MARCH 3, 1977

**OPTICAL COMMUNICATIONS SCORING HIGH WITH U. S. ARMY/65**

Biggest field-erasable read-only memory makes its bow/108

How thin-film magnetic heads enhance data-storage systems/97



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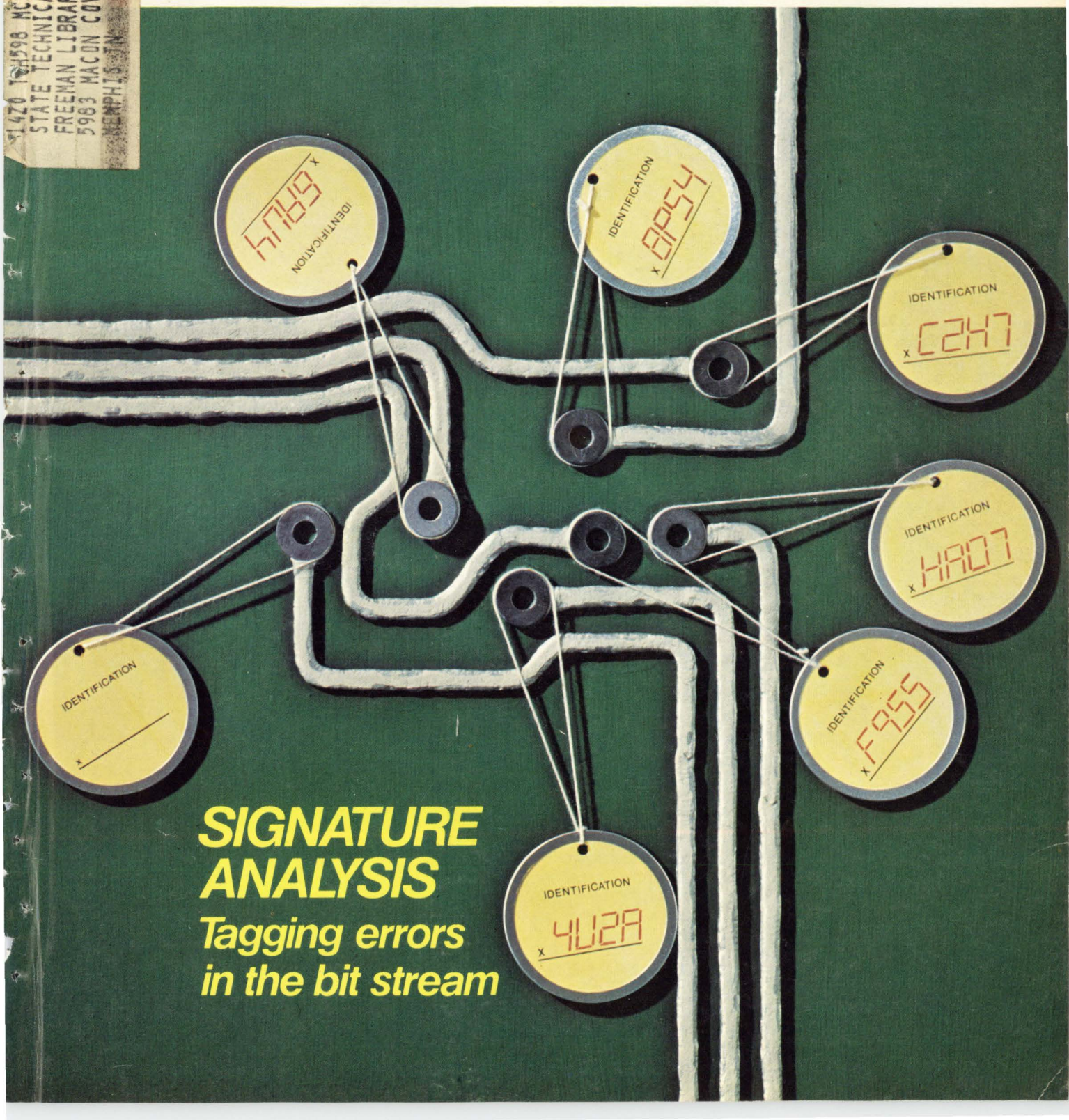

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097/42


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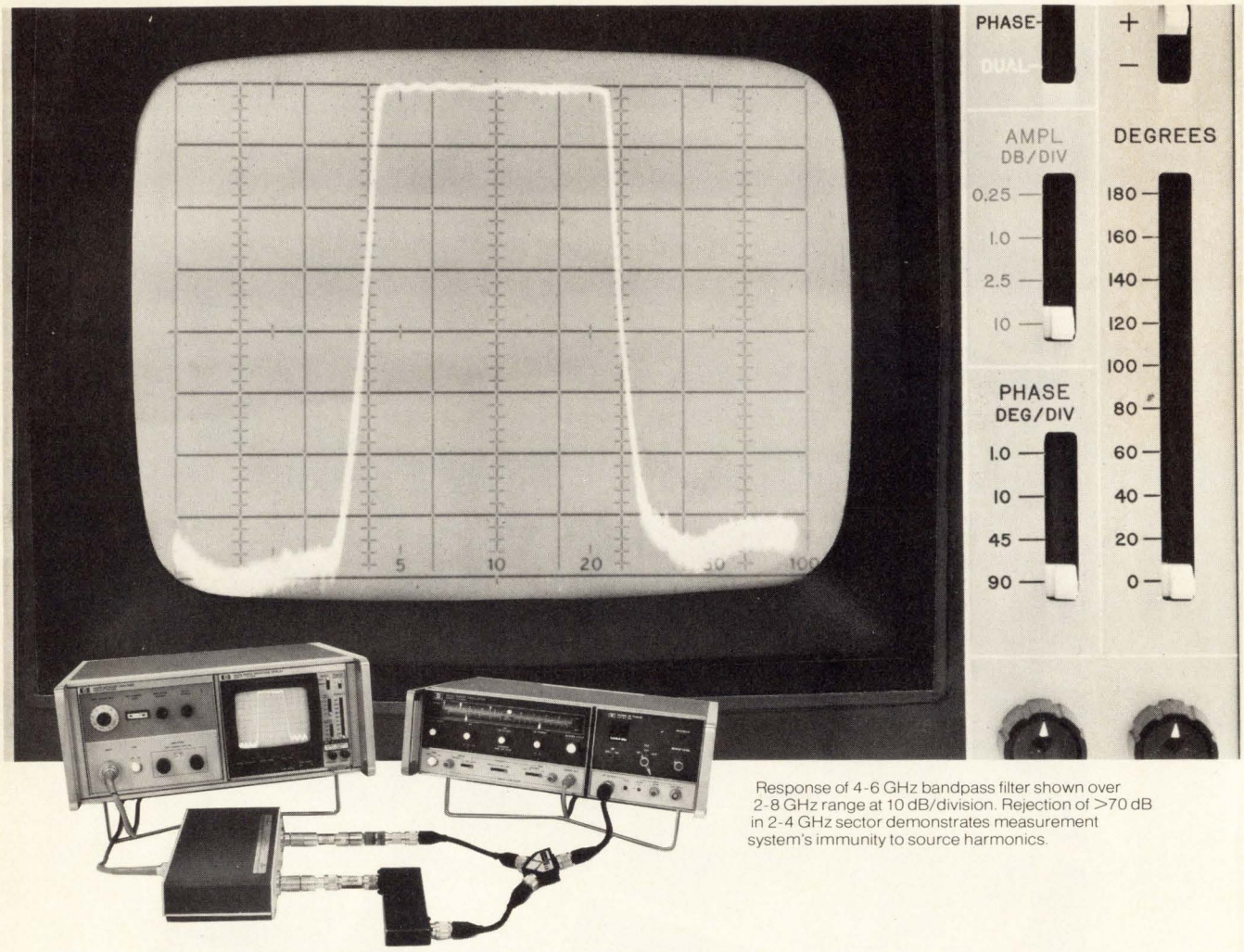


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# Electronics

**The International Magazine of Electronics Technology**

**Vol. 50, No. 5 • March 3, 1977**




## Highlights

**Cover: Signature analysis spots system faults, 89**

Servicing a microprocessor-based product at the component level can be more economical than replacing modules—if the product is designed to meet the requirements of signature analysis. Based on the technique of signal tracing, the process translates bit streams into hexadecimal "signatures" for comparison with the correct signatures on the circuit diagram.

Cover is by designer Ann Dalton

**Standard code to protect computer secrets, 74**

Theft of secrets entrusted to computers and compromises of the data they hold are two electronic nightmares that will dwindle now that the National Bureau of Standards has adopted a data encryption standard for government and industry use. Add-on equipment incorporating the standard will encode data transmissions and will prevent unauthorized access.

**Thin-film heads boost data recording, 97**

A new generation of computer disk and tape drives with higher data-transfer rates and more storage at lower costs per bit is the promise of thin-film magnetic read/write heads. Now entering the marketplace, the heads combine vacuum-deposited thin-film sensors with traditional housings.

**Erasable PROM packs 16,384 bits, 108**

Read-only memories that are erasable and programmable are finding a niche in production equipment as well as in the development cycle. Helping the trend along is a 16,384-bit ultraviolet-erasable PROM that is faster and easier to use than its smaller cousins.

**And in the next issue . . .**

A special report on packaging integrated circuits . . . using the SR-52 to plot graphs . . . the art of becoming a successful consultant.

Electronics



# Publisher's letter

**As the changes** wrought by the microprocessor ripple through all parts of the electronics industries, increasing attention is going to have to be given to troubleshooting and repairing the proliferating microprocessor-based products. The article on page 89—"Hexadecimal signatures help identify troublespots in microprocessor systems"—represents a major commitment to a new troubleshooting approach by industry giant Hewlett-Packard Co.

Author Gary Gordon says the idea presented in the article grew out of a desire to do for digital products what such troubleshooting aids as Sams Photofacts, annotated schematics showing waveforms and voltage levels, did for analog circuits and those who had to troubleshoot them.

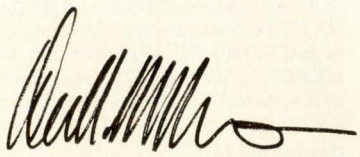
"The analog world has a lot in common with the game of horseshoes—being close counts—but the digital world is unforgiving. One bad bit out of a thousand can cause a malfunction," he notes. The technique of signature analysis finds those bad bits.

One HP engineer, he says, summed it up by observing, "We may just be sitting on the next volt"—a new unit of measure. Whereas logic probes simply detect digital activity, the signature analyzer quantizes it into a four-digit hexadecimal number. And such numbers can be listed on schematics just the way voltages are listed on analog-circuit schematics. Gordon figures that the approach, being the generator of a new unit of measure will generate a name to go with it. He adds that Hancock, a famous name in signatures, would be a good one.

**Gordon liked the** simplicity of the old-standby annotated-schematic approach and it "stuck in our minds for many years, but reducing the idea to practice proved to be very elusive." The first development was in HP's Colorado Springs division, where the use of a feedback shift register was found to be the best available way to derive a signature. HP's Loveland Instruments division contributed significantly by working out guidelines for writing the necessary stimulus routines.

First used in the HP's 3455A digital voltmeter, the technique of signature analysis now is being designed into practically all of HP's new microprocessor-based products. "About a year ago we offered 30 signature analyzers to other divisions," Gordon adds. "There now are about 40 projects under way, with some products already entering the marketplace."

He shares billing on the patent for signature analysis with development engineers Dan Kolody, George Haag, and Jan Hofland. Co-author Hans Nadig primarily worked on development of the instrument that derives the signatures, the 5004A signature analyzer, along with engineers Tony Chan and Bob Frohwerk, while Fred Coury provided a great deal of insight as a consultant on the problem of designing the technique into new products.



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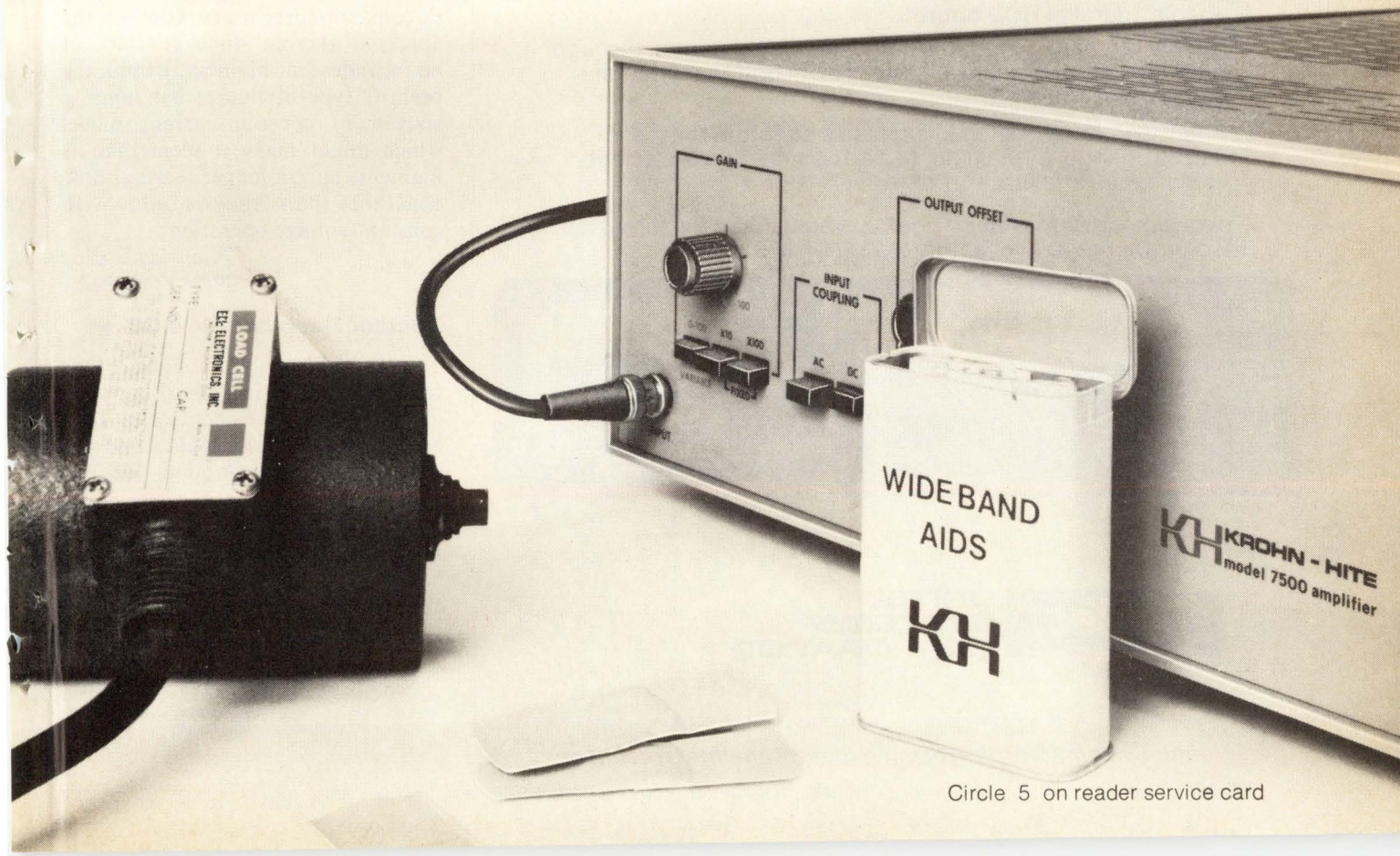


Circle 5 on reader service card

# Readers' comments

### More light on fluorescents

**To the Editor:** I certainly hope Mr. Soanes doesn't think the light of a fluorescent lamp comes (mostly) from its filaments [p. 6, Dec. 9]. Actually, I'd be willing to bet that the thermal time constant of the filaments in any type of fluorescent lamp (preheat, rapid-start, etc.) is longer than that of a typical incandescent lamp.

The pertinent parameters, I'd say, are the light-output-vs-time curve of the ionized gas inside the lamp and the decay time of the phosphor. Actually, the phosphor's spectrum seems to shift radically at twice the line frequency. It would be instructive to observe a fluorescent light through a phasable, "line-synchronized" optical chopper.

There is a special class of incandescent lamps that has a filament structure with a short thermal time constant. It might be quite practical to send Morse code with these lamps, although they may not have been used for that. See, for instance, the GE 4300, 4500, 4520, etc., which are probably in this category.

Another point that may be pertinent is the effect of constant-voltage vs constant-current operation on the apparent thermal time constant of an incandescent filament. I think the preheat type of fluorescent lamp is started in constant-current mode, which might make it seem that its filaments have a longer thermal time constant than they would with constant-voltage operation.

Nicholas Bodley
New York, N.Y.

### Another 7-segment-to-BCD-er

**To the Editor:** I thought other readers might be interested in knowing that Scarpa Laboratories Inc., Metuchen, N.J., also makes a seven-segment-to-binary-coded-decimal converter [Dec. 3, p. 116]. It is the SC-427, which is made with transistor-transistor-logic-Schottky technology. Tom Scarpa indicates that it also contains a programmed read-only memory.

Neil A. Benson
Northwest Computer Services Inc.
Minneapolis, Minn.

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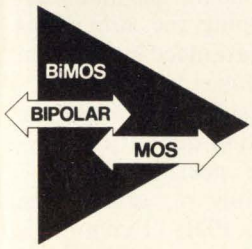


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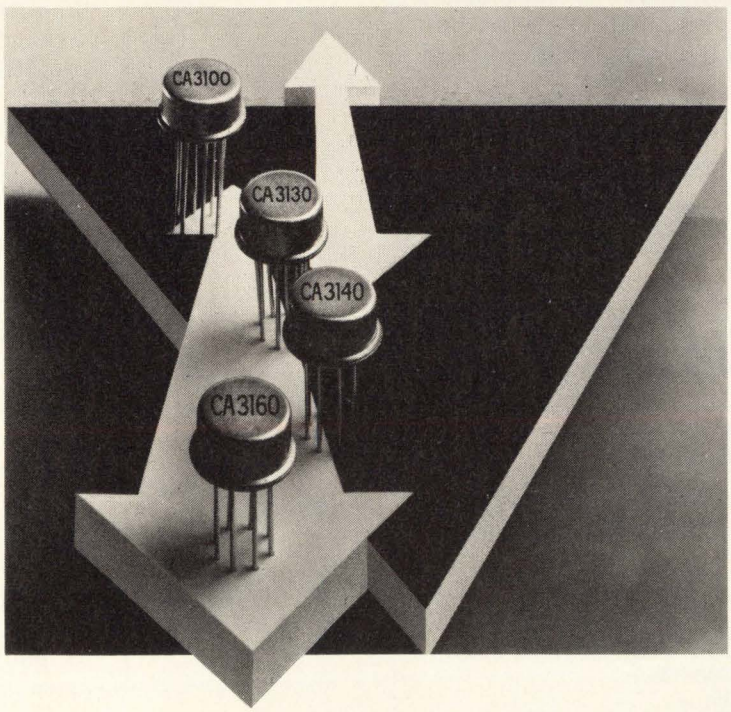


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## News update

■ Standard Microsystems Corp. of Hauppauge, N.Y., has delivered qualification prototypes of its n-channel MOS chips with the new synchronous data-link control (SDLC) protocol functions to Digital Equipment Corp. in Maynard, Mass. Standard is also making samples of the chip available to industry. At the same time, Signetics Corp. of Sunnyvale, Calif., is promising deliveries to DEC of its qualification prototype later this month, which is when both chip suppliers say they will have volume quantities of the SDLC devices available commercially.

The minicomputer company worked with both device manufacturers in developing the SDLC chips in return for guaranteed production orders [*Electronics*, Aug. 7, 1975, p. 76]. DEC doesn't plan to use the chips in production quantities, however, "until the next fiscal year," which begins July 1, says Vince Bastiani of DEC's PDP-11 communications engineering department. DEC presently supplies as an option a DUP-11 signal line interface board that provides the SDLC capability for the PDP-11 family of computers. "But that's a very dense printed-circuit board with about 110 integrated circuits on it. Using these [SDLC] chips," Bastiani continues, "can reduce the size significantly."

