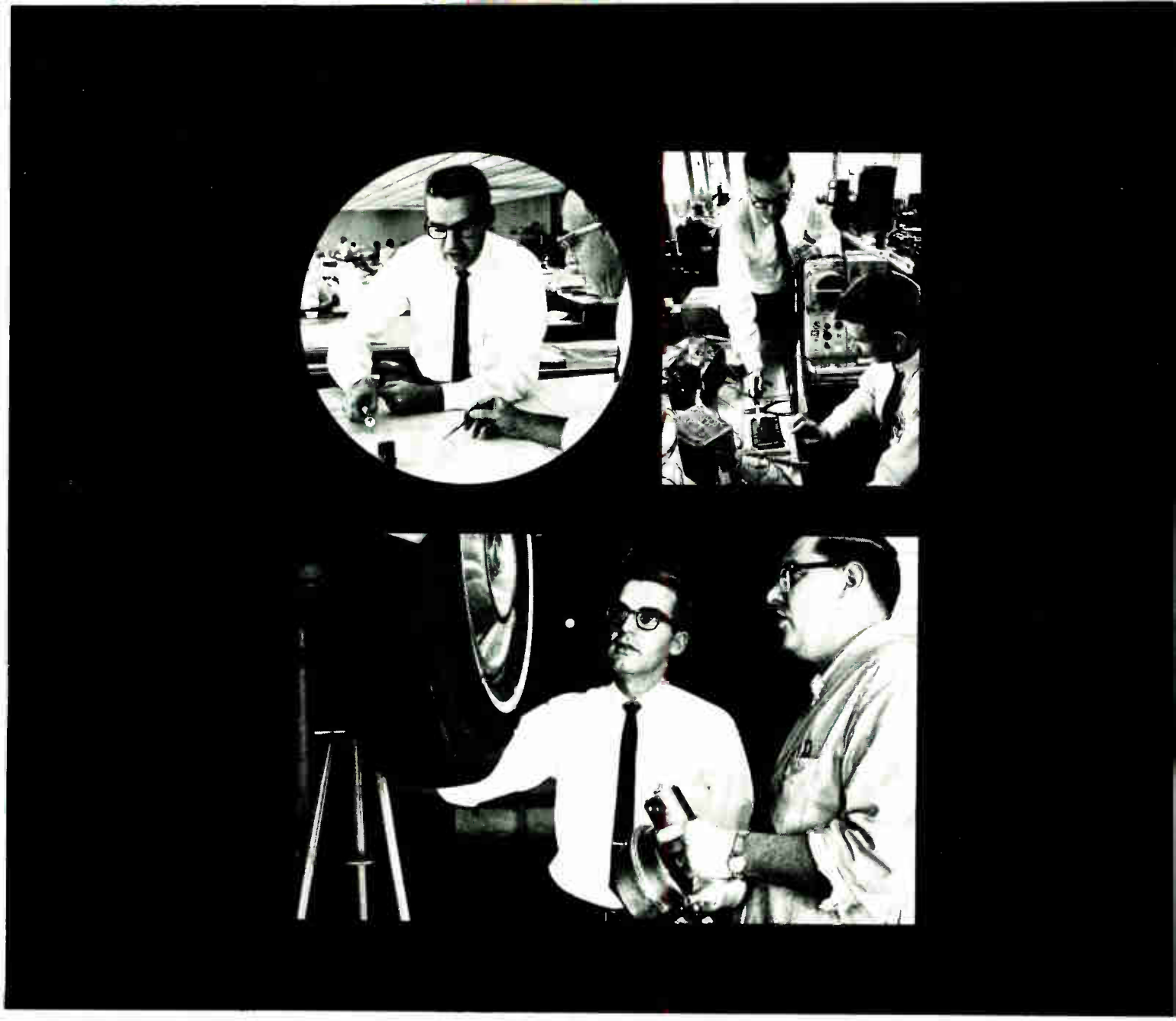
The low-noise transistors designated MS0026 and MS0046, have a noise figure of 6 decibels at 2 Ghz, and sell for $120. The linear amplifiers, designated MS0020 and MS-0103, provide 12 and 20 dbm gain respectively at 2 Ghz, and are priced at $120 and $200.

The two oscillators in the series are the MS0088 and the MS0089. The 88 provides 30 milliwatts at 4 Ghz and costs $120, and the 89 provides 200 mw at 2 Ghz and is priced at $45. Mixer diodes, of the Schottky barrier variety, have noise figures of 6 db for the X-band units and 7 db for the Ku-band devices. The six units available in the series are designated MS0189 to 191 for X-band and MD0219 to 221 for the Ku-band devices. Prices range from $20 to $50.

Six Gunn diodes, with output powers ranging from 5 to 20 mw, are designated MO232 to 235, and cost from $65 to $200.

According to J. Clifton, microwave products manager at TI, "We're not attempting a standard product line at this time; we only want to show our capability and limitations in each area." There is one MIC that has been given a model number, the MIC035, a broadband amplifier that operates between 100 and 800 Mhz and is priced at $179.

Texas Instruments Inc., Microwave Products div., Box 5012, Dallas, Texas 75222 **[335]**



# Tomorrow, Paul Barr may even get to his desk

Paul Barr is a hard man to catch. He may be at the bench sweating over a prototype circuit . . . or have his head under a car lift surveying the built-in problem. He's got lab people hopping and test drivers in and out of spins. A couple of friction experts shake their heads when they see him coming. But wherever development engineering leads on a sophisticated new braking system, Paul Barr's on his way. And no two Mondays ever start alike. The question is . . . can you say the same? Take a good look at how your career shapes up, compared with Paul's and his colleagues' at Delco. You might even call us collect. Area Code 317/459-2808. Or, write: Mr. C. D. Longshore, Supervisor, Salaried Employment, Dept. 404, Delco Radio Division of General Motors, Kokomo, Indiana.

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## New Books

### Once over, but not lightly

Principles of Quantum Electronics
William S.C. Chang
Addison-Wesley Publishing Co., 540 pp., $17.50

Most teachers ought to know how to write textbooks, but all too often they don't. In the electronics field, at least, the most lucid explanation is usually given by the working engineer who's been forced to explain his work to management. Happily though, this author—a professor and chairman of the electrical engineering department at Washington University in St. Louis—is an exception. He's done a monumental service in assembling a wealth of logically organized material and many useful tables under one cover.

His treatment can serve as a model to others in the field. After an initial chapter reviewing quantum mechanics, he discusses the energy levels of materials in quantum electronic devices, turning first to free atoms and molecules. While the order of presentation in this section of the book is fairly traditional, one is impressed by the clear writing, by the transitions from one subject to another, and by the rigorous mathematical statements for the physical principles.

But the next chapter isn't traditional. It deals with the crystal structure of solids from a mathematical group theory point of view, providing information that the author later draws on for his chapter on the quantum mechanical analysis of energy levels. The section on crystal structures is liberally illustrated in marked contrast to the sparseness of figures in the rest of the book. By ending the chapter with a discussion of impurity ion substitution and local fields, he allows the reader to appreciate the following treatment of energy levels in solids.

There, the author applies group theory analysis by discussing the mathematical representation of point groups, the effect of symmetry on the quantum mechanical properties of the medium, the use of symmetry to analyze the splitting of the energy levels of the atoms in the crystal field, and the application

of these analyses to commonly used quantum electronic materials. After following such a treatment one is struck by the short shrift crystal structure has been given in some of the other books on quantum electronics.

Following these sections are chapters on the interaction of electromagnetic radiation with individual atoms and with large numbers of atoms. Only then does the author introduce lasers in a general—though again mathematically rigorous—chapter. He covers gas, solid state, and semiconductor lasers but unfortunately doesn't discuss organic or inorganic liquid lasers. True, these are comparative newcomers, but some interesting and illuminating work has been done with them.

Excellent tables give transitions, wavelengths, and references for all the laser materials of the three types and include brief remarks about each. And in the following chapter, where each type is covered in detail, a six-page table tabulates all of the observed gas, solid state, and semiconductor laser oscillations.

Valuable also are the book's appendixes, which include information on the number of resonant modes in a large cavity, the 32-point crystal groups, and the lifetime of excited states in gas lasers. But one wishes that the author had also discussed—if not in the text certainly in the appendixes—such important and timely topics as mode locking, optical harmonic generation and parametric tuning, and optical modulation. Perhaps these were beyond the aims of this book, but nevertheless they would have nicely rounded out this impressive work.

### The big picture

Condensed Computer Encyclopedia
Philip B. Jordain
McGraw-Hill Book Co.,
605 pp., $14.50

It's very possible that an engineer who has become expert in computer circuits may never have to deal with the world of computer users who have a technical lan-

## New Books

guage of their own. This book, by speaking in user's language, could help bridge this barrier.

The author is a man of many hats: a research scientist with the First National City Bank, an associate with the Evans Research and Development Corp., and an associate with Artronic Information Systems Inc. He addresses the book to business men and junior programmers. Thus, the book's coverage of electronics terms is superficial as far as engineers go—integrated circuits and transistors, for example, are not even called out—but its coverage of computer users' terms is far from superficial.

Each entry is defined by the author in terms appropriate to its degree of generality. The very broad terms of the computer lexicon are described in layman's language, while the more specialized terms are described in a more detailed technical manner. For example, anyone who must look up automatic data processing will be satisfied with a quick, general description. But the person who must find out what is meant by a partitioned data set will obviously be further advanced and thus will require a more detailed description. In each entry, the author makes each paragraph self-sufficient; each successive paragraph expands on the previous one, and thus the reader doesn't have to read the entire entry to understand the meaning of a term.

### Recently published

**Infrared System Engineering, Richard D. Hudson Jr., John Wiley & Sons Inc., 642 pp., $19.75**

Delving into the elements of infrared technology, this book explains the functional relationships between the various systems elements and the effects of their interactions when assembled into a system. Contains an in-depth treatment of the applications of infrared techniques to the solution of military, industrial, medical, and scientific problems.

**The Art of Computer Programing Vol. 2, Seminumerical Algorithms, Donald E. Knuth, Addison-Wesley Publishing Co., 624 pp., $18.50.**

The aspects of computer programing most closely related to classical mathematics and to numerical analysis and statistics are covered in this volume. Number systems, radix conversion, floating point numbers, and polynomial arithmetic are considered. Generation, test, and use of random numbers are included. A knowledge of calculus is assumed and essential.

## Technical Abstracts

### Close watch

Digital radar system
for air traffic control
Andrew Hamilton and James Moffett
Airborne Instruments Laboratory,
Deer Park, N.Y.
and James Rennie
Canadian Department of Transport,
Ottawa

A processing and display system for en route air traffic control is being readied for tests at Canada's Department of Transport in Ottawa. Developed by Cutler-Hammer's Airborne Instruments Laboratory, the system will display, in three-dimensional form, inputs from prime and secondary surveillance radars.

Numerics and special symbols derived from the secondary surveillance radar are used along with filtered data according to the needs of their controller, speeding the acquisition and identification process and reducing the need for communications between pilot and controller.

Primary and secondary radar information is processed by six integrated-circuit modules into discrete digital messages that can be sent over long-distance telephone lines. The modules are an azimuth digitizer, a prime radar digitizer (PRD), a secondary surveillance radar digitizer (SSRD), a correlator and output unit, a display processor, and a display console. The azimuth digitizer is a solid state synchro-to-digital converter that divides the azimuthal 360° into 4,096 pulse-count increments for input to the radar digitizers.

The SSRD develops a discrete message for each aircraft detected on each antenna scan; the message contains the target's range and center azimuth, plus the identification code and altitude data picked up from the plane's transponder. The digitizer ungarbles inputs, rejects erroneous data, validates identity codes, and measures ranges up to 200 miles. It can detect 64 targets in any azimuthal beam, and has a small core memory for unattended operation.