Standard's COM5025, which will cost $94 each for 1 to 24 pieces and $72.70 in lots of 100 to 999, and Signetics' 2652 will have some unique features in addition to meeting the DEC specs. The Standard unit will have a control field that can be extended to 2 bytes and an address field extendable to almost any length, while the Signetics device will have one address byte and one control byte. In the non-SDLC mode, the 2652 can handle either 7 bits plus a parity bit or 8 bits and no parity, whereas the COM5025 can handle 8 bits of data plus a parity bit. Also, the Standard chip can handle an all-parties address mode for global addressing. The Signetics device has a "chip select" feature that, when activated, provides compatibility to any 8-bit microcomputer system. **Bruce LeBoss**

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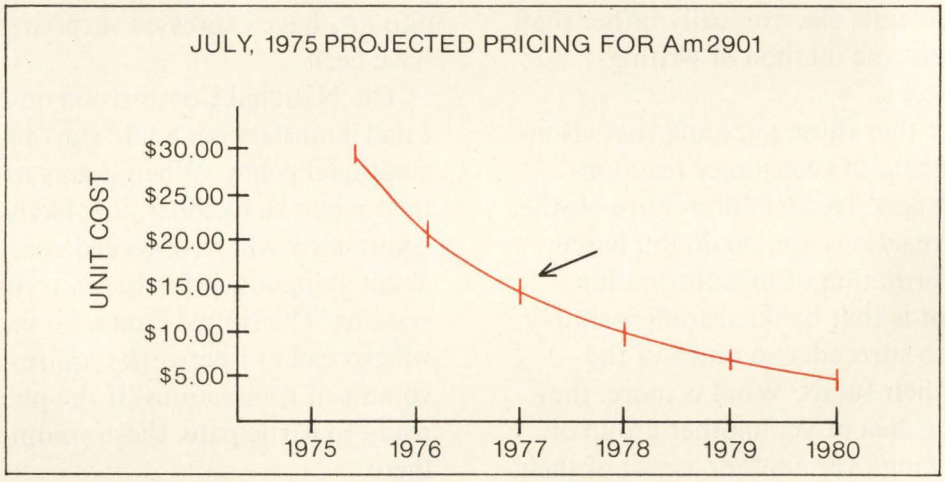


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# Editorial

## Consumers foreclose on EFT

Bankers, Government regulators, and equipment makers have all relearned a fundamental lesson in the drive toward electronic funds-transfer (EFT) systems. If the consumer is not willing to go along, the trip is off. That the consumer has been reluctant seems to be true, at least for the blue-sky vision of a national network of terminals linked to banks that would whisk money into and out of accounts electronically rather than by the cumbersome method of writing individual checks.

It turns out that those pursuing that vision did not anticipate the consumer reactions, which have ranged from indifferent to hostile. Some of the reactions are, no doubt, based on scanty information or misinformation, but the upshot is that bank customers simply do not want to surrender so much of the control over their funds. What is more, they do not like the idea of yet another group of computers taking over another aspect of their personal lives.

What consumers do like are systems that give them easier access to their money, such as cash-dispensing machines, or faster banking service, such as inquiry terminals. As long as they do not cost anything or do not impair traditional check-writing with its built-in float, new services are fine.

Apparently, consumer attitudes have not been shaped merely by reluctance to use terminals and computers, but by the impact a total EFT system would have on their ability to juggle their own finances. In addition, some 20% of the U. S. population, primarily the poor, does not use banks at all, and an EFT system is not likely to attract this segment. If anything, more automation is likely to increase this group's reluctance to have any dealings with banks.

One basic problem is that the banks and the large equipment manufacturers have not done a very good job of informing the public about EFT, probably because they were too busy working on the benefits to themselves and forgot the users. If the backlash is surprising—and some bankers who are deep into EFT have expressed surprise—it shouldn't have been.

The National Commission on Electronic Fund Transfers got a late start in formulating a national policy. When it gets to deliver its final report in October, it is likely the banking community will have cooled considerably about going much further in trying new systems. The simple economic fact is that a widespread EFT network requires a huge volume of transactions. If the public is not ready to participate, those volumes won't be there.

EFT is not the first big dream to receive a rude awakening—remember the cable-television "wired nation" concept?—and will not be the last. What is important is that the consumer (or for that matter the end-user of any product) is the final judge of what will fly. When, in their zeal to start a bandwagon rolling, companies neglect this fact, there's usually disappointment.

In a sense the EFT commission's work is already done. By forcing all the participants to focus on what EFT is and how it works, everyone came down to earth. Since it got under way, the commission has conducted its business briskly and has been open to the public as well as the press. It's a pity there was a delay in organizing it.

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# People

## Making it big in the U.S. is goal of Philips' de Lange

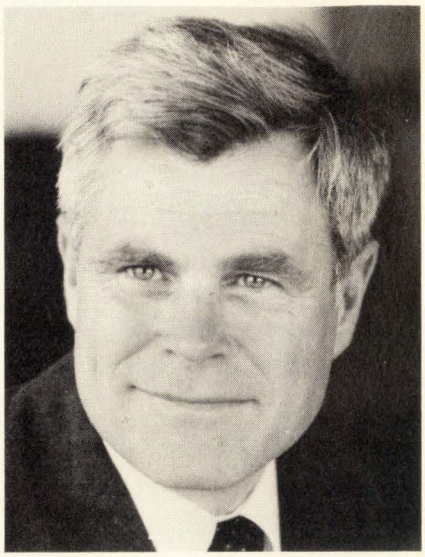
Marketing might is a major concern for the deputy director for technology of Philips Gloeilampenfabrieken's Industrial and Scientific Equipment division, Herman de Lange. He intends to help strengthen the Dutch electronics firm's position in test and measuring instruments in the world market and in the U. S. Partly for this reason, Philips recently decided to upgrade the division's test and measuring department to full "product group" status.

"The new group gives T&M operations a lot more profile and a higher degree of independence in planning investments and technical development," says the 46-year-old de Lange. A graduate of the Technical University at Delft, the Netherlands, and fluent in eight languages, de Lange points to automatic test equipment and, particularly, to test systems for microprocessors as two product areas that interest him and his company.

As for the U.S. market, he has no big changes to discuss yet. The move last month from Woodbury, N.Y., by Philips Test and Measurement Instruments Inc. to Mahwah, N.J., where the firm's X-ray and other equipment activities are housed, was made to enable sales support activities to expand, he says. Assembly operations in the U.S. are being considered for "within the next couple of years."

And Philips, which has become the No. 3 instrument maker behind Hewlett-Packard Co. and Tektronix Inc. since it entered the field in 1968, has no plans now for acquisitions in the U. S. But "this does not rule out the possibility of an expansion at some future time," he says from his Eindhoven headquarters.

How does the veteran executive of 20 years at Philips see the American market? "It makes no sense to enter that market with products that are not state-of-the-art according to U. S. criteria." The Dutch company introduced oscilloscopes into the U. S in 1973 and counters at last year's Wescon show that are "up to American standards," according to de Lange, and go beyond in terms of reliability and ease of operation for the user. "Our plans call for expanding U.S sales with high-quality general-purpose instruments and also with professional TV test equipment," he says.



**Expander.** Herman de Lange will push general-purpose, TV test equipment in U. S.

## Prime's Cashen keeps alert on technology advances

Applying new technology is an old way of operating for Prime Computer Inc.—witness its volume shipments beginning next quarter of minicomputers with high-density boards using 16,384-bit random-access memories. And Joseph F. Cashen, new vice president for engineering at the Framingham, Mass., firm, is out to keep the company alert to the latest developments in hardware technology.

For the future, the 42-year-old Cashen, in the computer business most of his career, is keeping close tabs on the development of bubble and charge-coupled-device memories. "We've seen vendors putting more emphasis on bubble and CCD memories in the past six months," he observes, adding that there seem to be accelerating CCD efforts at companies like Fairchild Camera and

# Tired of selecting 741's and 747's to get premium performance?

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If your design requires premium 741 performance that right now can be met only by a costly and time consuming "selection game," the PMI OP-02 is for you.

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Three steps to end your selection worries:

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2. Call your PMI distributor for a few OP-02's to convince yourself that PMI's specs are for real.
3. Specify the OP-02 as the **preferred** source. (You can still use the selected stuff as the second source.)

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|---|---|---|---|---|---|---|
| | MIL | Comm. | MIL | Comm. | MIL | Comm. |
| Industry Standard 741 | 6.0 | 7.5 | 500 | 300 | 1500 | 800 |
| PMI SSS741 | 3.0 | 7.5 | 10 | 50 | 100 | 200 |
| PMI OP-02 | **1.0** | **3.0** | **5** | **10** | **50** | **100** |
| Industry Standard 725 | 1.5 | 3.5 | 40 | 50 | 200 | 250 |
| PMI SSS725 | 0.18 | 1.6 | 4 | 25 | 120 | 180 |

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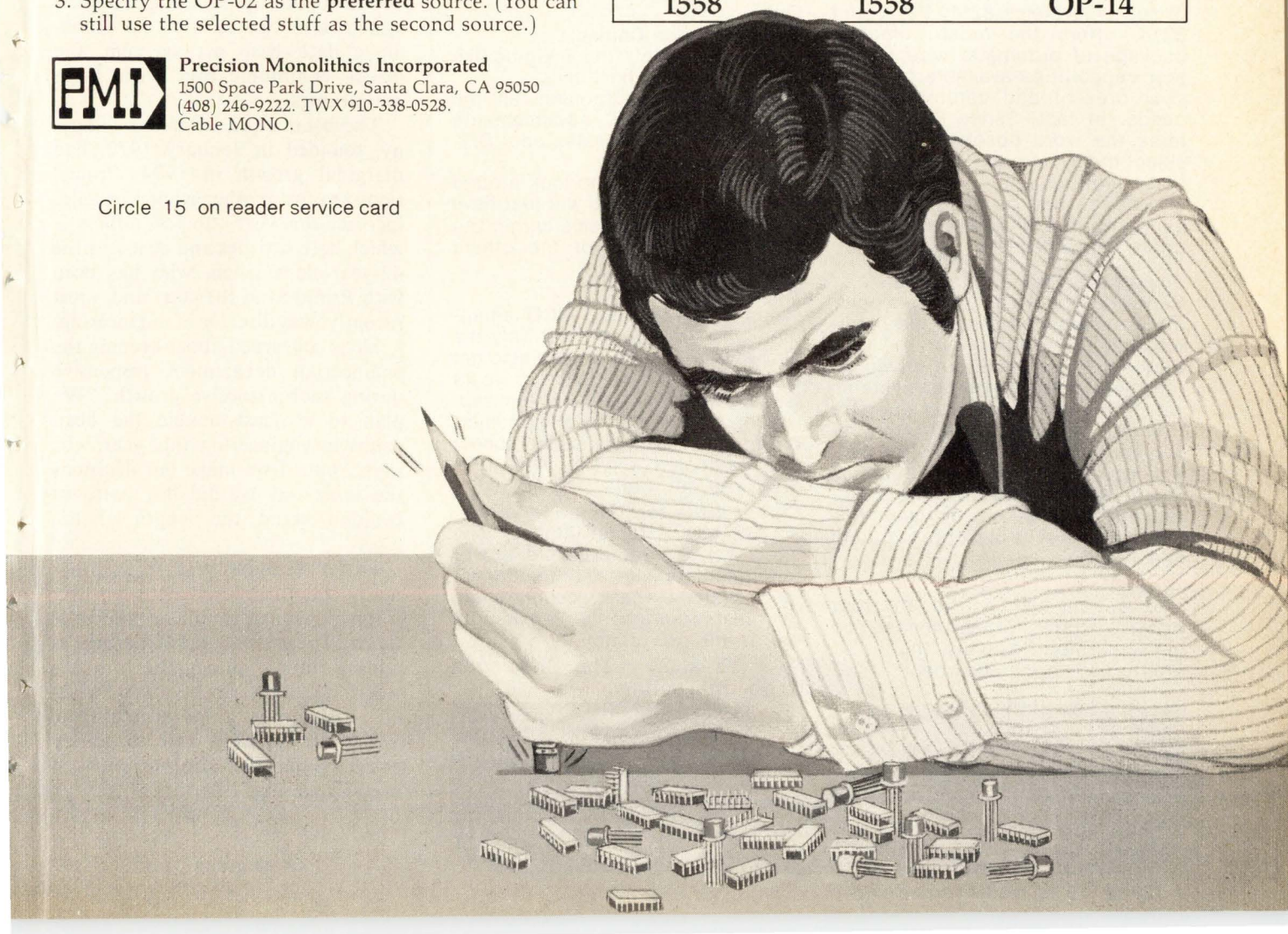

## People

Instrument Corp., RCA Corp., Rockwell International Corp., and Texas Instruments Inc.

"Things are really happening now" in CCDs, he notes. "We're not regarding them as competitive with MOS RAMs in price and performance yet, but they are beginning to push on the mass-memory technology," where Cashen expects them to be applied initially.

**Growth boom.** Things are really happening at Prime, too, as the company expands beyond its traditional computational time-sharing market into interactive data-base management systems. Prime doubled its 1975 sales of $11.3 million to $22.7 million last year as its larger computers, such as the Prime 400, began penetrating the business data-processing field. More than 70 of these systems, with prices averaging $125,000, have been shipped, and the company has just introduced the Prime 500-based Transact with a $500,000-and-up price tag. The new system also can be used for stand-alone data base management and direct communication with large mainframes.

The boom came after the company, founded in January 1972, had marginal growth in 1974. Projections are for another whopping sales increase this year—to $56 million—which both satisfies and concerns the 42-year-old Cashen, who has been with Prime from the start and, most recently, was director of engineering.

He is concerned about keeping the engineering department responsive during such explosive growth. "We plan to at least double the head count in engineering this year," he says, "but, if we make our decisions the same way we did last year, we couldn't stand the length of the pipe."

**Faster decisions.** He means that many decisions would take too long if top management alone could make them. To prevent that, Cashen is adding more management levels where decisions can be made "without building in a lot of red tape. We've always been able to deliver products quickly, and we want to keep it that way."

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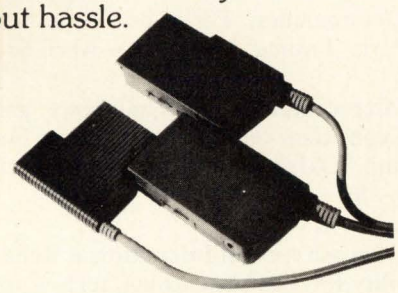

First, they're easy to interface. You simply connect your product to the appropriate HP interface card and plug into the computing controller. We know of users who have been up and running in less than a week. And you can choose from four commonly used interfaces—BCD, bit-parallel, RS-232C or HP-IB (HP's implementation of IEEE Standard 488-1975).

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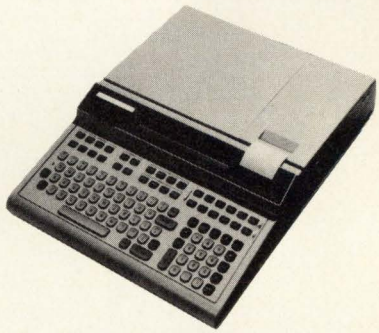

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## Meetings

**IECI '77: Industrial Applications of Microprocessors,** IEEE, Sheraton Hotel, Philadelphia, March 21–23.

**National Association of Broadcasters Annual Convention,** NAB (Washington, D.C.), Shoreham Americana and Washington Hilton Hotels, Washington, D.C., March 27–30.

**1977 International Semiconductor Power Converter Conference,** IEEE, Walt Disney Contemporary Hotel, Orlando, Fla., March 28–31.

**Salon International des Composants Electroniques,** Porte de Versailles, Paris, France, March 31–April 6.

**Microcomputer '77 Conference and Exposition,** IEEE, Lincoln Plaza Forum, Oklahoma City, Okla., April 6–8.

**Fifteenth Annual International Reliability Physics Symposium,** IEEE, Caesars Palace, Las Vegas, April 12–14.

**Fifth Annual New England Bioengineering Conference,** University of New Hampshire, New England Center, Durham, N.H., April 14–15.

**National Information Conference and Exposition,** Information Industry Association (Bethesda, Md.), Shoreham Americana Hotel, Washington, D.C. April 18–21.

**Electro '77,** IEEE, New York Coliseum and Americana Hotel, New York, April 19–21.

**Society for Information Display International Symposium,** SID (Los Angeles), Sheraton Boston Hotel, Boston, April 19–21.

**Eighth Annual Pittsburgh Conference on Modeling and Simulation,** IEEE, University of Pittsburgh, *et al.*, Pittsburgh, Pa., April 21–22.

**Annual Meeting and Exposition of the Electronics Division of American Ceramic Society,** (Columbus, Ohio), Conrad Hilton Hotel, Chicago, April 23–28.

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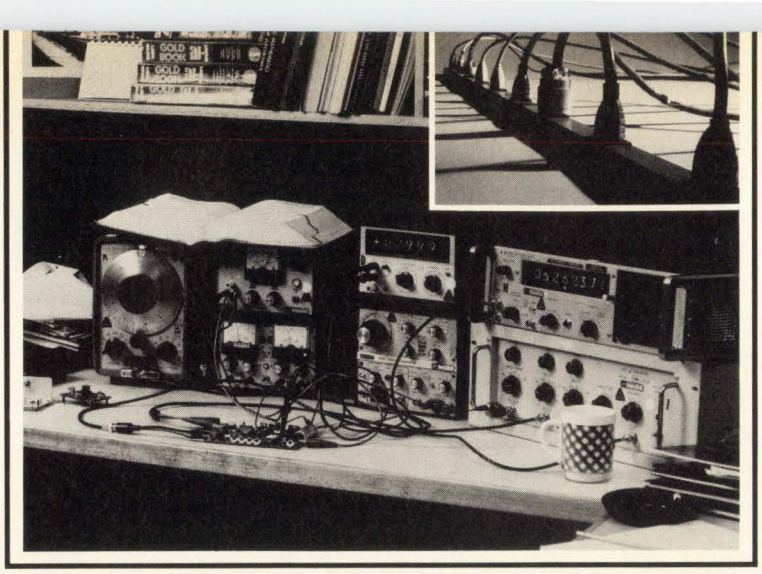
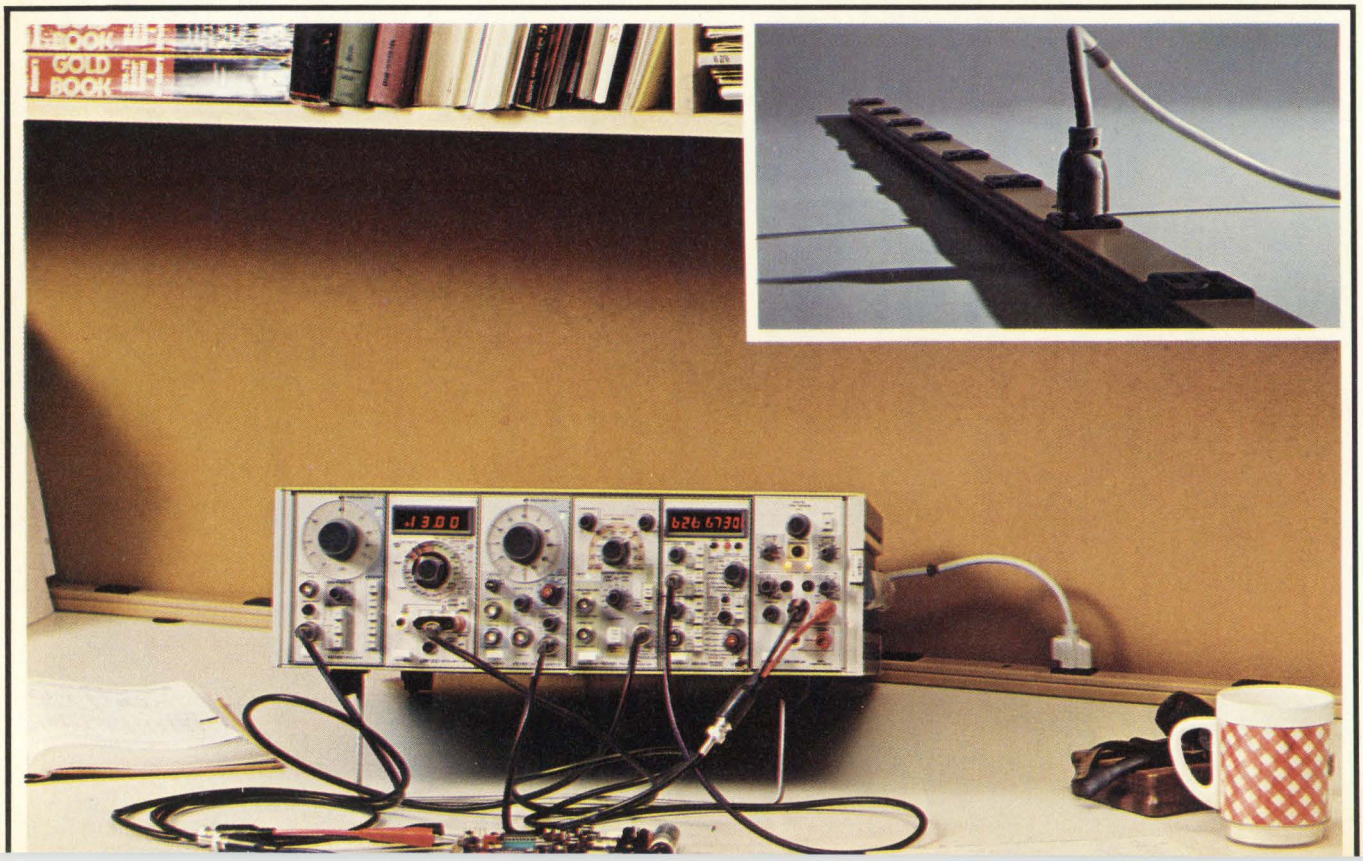
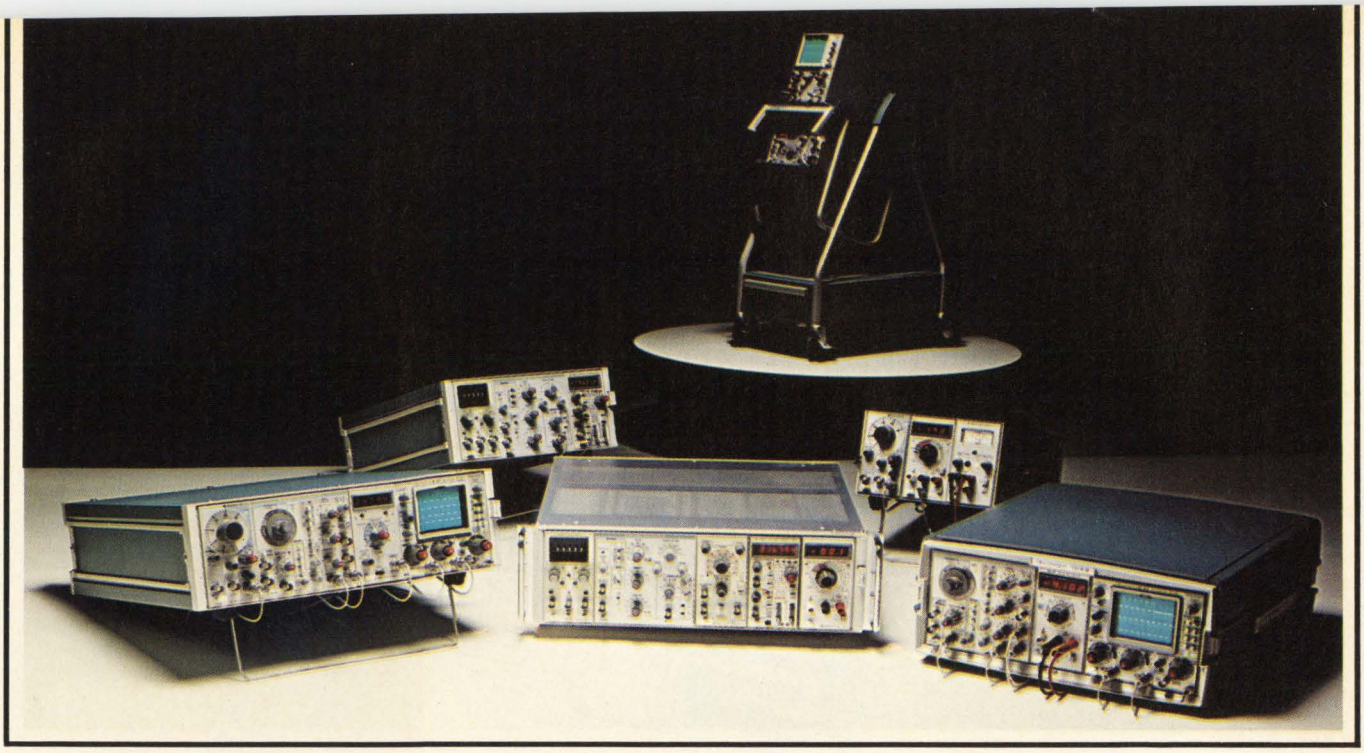


# Here's an idea that could change your thinking about test equipment.

A complete test station doesn't have to be an assortment of special-function instruments. A working workbench doesn't have to be crowded and unhandy. And a truly portable test lab doesn't have to be out of reach.

**TM 500 offers you an alternative:** a modular line of compact, interchangeable plug-ins and mainframes. Multiconfigurable both in packaging and in performance, TEKTRONIX TM 500 is designed around the idea that test equipment which is compatible in every respect can, in fact, cover a broader range of functions and meet a wider variety of measurement situations. To say nothing of its ability to adapt more readily to new challenges.





**Modular** DMMs, counters, generators, amplifiers, power supplies, oscilloscopes, logic analyzers, and word recognizers can be interfaced electrically. Signals

can be routed from one plug-in board to another via the mainframe mother board, thus enabling you to build a test instrument that's more powerful than the sum of its parts.

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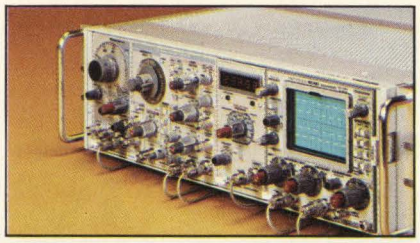

side-by-side in a 5¼-inch rack; build a rollabout station that "follows" you around the lab. Or

pack a portable test station in the small-as-a-suitcase TM 515 Traveler Mainframe, which carries up to 5 modules and typically weighs less than 35 pounds, including the modules.

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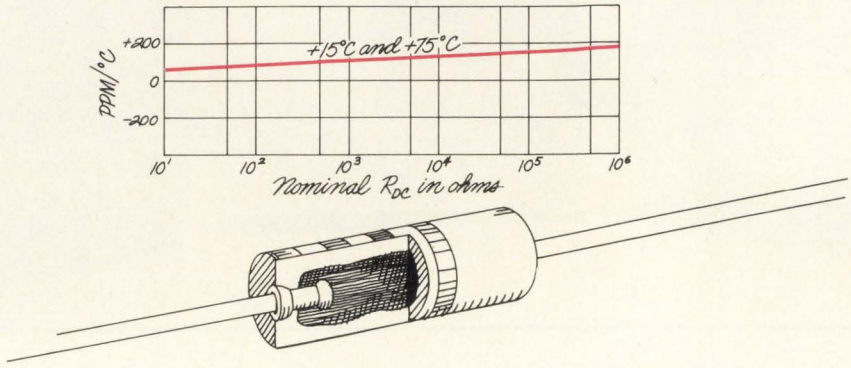


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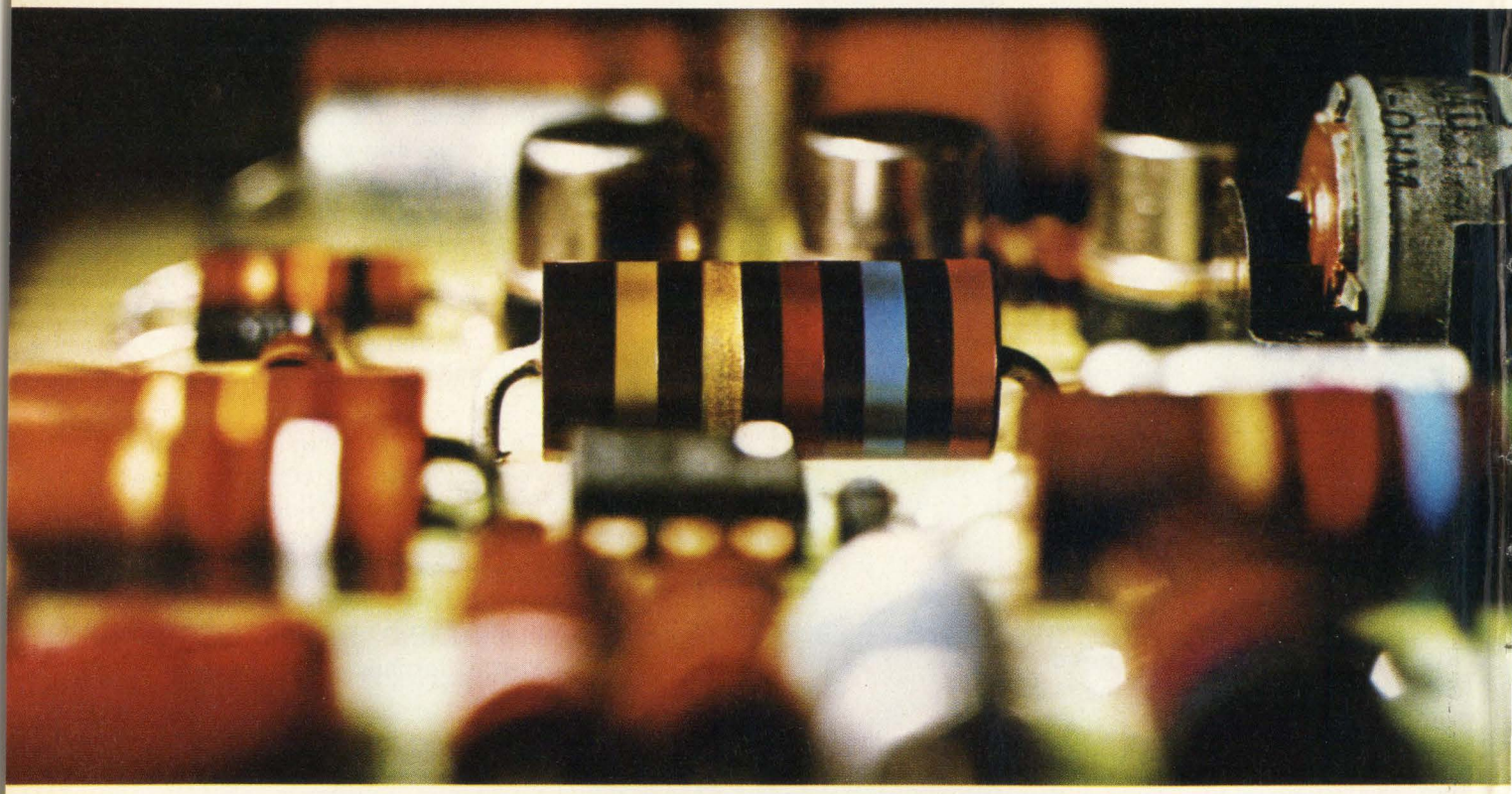

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# Electronics newsletter

**Intel to double microcomputer chip program memory . . .**

Even as Intel Corp. begins shipping samples of its one-chip MCS-48 microcomputer [*Electronics*, Nov. 25, 1976, p. 99], it is planning more powerful versions. Coming in the third quarter is a 2,048-byte read-only-memory version of the 8048 chip that **not only contains twice the program memory, but also has beefed-up computational capability.** A ultraviolet-erasable 2-kilobyte chip using Intel's new EPROM 5-volt process is also in the wind, as is a cheaper, less powerful 8047 stand-alone one-chip device for very-low-end controller applications.

**. . . and readies microprogrammable serial controller**

To work with high-performance multichip microprocessor designs such as the 8085, Intel will make available in the second quarter a microprogrammable controller chip, which Intel will program as either a floppy-disk or a synchronous data-link controller. **Most impressive is the chip's architecture: it is a dual processor.** The front-end bit processor handles high-speed (250-ns) data-bit operations, and a back-end byte processor has 46 instructions with minimum execution time of 1.25 microseconds. Easily the most impressive of the big controller chips coming on the market, the 5-volt device is built with the company's high-performance oxide-isolated n-channel MOS process, which borrows depletion-loading and substrate-biasing from its high-speed random-access-memory designs.

**Will Heath market a hobby computer kit?**

Neither company will confirm the strong rumors along the hobby-computer grapevine that Heath Co. is readying a personal-computer kit based on Digital Equipment Corp.'s LSI-11 microcomputer technology. DEC won't comment on the rumors, **but it's known that a Heath delegation recently visited the Digital Components group** in Marlboro, Mass. Of that visit, a Heath official says only that "we will have been a lot of places by the end of the year."

**Liquid-crystal light modulator moves toward development**

Reflecting considerable industry interest, Hughes Aircraft officials are moving toward commercial development of its cadmium sulfide/liquid-crystal "light valve." Developed at Hughes' Malibu research laboratories [*Electronics*, Dec. 11, 1975, p. 30], **the device allows real-time manipulation on an image, including brightening, enhancing, and projecting.** Along with transferring work from Malibu to the Industrial Products division, Carlsbad, Calif., for engineering development, a market study will be conducted on the best way to exploit the device. Alex Jacobson, who was instrumental in earlier valve work, will direct the effort as manager of liquid-crystal programs.

**Distributed processing will 'fly' at RCA**

Distributed processing systems in space are no more than one or two years away, says Charles Staloff, manager of command and data handling at RCA Astro Electronics in Princeton, N.J. **Replacing brute-force logic and a central computer, a distributed-processing architecture with microprocessors allotted for distinct functions will appear in the next generation of spacecraft,** he says. The RCA Corp. division has already developed some microprocessor-based modules to handle such functions as telemetry, powering, attitude control, command decoding and processing, data busing, and some guidance calculations.

# Electronics newsletter

**Congress urged by IEEE to halt wage busting**

The Institute of Electrical and Electronics Engineers is lobbying Congress hard to support legislation to halt "wage-busting" tactics by service contractors at Federal installations. Wage busting, according to IEEE, occurs when **engineers are threatened with layoffs unless they agree to accept salary cuts when a service contract must be renewed.** The outlook for the institute's efforts appear promising in view of the introduction of legislation cosponsored by Representatives Frank Thompson, Jr. (D-N.J.), chairman of the House Education and Labor subcommittee on labor-management relations, and James C. Corman (D.-Calif.).

**TI halves 8-k EPROM prices . . .**

In a move that signals still further reductions, Texas Instruments is halving the prices of its family of erasable programmable read-only memories. In lots of 100, the company's 8,096-bit TMS2708 is now $32.75, and the TMS27L08, the low-power version, is dropping to $37.75. **What is more, the price of its new 16,384-bit TMS2716, samples of which were ready last month, will be $54.75**—less than the published price for Intel Corp.'s 8-bit part. The TI 16-bit EPROM, which will go into volume production next month, plugs into 2708 sockets, and it has an access time of 450 nanoseconds. Typical power dissipation is 375 milliwatts; maximums are 700 mW at 0°C and 500 mW at 70°C. This month, the company also will start distributing samples of the industry's first full-temperature-range (−55 to +125°C) 8-k EPROMS.

**. . . as National cuts op-amp price tags**

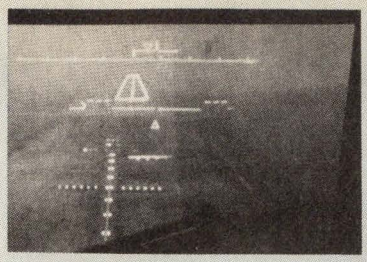
Citing improvements in manufacturability and yields, National Semiconductor Corp. is reducing prices on its bi-FET series of operational amplifiers by 25% to 70%. In addition, the Santa Clara, Calif., firm is introducing the LF351 op amp, **a possible precursor of a new series based on an improved, lower-cost process.** Priced at 48 cents in volume, the new part has performance specifications that are 30% to 60% better than the nearest comparable part, Texas Instruments' TL081, which costs 52 cents.

**Semi readies 8-k static RAM**

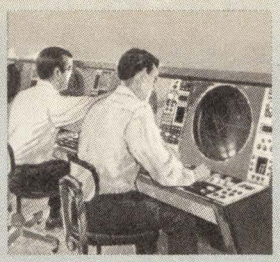
While most of the industry still struggles with 4,096-bit MOS static RAM designs, Semi Inc., the Phoenix-based semiconductor division of Electronic Memories and Magnetics Corp., is looking ahead to the 8,192-bit level. According to John M. Hartman, product design manager, the firm will be offering a 1,024-by-8-bit device by the end of the year. **The 24-pin 8108, which will run from a single 5-volt supply and operate in the 300-nanosecond range,** will be pin-to-pin compatible with the popular 2708 ultraviolet-erasable PROMS. Also to be introduced is a 2-k static RAM that will be socket compatible with Fairchild's 3539, which Semi plans to supply in its own 300-ns version.

**Univac computer to use bubbles**

Sperry Univac's R&D work in bubble memories may bear its first fruit before 1977 is out. The Sperry Rand Corp. division in Blue Bell, Pa., plans to use bubble memories in a computer system, and feasibility models will be out for field evaluations no later than early 1978, according to a spokesman in the division's Research and Advanced Technology department. **Whether the bubble memories initially will be used for a new computer or retrofitted into an existing system has not been decided yet.**



HEAD-UP DISPLAY SYSTEM



GROUND STATION DISPLAY SYSTEM

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These low-noise, high-quality thick-film D/A converters are all processed in accordance with the exacting requirements of MIL-STD-883 . . . and are actively at work in such demanding environments as head-up display systems, ground station displays, video processing systems and others where ruggedness and reliability are the only things that really counts! All are proven performers.

If your requirements are for the best possible display DACs, let us send you full details on these perfect problem solvers.

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- DDAC — Ultra-low glitch available as two DDIP packages, plus TO-3 case with 13-bit monotonic output, programmable ±2.5, 5 or 10V outputs with 500 mA coax drive capability. 25ns one LSB settling, internal or external reference with short circuit protected output.
- SDAC — Compact 13-bit, 24-pin DDIP with settling time of 500ns @ 2.5V, 1μsec. for .5V and 1.6 μsec. for 10V, to .05.

# DDC sets the pace in display DACs...

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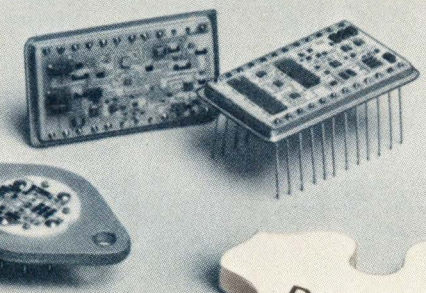

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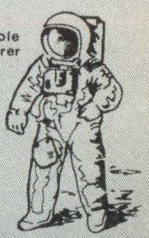

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## The PPS 4/1 family of one-chip computers.

| Model | MM76 | MM77 | MM78 | MM75 | MM76C | MM76D | MM76E |
|---|---|---|---|---|---|---|---|
| Description | Basic 76 | Basic 77 | Jumbo 77 | Economy 76 | High speed counter* | 12-bit A/D converter | Expanded 76 |
| ROM (x8) | 640 | 1344 | 2048 | 640 | 640 | 640 | 1024 |
| RAM (x4) | 48 | 96 | 128 | 48 | 48 | 48 | 48 |
| Total I/O lines | 31 | 31 | 31 | 22 | 39 | 37 | 31 |
| Cond. Interrupt | 2 | 2 | 2 | 1 | 2 | 2 | 2 |
| Parallel Input | 8 | 8 | 8 | 4 | 8 | 8 | 8 |
| Bidirectional Parallel | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Discrete | 10 | 10 | 10 | 9 | 10 | 10 | 10 |
| Serial | 3 | 3 | 3 | – | 3 | 3 | 3 |
| In-line package | 42 pin quad | 42 pin quad | 42 pin quad | 28 pin dual | 52 pin quad | 52 pin quad | 42 pin quad |
| Availability | Now | Now | Now | 2Q 77 | 2Q/77 | 3Q 77 | 16 wk ARO |

Power supply is 15v except low voltage version of Basic 76 available 3Q 77.
Typical power dissipation is 70mw.
*Two 8-bit or one 16-bit presetable up/down counter with 8 control lines.