The PRD accepts both normal and moving-target-indicator video signals plus azimuth data. It pro-

## Technical Abstracts

duces digital target reports that include range and beam-split azimuth.

The display console uses a dual-gun cathode-ray tube with an optical port for direct projection of map reference information. Each new target message is displayed at full brightness, while target trail information can be retained at reduced brightness. Flicker is negligible.

Presented at the National Convention of the Canadian Air Traffic Control Association, Ottawa, May 4-7.

### Talking with IMP

Data handling equipment requirements for convolutional pcm telemetry
John Y. Sos
Goddard Space Flight Center, Greenbelt, Md.

The Interplanetary Monitoring Platform, (IMP-1), scheduled for a 1970 launching, can compress and average the data it gathers, and then transmit the data at a rate of 1,600 bits per second. Both the onboard computation and the high data rate would be impossible with simple pulse-code-modulation telemetry, so IMP will use convulutional coding. This channel coding technique quadruples a pcm system's bit rate and drops its bit error to less than $10^{-5}$.

In its telemetry system, the IMP uses a systematic convolutional code. The encoder's constraint length is 48 bits and its output is a serial split-phase bit stream which phase modulates a 136-megahertz carrier.

Information rates are 400 and 1,600 bits per second, and the symbol rates are 800 and 3,200 per second. The frame synchronization pattern is 32 consecutive symbols, and the frame length is 1,024 information bits.

A decoder, actually a computer and two racks of other hardware, processes the IMP's transmissions. A standard pcm-bit and a standard pcm-frame synchronizer pick up the synchronization information, and an eight-level analog-to-digital converter integrates and quantizes the received waveforms. The computer stores each quantized symbol

until a full data frame is accumulated. Then either the computer or a special-purpose decoder sequentially decodes the frame.

The demands on some of the decoder's components are more severe than they would be in an uncoded pcm telemetry system. For example, the bit synchronizer must work with inputs whose signal-to-noise ratios are as low as 1 decibel. Most commercial synchronizers show bit slippage at this low ratio; however, two manufacturers have made units that work with ratios as low as —2 db.

Frame synchronizers aren't a major problem. Standard units have an acquisition time under four frames and a 0.01% loss of data due to false loss of synchronization.

As far as the recording tape goes in a test of 2,500 IMP-F tapes, 1.3% had dropouts in the 10-kilohertz reference frequency track. The test results indicate that the depth of the dropout is directly proportional to the recorded wavelength. So dropouts can be expected around 1.9 db in 1.3% of the tapes recorded at 3.2-khz symbol rate. If this is the extent of the problem, tape dropouts won't adversely affect the decoder.

Presented at the National Telemetering Conference, Washington, D.C., April 22-24.

### Other uses for films

Applications of thin magnetic films
S. Middelhoek
IBM Research Laboratory
Zurich, Switzerland

Some engineers don't seem to think too much of thin magnetic films, even though physicists believe that a great deal of progress has been made during the 15 or so years since films were first seriously investigated. Most of the interest in films has been in using them as computer memory elements, where their extremely short switching time would be a considerable advantage. But difficulties in fabrication and operation have limited the development of thin-film systems, whereas ferrite-core systems have continued to improve, and monolithic semiconduc-

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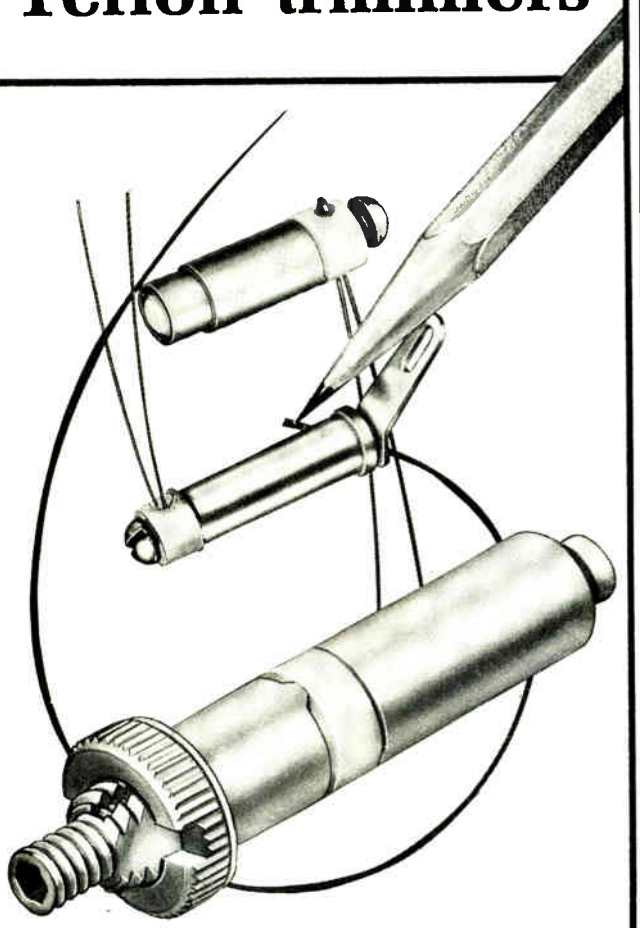

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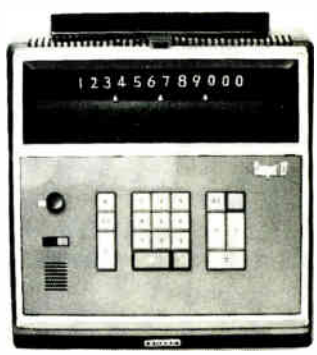


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## Technical Abstracts

tor memories now seem likely to replace both technologies.

What many engineers have overlooked is that thin magnetic films have great advantages in other applications besides memories. Applications that deserve more attention include magnetic logic circuits, microwave attenuators and filters, transducers, Kerr-effect or Faraday-effect displays, and superconducting switches.

In such applications the tight restrictions in composition that memory applications require are absent. Thin-film memories must be made of films composed of about 83% nickel and 17% iron; these proportions must be maintained, even when tiny quantities of other elements are added. Tolerances are much looser on magnetic films intended for other applications; this let up leads to lower fabrication costs.

Furthermore, these consideration apply only to conventional thin films made by evaporation, electroplating or sputtering.

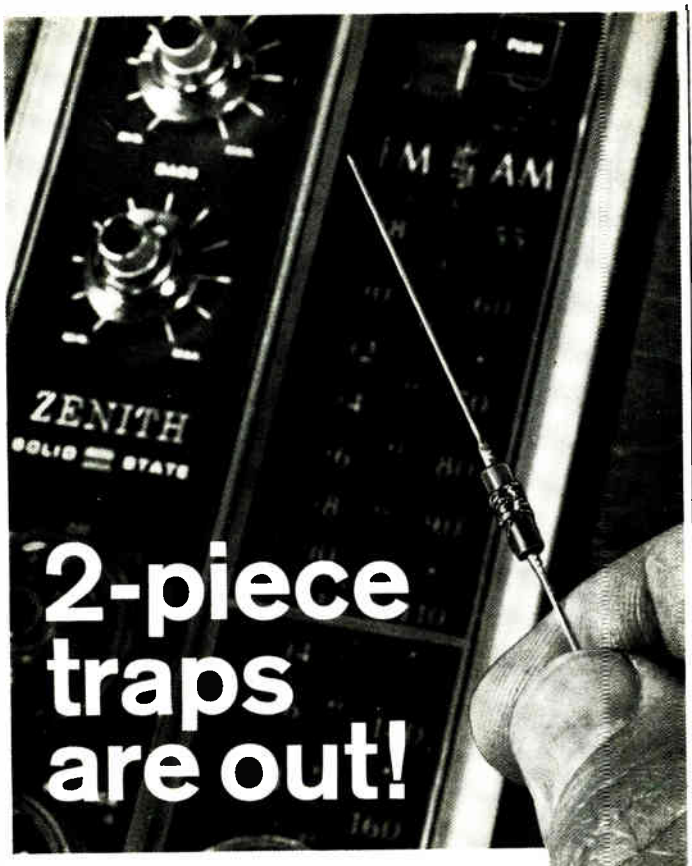
Presented at the International Conference on Magnetics, Amsterdam, April 15-18.

### Looking back

Surveying Earth Resources
with remote sensors
John D. Outsandreas
NASA, Washington, D.C.

Aircraft serving as laboratories are carrying aloft batches of sensors. The National Aeronautics and Space Administration evaluates the performance of the sensors. This evaluation is, in effect, the purposes of its Earth Resources Survey Aircraft program. Other government agencies participating in the project hope to be able to gather data relating to agriculture, geology, geography, hydrology and oceanography.

The program is divided into low-altitude and high-altitude phases. Initial low-altitude tests were run with sensors mounted in a Convair 240 and an Electra P-3A. Later, a Lockheed C-130 B, which can carry a larger payload than the other two planes and which can fly higher, replaced the 240. In the

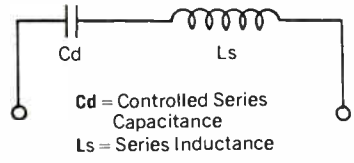



# 2-piece traps are out!

## Zenith uses Dale hybrid Series-Resonant Trap in FM circuitry

Zenith wanted a better way to bypass 10.7 MHz in its FM receivers. To replace the standard 2-component inductor-capacitor trap, Dale provided this unique hybrid.

Dale's Series-Resonant Trap has the electrical characteristics of an inductor and a capacitor in series and provides a method of controlling both functions. The result: Controlled self-resonance in a miniaturized circuit.




**Cd** = Controlled Series Capacitance
**Ls** = Series Inductance

After four years of production use, *Zenith says* of the Series-Resonant Trap: *"It saves space, saves time, works satisfactorily."* Here are the basic specs:

- **Resonant Frequency:** 10.7 MHz ± .5 MHz (Other frequencies available)
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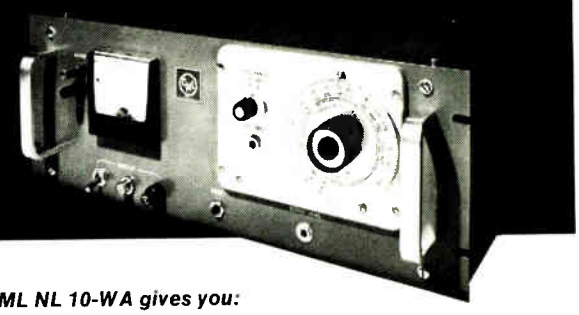

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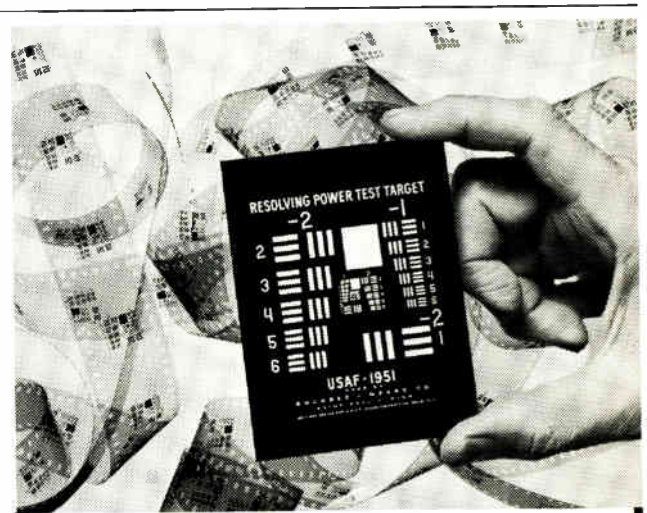


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## Technical Abstracts

high-altitude phase, which will begin this year, the sensors will be carried up to 50,000 feet by an Air Force RB-57F.