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To help control development costs, Rockwell makes available a universal Assemulator that lets you assemble, edit, develop and debug programs, as well as load PROMs. Special development circuits enable prototyping.

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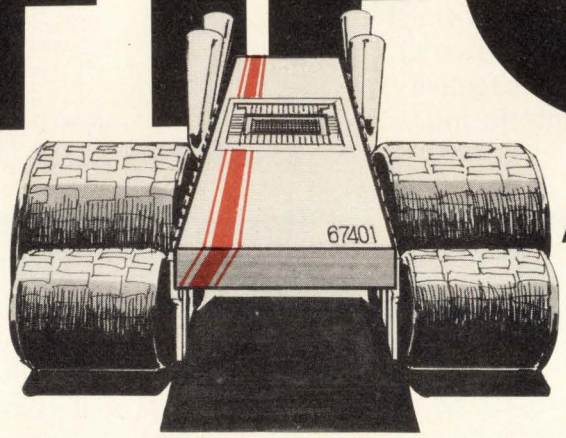


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| Device | Temperature | Pins | 100 up Price |
|---|---|---|---|
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| 57401 | Military | 16 | $56.00 |

## Features

15 MHz typical speed
64 x 4 organization
Expandable in width and length
16 pin package
Pin compatible with Fairchild 3341 1 MHz MOS FIFO
TTL compatible

## Applications

Disc to system data transfer
Buffer between head-per-track disc and memory
Slow memory to high speed CPU data transfer
Radar data acquisition

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# Monolithic Memories

# Three-pound printer duplicates a CRT screen in a second

Spinning at 1,800 rpm, unit prints 2,200 c/s on 4-inch-wide paper, costs as little as $300

**Using a radically** new design, a company has put together a printer that operates at 2,200 characters per second, yet sells in quantity to original-equipment manufacturers for as little as $300. Before next year, the company, which had never before built a printer, will be making a 4,000-c/s machine for only 30% more.

The innovator is SCI Systems Inc., a $25-million-a-year designer and manufacturer of electronic systems and products for aerospace and industrial applications. The Huntsville, Ala., company has supplied its printer to Docutel Corp., which is ecstatic about its performance in a cathode-ray-tube administrative terminal being built for banks.

"It's unbelievable," declares Christopher H. Williams, a senior product manager at Docutel in Dallas. "Not everybody we show it to believes it, either. They think we have a trick up our sleeves when they see a whole [CRT] screen put on paper in a second."

Even though chain printers of the IBM 1403 type, as well as drum and laser printers, can print 2,200 characters per second and more, they sell for well above $20,000.

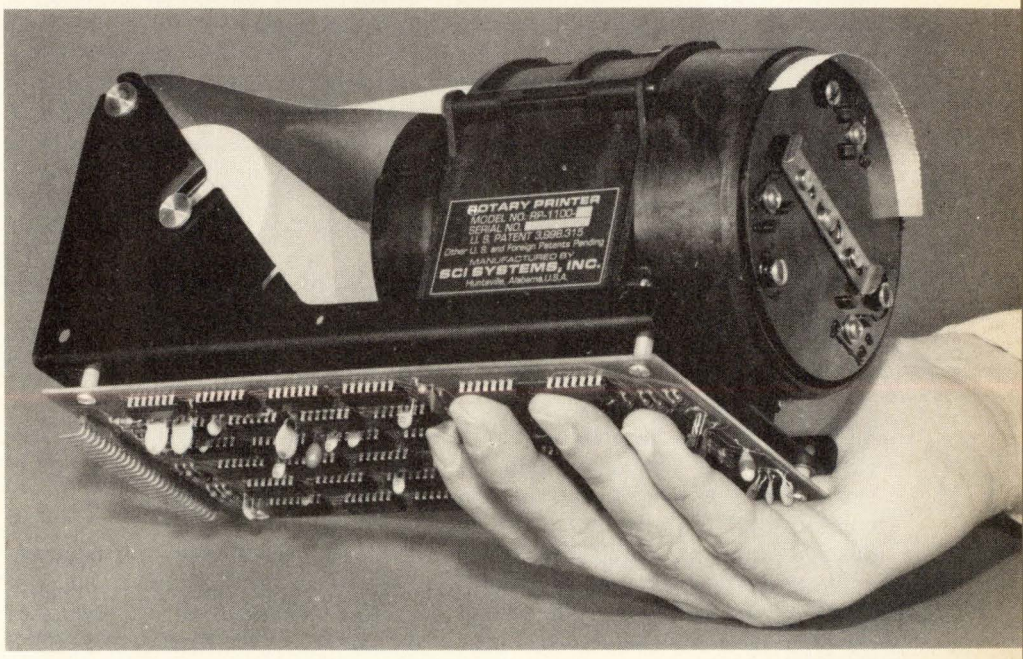
The operating assembly of SCI's rotary printer, which writes by zapping current through electrosensitive paper, resembles a squat electric motor and is about 4 inches in diameter and 6 in. long. It writes across 4-in.-wide paper in the 132- or 136-column format of standard computer printouts. With its electronics and a paper feeder, the printer is about 9 in. long and weighs three pounds. It prints in a 5-by-7-dot matrix, but a 7-by-9-dot format will be available within four months, says president Olin B. King.

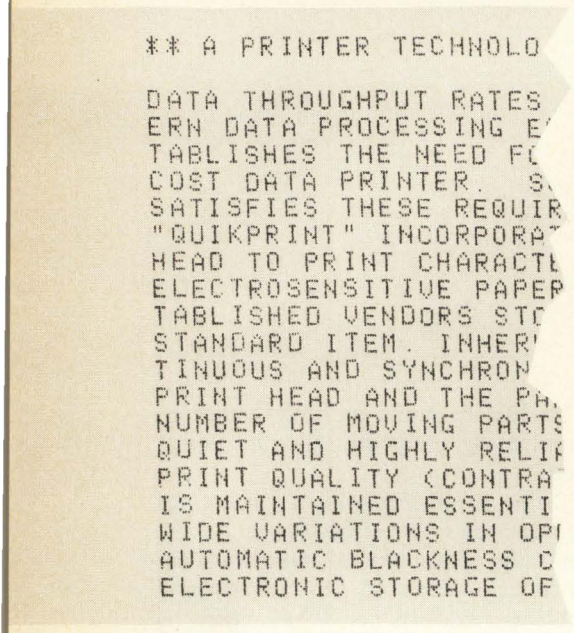
SCI's printer design is different because there is continuous motion of both the writing head and paper; once in motion, there is no stopping or starting of one or both as is usually the case, says King. In addition, the actual speed of the writing head is flexible; electronics synchronizes it to the speed of the paper at any instant. Writing is so fast, it is feasible to make multiple copies by reprinting each message, he points out.

The print mechanism consists of three rows of styluses, each row parallel to the axis of the cylindrical printer and spaced 120° apart round its circumference. The paper is curved to match the cylinder, in an arc that subtends the same 120°.

For the 5-by-7-dot matrix, there are five weighted tungsten-alloy styluses in each row, connected to a central rotor by fiberglass leaf springs. A small dc motor turns the rotor with a nylon belt. As the styluses whirl around at 1,800 revolutions per minute, centrifugal force pushes them outward against the paper. An entire vertical column of

**Speeder.** With a 4-inch-wide roll of electro-sensitive paper and its electronics on a printed-circuit board, rotary printer from SCI Systems fits easily in one hand.






characters is printed as the print head turns through 120° across the 4-in. depth of the paper, and the paper then moves into position for the next vertical column.

**Perseverance.** King had the idea about two and a half years ago, but it took about $1 million for his engineers to realize it. "At first they told me it couldn't be done, but I told them to keep at it," says King. "I had to maintain my self-respect," he adds with a chuckle. SCI has built the print head into a hockey-puck-like package that plugs easily into one end of the printer. At $40, or $25 with a trade-in, the head is "quasi-expendable," says King, who adds that it is good for 25 million characters before it must be replaced.

Most of the electronics for the printer fits on a single printed-circuit board mounted beneath the unit. It contains a standard RS-232-C serial or parallel interface to go "from the outside world to a full-page buffer memory," King says. However, he will supply any interface desired.

The buffer memory consists of 4,096-bit metal-oxide-semiconductor random-access devices. Eight of them buffer a page of up to 136 columns of data. Information is read out through an off-the-shelf character generator that drives the inputs to the stylus drives. The position of the styluses is indicated by slots near the outer circumference of an optical code wheel, which are sensed by a photocell. The position of the code wheel determines the time writing current is applied to each stylus. The printer dissipates 5 watts standing by and 50 watts when it is printing.

**Here's the word.** Print head, which pops into printer's plastic housing, writes one complete column at a time as paper, shown in real size, moves from right to left.

**Larger printer.** By the end of the year, SCI will be producing a larger-diameter 6-pound unit that will write at 4,000 c/s, King claims. Its 7-by-9-dot matrix will write in several modes, including 50 lines and 80 columns, 50 lines and 132 or 136 columns and on 8½-by-11 or 8½-by-14-in. paper.

SCI's $300 price applies to OEMs that order at least 1,000 printers per year. These are supplied with a simple interface and work off a power supply in the OEM's terminal. The price for a more complex unit with an RS-232-C interface, a power supply, and fully buffered for 136 columns can reach $995. □

## Memories

# Intel, AMI promise 50-ns devices

Memory speeds below 50 nanoseconds are the promise of two metal-oxide-semiconductor technologies announced at the recent ISSCC. Such speeds signal an invasion by static-MOS random-access memories of the territory pretty much owned by bipolar RAMs—high-performance cache and buffer memories. At stake is a $50 million market expected to double by 1980.

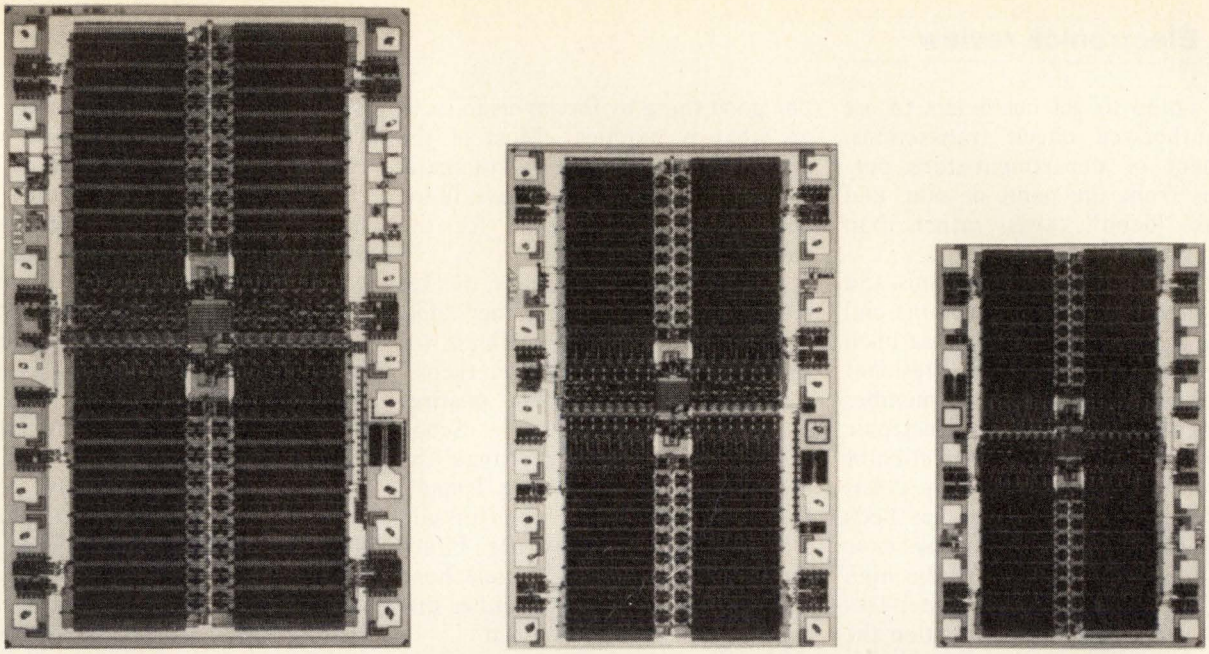
Two Santa Clara, Calif., firms unveiled the new MOS techniques last month at the International Solid State Circuits Conference in Philadelphia. Intel Corp. presented an advanced oxide-isolated process, and American Microsystems Inc. reported on its V-groove process.

Unlike the mainframe memory market, which is dominated by 150-to-300 ns dynamic MOS RAMs, the cache and buffer systems presently are served almost exclusively by static RAMs built with bipolar technology. Fairchild Semiconductor, Mt. View, Calif., is the principal supplier of these RAMs with over thirty 256- and 1,024-bit transistor-transistor and emitter-coupled logic devices. The only MOS device that's presently available for these applications, Intel Corp.'s 70-ns 2115 and 2125, are acceptable for only the slowest systems.

**All stops out.** Intel Corp.'s memory design group, directed by Richard Pashley, has developed an advanced MOS technology that pulls out all MOS processing stops: 4-micrometer channel length (compared to 6 μm for products on MOS chips), a gate-oxide thickness of less than 1,000 angstroms (compared to 1,200 angstroms), and arsenic-doped junctions of less than 1 μm. (Many semiconductor specialists feel these parameters are about the limit obtainable with present production-line photolithographic methods).

When this scaled-down cell geometry is applied to Intel's substrate-biased static RAM designs (2115 and 2125 types), it results in single 5-volt devices with typical access times of 45 ns, active power dissipation of 500 milliwatts, and standby power dissipation of 35 milliwatts.

The new 2147 4,096-bit MOS statics fit on a die measuring only 25,000 mil², about the same size as proposed 4-k bipolar RAMs but with considerably less power dissipation.



**V-MOS power.** AMI's soon-to-be available S4015 1-k static RAM, left, has access time of 45 ns on 10,000-mil² die. Versions to come—with 35 ns on 6,900 mil², middle, and 28 ns on 4,400 mil², right—indicate performance potential of V-MOS technique.

In memory fabrication, die size determines production costs for a given process. So the Intel MOS devices, in volume production, could for the first time provide an extremely competitive cost-performance alternative to bipolar RAMs for buffer systems.

The firm will not disclose its production schedule for the 2147; some industry sources say it is already in sample production. In any case, the company generally saves its most impressive design disclosures for the ISSCC and has rarely disclosed the details of a device it did not build within the year.

**V-MOS RAM.** Just as impressive are the V-MOS RAM techniques developed at AMI. According to T. J. Rodgers, director of the firm's static program, applying the technique to a 1,024-bit static device results in extremely impressive performance, even when the chip uses relaxed 6-$\mu$m rules. The 5-V 1-k part, AMI's S4015, will have a typical access time of 45 ns and a chip about 10,000 mil², or about as large as the best oxide-isolated walled-emitter TTL 1-k RAMs from Fairchild. It will be ready for sampling in May or June.

More important in gauging the V-MOS impact on RAM designs is the scaling data Rodgers has made available. Shrunk versions of the 4015, built with 5-$\mu$m rules, would operate typically at 35 ns on 6,900-mil² dice. With the 4-$\mu$m rules, a 1-k 4015 would operate at 28 ns and occupy only 4,400 mil². Such scaling also holds for 4,096-bit designs, where most of the MOS and bipolar competition will unfold. Using current 6-$\mu$m rules, a V-MOS 4-k part would fit on a chip less than 22,000 mil², with 45-ns typical access times. When shrunk, the 4-k static chip would attain 35 ns and measure about 15,000 mil²—considerably less than either Intel's disclosed 4-$\mu$m part or an equivalent bipolar 4-k design.

Of course, Fairchild is not sitting still over its bipolar process, which dominates the high-speed memory market. Recently, the company shrank its entire line of 1-k parts about 30%, while lowering access times to the 35-ns range. It has ready samples of a 4-k design (TTL and emitter-coupled-logic versions) that should stand up well under the MOS attack.

Thomas Longo, vice president and director of research for Fairchild Camera and Instrument Corp., Mountain View, Calif., says the 93470 and 93471 4-k TTL parts, scheduled for sampling next quarter, have typical access times in the 30-to-35-ns range and fit on chip areas of 23,500 mil². An ECL version scheduled for the third quarter will have 25-ns typical access times. Shrunk versions of the 4-k parts will fit on 21,000-mil² chips. □

## Commercial

# Depositors balk at funds-transfer services, forcing banks to modify their system plans

A funny thing happened to electronic funds transfer systems on the way to the bank—depositors decided that they prefer to hang onto their present check-writing procedures, thank you. This resistance has caused bankers to modify their dreams of a national computerized communications network that would convert all transactions from paper to electronic signals triggered by plastic cards.

"Usage of most EFT systems [initiated by banks or bank consortiums] has ranged from minimal to nonexistent," says Robert L. Kramer, president of Actionfacts Inc., a New York research firm. Banks

have failed to get customers to use pre-authorized check transactions, payment of department-store purchases from the point of sale, and plastic "debit" cards, rather than credit cards.

Just what types of programs and hardware savings and commercial banks will actually use were outlined in an interim report to President Carter last week by the 27-member National Committee on Electronic Fund Transfers at the completion of its first year of intensive study. EFT is not dead, but the concept has been toned down by consumer resistance to radical changes and by the high cost of converting to paper-less credit and debit, not to mention the myriad problems of standardizing procedures and regulating the whole network. Also, fears that the present check-handling system would founder under a wave of paper, estimated at some 27 billion checks last year, proved to have been exaggerated.

**Balkers.** Why have consumers balked at electronic money? Speaking to a recent meeting of mutual savings banks' operations managers, Verne S. Atwater, president of Central Savings Bank of New York and a member of the EFT commission, said the two major concerns have been loss of control over personal funds and loss of privacy in managing them. Atwater has proposed that the commission recommend a "consumers' EFT code" that would specify the respective rights and responsibilities of the consumer and financial institutions in the use of plastic cards, direct payroll deposits, and pre-authorized payments. The code would cover liability for a lost card, stop-payment procedures, and other measures for consumer protection.

But despite EFT setbacks, the commission will include some important EFT successes when it submits its final report in October, Atwater says. For example, consumer acceptance of cash-dispensing machines and automated teller terminals is now widespread, and hardware manufacturers are marketing them hard. As one sales manager observes, "The EFT commission has already done one good thing by forcing us to focus on what is practical. Most of the glamorous things, such as automatic exchange among banks, have failed because they were good for the banks, not the users."

Concurring with this view, market researcher Robert L. Kramer adds, "Such failures are not worthless, for the industry has learned from them." Among these pioneering misfires have been the California Scope project for interbank exchange, the Hempstead Bank of Long Island's Instant Transaction point-of-sale store hookup, and Seattle First's attempt at marketing a telephone transfer system—all now either discontinued or greatly modified.

Hardware manufacturers, such as IBM, NCR, Mosler Safe Co., and TRW, agree with bankers, however, that EFT systems have a future, even though the pace of their adoption has been greatly slowed. Besides the cash-dispensing and automated teller machines there have been other successes. The direct deposit of Social Security payments is catching on; by last summer, about 14% of all Social Security recipients were having their payments sent directly to their bank accounts.