Just about every conceivable surveying instrument is being pressed into service. The sensors set up so far are RC-8 metric cameras, multiband cameras, infrared cameras, infrared spectrometers, infrared radiometers, microwave radiometers and imagers, scatterometers, and side-looking radars.

The metric camera helps to correlate and index photographs taken by black-and-white, infrared, and color cameras. Its resolution is 50 lines per millimeter and its field is 74° by 74°.

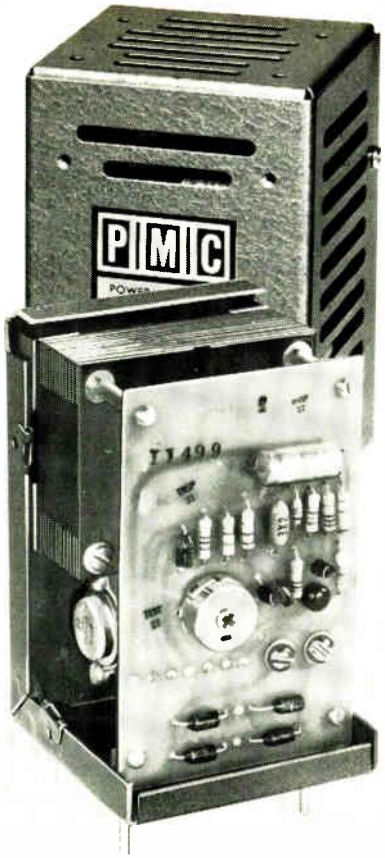
Hydraheaded, the multiband camera is actually four to six cameras, which operate synchronously. Each has a different spectral bandpass filter. The multiband camera's pictures show differences in tone density due to differences in the terrain's reflectance characteristics. These pictures can be used to identify crops, determine drainage patterns and soil moisture content, and study migratory patterns.

Since it has two channels, the infrared camera is sensitive to radiation in both the 0.3 to 5.5 micron range, and the 8-to-14 micron range. Infrared photography is useful in detecting sand bars and sea mounts, and finding minerals.

Also useful in this area is the infrared spectometer which detects energy within a 0.4° beam width and has a wavelength between 6.5 and 13 microns. The primary use of spectroscopy in this program is identifying rocks and determining their mineral content.

Two types of radiometers are used in the program. The first is the infrared radiometer used to measure temperature differences along the earth's surface and help calibrate other infrared devices. The second one is the microwave radiometer, which measures microwave radiation and has an accuracy of 1°K. It gathers data related to the physical, chemical, and geomorphological features of terrain.

Presented at the National Telemetering Conference, Washington, D.C., April 22-24.

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| RC-9 | 7-11 | 1.0 | 0.1 | 0.3 |
| RC-12 | 11-13 | 1.0 | 0.075 | 0.1 |
| RC-15 | 13-16 | 0.5 | 0.075 | 0.1 |
| RC-19 | 16-21 | 0.5 | 0.075 | 0.1 |
| RC-24 | 21-26 | 0.5 | 0.075 | 0.1 |
| RC-28 | 26-31 | 0.5 | 0.06 | 0.1 |
| RC-34 | 31-37 | 0.5 | 0.05 | 0.1 |
| RC-40 | 37-43 | 0.5 | 0.05 | 0.1 |
| RC-48 | 43-50 | 0.5 | 0.05 | 0.1 |

| MODEL NO. | OUTPUT VOLTS | OUTPUT AMPS | REGULATION ±% LINE | REGULATION ±% LOAD |
|---|---|---|---|---|
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| RD-9 | 7-11 | 1.0 | 0.2 | 0.6 |
| RD-12 | 11-13 | 1.0 | 0.15 | 0.2 |
| RD-15 | 13-16 | 0.5 | 0.15 | 0.2 |
| RD-19 | 16-21 | 0.5 | 0.15 | 0.2 |
| RD-24 | 21-26 | 0.5 | 0.15 | 0.2 |
| RD-28 | 26-31 | 0.5 | 0.12 | 0.2 |
| RD-34 | 31-37 | 0.5 | 0.1 | 0.2 |
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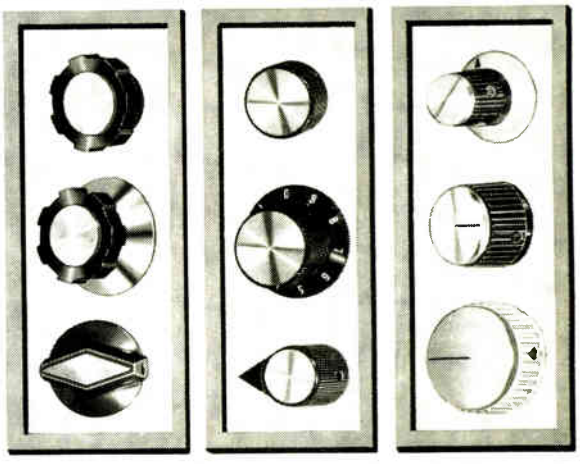

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Circle 268 on reader service card

## New Literature

**Graphic recording instruments.** Esterline Angus Division of Esterline Corp., P.O. Box 24000, Indianapolis 46224. The importance of graphic recording instruments in various monitoring applications is covered in bulletin 269. Circle **446** on reader service card

**Pulse generator.** Syntelex, 39 Lucille Ave., Dumont, N.J. 07628. General-purpose pulse generator SPG-210 is described in a preliminary data sheet. **[447]**

**Communications amplifier.** American Electronic Laboratories Inc., P.O. Box 552, Lansdale, Pa. 19446, has available a bulletin on the VHFA-20, a 1,000-watt broadband amplifier that has only one tube and is tunable over the range of 20 to 76 Mhz. **[448]**

**Plug-in power supplies.** Acopian Corp., Easton, Pa. 18042, announces its 1969 catalog listing more than 82,000 all-silicon, a-c to d-c plug-in power supplies. **[449]**

**Thermistor components.** Yellow Springs Instrument Co., P.O. Box 279, Yellow Springs, Ohio 45387, has released an eight-page catalog describing the characteristics of its precision thermistors and linear output thermistor components. **[450]**

**Telemetry equipment.** Aertech Industries, 815 Stewart Dr., Sunnyvale, Calif. 94086, has published six data sheets on its updated telemetry-equipment product line. **[451]**

**Data sets.** Sangamo Electric Co., P.O. Box 359, Springfield, Ill. 62705. Four-page bulletin 5320 describes the Transidata T103A series of data sets. **[452]**

**Logic handbook.** Digital Equipment Corp., Maynard, Mass. 07154. A 416-page, thoroughly illustrated paperback serves as a guide to the company's complete line of logic modules, associated hardware, and applications information. **[453]**

**Test equipment.** Sage Laboratories Inc., 14 Huron Dr., Natick, Mass. 01760, offers a 16-page catalog describing its line of microwave oscillators, phase-lock synchronizers, and moving-target-indicator radar test equipment. **[454]**

**Elapsed-time indicators.** A. W. Haydon Co., 232 N. Elm St., Waterbury, Conn. 06720. The K49200 series of micro-miniature elapsed-time indicators is the subject of product information bulletin 137. **[455]**

**Coaxial components.** Weinschel Engineering, Gaithersburg, Md. 20760, has prepared a brochure to provide communications, radar, and ECM systems

## New Literature

designers with a handy reference to the important characteristics of its coaxial components. **[456]**

**Switch selection.** Master Specialties Co., 1640 Monrovia, Costa Mesa, Calif. 92627. A six-page guide that summarizes the company's entire product line permits a quick selection of the proper switch for a specific application. **[457]**

**Software/wiring service.** Scanbe Mfg. Corp., 1161 Monterey Pass Road, Monterey Park, Calif. 91754, has published a four-page brochure describing its software/wiring service called Micromatics. **[458]**

**Teflon-insulated terminals.** Sealectro Corp., 225 Hoyt St., Mamaroneck, N.Y. 10543, has issued a four-page catalog on a comprehensive line of semiassembled Teflon-insulated terminals. **[459]**

**Temperature controller.** West Instrument Division of Gulton Industries Inc., 3860 N. River Rd., Schiller Park, Ill. 60176. An illustrated eight-page brochure, bulletin 700, describes the Gardian series potentiometric temperature controller. **[460]**

**Recorder/reproducer.** Ampex Corp., 401 Broadway, Redwood City, Calif. 94063, has available an updated specification sheet on the AR-1600 wideband instrumentation recorder/reproducer. **[461]**

**Galvanometers.** Honeywell Test Instruments Division, Box 5227, Denver, Colo. 80217. Bulletin D2199 describes high-voltage galvanometers and magnetic banks used in the company's Visicorder oscillographs for recording dynamic data. **[462]**

**Germanium power transistors.** KSC Semiconductor Corp., KSC Way, (Katrina Road), Chelmsford, Mass. 01824. A data sheet covers a series of germanium power transistors in a reduced T0-8 case. **[463]**

**R-f chokes.** National Radio Co., 37 Washington St., Melrose, Mass. 02176, offers five pages of tabular selections data for wirewound and ferrite r-f chokes, including encapsulated types, with inductance ranges from 0.10 $\mu$h to 10 mh. **[464]**

**Coaxial connectors.** Star-Tronics Inc., Georgetown, Mass. 01830, has released an engineering data sheet describing the characteristics of its miniature, high-voltage coaxial connectors. **[465]**

**Power supply.** Quindar Electronics Inc., 60 Fadem Road, Springfield, N.J. 07081. A two-page product data sheet describes the QP-17 solid state regulated power supply. **[466]**

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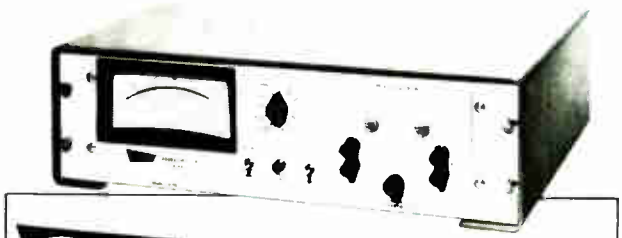

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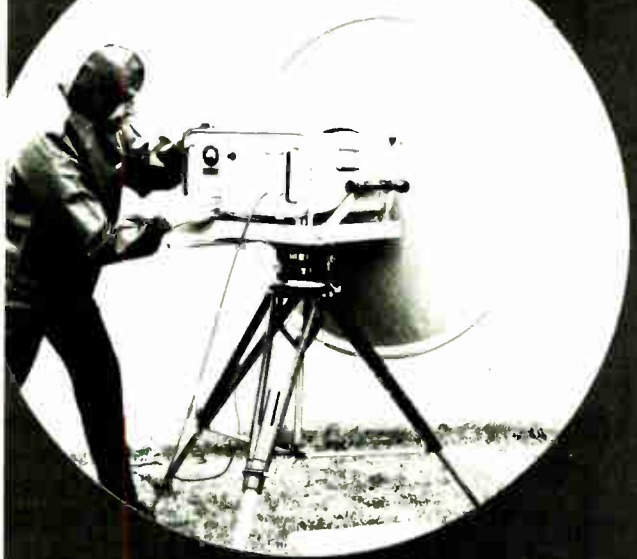

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Circle 225 on reader service card

## New Literature

**R-f power equipment.** Acrodyne Industries Inc., 666 Davisville Road, Willow Grove, Pa. 19090, has available a brochure featuring recent developments in advanced r-f power equipment. **[467]**

**Data Sets.** Rixon Electronics Inc., 2120 Industrial Parkway, Silver Spring, Md. 20904. The 1969 modern short-form catalog describes standard commercial and industrial data sets operating at speeds up to 4,800 bps. **[468]**

**Terminal blocks.** Curtis Development & Mfg. Co., 3250 N. 33rd St., Milwaukee 53216. Twenty-four-page catalog 369 covers a complete line of terminal blocks. **[469]**

**Beryllia ceramics.** American Lava Corp., Manufacturers Road, Chattanooga, Tenn. 37405, offers technical bulletin 693 on AlSiMag beryllia ceramics. **[407]**

**Panel meters.** Honeywell Precision Meter Division, Manchester, N.H. 03105. Descriptions of a full line of precision panel meters have been condensed into a four-page bulletin. **[471]**

**Rear projection readout.** Shelly Associates Inc., 111 Eucalyptus Dr., El Segundo, Calif. 90245. A four-page brochure describes the model SRO-90 rear projection readout for decimal input to visual display. **[472]**

**Pulse generator.** Datapulse Division, Systron-Donner Corp., 10150 W. Jefferson Blvd., Culver City, Calif. 90230. Technical bulletin 112 covers a pulse generator that offers repetition rates to 125 Mhz, rise and fall times of 1.3 nsec, and pulse widths from 3 nsec to 5 msec. **[473]**

**IC tester.** Intrex Systems Inc., 729 Centinela Ave., Inglewood, Calif. 90302, has published a data sheet describing a portable, battery-operated IC tester for field and laboratory use. **[474]**

**Shaft encoders.** Airflyte Electronics Co., New Hook Rd., Bayonne, N.J. 07002, offers a bulletin describing small, self-select multiturn shaft encoders. **[475]**

**Air trimmer capacitors.** Voltronics Corp., West St., Hanover, N.J. 07936. Four-page illustrated catalog 868 discusses a line of air dielectric piston trimmer capacitors. **[476]**

**Rectifier modules.** Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172, has prepared 20-page application note N130B on direct plug-in replacement of high-voltage, high-current rectifier tubes with stackable Doorbell rectifier modules. **[477]**

**IC sockets, systems, accessories.** Robinson-Nugent Inc., 800 E. 8th St., New Albany, Ind. 47150. Sixteen-page catalog 1268 is complete with photographs

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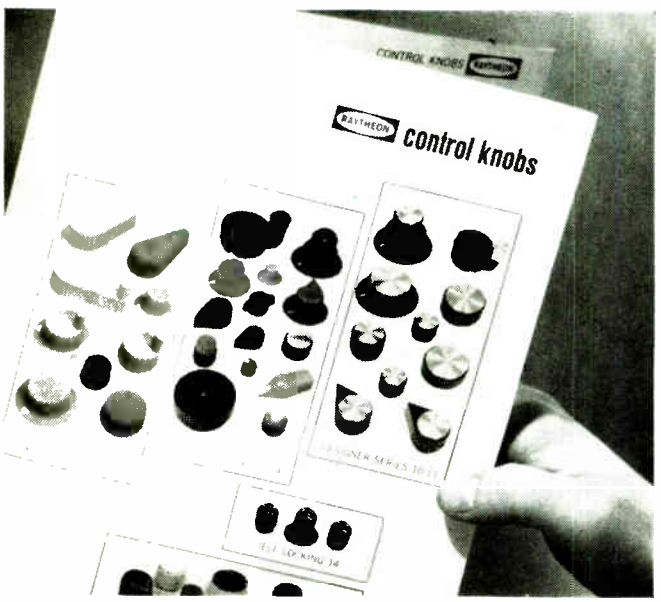


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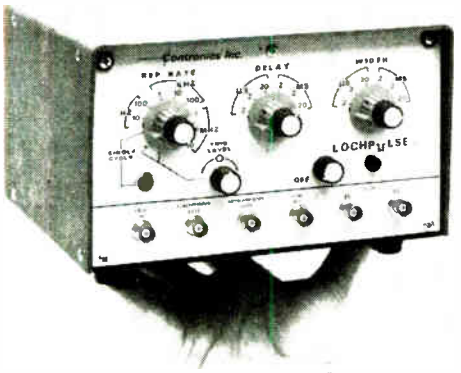


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## New Literature

and technical illustrations of IC sockets, systems, and accessories. **[478]**

**Lamination.** Magnetics Inc., Butler, Pa. 16001. A new-size lamination, F26-27, used in electromagnetic devices is detailed in a data sheet. **[479]**

**Static relays.** Flight Systems Inc., P.O. Box 25, Mechanicsburg, Pa. 17055, has released a general catalog covering a complete line of static relays, including polar, dry-circuit, time-delay, proportional, and circuit-breaker types. **[480]**

**Components applications.** Texas Instruments, P.O. Box 5012, Dallas 75222. Eight-page bulletin CM-102 contains abstracts of over 50 application reports and notes related to solid state devices and IC's. **[481]**

**Servo recorder.** Esterline Angus, Division of Esterline Corp., P.O. Box 24000, Indianapolis 46224, offers an illustrated catalog sheet on its Port-A-Graph servo, a portable, battery-operated servo recorder priced at $750. **[482]**

**Resolver/synchro bridge.** North Atlantic Industries Inc., Terminal Drive, Plainview, N.Y. 11803. A data sheet describes the model 540 resolver/synchro bridge that features 2 arc-seconds accuracy, 0.0001° resolution. **[483]**

**Sample-and-hold circuits.** Data Device Corp., 100 Tec St., Hicksville, N.Y. 11801. An application note explains the terms used in defining sample-and-hold circuits, and discusses typical applications. **[484]**

**Switches and indicator lights.** Controls Co. of America, 1420 Delmar Dr., Folcroft, Pa., has issued a 24-page catalog giving detailed specifications, dimensions, and part numbers for over 230 switches and indicator lights designed to military specifications. **[485]**

**Perforated tape.** Data-link Corp., 100 S. Ellsworth Ave., San Mateo, Calif. 94402. A 12-page catalog describes a full line of perforated tape equipment and supplies. **[486]**

**Variable resistor.** CTS Electronics Inc., 1010 Sycamore Ave., South Pasadena, Calif. Data sheet 1151 describes a single section variable resistor with direct and vernier drive. **[487]**

**Transistors.** Solitron Devices Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. A 52-page book features a line of silicon and germanium small signal and power transistors. **[488]**

**Modular housing systems.** Wyco Metal Products, 6914 Beck Ave., N. Hollywood, Calif. 91609, offers a catalog structured as a design handbook for engineers to use in selecting and styling modular electronic housing systems. **[489]**

**SCR applications.** National Electronics Inc., Geneva, Ill. 60134, has published an application bulletin on NL-H150/H152 series SCR's with regenerative gate signal output. **[490]**

**Spectrum analyzer.** Federal Scientific Corp., 615 W. 131 St., New York 10027, has issued a technical bulletin describing the UA-9, a 1,000 line Ubiquitous spectrum analyzer for the processing of radar, sonar, and other data. **[491]**

**R-f generators.** Westinghouse Electric Corp., P.O. Box 868, Pittsburgh 15230, has available a two-page publication describing the type 125K67 r-f generators with stepless power control for high-power induction heating. **[492]**

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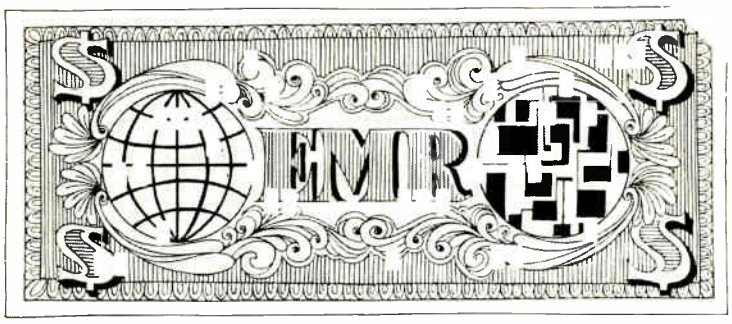


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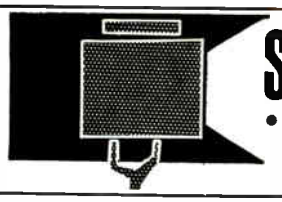

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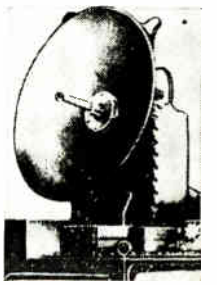

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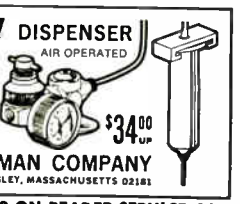

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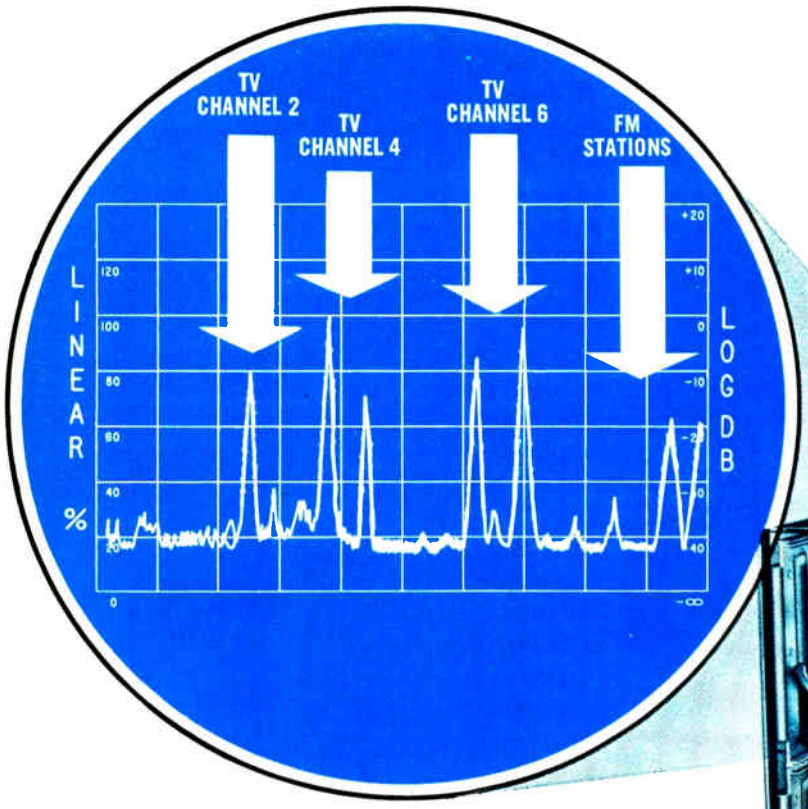


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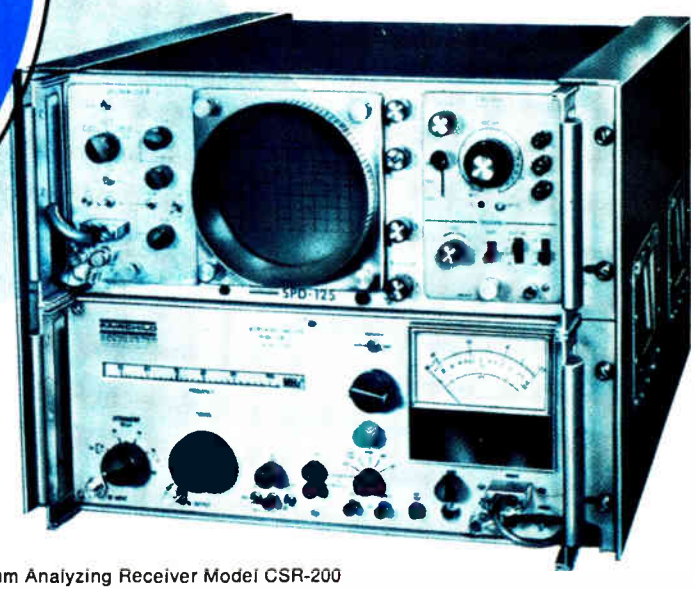

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# International Newsletter

May 12, 1969

## French electronics won't fare badly under new regime

Now that there's been no virulent reaction to the political demise of President de Gaulle, French electronics companies believe they'll feel only ripples rather than a tidal wave of change under the new regime.