Moreover, as high as 10% of the work force in some states participates in direct-payroll-deposit programs. Both consumers and merchants have accepted bank systems that review deposits and guarantee check payments at the point of sale.□

## Microprocessors

# Texas Instruments and Motorola pare down microprocessors for lower-range market

With an eye toward the medium- and low-performance range of the microprocessor market, Texas Instruments Inc. and Motorola Inc. are readying devices that will pare minimum system requirements to two chips, rather than the five or more now needed. What's more, for the low-end controller market both firms are talking about year-end availability of single-chip microcomputers that will retain software compatibility with their existing flagship microprocessors: the 16-bit TMS9900 for TI and Motorola's 8-bit MC6800.

These new entrants are intended to compete in the burgeoning byte-oriented market that falls just below the multichip high performance microprocessor families such as Intel Corp.'s new 8085 [*Electronics,* Dec. 9, p. 31], Motorola's 6800 and Rockwell's PPS-8. They will compete with other two-chip systems already on the market such as the F-8 from Fairchild and Rockwell's PPS-8/2 [*Electronics,* Sept. 16 p. 52].

Texas Instruments started offering samples of its TMS9980 last month. While internal operations match that of the 9900, the firm has gone to an 8-bit bus to drive down costs. "The 16 bits of data have to be multiplexed in, but that saves us enough pins to use a 40-pin package," says Edwin S. Huber, microprocessor marketing manager at the firm's Houston facility. Forty pins, instead of the 9900's 64, allow use of plastic packages "that will give the 9980 a two-to-one cost advantage over the 9900," he says. The company plans to sample the part in the second quarter.

Besides the processor, the new 9980 includes an on-chip clock, and users will be able to strip even more cost out of the system when a companion chip comes along in the third quarter. Designated the TMS9972, it will incorporate 2,048-by-8 bits of read-only memory, 128-by-8 bits of random access memory, and input/output circuitry.

"We anticipate the customer will be able to build a complete system for a cost equal to or less than that of an 8080 system," Huber says. But he emphasizes differences that keep the systems from head-on competition. While TI is retaining the full

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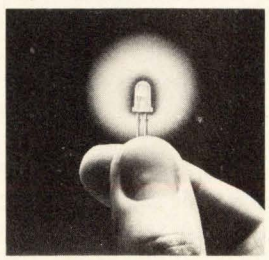

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## Electronics review

3-megahertz operation of the 9900, some operations—such as high-speed interrupt handling or moving blocks of data—will be slower because of the multiplexing.

But the instruction set of the 9980, with high-speed multiply and divide and the ability to perform multiple-bit shifts, will edge it into higher performance applications. "It will be especially good for those cost-conscious 8-bit applications that need some high numerical precision, such as numerical-control or process-control systems," Huber says.

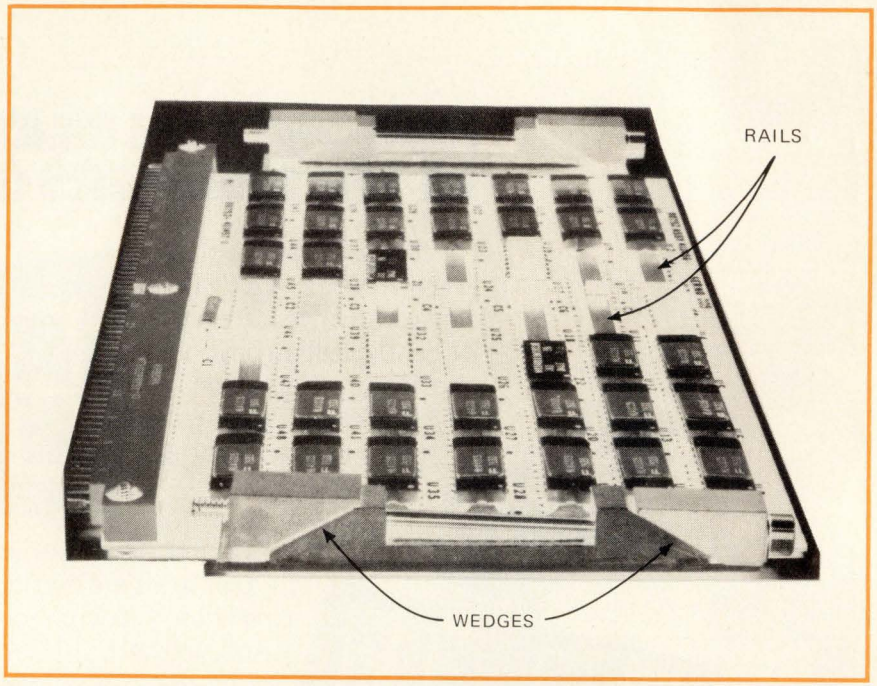
Motorola has taken a similar partitioning approach on chips that will be available in samples later this month. Besides the registers and accumulators of the MC6800, the new MC6802 will contain an on-chip clock oscillator and driver and 128 bytes of RAM, says Colin Crook, group operations manager for micro products in Austin, Texas. The MC6802 is matched with the custom MC6846, giving the two-chip system 2,048 by 8 bits of mask-programmable ROM and an 8-bit bidirectional data port. The second chip also has a 16-bit programmable timer, unloading some of the processor's responsibility for interrupt timing and counting functions.

Further down the low-end spectrum are the firms' one-chip microcomputers. Both are reluctant to discuss details of the devices. "Unlike new Intel on-chip offerings, ours will be totally compatible with the rest of 6800 family," Motorola's Crook says. Texas Instruments, too, is aiming for such compatibility. □

## Packaging & production

# Rails, wedges keep pc cards very cool

Photocircuits' proprietary technique for achieving high-density wiring on printed-circuit boards has been employed primarily as an alternative to multilayer pc boards. However, with some modification, the so-called multiwired boards can also significantly increase power dissipation,




**Cooler.** Rails and wedges added by AIL division of Cutler-Hammer conduct heat more efficiently from multiwired circuit boards in B-1 avionics.

say thermal-design specialists now checking out the defensive-electronics package for the B-1 bomber at AIL division of Cutler Hammer Inc., Deer Park, N.Y

The package incorporates high-speed logic circuits. By adding heat sinks to the boards and improving heat-transfer techniques, the designers have boosted heat dissipation until it is five to eight times as high as from conventional pc boards. In the process, the engineers are thermally controlling some 70 "black boxes," or line-replaceable units, which cover a broad range of power dissipations and environmental conditions. Dissipation per box, placed at locations in the bomber where the maximum temperature varies from 160°F to 265°F, starts at 8 watts and reaches 150 W.

**Short lead time.** One of the most compelling reasons for using the modified multiwired circuit boards is the ability to design and fabricate them in relatively short order. The lead time for heat-sunk multilayer boards would have been much too long, especially when it came to making modifications suggested by flight-test results, explains Pete Ingrassia, AIL's section head for mechanical design on the B-1 project.

The multiwired boards are fabricated at the Glen Cove, N.Y., facility of the Photocircuits division of Kollmorgen Corp. There, special machines lay a matrix of insulated wires on an adhesive-coated glass-epoxy board. In component density, it is equivalent to a multilayer board.

Power dissipation is boosted by adding heat-sink rails along with special mounting wedges (see photograph above). These wedges, in turn, transfer heat to the main heat sink of each line-replaceable unit. This sink is an oil-cooled chill plate, assembled with a special fluxless brazing technique to prevent long-term corrosion.

The rails, made of aluminum, or, for higher power dissipation, copper, are riveted onto each pc board. They bear directly against the bottom surface of the dual in-line packages mounted on the board. This contact transfers heat more efficiently than can a conventional pc board, which has a gap of 20 to 60 mils between the DIP and the board.

With heat-sink rails alone, a 4-by-7-inch board could dissipate 5 to 7 W. However, the thermal wedges raise power dissipation of the card to 24 W, points out Ken Garcia, AIL's

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in-house consultant on thermal design. He predicts that this kind of board design is "the future circuit card for high-speed logic applications with their high power-dissipation requirements." □

## Communications

# Carrier asks to set up Motorola system

American Radio-Telephone Service Inc., a regional radio common carrier in Baltimore, has asked the Federal Communications Commission for permission to establish a cellular mobile-radiotelephone service in the Baltimore-Washington area. ARTS is proposing a three-phase 24-month, $2.5 million program for a system operating between 800 and 900 megahertz to cover 1,500 square miles. The carrier is relying on technology and equipment from Motorola Inc.

The FCC is also reconsidering a request by AT&T's Illinois Bell Telephone, rejected last year, to build a similar system in the Chicago area—Motorola's headquarters. A cellular system divides a geographic area into hexagonal units and places antennas at alternate corners of each hexagon. The antennas broadcast signals to mobile users, who are handed off from one cell to the next as they drive through the system [*Electronics*, Jan. 3, 1972, p. 100].

**Markets.** Beyond the ARTS system, which Motorola calls Dynatac, for dynamic adaptive total area coverage, Motorola expects its investment in developing cellular mobile technology to run between $18 million and $19 million. Starting five years ago, Motorola submitted two technical proposals to the FCC for cellular telephone systems in accordance with the commission's Docket 18262 that makes available the so-called 900-MHz region for land-mobile service in the 800-to-900-MHz band. Since then, it has also applied for experimental licenses in both Chicago and New York which were never acted upon. Now, however, Motorola says it will only supply common carriers.

If ARTS fails to obtain FCC approval, Motorola will consider developing its concept outside the United States, says Martin L. Cooper, a vice president and the general manager of the Communications Systems division, Schaumburg, Ill.

The Motorola system is compatible with Illinois Bell's approach. Both companies specify channel spacings of 30 kilohertz, with Bell coming down from an earlier 40 kHz and Motorola moving up from 25 kHz, according to Cooper. The system for ARTS will operate at 838.75 to 845 MHz and 883.75 to 890 MHz.

ARTS will use seven towers with a total of 55 transceiver base stations and antennas. Frequencies will be reused every 19 and 38 miles from the towers. The system will demonstrate cell hand-off and vehicle-location techniques, as well as the capacity to "grow gracefully by employing reuse," the FCC was told. Seven of the transceivers will be used for signalling the mobile units digitally, the other 48 will handle the conversations.

In the first year and a quarter, the ARTS system will report on propagation factors and vehicle location and direction required for hand-off. Later, the complete hardware and software will be installed and tested with as many as 1,000 users. The system could handle up to 32,000 subscribers within a 12.5-MHz band, Motorola says, but this could be ultimately expanded to 129,000. Cooper says hand-held units will cost about $2,000; units mounted in vehicles about $200 less. □

## Components

# TI readies 50¢ temperature sensor for automotive applications

Aiming squarely at automakers, Texas Instruments has developed a low-cost temperature sensor that dramatically improves the linearity and response time of the firm's Sensistor line of positive-temperature-coefficient silicon thermistors. The use of standard semiconductor manufacturing techniques pushes its price down much lower, to about 50 cents each, depending on tolerance.

TI intends its sensor for ambient temperature sensing in automobiles, both under the hood and in the passenger compartment. It described the device for the first time this week at the Society of Automotive Engineers' annual meeting in Detroit.

**Many uses.** "It will be inexpensive enough to go into almost any adjustable-thermostat application," says Bryan Zimmerman, who heads new-product development for the firm's Silicon Small Signal department in Dallas.

The TSP 102, as it is called, relies on a spreading-resistance phenomenon that is the basis of a TI patent application. An n-type silicon substrate is covered with a double dielectric layer of nitride and oxide. Dopants are diffused through a hole placed photolithographically in both dielectric layers. These dopants help form an ohmic contact, instead of a junction between the silicon and an aluminum bonding pad.

"Where the Sensistor is nothing more than a bar of n-doped silicon with metalized contacts on either end, this one is built with the standard planar process," Zimmerman says, "The current applied to the relatively small, precisely dimensioned contact spreads through the silicon to the vacuum-deposited gold base of the chip, which provides the second contact. The resistance of the device is controlled to a large degree by the contact size, instead of the bulk resistance of the silicon—and it's easier to control the size of the hole than the size of the bar."

In contrast, the resistance of a Sensistor is determined by the physical dimensions of the bar. Assembly

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## Electronics review

### News briefs

**FCC gets request for interactive educational broadcasting**

The Federal Communications Commission is considering a petition to establish a community radio service dedicated to education, one that would allow interaction between participants in different locations. Cosponsored by the Center for Advanced Study in Education of the City University of New York and a group called the Communicasting Association of America, Syosset, N.Y., the petition asks for 84 megahertz of spectrum space in the 470-to-930-MHz range of the land-mobile radio service bands. Preferred are the ultrahigh-frequency television channels 70 through 83 (806 to 890 MHz). The cost of equipment for this region would be two orders of magnitude less than for the instructional television fixed service in the 2.5-to-2.69-gigahertz band, says S. Edwin Piller, Communicasting Association's president.

**Rockwell consolidates MOS LSI efforts**

Rockwell International Corp.'s delay in entering n-channel MOS LSI production may have been one factor that prompted its latest reorganization. LSI activities have been consolidated in a single Electronic Devices division, headed by Howard D. Walrath, who came from Rockwell's Collins Radio group. Walrath's bailiwick includes the old Microelectronic Devices division, which handles Rockwell's microprocessor and other LSI activities, plus additions such as MOS LSI modem subsystems and filters from Collins, special devices from Autonetics group, and segments of hybrid microelectronics from both Collins and Autonetics. Also, the Autonetics' Electronics Research division, renamed the Electronics Research Center, is assigned to Walrath, who will be based in Dallas. He says it is too early to comment on n-channel plans. Charles V. Kovac, former general manager of Microelectronic Devices, who becomes division vice president for business development, reports to Walrath.

**New dielectric fluid replacing PCBs**

General Electric Co. has developed a new dielectric fluid for its power capacitors that it is substituting for polychlorinated biphenyls, cited as environmentally harmful. The company will stop using PCBs entirely after June 30. The new fluid, called Dielektrol, is biodegradable, says GE's Capacitor Products department, Hudson Falls, N.Y.

is a tedious manual process of sawing it, etching it to a precise cross section, and metalizing the ends.

**1% tolerance.** The linearity of the spreading-resistance principle allows TI to specify the device's 1,000-ohm nominal resistance to tolerances as tight as 1%, though tolerances as loose as 20% are planned. The firm eventually wants to offer a range of resistances from 500 ohms to 5 kilohms. Temperature coefficient of resistance is about 0.7%/°C.

The TSP 102, offered in a plastic TO-92 package, also responds quickly to changes in temperature. Its thermal time constant is roughly 1.5 seconds, compared to 35 seconds for the Sensistor family. It is also faster and cheaper than the wirewound-nickel bobbin-type sensors Detroit now uses. □

## Automotive

# Ford's vendor plans beyond 1978 unclear

Ford Motor Co. may have chosen vendors for its engine-control electronics beginning with the 1978 models, but it will be later this year before it is clear exactly what they will supply for 1979 cars and beyond. And it is possible that Ford will reopen the bidding for the more advanced engine-control modules that it would like to use beginning with 1980 cars.

"Obviously, all existing suppliers will be considered part of the supply source for the total engine control modules in the 1980-1981 time

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## Electronics review

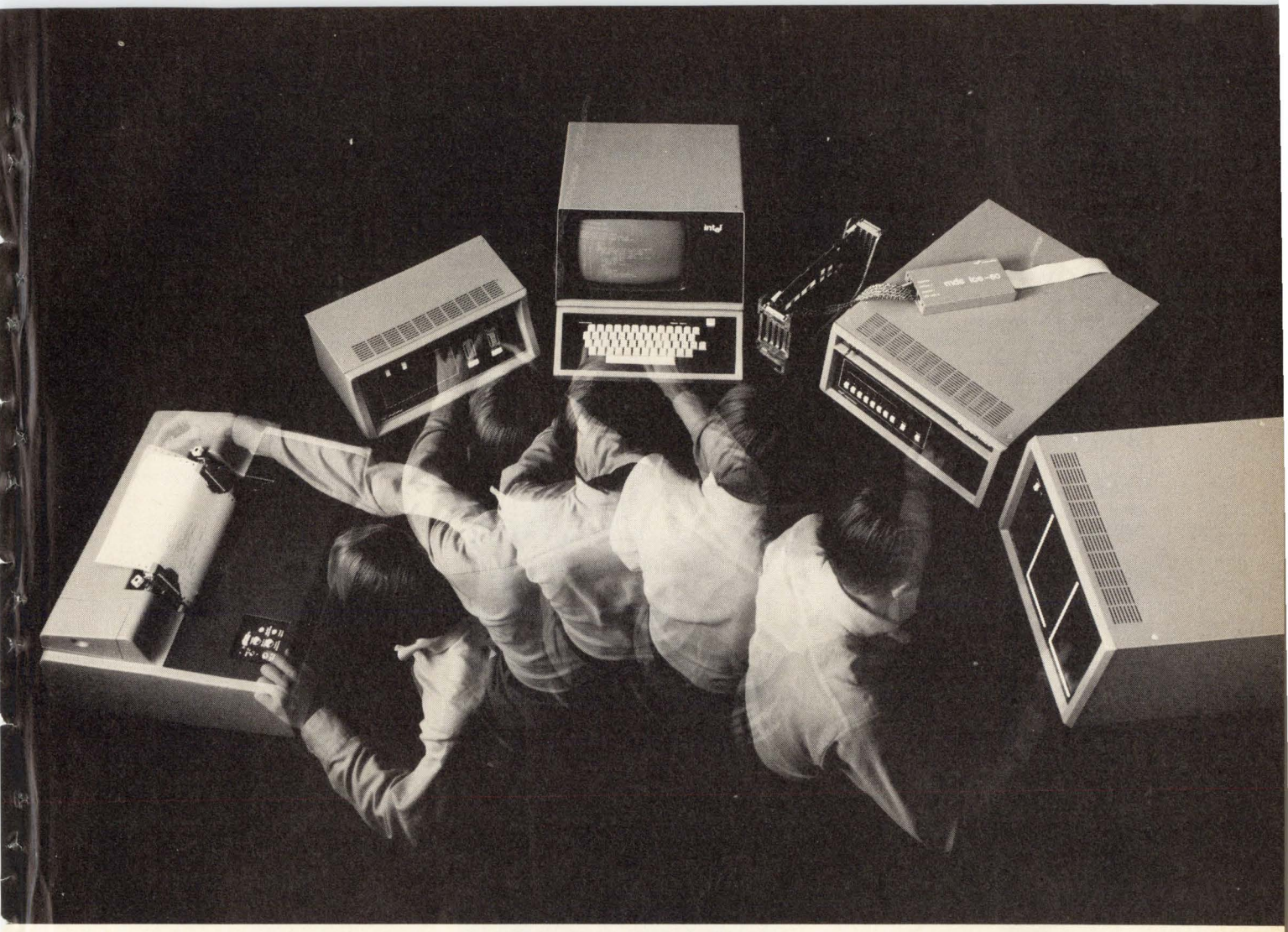
frame," says Robert S. Oswald, manager of electronic engine controls at Ford's Dearborn, Mich., engine engineering office. The suppliers are Tokyo Shibaura Electric Co. (Toshiba), the Essex group of United Technologies Corp., and Ford's Electrical and Electronics division [*Electronics*, Feb. 17, p. 26].

**Others a question.** "We haven't made up our minds whether we will allow other people to bid on the 1980 system," Oswald continues. "We are concerned about the amount of resources in the vendor arena we're tying up on one product." Several automotive-systems suppliers, including Eaton Corp., Motorola Inc., and Bendix Corp. are still actively working on proposals.

Motorola, through its Automotive Products division, reportedly is developing a system based on a custom microprocessor with 10-bit instructions and 8-bit data bus. Bendix is designing its module with a standard MC6800 Motorola microprocessor.

Ford also has to decide whether its three systems suppliers will be allowed to use their own module designs or assemble a single module design from identical, but second-sourced, components. For 1978-model-year engine modules, with ignition-timing and exhaust-gas-recirculation (EGR) control, production has started using a set of nine integrated circuits, including a 12-bit processor, supplied by Toshiba. "But EED (Ford's Electrical and Electronics division) and Essex will be manufacturing those devices as soon as they can launch their semiconductor manufacturing plans," Oswald says.