**Most are convinced the winner of next month's presidential election will be a moderate—probably Gaullist protege Georges Pompidou. That would mean only slight changes in French economic life.** "We're in for a change of style rather than substance," says Marcel Loichot, chairman of the SEMA-METRA group, France's largest computer software and management consulting firm.

Industry leaders do foresee a few shifts. Andrew Danzin, president of Thomson-CSF, the professional electronics subsidiary of the big Thomson-Brandt Group, predicts de Gaulle's successor will rely more on European defenses than on a purely French deterrent. **This portends a cut in military spending and very likely a slash in funds for de Gaulle's nuclear "force de frappe."**

But Pompidou—or for that matter any potential French president—would be inclined to favor European ventures like satellites and aircraft development. **Higher allotments for joint programs very likely will offset some of the expected cutbacks in domestic ones.**

The "Plan Calcul," de Gaulle's scheme to give France a strong computer industry, looks untouchable. Most of the credits for the five-year effort have been budgeted. "No government would be foolish enough to call off the Plan Calcul at this point," says Loichot of SEMA-METRA. "It would be an outright gift to the American computer companies."

**One benefit from de Gaulle's departure that will accrue to French hardware producers is the now-certain devaluation of the franc,** possibly coupled with adjustments in exchange rates of the pound sterling and the German mark. A higher value for the mark and a devaluation of the franc, which de Gaulle refused to make because he felt it tarnished French prestige, will make French producers more competitive in export markets.

**At home, though, French companies might face more American competition in the long run.** Pompidou has a reputation for greater "flexibility" than his former boss, and American electronics firms may get warmer receptions in post-Gaullist France than they've been getting. But until the successor regime has settled in, there'll be a halt in new plant investments.

## Plessey and Mullard ready IC's for tv

The leading British consumer electronics components suppliers, the Plessey Co. and Mullard Ltd., have started to joust for market positions in integrated circuits for color-tv sets.

**Mullard has its salesmen making the rounds with five linear IC's developed in West Germany by Valvo and catching on fast there** [see story on p. 237]. Both Mullard and Valvo are subsidiaries of Philips' Gloeilampenfabrieken. The response, Mullard maintains, has been "enthusiastic" and the company plans to start quantity deliveries within 12 months.

**Plessey has three circuits well along in development and expects to make samples available to potential customers this summer.** The IC trio will be backed up with custom designs, developed for Rank-Bush-

# International Newsletter

Murphy, that will later be sold to all comers. **The market for color-set IC's figures to boom once 625-lines-only sets become practical in Britain. That will happen next year.**

## Norwegians tapped for USAF contract

A Norwegian intercom maker has cracked the tough U.S. military market. **Gustav A. Ring Sytemmaskiner A/S expects to get formal notification any day now that it has been picked to supply its Garex voice-switching equipment to the U.S. Air Force for the TPN-19 mobile air traffic control system.**

Ring, taking advantage of a waiver of the "Buy-American" provisions for U.S. military procurement that's included in a Norwegian-American defense hardware deal, will be a subcontractor to Raytheon for the TPN-19 hardware.

The Garex deal means nearly $3 million for Ring initially, and may be the beginning of a U.S. bonanza for the Norwegian company. **Ring hopes to crack the civil air traffic control market once it's made its mark with the military.**

## Egyptians choose Germany and Japan for communications

Watch for the Egyptian government to make a big buy of communications gear from Free World suppliers within a few months.

The Cairo government has earmarked $10 million for both cable and radio transmission systems in its budget for the 1969-70 fiscal year, which starts July 1. **Most of this business, apparently, will go to West German and Japanese companies. In recent years, Cairo had been leaning heavily on East German suppliers for communications equipment.**

AEG-Telefunken seems to be the main contender for the Germans' share of the order. Company officials admit they've been negotiating with the Egyptian Ministry of Transport.

## French firm builds trillion-watt laser

Researchers at the Compagnie Generale d'Electricite, France's largest electrical-electronics company, have nailed down the **number two ranking in the world's laser sweepstakes with a 4-terawatt output.** The record is 10 terawatts, obtained by the Sandia Corp. with a modified version of a 2-gigawatt neodymium-doped-glass laser made by the American Optical Co.

Except to say it was built under government contract as a basic tool for plasma research, CGE officials are keeping details of the laser to themselves.

## Addenda

**British phonograph makers have asked the Board of Trade to check into the amazing prices East European producers are quoting in the UK.** Landed prices range from $22 for Polish sets to $43 for Russian sets. East European consumer electronics gear enters Britain under reciprocal trade pacts . . . **West Germany may get a giant aerospace concern.** Messerschmitt-Boelkow GmbH, formed by the merger last year of two south German companies, plans to join forces with a north German firm, Hamburger Flugzeugbau GmbH. The combine would have 19,000 employees and be Germany's largest in the field . . . Philips' Gloeilampenfabrieken has developed wide-angle color-tv picture tubes in two sizes—22 and 25 inches. The company expects to get into quantity production on the 110° tubes in 18 months or so.

# Five IC's for color-tv sets get warm reception in Germany

## Monolithic circuits replace tangle of components in luminance and chrominance channels; outputs can drive discrete transistors

**Whenever** there's an opening in the lineup of integrated circuits for consumer products made in West Germany, look for Valvo GmbH to close it fast.

Last year, for example, Valvo got onto the German market first with a monolithic voltage-stabilizing IC for diode television tuners. Several months ago, the company again scored a beat on the competition with an IC for camera-shutter controls. And at the Hanover Fair this month, it became clear that Valvo had done it again with IC's for color-tv sets.

Valvo, a subsidiary of Philips' Gloeilampenfabrieken of the Netherlands and the largest producer of linear IC's in Germany, let out at the fair that it had a pair of video circuits in production and—better still—orders for them from West Germany's five major set makers, all of whom have one or two IC's in the new color sets they'll introduce this summer. What's more, Valvo has three other circuits nearly ready for production and very good prospects that the set makers will adopt them for next year's receivers.

**Advantageous.** It's not hard to see why these top set makers—among them they account for nearly 80% of German color-tv production—are pressing to get IC's into their receivers. For one thing, there's cost. Valvo sidesteps questions about price schedules, but it's a good bet that the color-tv IC's will sell for less than the kit of discrete components needed to do the same job.

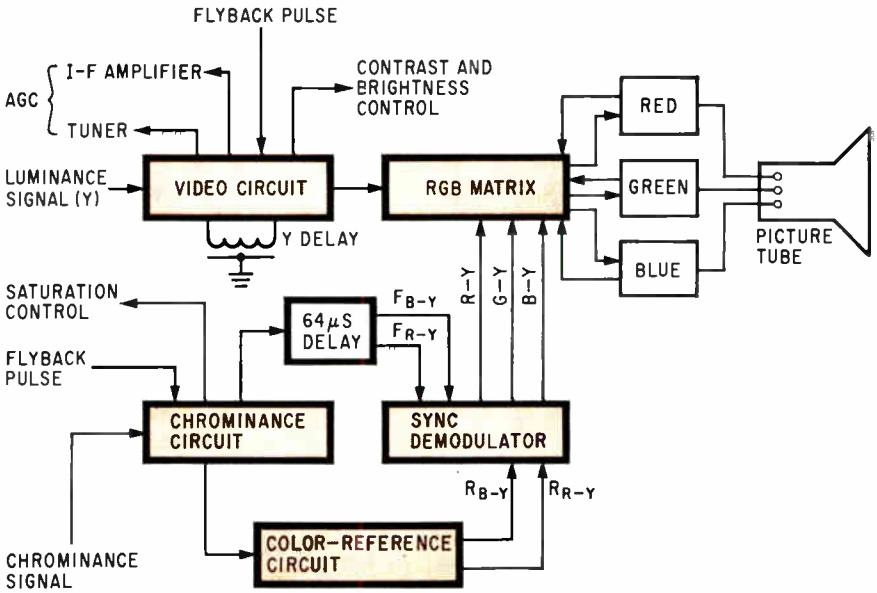
Then there's the components shortage that's developed in Germany this year, largely because of a boom in consumer electronics production. The color-set market, particularly, has been running ahead of the most bullish year-end projections. Instead of 400,000 sets this year, the figure will run close to 500,000. At a time when set makers have outstripped their parts suppliers, the IC's are a boon.

Finally, there's added thrust for IC's—with their edge in insertion costs—at a time when labor is tight in West Germany. For all these reasons, German set makers are shifting to IC's much faster than U.S. producers.

**Clearings.** Valvo's five IC's are designed to clear up the "video jungle" in color-sets, the parts-studded section that handles the luminance (Y) and chrominance channels. It's in this section that the color difference signals are detected and fed to a matrix where they are added to the luminance signal. The matrix outputs are the red (R), green (G), and blue (B) signals that go to the drive stages for the picture tube.

The two circuits Valvo now produces are a sync demodulator and an RGB matrix. The three to follow are a video circuit, a chrominance circuit, and a color-reference circuit. All five are designed to function with very few outboarded components. All can dissipate 0.5 watt and can handle signals between 50 millivolts and 1 volt. Their outputs, then, are high enough to drive discrete-transistor stages. The packages, too, are identical: dual in-line with 16 leads and an integral copper heat sink.

The sync demodulator circuit,




**Colorful quintet.** Color-tv signals from video i-f amplifier are processed by five IC's and two delay lines. Sync demodulator and matrix are in mass production. The other three should be in production next year.

which is called the TAA 630, has two stages, one for the R-Y signal and one for B-Y. The G-Y signal is obtained from these two demodulated difference signals by a matrix.

The IC also has a phase-alternation-line (PAL) switch, a flip-flop to control the PAL switch, and a color-killer circuit. Voltage gain of the sync demodulator is about 10.

The RGB matrix, called the TAA 470, preamplifies the sync demodulator R, G, and B output signals for the transistor stages that drive the picture tube. Nominal voltage gain of this circuit is about 500, but actually the gain is four. This is because the IC is operated in a closed loop with d-c feedback to stabilize black level and a-c feedback for white balance. The circuit has a 3 decibel bandwith up to about 6 megahertz.

**Adding on.** Actually, the sync demodulator and the matrix circuits are the last two functional blocks before the R, G, and B discrete-transistor stages. The three circuits that will complete the series of five will carry the integration all the way upstream to the video i-f amplifier.

One of them, the video circuit, processes the luminance signal. It has a two-stage preamplifier designed so that a Y-delay line can be outboarded. This circuit also has a stage for keyed automatic gain control, a flyback blanking circuit and controls for brightness and contrast.

For brightness and contrast, set users will twiddle with a potentiometer knob as always. When they do, they'll be remotely changing the setting of an electronic potentiometer on the chip. It consists of a differential amplifier that keeps the level of the output luminance signal a linear function of a d-c control voltage.

**Color block.** The chrominance circuit comprises a gain-controlled chrominance amplifier, an age amplifier and a driver stage for the PAL 64-microsecond delay line. As in the video circuit, there are remote controlled electronic potentiometers, this time for contrast and saturation. The chrominance circuit also has a stage for burst blanking and gating, as well as a color-killer circuit. The voltage gain control range is about 30 db.

The color-reference circuit, last of the five, generates a 4.4-Mhz subcarrier signal and in addition has a synchronizing circuit and a pulse shaper.

## Detached

Sooner or later, just about every telephone user finds the tie that binds his handset to his phone anything but a blessing. Examples abound: a business man who wants to keep talking while he checks some figures filed out of cord's reach from his desk; or a housewife who's caught in mid-conversation by a doorbell ringing.