For 1979 cars, Toshiba is repartitioning its system into six chips. Ford will decide in the third quarter whether Essex and EED, which contracted with Texas Instruments Inc. and Intel Corp. for semiconductors, will implement its own designs. In the 1980 model year, fuel management will be added to the repertoire handled by Ford's electronic controls. By then, "as the processor's speed increases, an 8-bit system will clearly be capable of doing our job," Oswald says. □



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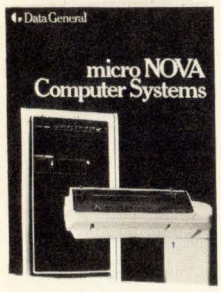


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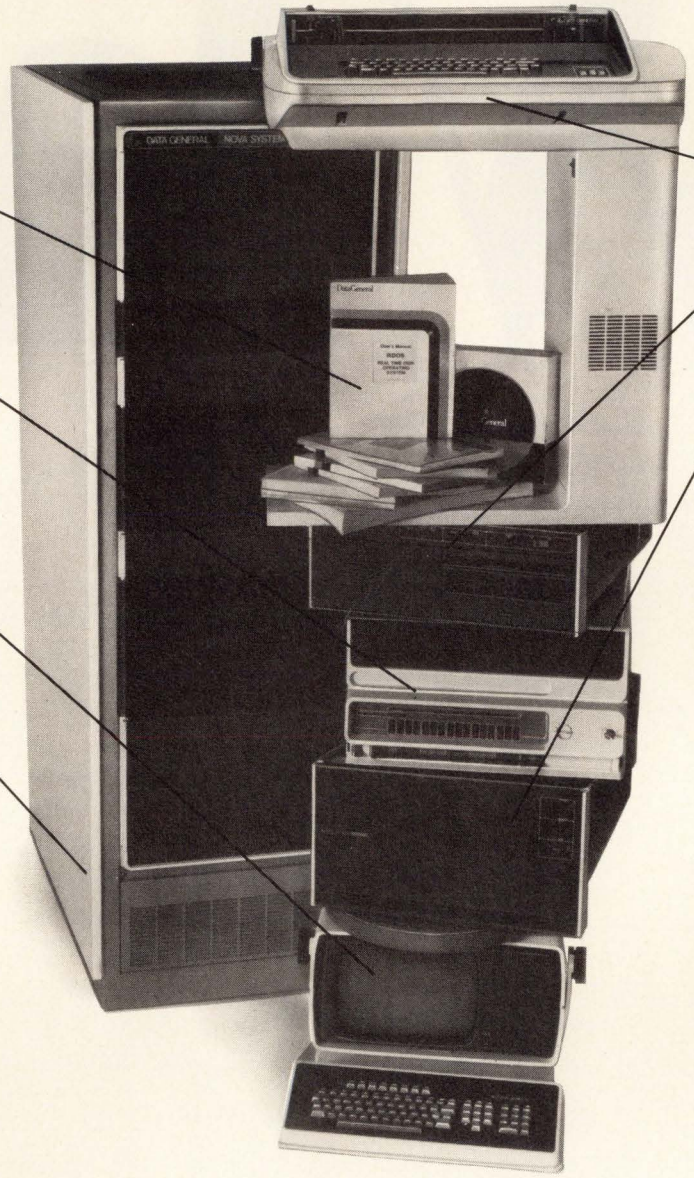

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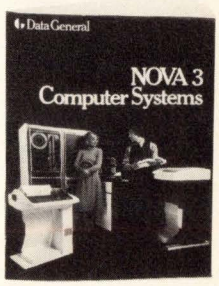


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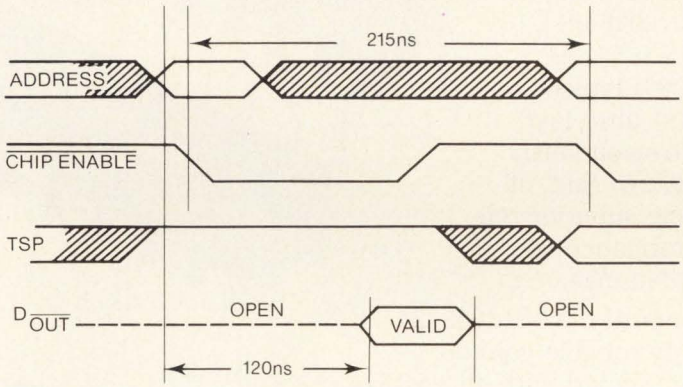


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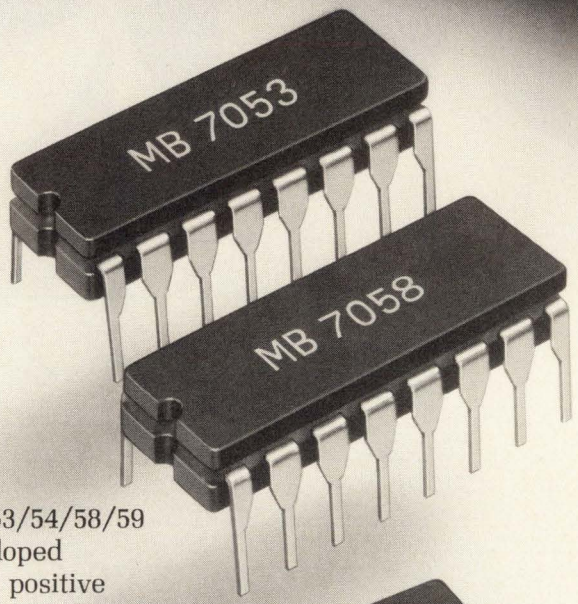


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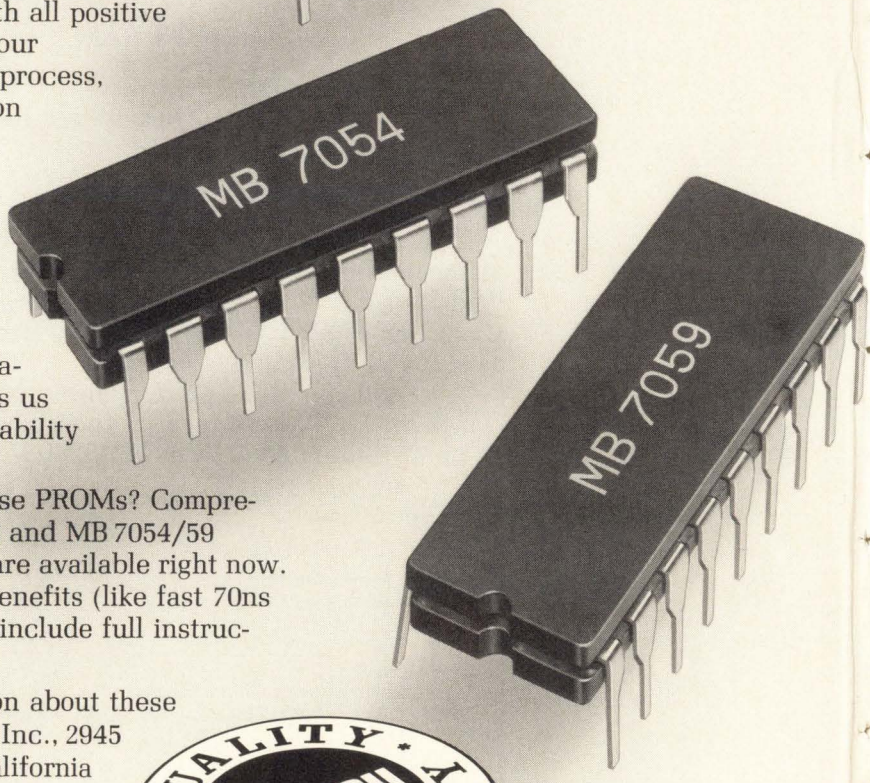


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# Washington newsletter

**Electric-vehicle demonstration funded for $40 million . . .**

The Energy Research and Development Administration won and lost some electronics-oriented money with President Carter's amendments to Gerald Ford's last budget. ERDA officials are delighted with the $40 million proposed to start its electric-vehicle demonstration program [*Electronics*, Feb. 17, p. 47], which was not in the budget.

But the ERDA officials are downcast at the **loss of all but $10 million of the $65 million proposed in January to build a pilot 10-megawatt solar electric power plant** [*Electronics*, Feb. 3, p. 80]. A reshuffling of other ERDA monies to accelerate solar thermal programs supports the view of agency sources that the Carter energy proposals are oriented toward programs with a quick payoff.

**. . . NASA gets money for Landsat-D spare, Mars studies**

The National Aeronautics and Space Administration picked up $15 million more in budget authority, including $12 million to be spent in fiscal 1978, **as the Carter proposals raised the agency's budget slightly.** Of the total, $5 million will be used to start procurement of a backup satellite for the Landsat-D earth resources spacecraft, a buy that will require $60 million over six years. NASA also got $10 million for studies of alternative Mars follow-on missions in the 1980s.

**Amateurs hit FCC on proposed ban of rf amplifiers**

Amateur radio operators are in an uproar about two new Federal Communications Commission proposals to require type acceptance of all amateur transmitters and amplifiers and to ban marketing of external rf amplifiers capable of operating from 24 to 35 megahertz. The stricter rules are **aimed at preventing the extensive illegal use with citizens' band radios of high-power external amplifiers,** which interfere with legitimate CB operations and with radio and television reception.

**Amateur operators contend they are being unduly penalized for violations caused by only a handful of CB operators.** FCC chairman Richard Wiley, who concurred in the 5-0 vote, agrees. "In attempting to deal with the rapidly proliferating and sometimes troublesome CB service, we may appear to be penalizing the amateur community—one of the most 'professional' and self-regulated services," he notes. Comments on the proposed ban on external amplifiers (Docket 21116) and amateur equipment type acceptance (Docket 21117) are due May 25 with reply comments by June 6.

**DOD pushes NATO decision on Awacs; Air Force buy halved**

In a move regarded as leverage on America's NATO allies to bring about a decision on buying an uprated version of Boeing's E-3A Airborne Warning and Control System, Secretary of Defense Harold Brown has, as expected, proposed halving the Air Force 1978 buy to three planes, cutting the procurement by $150 million, or 38%, from the requested $393 million [*Electronics*, Feb. 3, p. 57]. **Brown wants to defer more Awacs buys until NATO acts and then upgrade the Air Force planes to achieve a superior common aircraft.** Another Brown goal is to get the Air Force moving on a common version as well as on a decision about just how many Awacs will be needed for continental air defense.

# Washington commentary

## The coming controversy over Carter's budget

After just four weeks in office, President Jimmy Carter has delivered to Congress 101 pages of proposed changes to Gerald Ford's last budget that clearly reflect Carter's desire to stimulate the national economy quickly. Overall, budget authority would rise by $26.8 billion to $507.3 billion, some 5.5% more than Ford sought, while Federal spending would climb by $19.4 billion to $459.4 billion, a 4.4% boost. For the electronics industries, specific program changes contain bits and pieces of unexpected good news for agencies like the National Space and Aeronautics Administration and the Energy Research and Development Administration (see p. 49), but much more bad news—most of it expected—at the Pentagon.

The widely heralded cut of $2.7 billion in Ford's defense budget, for example, comes in total obligational authority, not spending. In the fiscal year beginning Oct. 1, the spending level will drop no more than $400 million to $109.7 billion—a figure that is still nearly 5% more than this year. But NASA gains $15 million in budget authority under Carter's amendments, of which $12 million will be spent next year, while ERDA will get its budget authority doubled to $318.3 million, of which $105 million more will be spent in 1978.

### Boosting combat readiness

Defense Secretary Harold Brown's cuts include an expected $160 million in the funds for the development of the next-generation intercontinental ballistic missile, the Air Force M-X, deferring full-scale development another year. But that 46% cutback in funds still leaves $134.4 million to pursue development of such electronics as a new guidance system and other components, as has been expected [*Electronics,* Feb. 3, p. 58.].

Carter's goal, apparent throughout his changes in military programs, is to improve the combat readiness of existing forces by increasing maintenance and overhauls at the expense of new systems like M-X still in development. The $290.5 million in the existing 1977 budget to buy 60 more Minuteman III ICBMs, Brown says, "will be applied instead to components to support the existing force and maintain essential component-production capability, without further procurement of complete missiles." Similarly, Carter is increasing 1978 budgets for NATO maintenance facilities and overhauls of ships and aircraft by $390 million, while saving $187 million by cancelling the nuclear strike cruiser proposed as an Aegis missile platform for fleet air defense; terminating the Navy's final buy of six A-7E Corsair II attack aircraft to save $24 million; and killing the Army's Lance missile, which was set for a buy of 360 at a cost of $77.5 million.

### Cutting off LTV

Congressional hackles have risen at these and other cuts. The White House is already getting heat from the Texas delegation—including House majority leader James C. Wright—on the termination of the Corsair and Lance programs. Both are products of Texas-based LTV Corp.'s Vought operation and would deal the company a serious blow as a major prime contractor. At stake are an estimated 7,000 jobs in Texas and another 1,100 in Sterling, Mich., where Vought produces Lance.

Deferrals in other areas are troubling other delegations, too. One example is the Air Force's F-15 interceptor. Slowing McDonnell Douglas' annual F-15 production to 78 planes—a reduction of 30—is expected to "save" $334 million of the $1.7 billion originally proposed, but Air Force officials say it will only push the unit cost up later. Another blow to McDonnell was the deferral of another $26 million in advance procurement money for F-15s as follow-on interceptors.

### Time for more thought

But Carter and Brown are convinced they need more time to evaluate the overall weapons mix. Thus the production decision on Rockwell's B-1 bomber is being deferred now from March to June while the 1978 buy of planes is being reduced from eight to five for a $280 million "saving." And this leads to a slowdown in the plane's Short-Range Attack Missile schedule for another $23 million reduction. Similarly, the Army's Advanced Attack Helicopter contracted to Hughes Aircraft has been halved to $100 million in the RDT&E budget so that Brown can make "a more thorough evaluation of options."

Consequently, the small improvements in the budgets of agencies like NASA and ERDA are likely to pass virtually unnoticed in the forthcoming congressional budget battle as the action centers around the more controversial military cutbacks.

**Ray Connolly**

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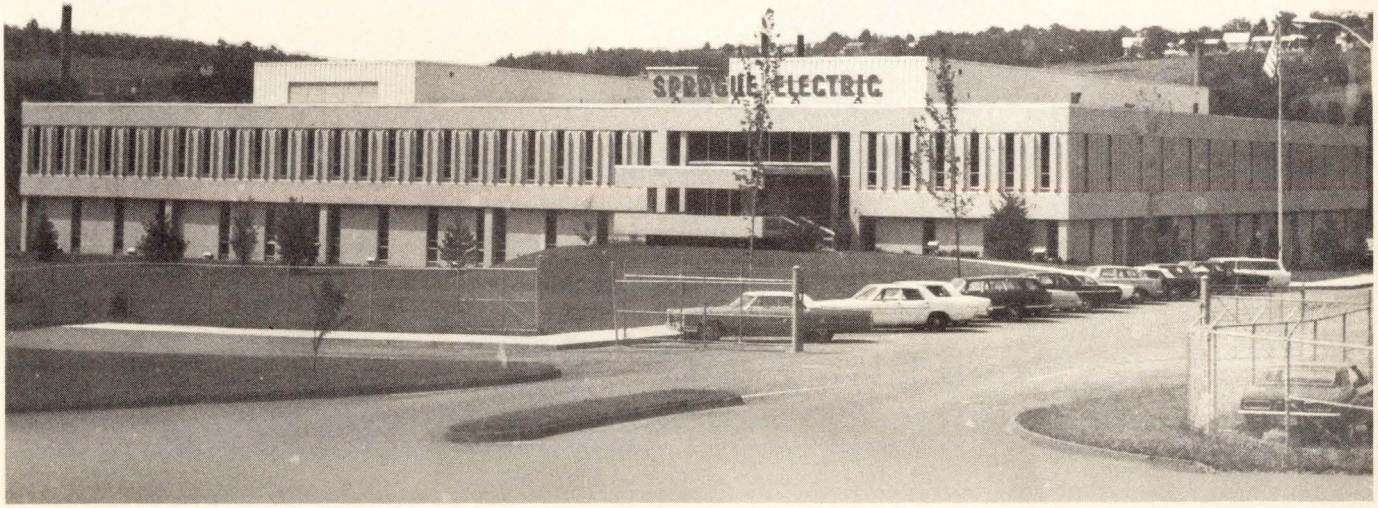
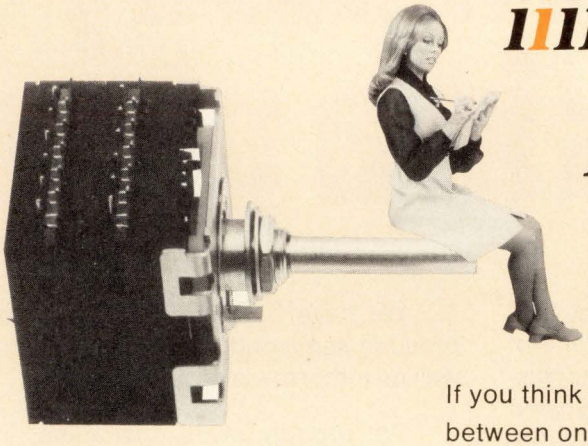


# iiimpressive figures:



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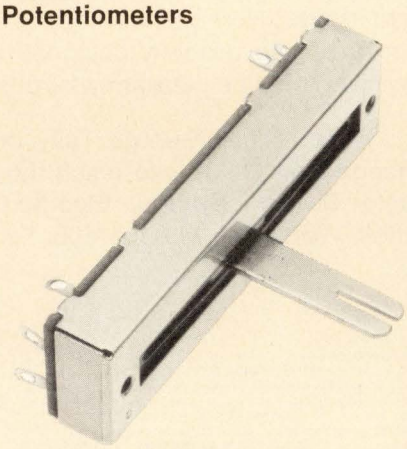

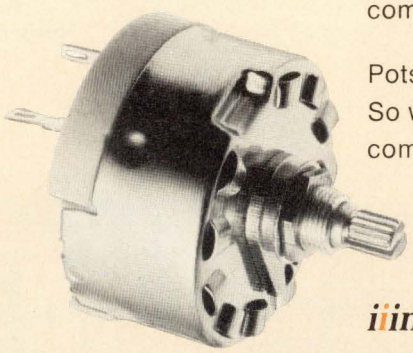

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# International newsletter

## 220 scientists to participate in Spacelab tests

Some 220 scientists, more than half of them from a dozen European countries, will get involved in the experiments that will go aloft in the European Space Agency's Spacelab. Scheduled for launching aboard NASA's Space Shuttle in the second half of 1980, this first flight is intended mainly to check out the Spacelab system and the environment surrounding the shuttle. Nonetheless, 100 hours—split equally between ESA and NASA—have been earmarked for experiments during the one-week mission.

For the flight, ESA plans to arrange the Spacelab in two main sections: **a long pressurized module, where two "payload specialists" will work, and a pallet section for large telescopes, antennas, and similar apparatus.** Along with the payload specialists—one European and one American—will be three Americans in the shuttle itself.

## Siemens introduces two subnanosecond dense ECL arrays

Siemens AG has joined the élite group of semiconductor firms offering subnanosecond logic arrays. The West German firm has developed two high-density large-scale-integrated emitter-coupled-logic devices—master slices that provide functions ranging from basic OR/NOR gates to multiplexers, latches, and even a four-stage counter. One chip packs roughly 700 gate functions on a chip of 36 square millimeters that consumes less than 2.8 watts, and the other provides 400 gate functions on a 28-mm$^2$ chip that uses less than 2 W. Both 64-pin devices have gate delays of 0.5 nanosecond.