One answer is to combine telephones with intercoms, an idea that's already caught on strong in Scandinavia. Still another answer turned up at the Hanover Fair this month, where Standard Elektrik Lorenz AG (SEL) showed a prototype cordless phone. It uses an inductive path for transmission up to the handset from the table set. In the opposite direction, radio is used.

SEL, a subsidiary of the International Telephone & Telegraph Corp., cautions that it will be a long time before its cordless phone appears on the market. The government-run phone systems in Western Europe move slowly when it comes to approving new kinds of equipment. And with the cordless phone there's an added complication—radio transmission is involved, albeit at low level. SEL's aim in building the prototype was to ready itself for the day that phone officials are ready to seriously consider untying their handsets.

**Simple.** For the user, the cordless phone presents no problem. He simply picks up the handset, dials his number, and starts talking. The principles of operation are equally simple. The table equipment feeds incoming signals to an inductive loop installed in the room where the phone is. A receiver in the handset picks up this "broadcast", which can be on any of eight frequencies between 40 and 135 kilohertz.

For outgoing communications, a small transmitter in the handset broadcasts on a 37-megahertz carrier to a receiver in the table equipment. The signal, radiated by a small ferrite antenna, is demodulated in the receiver and the low-frequency voice signals are fed to the phone line.

**Liberated.** Cordless telephone handset gets the message through as long as user is not more than 60 feet from table top equipment.

**Light.** The receiver and the transmitter, together with the microphone, the earpiece, and five nickel-cadmium cells, are packed into a plastic handset housing that's standard for German telephones. Despite its additional gear, the handset weighs only about half a pound—actually less than regular handsets, which have fairly heavy microphones and earpieces.

In the handset, both the receiver and transmitter contain integrated circuits. The transmitter has an output power of 5 milliwatts, sufficient for a range of about 60 feet. The receiver sensitivity is 20 microvolts.

One drawback of the cordless phone system, of course, is that conversations can be monitored by others inside the inductive loop. One way out, SEL says, would be a telephone with two handsets, only one of them cordless. When the tie that binds is a blessing, SEL proposes using it.

## Japan

### Color by cassette

Designers at the Sony Corp. have taken an audio idea of Philips' Glocilampenfabricken, added to it a video idea of their own, and expect the result will be the synergistic sum of considerably more than two.

The sensational sales of audio cassettes and cassette tape recorders, Sony figures, can be accounted for in large measure by the fact that most producers around the world adopted Philips' design. For that reason, prerecorded tapes are compatible, a sine qua non for a mass market.

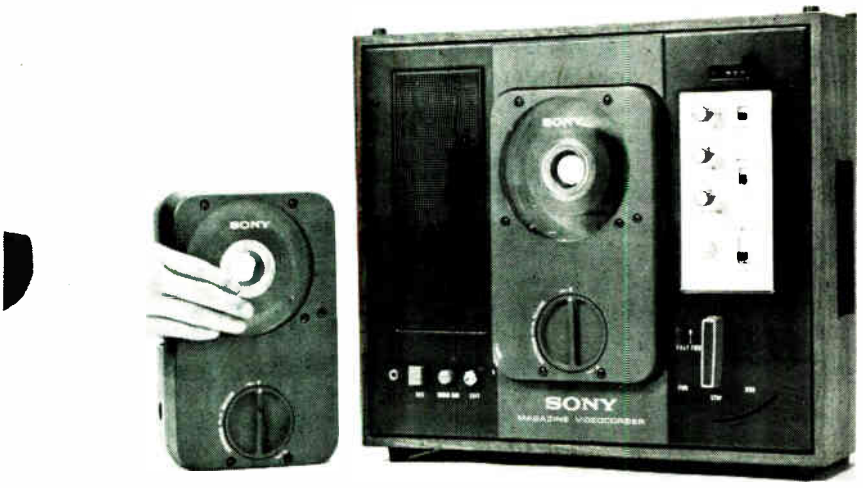
Sales of video tape recorders, on the other hand, have been slow. Cost is one reason, of course, but Sony also has a hunch that another brake on vtr sales is incompatibility—tapes recorded on one make of vtr often can't be played back on another make.

So Sony has done what comes naturally and developed a color vtr that plays an hour on a cassette of tape. As it unveiled the prototype late in April, the company reported it could get the vtr into production within two years and sell it for something like $500.

The early announcement, though, wasn't aimed at potential customers. Rather, Sony hopes to nudge the industry toward a standard color-tv cassette design—Sony's or even somebody else's. And, the company apparently wants to line up allies to help it take on the electronic video recording system (EVR) that the Columbia Broadcasting System is trying to get on the market.

Because it can record broadcasts as well as play back prerecorded material, the cassette vtr looks like a serious competitor to EVR. Sony figures it could deliver prerecorded tapes for about $28 each. Since the tapes would be good for about 1,000 replays, the cost per showing should be within reach of a mass audience. A vtr with playback only could sell for about $370.

**Wide track.** The prototype cassette measures about 6 by 10 by 3¾ inches and to get it that small Sony had to use 1-inch tape with two tracks rather than the more usual ½-inch tape. In addition to making it possible to cram an hour's playing time onto smaller reels, the 1-inch tape tends to hold down jitter since its added width makes it stiffer.




**Viewers' choice.** Cassette for color vtr carries a 1-hour program that can be prerecorded or recorded off the air for later playback.

The two reels in the cassette are mounted coaxially. Tape comes off one reel, passes around a hub that is slightly larger than the vtr head drum, and then winds onto the second reel. When the cassette is slipped into the vtr, the hub slips over the drum. Locking the cassette into place rotates the hub so that a window in it lets the tape contact the drum.

**Slight shift.** Tape speed in the cassette vtr is 3¼-inches per second. And the format of the color video recording is a modification of the NTSC signal. The luminance signal is recorded by f-m modulation of a subcarrier. Its frequency is about 3 megahertz and the modulation swing is from 3 Mhz to 4.5 Mhz. This leaves room on the same track for the NTSC color signal, which is shifted to a center frequency of 900 kilohertz and recorded with a bandwidth of ±700 Khz around the center frequency. Other vtr's use a separate track for the color signal. In the cassette vtr, the second track is for audio.

The color signal is both amplitude and phase modulated, like a regular NTSC color signal and so needs only to be shifted back to its rightful space in the signal spectrum for playback. In Sony's prototype, the recorded video signals are r-f modulated to put them on Channel 2, unused in Tokyo.

## Soviet Union

### The computer mess

Even the party faithful these days admit there's much amiss in the Soviet Union's computer industry.

Rumblings of dissatisfaction about the way the industry has been stumbling under its six masters have been surfacing for the past couple of years. But now criticism of the computer setup has received an official cachet. The leading government newspaper, Izvestia, has published a sarcastic, often witty, critique of the industry by one of the top Russian computer experts. The byline: Guri I. Marchuk, director of the computer center at Novosibirsk [*Electronics*, July 10, 1967, p. 193].

In contrast to much of the breast-beating self-criticism that comes out of Moscow, Marchuk has backed up his critique with a program that adds up to full-scale reform of the organization in the Soviet computer sector. Marchuk wants more computers, better processors and peripherals, more time sharing, more programers and better ones.

The only way to get all these

betterments, he maintains, is to put all computer activities under one man. As it is now, five different ministries and the Academy of Sciences all have a say in computer activity. Marchuk, a Ukranian, sums up the situation with a Russian proverb, "If a child has seven nurses, he won't have one eye."

Marchuk, obviously wouldn't nominate his candidate for computer czar in the public print. But Westerners who follow the politics of Soviet industry say a likely choice—if and when the reform comes—is Konstantin N. Rudnev, who currently heads the Ministry of Automation and Control Systems.

That makes Rudnev one of the too-many nurses now hovering over the computer industry. But his qualifications go well beyond his current job. Earlier, Rudnev was chairman of the State Committee of Defense Technology and before that headed a group that coordinated Russian research. He is also a driving force in the current economic reform which depends so heavily on computers and automation.

Chances are reasonably good that control of the industry will be handed to Rudnev or another high government official. Conditions in the industry are similar in many ways to the hydra-headed setup that led to reform of the refrigerator industry several years ago.

**Head start.** A computer czar, Marchuk points out, wouldn't have to start out from scratch. Russian central processors, in his view, are world class. And there's the nucleus of a national time-sharing network in the three big Soviet computing centers—at Moscow, Kiev, and the one at Novosibirsk that Marchuk directs.

But there's much catching up to do in peripherals, according to Marchuk. Terminals with graphic displays are badly needed, as are disk memories. And there's a third main soft spot—lack of a small "routing" computer to direct time-sharing traffic to large computers. Marchuk's center is trying to adapt a Minsk 220 as a control for its BESM 6, the largest Russian "commercial" computer.

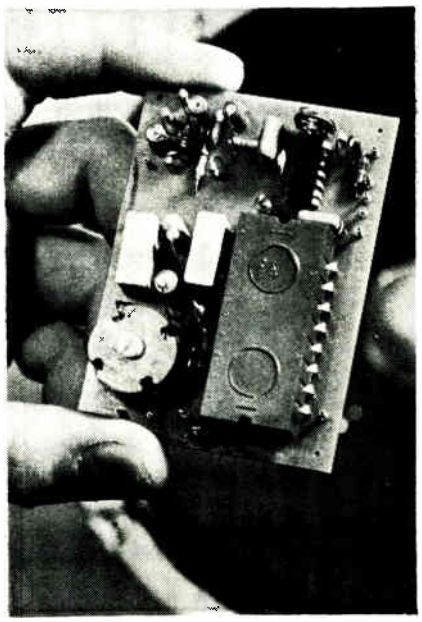
## Great Britain

### Beating the heat

The idea of modulating analog waveforms by converting them to a train of pulses that vary in duration has been around for 45 years. But it wasn't until transistors came along that pulse-duration-modulation (pdm) amplifiers became practical. What's needed for the technique is fast switching.

At switching speeds of 200 kilohertz, pdm amplifiers make admirable amplifiers for servos, where the analog waveforms have low frequencies. The transistors in the amplifier operate only as switches, and about the only power consumed comes from transistor saturation losses, which are low. Efficiencies between 90% and 95% are typical, meaning there's little heat generated by the amplifiers.

All this makes pdm ideal for audio hi-fi amplifiers—for anyone with a device that can switch high currents at gigahertz speeds. Mullard Ltd., a subsidiary of Philips' Gloeilampenfabrieken, now has one. At the International Components Show in London later this month, Mullard will have on its stand a 30-watt hi-fi amplifier based on an experimental pdm integrated circuit.



**Cool.** Mullard's experimental pdm circuit (black dual in-line package at top) and the power pack paired with it switch so efficiently that this 30-watt audio amplifier needs no heat sink.

**Triangle.** Brian Attwood and Brian Buckingham spearheaded the work for Mullard. Their IC has two main function blocks, a triangle pulse generator and the modulator. The pulse generator can be adjusted externally to run at frequencies up to several gigahertz. It feeds the modulator, whose index is 0.95 at 1 Ghz and 0.9 at 2 Ghz. Rise times of the output pulses from the modulator run 7 nanoseconds and fall times 10 nsec.

To turn the modulator into an amplifier, it is operated at 2 Mhz and paired with a solid state power block that amplifies the pulses to peak currents of 3 to 4 amperes with rise and fall times between 25 and 30 nsecs. The amplified analog waveform is extracted by a low-pass filter. With 30 decibels of feedback, the total harmonic distortion is 0.25%. Despite its 30-watt output and its small size—no bigger than a cigarette package—the demonstration amplifier needs no heat sink.

**Fixed.** Attwood says that once he was convinced that a high-speed analog-to-digital modulator could be integrated at a reasonable cost and paired with equally speedy high-current output circuitry, he had no hesitation about going directly to fixed-frequency switching. The low-speed pdm systems now used for servo amplifiers and like applications generally vary their switching frequency as the modulation index changes.

Attwood can trot out a long list of reasons why fixed-frequency switching is the better scheme. For one thing, filters can be smaller. For another, radiation around the amplifier is limited to a few inches, without special precautions. This is because the ratio of the switching frequency to the analog waveform's frequency is so high that there's very little ripple. This same high ratio also cuts down intermodulation distortion.

Another advantage, says Attwood, is that the bandwidth of the analog signal can be as much as 500 khz—even higher if a lowered modulation index can be tolerated.

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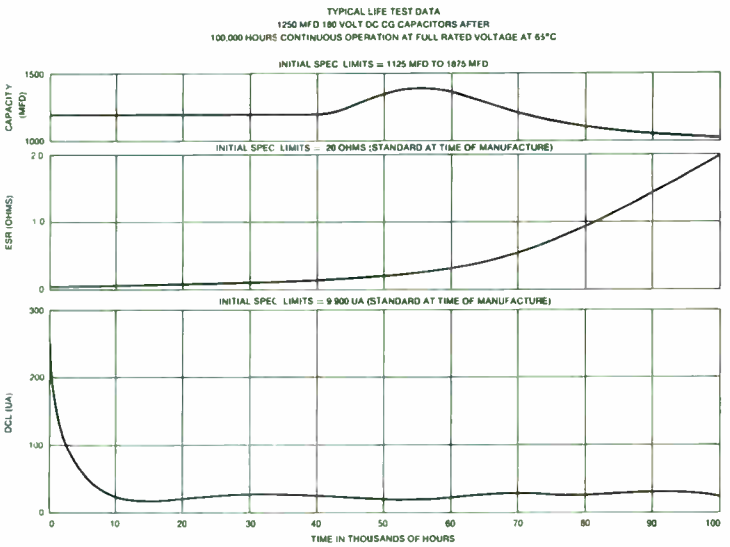



All Mallory CG capacitors should have a useful life of about ten years, when operated at specified conditions. They will last even longer if derated in one or more operating conditions.

### Temperature Range

CG capacitors are designed to operate within a range of −40°C to +85°C. They have been tested at 105°C at less than rated voltage without immediate catastrophic failure. Extended operation under these conditions, however, will shorten their life.

### Capacitance

Capacity is measured at 120 cps and at 25°C. Tolerance of capacitors rated at 3 to 150 volts is −10, +75%. For capacitors rated at 151 to 450 volts, the tolerance is −10, +50%.

### Low Temperature Capacitance

Capacitance of Mallory CG capacitors at reduced temperatures and 120 cps does not fall below the following percentage of nominal rated room temperature (+25°C) capacity.

| Rated DC Voltage | Percent of Nominal Rated Capacitance | | |
|---|---|---|---|
| | −20°C | −30°C | −40°C |
| 0-15 | 65 | 50 | 30 |
| 16-100 | 80 | 65 | 40 |
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### Equivalent Series Resistance

ESR measurements are made at 120 cps and 25°C. ESR for Mallory computer grade capacitors is very low.

Mallory wants the highest possible rating for its CG capacitors —but not at the expense of long life and reliable operation. The object of all our research and care in manufacturing and testing is to provide our customers with the "best" capacitor. For data, write or call Mallory Capacitor Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.



 

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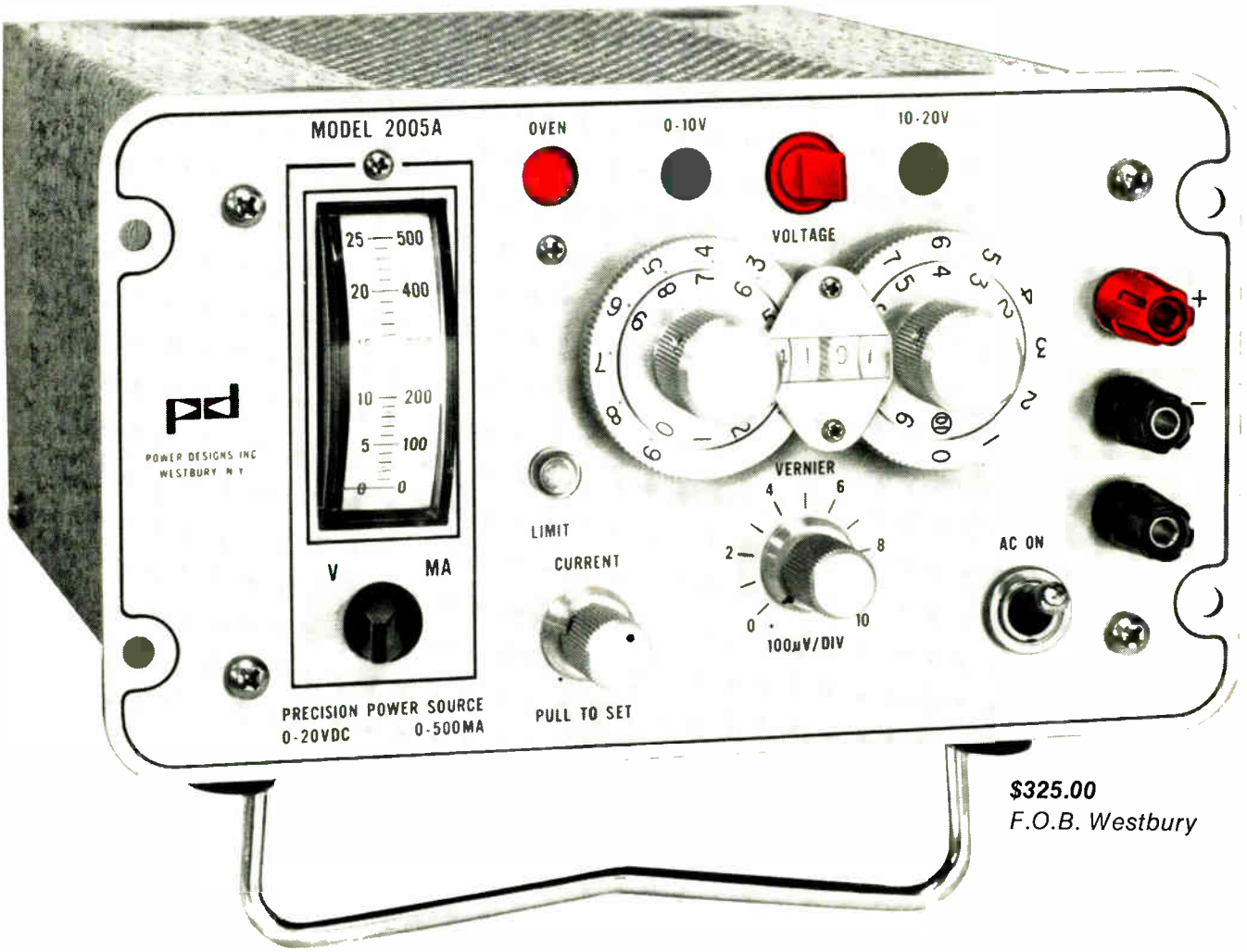


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| 2 | 21 | 40 | 59 | 78 | 97 | 116 | 135 | 154 | 173 | 192 | 211 | 230 | 249 | 268 | 287 | 306 | 325 | 344 | 363 | 382 | 401 | 420 | 439 | 458 | 477 | 496 | 515 | 963 |
| 3 | 22 | 41 | 60 | 79 | 98 | 117 | 136 | 155 | 174 | 193 | 212 | 231 | 250 | 269 | 288 | 307 | 326 | 345 | 364 | 383 | 402 | 421 | 440 | 459 | 478 | 497 | 516 | 964 |
| 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 |
| 5 | 24 | 43 | 62 | 81 | 100 | 119 | 138 | 157 | 176 | 195 | 214 | 233 | 252 | 271 | 290 | 309 | 328 | 347 | 366 | 385 | 404 | 423 | 442 | 461 | 480 | 499 | 518 | 966 |
| 6 | 25 | 44 | 63 | 82 | 101 | 120 | 139 | 158 | 177 | 196 | 215 | 234 | 253 | 272 | 291 | 310 | 329 | 348 | 367 | 386 | 405 | 424 | 443 | 462 | 481 | 500 | 900 | 967 |
| 7 | 26 | 45 | 64 | 83 | 102 | 121 | 140 | 159 | 178 | 197 | 216 | 235 | 254 | 273 | 292 | 311 | 330 | 349 | 368 | 387 | 406 | 425 | 444 | 463 | 482 | 501 | 901 | 968 |
| 8 | 27 | 46 | 65 | 84 | 103 | 122 | 141 | 160 | 179 | 198 | 217 | 236 | 255 | 274 | 293 | 312 | 331 | 350 | 369 | 388 | 407 | 426 | 445 | 464 | 483 | 502 | 902 | 969 |
| 9 | 28 | 47 | 66 | 85 | 104 | 123 | 142 | 161 | 180 | 199 | 218 | 237 | 256 | 275 | 294 | 313 | 332 | 351 | 370 | 389 | 408 | 427 | 446 | 465 | 484 | 503 | 951 | 970 |
| 10 | 29 | 48 | 67 | 86 | 105 | 124 | 143 | 162 | 181 | 200 | 219 | 238 | 257 | 276 | 295 | 314 | 333 | 352 | 371 | 390 | 409 | 428 | 447 | 466 | 485 | 504 | 952 | 971 |
| 11 | 30 | 49 | 68 | 87 | 106 | 125 | 144 | 163 | 182 | 201 | 220 | 239 | 258 | 277 | 296 | 315 | 334 | 353 | 372 | 391 | 410 | 429 | 448 | 467 | 486 | 505 | 953 | 972 |
| 12 | 31 | 50 | 69 | 88 | 107 | 126 | 145 | 164 | 183 | 202 | 221 | 240 | 259 | 278 | 297 | 316 | 335 | 354 | 373 | 392 | 411 | 430 | 449 | 468 | 487 | 506 | 954 | 973 |
| 13 | 32 | 51 | 70 | 89 | 108 | 127 | 146 | 165 | 184 | 203 | 222 | 241 | 260 | 279 | 298 | 317 | 336 | 355 | 374 | 393 | 412 | 431 | 450 | 469 | 488 | 507 | 955 | 974 |
| 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 |
| 16 | 35 | 54 | 73 | 92 | 111 | 130 | 149 | 168 | 187 | 206 | 225 | 244 | 263 | 282 | 301 | 320 | 339 | 358 | 377 | 396 | 415 | 434 | 453 | 472 | 491 | 510 | 958 | 977 |
| 17 | 36 | 55 | 74 | 93 | 112 | 131 | 150 | 169 | 188 | 207 | 226 | 245 | 264 | 283 | 302 | 321 | 340 | 359 | 378 | 397 | 416 | 435 | 454 | 473 | 492 | 511 | 959 | 978 |
| 18 | 37 | 56 | 75 | 94 | 113 | 132 | 151 | 170 | 189 | 208 | 227 | 246 | 265 | 284 | 303 | 322 | 341 | 360 | 379 | 398 | 417 | 436 | 455 | 474 | 493 | 512 | 960 | 979 |
| 19 | 38 | 57 | 76 | 95 | 114 | 133 | 152 | 171 | 190 | 209 | 228 | 247 | 266 | 285 | 304 | 323 | 342 | 361 | 380 | 399 | 418 | 437 | 456 | 475 | 494 | 513 | 961 | 980 |