The company claims **chip density is four to five times higher than comparable arrays, an achievement it credits to the use of series gating and a logic swing of 400 millivolts inside each chip.** Level-shifter gates at the periphery make the chips compatible with ECL 100 K devices.

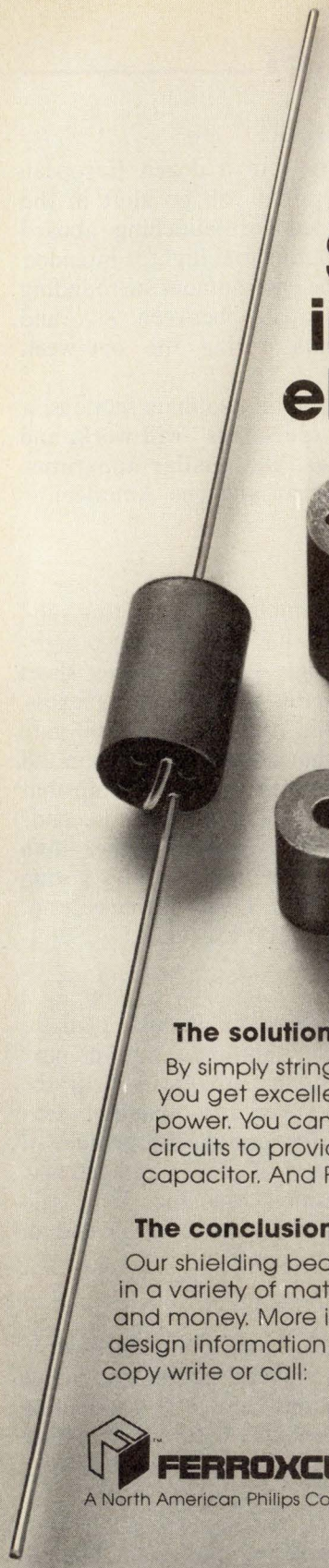
## Commodore offers TV-game module in European market

Commodore, a manufacturer of personal calculators in Britain, plans to begin playing for a share of the European television-game market next month with introduction of a module compatible with PAL sets at the Hanover Fair. **Based on an MOS chip from recently acquired MOS Technology Inc., the add-on module provides for games with choices of three ball speeds, five ball angles, and two levels of player competence.** Commodore, a subsidiary of Commodore Business Machines Inc., Palo Alto, Calif., may also market a cassette-loaded PAL game built around an MTI microprocessor, as well as a Teletex-Viewdata decoder.

## Japanese firm plans computer sales in U.S., Europe

After a successful start in the Australian market, Japan's Nippon Electric Co. is introducing its office computers and peripheral equipment in the U.S. and is planning to move into Europe. **In the U.S., it is conducting market surveys preparatory to establishing a company before midsummer** to sell its NEAC System 100E business systems, its Badminton Crown printer, its Hiprinter wire-matrix printer, and its intelligent terminals.

In Australia, NEC has already begun marketing its computers as the NEC System 100 through Honeywell Information Systems subsidiary, Honeywell Pty., which two years ago arranged to sell earlier models of the same computer as the Honeywell System 6. Already more than 100 have been ordered. Complete systems sell in Japan for $25,000 to $75,000. The central processing unit consists of a 16-bit microprocessor, 4-kilobit memory chips, and an interface of large-scale-integrated circuits.



# Simple, inexpensive ways to eliminate RF noise and high-frequency transients.

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# UK firm's auto instrument panel glows with direct-current electroluminescence

**Solid-state displays will** undoubtedly brighten future automobile dashboards. Britain's Smiths Industries Ltd. hopes to generate the first glow with a production-oriented solid-state instrument panel using direct-current electroluminescence.

The company plans later this year to complete a DCEL module using custom integrated circuits designed jointly with Plessey Semiconductors, says Brian Shepherd, electronics director of Smiths' Vehicle Instrumentation division. The company should be sending samples to selected British and European car makers next year in time for the 1980 models. Smiths expects car manufacturers to adopt the solid-state display quickly, because it combines into one unit instruments, gauges, and warning lights.

**Simple.** A solid-state display has only 35 parts or processes, compared with about 430 parts of a conventional instrument panel, and information can be changed by simply redirecting the display's conductor patterns. Shepherd says that solid-state displays are more reliable, much smaller, and more versatile than conventional electromechanical instrumentation.

Besides DCEL, other technologies being pursued around the world include electrochromic and gas-discharge panels, light-emitting diodes, and liquid-crystal displays. But Smiths chose DCEL because its inherent emission of light eliminates the need for illumination, and packaging costs are low. Shepherd says that light from such a display can be made variable and does not degrade sharply.

**Versatile set.** Smiths wants to develop a set of four to eight chips—each about 0.009 inch square—so that it can have displays to serve vehicles from economy cars to luxury vehicles. Besides the driving chips, Plessey also has reconfigured a switched-mode power-supply chip from a consumer-television circuit and is designing an odometer chip of integrated injection logic; $I^2L$ was chosen for the 700-gate device because it can handle a large mass of logic with low power.

The DCEL display is based on laminar glass construction enclosing phosphor patterns. When a direct current is passed through the phosphor, the molecular layer immediately in contact with the conductive pattern emits light. This excitation is caused by pulsed dc current, which provides long life, consumes little power, and stays cool. The emitted light is yellow because of the zinc-sulphide phosphors being used, but Smiths is working on other phosphors for different colors.

For the custom ICs, Plessey uses a high-voltage variant of one of its standard bipolar processes. The high voltage is needed because the display requires about 120 volts, split evenly between the front and back plates of the display. According to Shepherd,

## Around the world

### Two UK firms ready Teletext decoders

GEC Semiconductors and Mullard Ltd. are about to challenge the early lead that Texas Instruments Ltd. has won in the budding European consumer market with a Teletext decoder built around large-scale-integrated circuits. The two British companies, now canvassing television-receiver manufacturers, plan to announce their LSI decoders in time for this summer's international radio and TV exhibition in Berlin. The show is expected to be an important commercial showcase as the Continent begins to pick up Teletext broadcasting, which originated in Britain [*Electronics*, Feb. 5, 1976, p. 68].

Both companies are building decoders around custom bipolar, custom n-channel MOS, and standard MOS random-access-memory chips, plus a few off-the-shelf interface circuits. The Mullard decoder uses three custom n-channel MOS digital circuits, which format data for the memory, frequency division, and code conversion; one custom bipolar video-processor circuit; seven standard 1,024-bit static RAMs, and three standard TTL ICs. The video processor retrieves the data from the signal and acts as a display-clock generator. GEC uses a custom MOS chip to process the Teletext page and a custom bipolar circuit to produce the clock and data signals.

### Siemens machines irradiate large cancerous areas

Three linear accelerators from West Germany's Siemens AG can radiate hard X rays and electron beams uniformly over relatively large cancerous areas at high dose rates. The Mevatron 6 and Mevatron 12, being built at the firm's facilities in Walnut Creek, Calif., can focus X rays on an area 35 centimeters square at the rate of 300 roentgens per minute at the isocenter. This is the point where the radiated beam intersects with the axis about which the equipment's radiating head swings like a pendulum over the area being treated.

The Mevatron 20 now being added can project X rays on an area 2 to 40 cm square at the same dose rate, and its electron beams can treat an area 5 to 25 cm square. The three machines have energy ranges of as much as 6, 12, and 20 megavolts, respectively. The 5.5-ton linear accelerators, all about 2.5 meters high and 2.5 m wide, differ only in the components that generate the different levels of energy. The 3-gigahertz energy source is a high-power energy generator—a magnetron in the older machines and a klystron in the model 20.

the front plates require only one driving circuit, whereas the number needed by the back plates depends on the number of warning lights. In addition, the two companies have worked out a form of multiplexing the current-driving functions among the driving circuit. The goal was to cut down the number of interconnections needed. □

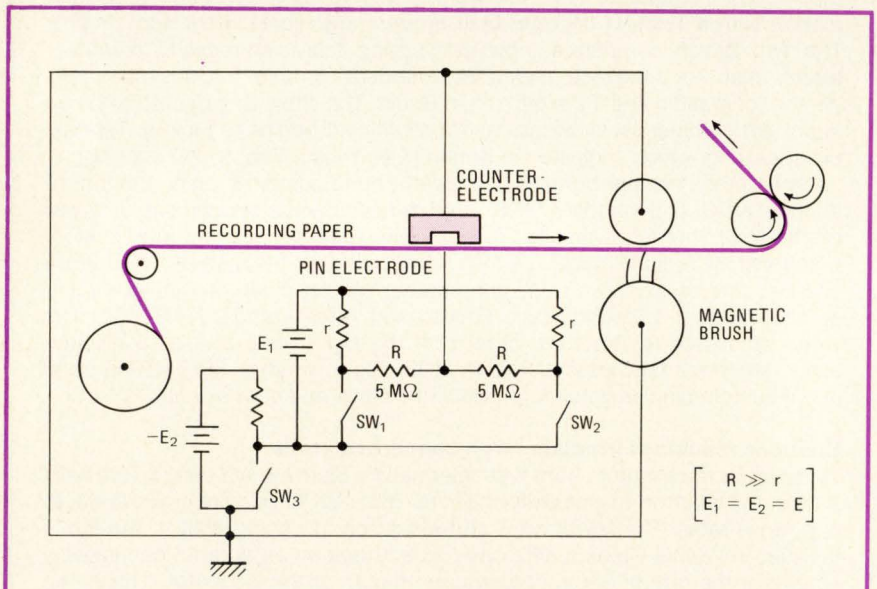
## Japan

# Japanese electrostatic printer deposits two colors with pigmented resins

An experimental electrostatic printer developed by Japan's Yokogawa Electric Works can print in two colors to call attention to portions of a printout or to differentiate between types of information. It uses red and black toners that pick up positive and negative charges respectively.

The toners consist of 10-micrometer-diameter particles of two separate resins that are mixed with iron particles, called carriers, 100 $\mu$m in diameter. One resin, which acquires a positive charge when stirred with the iron particles, contains the red pigment; the other resin, which picks up a negative charge, carries the black. The toners develop the latent image on electrostatic paper coated with a plastic dielectric layer, and heat fuses the resin to fix the image.

Pins having a potential of about 700 volts write the latent image on the paper. A positive voltage makes the image black, and a negative one makes it red. At a potential below ±400 v, no charge is transferred from pin to paper. This threshold effect permits a matrix arrangement of resistors that minimizes the number of expensive high-voltage transistor switches needed. The resistor matrix feeds +700 v or −700 v to the desired pins and +350 v, 0 v, or −350 v to the others. The extraneous half-strength voltage does not degrade performance.




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| $SW_1$ | ON | OFF | ON | OFF | OFF | ON | OFF | ON |
| $SW_2$ | ON | ON | OFF | OFF | OFF | OFF | ON | ON |
| $SW_3$ | ON | ON | ON | ON | OFF | OFF | OFF | OFF |
| Pin voltage | 0 | E/2 | E/2 | E | 0 | −E/2 | −E/2 | −E |

**Switching colors.** $SW_1$ is one of the 28 switches that selects pins within a block of the printer matrix, $SW_2$ is one of the 20 block selectors, and $SW_3$ determines polarity. E on the bottom line indicates black, −E means red, and the other two result in no printing.

**Printing.** The machine prints lines 140 millimeters wide with a resolution of four lines per mm. The electrostatic image is deposited on the paper by 560 pins across the printing head, and the paper advances 250 micrometers between the lines. For ease in fabrication, the prototype uses 560 lines on an epoxy-glass printed-circuit board, rather than true pins. The 800-v charges in the pins are switched by readily available switching transistors used in television horizontal-output circuits, even though the printer currents are much smaller than the ones the transistors were designed for. Only positive voltages are switched to the pins, and a single additional switch shifts the level for negative voltages.

A conventional switching arrangement would have required 560 of these switching transistors. But because that would have been both expensive and bulky, the resistor matrix was developed. This configuration, which handles pins in blocks of 28, limits the number of switching transistors to 20 for block selection, 28 for pin selection within the blocks, and a single transistor to shift the voltage in order to make it negative.

**Resistors.** However, 1,120 5-megohm resistors are needed for the matrix. The experimental unit had discrete devices, but resistors will probably be printed directly on the board in the future. For compactness and convenience, the high-voltage switching circuits were built as hybrid integrated circuits.

For ease in printing the two colors, the machine actually advances the paper in 125-$\mu$m increments, or half of the line pitch and alternates printing of the half-pitch lines in red and black. The displacement between the colors is not apparent. □

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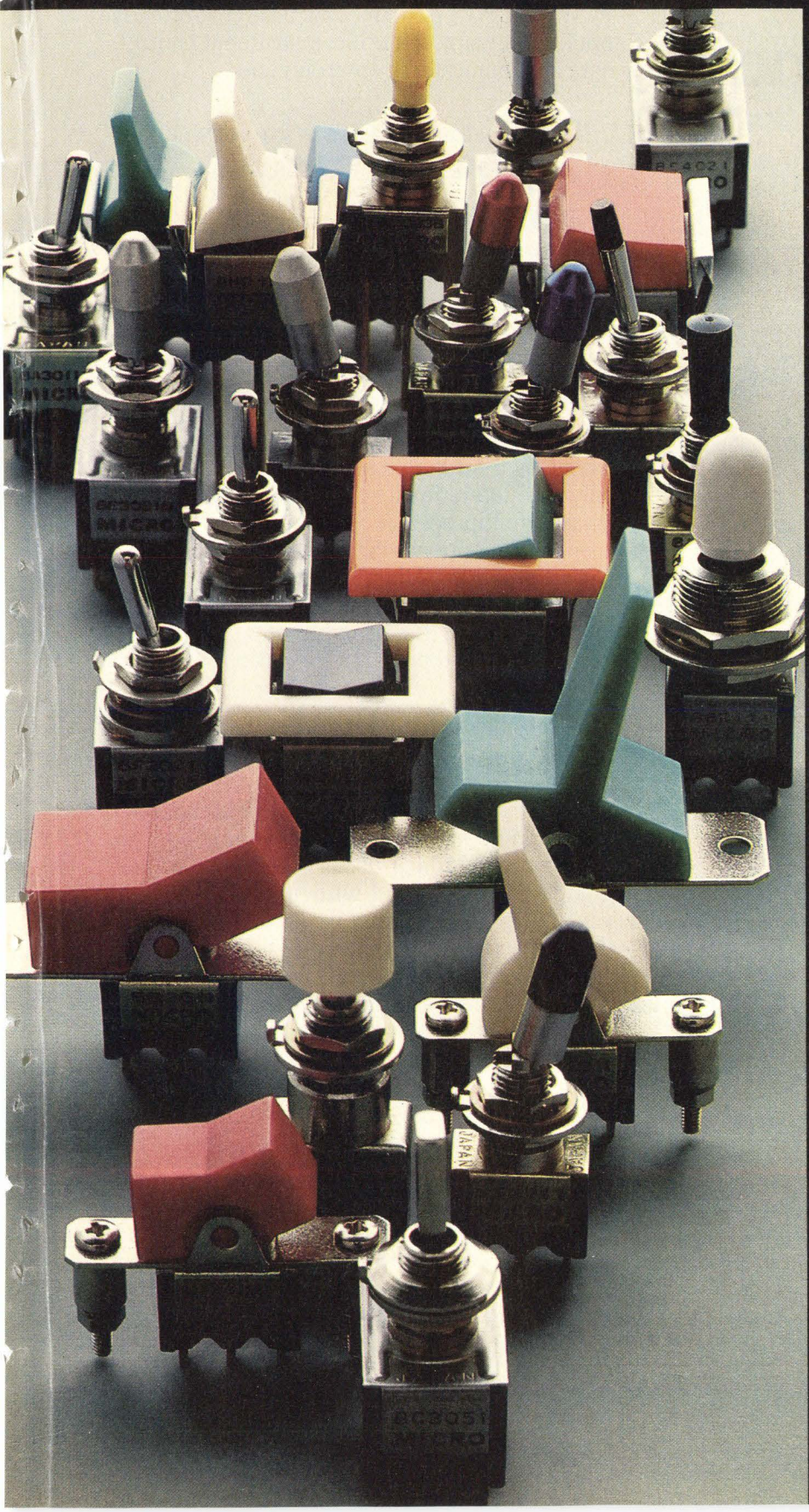

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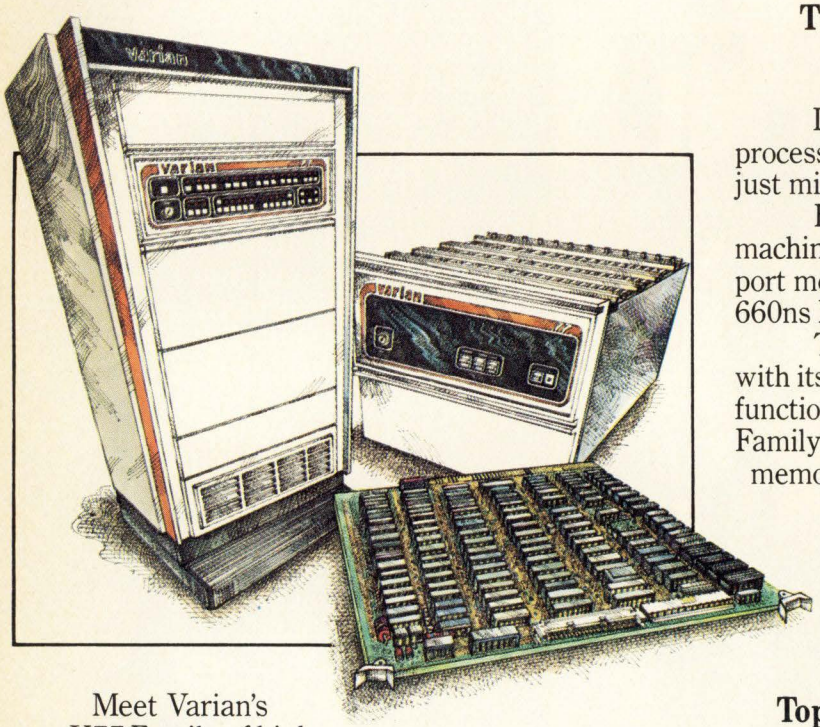


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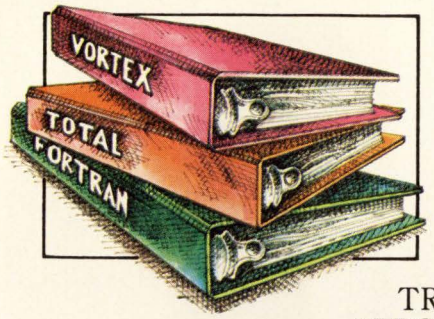


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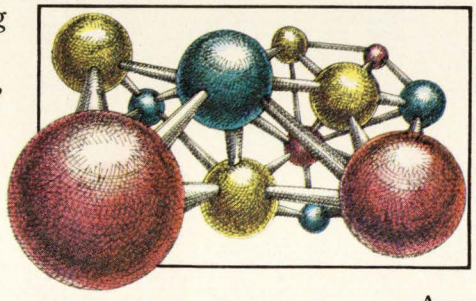

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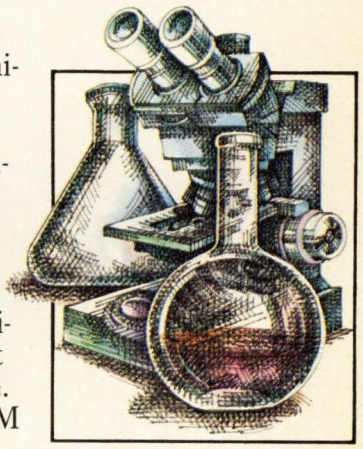