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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 |
| 3 | 22 | 41 | 60 | 79 | 98 | 117 | 136 | 155 | 174 | 193 | 212 | 231 | 250 | 269 | 288 | 307 | 326 | 345 | 364 | 383 | 402 | 421 | 440 | 459 | 478 | 497 | 516 | 964 |
| 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 |
| 5 | 24 | 43 | 62 | 81 | 100 | 119 | 138 | 157 | 176 | 195 | 214 | 233 | 252 | 271 | 290 | 309 | 328 | 347 | 366 | 385 | 404 | 423 | 442 | 461 | 480 | 499 | 518 | 966 |
| 6 | 25 | 44 | 63 | 82 | 101 | 120 | 139 | 158 | 177 | 196 | 215 | 234 | 253 | 272 | 291 | 310 | 329 | 348 | 367 | 386 | 405 | 424 | 443 | 462 | 481 | 500 | 900 | 967 |
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| 8 | 27 | 46 | 65 | 84 | 103 | 122 | 141 | 160 | 179 | 198 | 217 | 236 | 255 | 274 | 293 | 312 | 331 | 350 | 369 | 388 | 407 | 426 | 445 | 464 | 483 | 502 | 902 | 969 |
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| 11 | 30 | 49 | 68 | 87 | 106 | 125 | 144 | 163 | 182 | 201 | 220 | 239 | 258 | 277 | 296 | 315 | 334 | 353 | 372 | 391 | 410 | 429 | 448 | 467 | 486 | 505 | 953 | 972 |
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| 11 | 30 | 49 | 68 | 87 | 106 | 125 | 144 | 163 | 182 | 201 | 220 | 239 | 258 | 277 | 296 | 315 | 334 | 353 | 372 | 391 | 410 | 429 | 448 | 467 | 486 | 505 | 953 | 972 |
| 12 | 31 | 50 | 69 | 88 | 107 | 126 | 145 | 164 | 183 | 202 | 221 | 240 | 259 | 278 | 297 | 316 | 335 | 354 | 373 | 392 | 411 | 430 | 449 | 468 | 487 | 506 | 954 | 973 |
| 13 | 32 | 51 | 70 | 89 | 108 | 127 | 146 | 165 | 184 | 203 | 222 | 241 | 260 | 279 | 298 | 317 | 336 | 355 | 374 | 393 | 412 | 431 | 450 | 469 | 488 | 507 | 955 | 974 |
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| 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 |
| 16 | 35 | 54 | 73 | 92 | 111 | 130 | 149 | 168 | 187 | 206 | 225 | 244 | 263 | 282 | 301 | 320 | 339 | 358 | 377 | 396 | 415 | 434 | 453 | 472 | 491 | 510 | 958 | 977 |
| 17 | 36 | 55 | 74 | 93 | 112 | 131 | 150 | 169 | 188 | 207 | 226 | 245 | 264 | 283 | 302 | 321 | 340 | 359 | 378 | 397 | 416 | 435 | 454 | 473 | 492 | 511 | 959 | 978 |
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| 19 | 38 | 57 | 76 | 95 | 114 | 133 | 152 | 171 | 190 | 209 | 228 | 247 | 266 | 285 | 304 | 323 | 342 | 361 | 380 | 399 | 418 | 437 | 456 | 475 | 494 | 513 | 961 | 980 |

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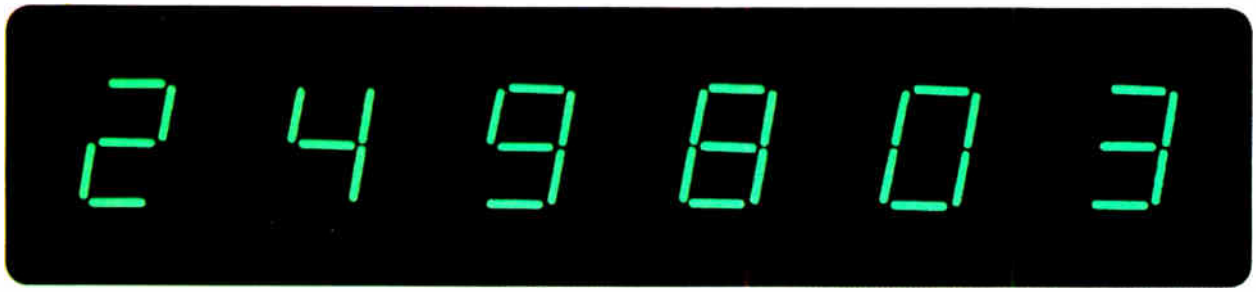
Gas discharge tube

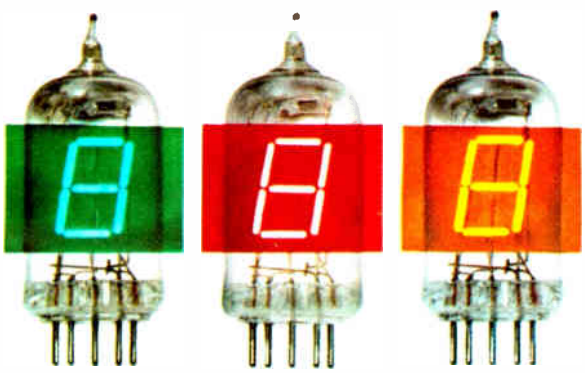

Digivac S/G




# How's this for legibility?

Judge for yourself the clarity of the Tung-Sol Digivac S/G readout as compared to a gas discharge tube. Single plane, up-front display is uniformly distinct. Reading is fast and accurate, with exceptional wide-angle visibility. Characters don't "dance" as numerals change. Normal blue-green color is easier to view than the familiar "bloodshot eye." Digivac S/G can be successfully used in "time sharing" applications. □ These advantages are enhanced by the low price of Digivac S/G and matching IC logic which provides features not present in other readout devices. Get the whole story. Write for the portfolio on Tung-Sol Digivac S/G readouts.

**TUNG-SOL DIVISION / WAGNER ELECTRIC CORPORATION**
ONE SUMMER AVENUE, NEWARK, NEW JERSEY 07104



**CHOICE OF COLOR WITH FILTERS**
Simple filtering provides an almost unlimited choice of colors for identifying individual readout arrays.

**TUNG-SOL®**
**DIGIVAC S/G™**
...the newest state of the readout art

Circle 901 on reader service card

**Here's 15 A to 50 A Performance for your High-Speed Switching Circuits.**

Now, RCA brings you high-speed, high-current switching in four of the industry's newest high power units—2N5671 and 2N5672 in regular TO-3 case available in production quantities, and developmental types TA7337 and TA7337A in modified TO-3 case (two 60-mil pins) available on a sampling basis.

These high-current transistors now make available for industrial and commercial users a state-of-the-art combination of high performance and reliability originally dictated by the rigid requirements of aerospace.

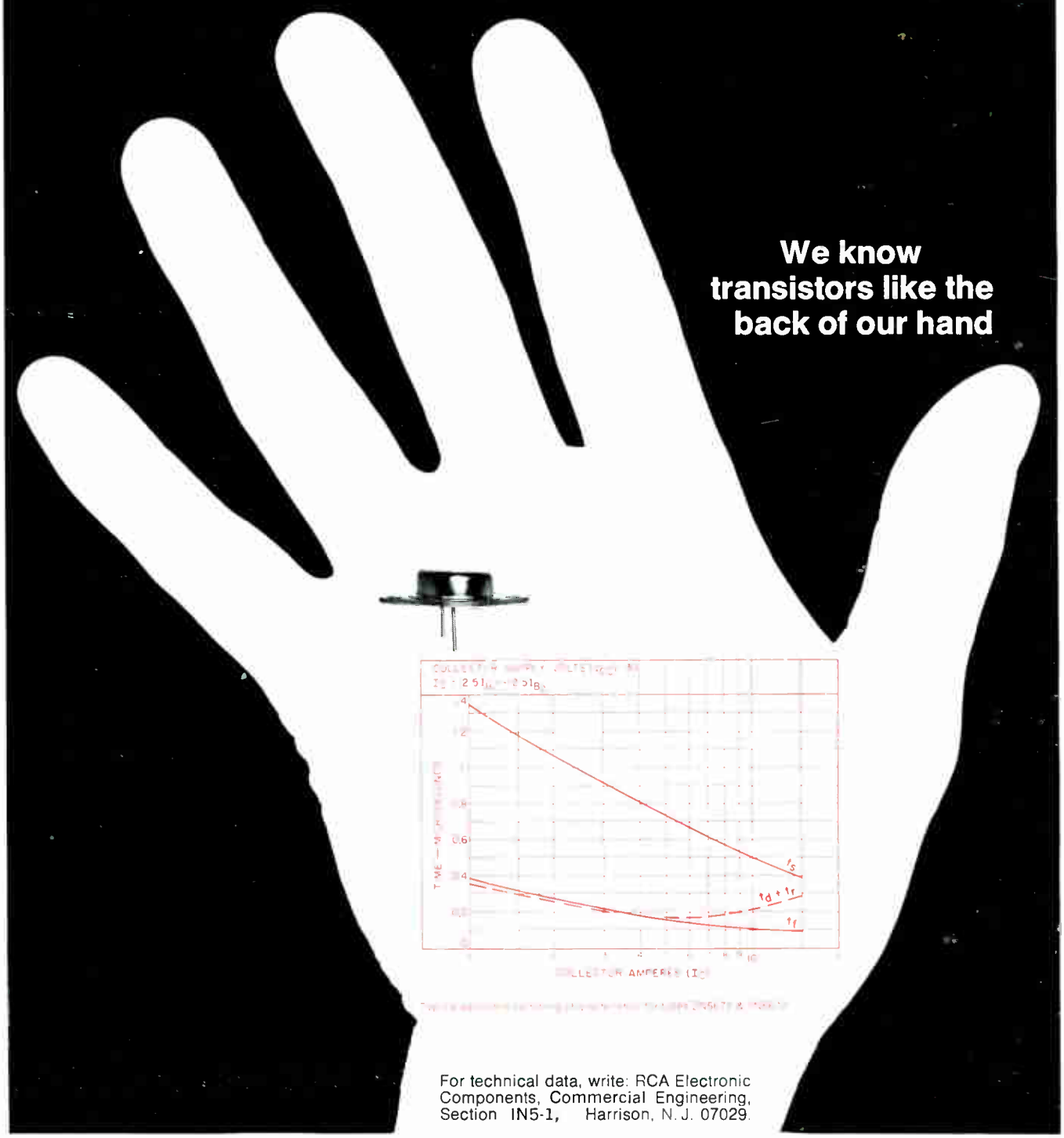
All four devices are characterized by double-diffused, double-epitaxial design techniques. As a result, you get reduced saturated switching times, increased current handling capability, and low saturation voltage. These silicon transistors have enhanced second breakdown capability under forward and reverse-bias conditions...backed by safe area operating curves.

Among the applications for these units: switching control amplifiers, power gates, switching regulators, DC-DC converters, DC-AC inverters, DC through RF linear power amplifiers and oscillators.

Check the chart for some of the key parameters of these four new types. Then ask your local RCA Representative or your RCA Distributor for prices and delivery details.

| Unit | $V_{CEO}$(sus) (V) | $I_C$ (A) | $V_{CE}$(sat) | $f_T$ MHz | $t_{on}$ |
|---|---|---|---|---|---|
| 2N5672 | 120 | 30 | 0.75 V @ 15 A | 50 | 0.5 μs @ 15 A |
| 2N5671 | 90 | 30 | 0.75 V @ 15 A | 50 | 0.5 μs @ 15 A |
| Above types available *now* in production quantities. | | | | | |
| TA7337A | 120 | 40 | 1.2 V @ 40 A | 50 | 1.0 μs @ 40 A |
| TA7337 | 90 | 50 | 1.5 V @ 50 A | 50 | 1.0 μs @ 40 A |
| Above types available *now* in sample quantities. | | | | | |

RCA




For technical data, write: RCA Electronic Components, Commercial Engineering, Section IN5-1, Harrison, N.J. 07029.

Circle 902 on reader service card