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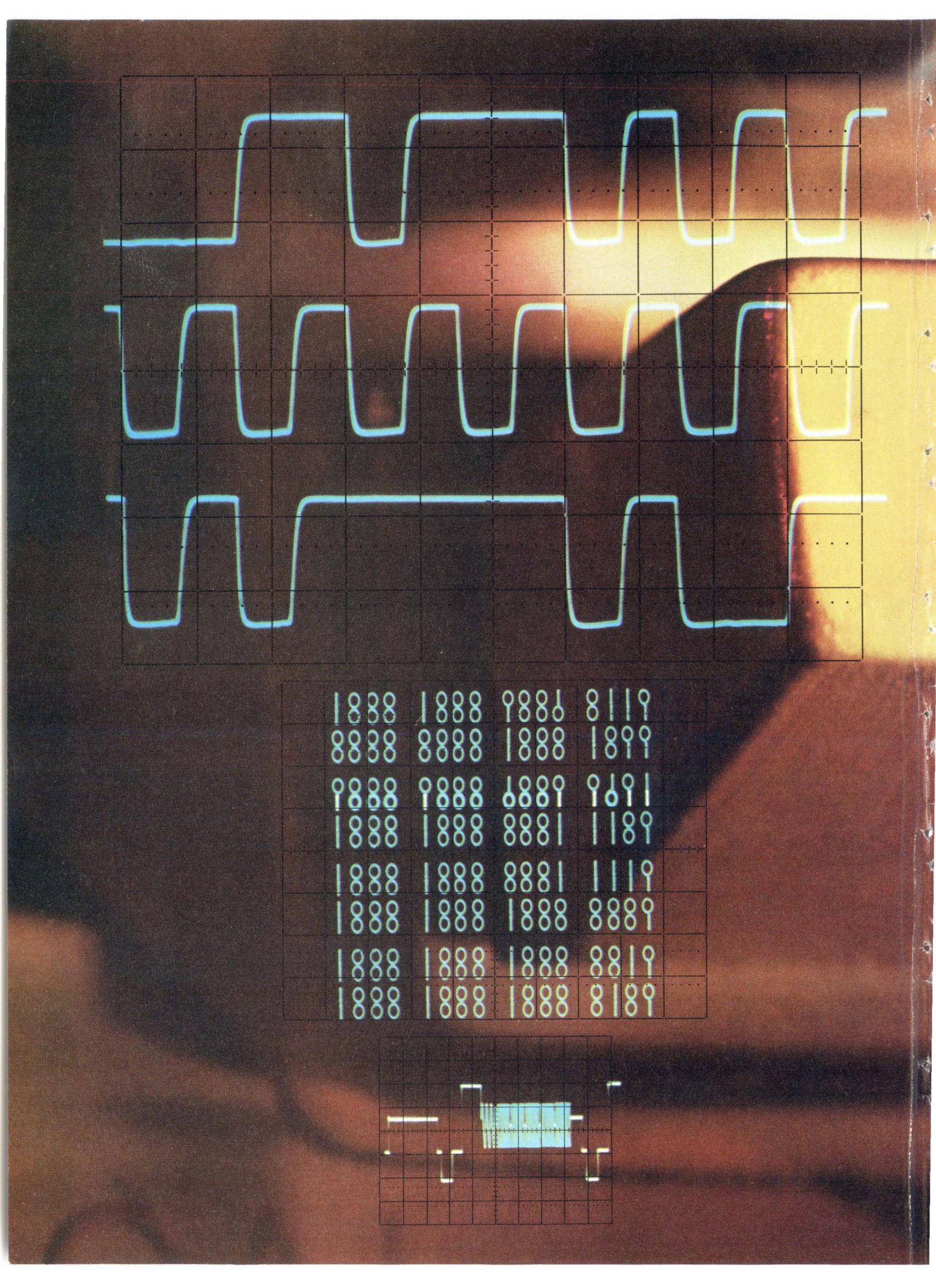

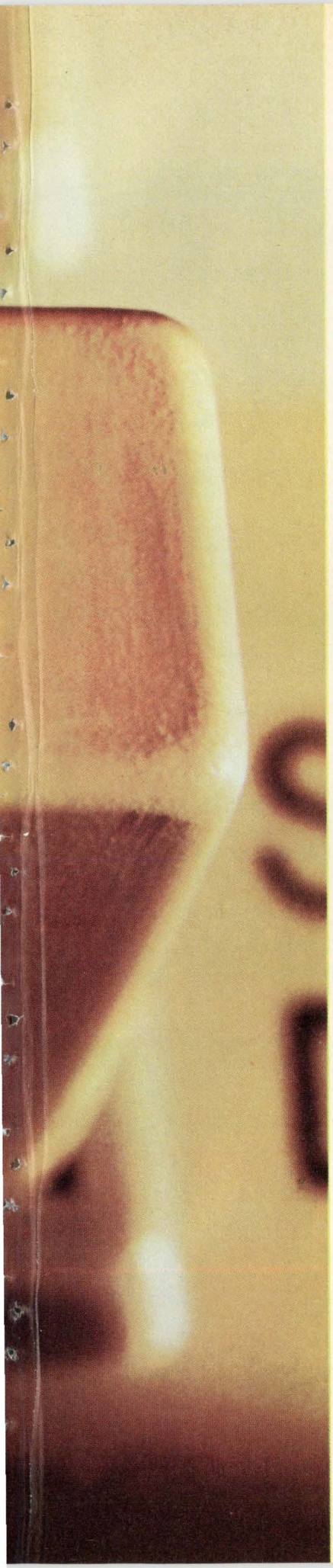

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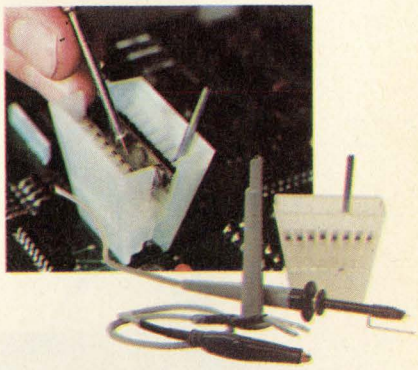

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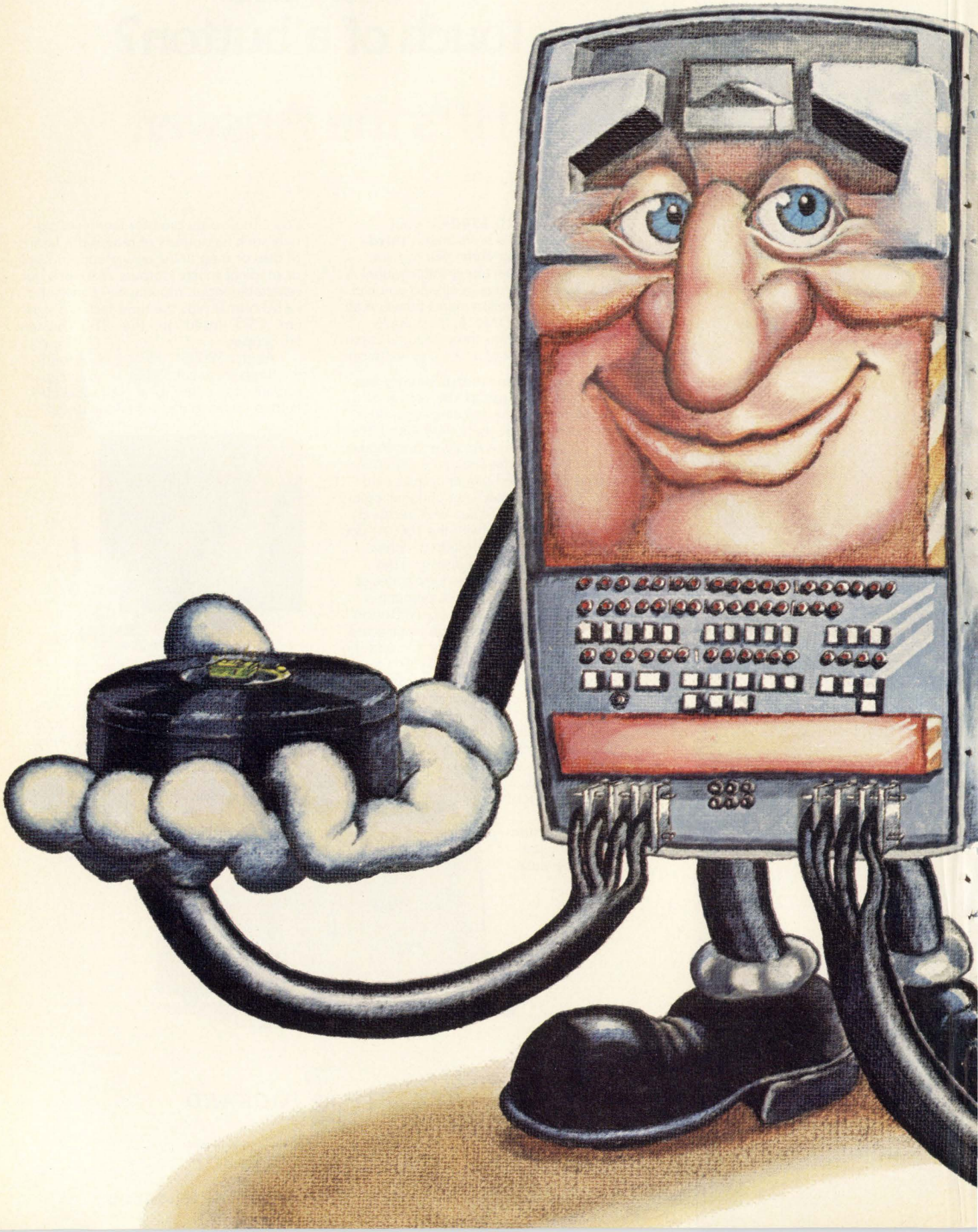

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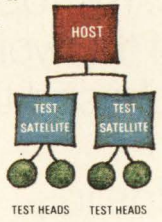


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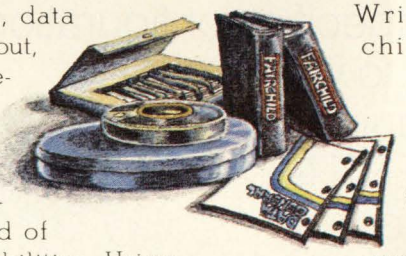


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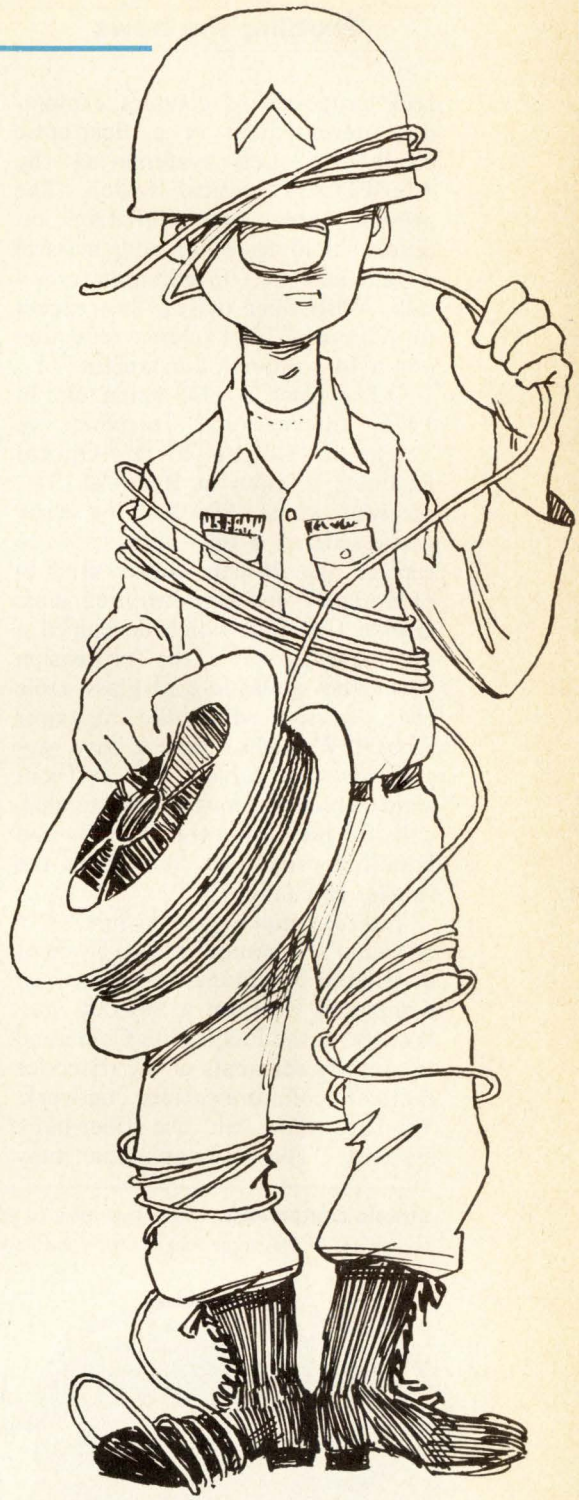
# Army speeds fiber optics

## Optical fibers expected to replace cable in the 1980s; test results exceed specs

*by Bruce LeBoss, New York bureau manager*



**The U.S. Army** is confident that by the mid-1980s it will be replacing copper wire with optical fibers in its tactical communications systems. The fiber-optic conductors, which are markedly lighter and smaller, will provide larger bandwidths at potentially lower costs—perhaps down to 10 cents per meter.

"Thus far, fiber optics equals or exceeds our expectations," states Robert Christian, electromagnetic-transmission team leader at the Army Electronics Command's Communications Automatic Data Processing Laboratory at Fort Monmouth, N.J. Like the Air Force and Navy, which are working on fiber-optic replacements for coaxial cable in aircraft and ships, the Army is aiming its fiber-optics developments at that mid-1980 target.

In the words of Gerald Aaronson, division program manager of GTE Sylvania Inc.'s Communications Systems division, "Progress in fiber-optics techniques is so rapid that, within the next few years, they will appear in a number of defense-communications systems now in the design and development stages." They are particularly suited for defense communications because of their immunity to electromagnetic interference, and they are "only 1/50 the size and weight of 1/4-inch-diameter copper coaxial cable."

**Setting the objectives.** Since 1974, when the Army first became seriously interested in fiber-optic communications, its primary aim has been to replace the twin-coaxial cable used for long-haul communications systems and the 26-pair cable used in local-distribution systems. "To date," says Christian, "all of the fiber-optic developments for these two programs, as well as for supporting programs, have met all of our specs with one exception." That exception is a hammer test, "which may not be a necessary spec at all for the environment that the equipment will be used in."

For long-haul communications, the objective is a ruggedized fiber-optic system that will transmit up to at least 8 kilometers, unattended, without repeaters. "Right now, if we were to go to a 64-km system with present cabling," says Christian, "we would need 19 repeaters every 8 km, or one in less than every half mile. But with a fiber-optic cable, the indications are we could do the same job with only one repeater every 8 km, or seven repeaters in all." Perhaps more important, "this would result in a big savings in cost and a significant improvement in reliability."

**Useful.** Under an $80,000 contract awarded in 1974, Corning Glass Works of Corning, N.Y., "demonstrated that we could create a useful waveguide cable with a reasonable set of useful properties, such as lighter weight and smaller size, with attributes that made it desirable for long-distance communications," states Al Fairaizl, Corning's senior sales engineer in charge of Government sales. Corning's work yielded a first-generation fiber-optic cable that has an attenuation of less than 20 decibels per km.

Corning, at its own expense, further refined the cable, sold commercially as Corguide. The company is now selling to the military and commercial markets cables that attenuate less than 10 dB/km, are more resilient, less subject to temperature variations, and provide better optical performance than the original Corguide. These cables are part of a Corning proposal to the Army in competition for a one-year, $100,000 contract for exploratory development of a long-haul fiber-optic communications system.

In the second half of this year the Electronics Command expects to

seek proposals to conduct exploratory development of a fiber-optic cable for such systems as the AN/TTC-38 tactical switch. The present cable, says Christian, requires shielding, which adds massive weight and size, to eliminate crosstalk. With fiber optics, "we expect to achieve a 10:1 volume reduction and a 14:1 reduction in weight."

Other work is also going on. In 1975, International Telephone & Telegraph Corp.'s Electro-Optical Products division in Roanoke, Va., received about $90,000 for early prototypes of a fiber-optic cable to replace the 26-pair cables used in command-post-type applications. Unlike Corning, which developed a glass-on-glass cable, the ITT division developed a plastic-clad glass cable that, says product-line manager Robert Williams, "was a very rugged, low-cost cable." The ITT contract, which is about to be extended, calls for increasing the flexiblity and handling properties, as well as the impact resistance.

**Tri-Tac input.** Meanwhile, GTE Sylvania's Communications Systems division in Needham, Mass., has just completed work on a $63,000 contract from the Electronics Command to identify segments of the triservice tactical communications network, Tri-Tac, that can use fiber-optic systems. "The first application may be as transmission links in the AN/TTC-39 switch GTE is developing for the Department of Defense's Joint Tactical Communications Office network," says program manager Aaronson.

GTE was to examine how best to use fiber-optic cable to replace coaxial copper cabling for signaling, but not power functions. The problems of powering fiber-optic communication systems and determining the data format, among others are being explored under an $80,000 contract awarded to ITT last September. That eight-month contract calls for the Roanoke division to develop a fiber-optic system for use in a simple pulse-code-modulation communications network.

**Backup.** The Army also has several backup programs to develop methods of manufacturing light sources and photodetectors, as well as developing ultra-low-loss cables, connectors, and rapid payout systems from which it can distribute cables from vehicles, including the helicopter. One of the largest of these programs is being conducted by Valtec Corp.'s Laser Diode Laboratories subsidiary. It has two contracts totaling almost $500,000 to build reproducible high-brightness light-emitting diodes and injection diode lasers.

The Laser Diode work, contracted for by the Electronics Command's Combat Surveillance and Target Acquisition Laboratory, follows some preliminary work by the RCA Laboratories in Princeton, N.J., which developed a triple-stripe laser that operates in the 820-nanometer range and emits three beams in parallel on a laser substrate.

RCA built a system that emits 250-milliwatt 10-nanosecond pulses and has a repetition rate of 10 MHz. "We achieved 6,000-plus hours of life tests by the time the contract expired" in mid-1976, notes Henry Kressel, RCA semiconductor devices group head. The Army is looking for 10,000 hours of life testing, and "we're confident we could have done it," he adds. Major contracts for sources and detectors in the 1.06-micrometer range will be out later this year.

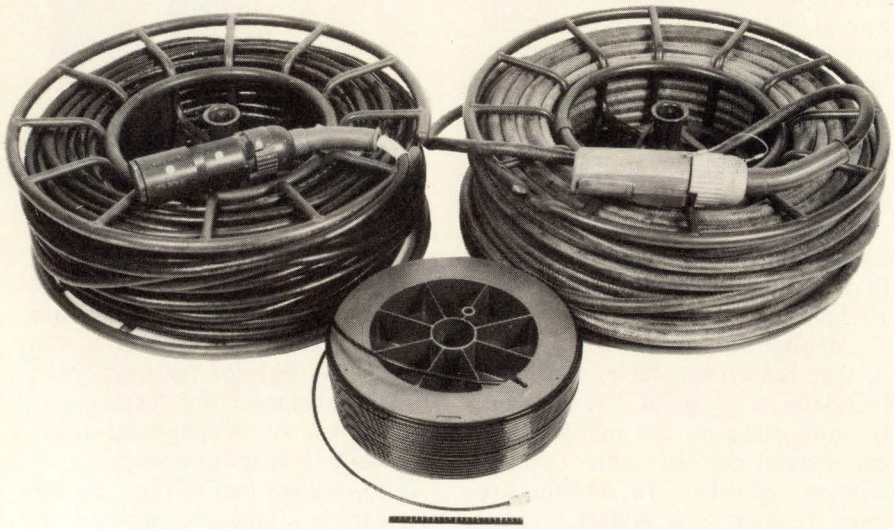
Of course, as is so often the case with emerging technologies, an unsolved problem lies with the connectors, says the Army's Christian. "We don't yet see a military connector for a fiber-optic system, but we don't doubt that we'll have them eventually," he says. The Army is looking for connectors that can accurately and repeatedly align multiple fibers in a small core in the field.

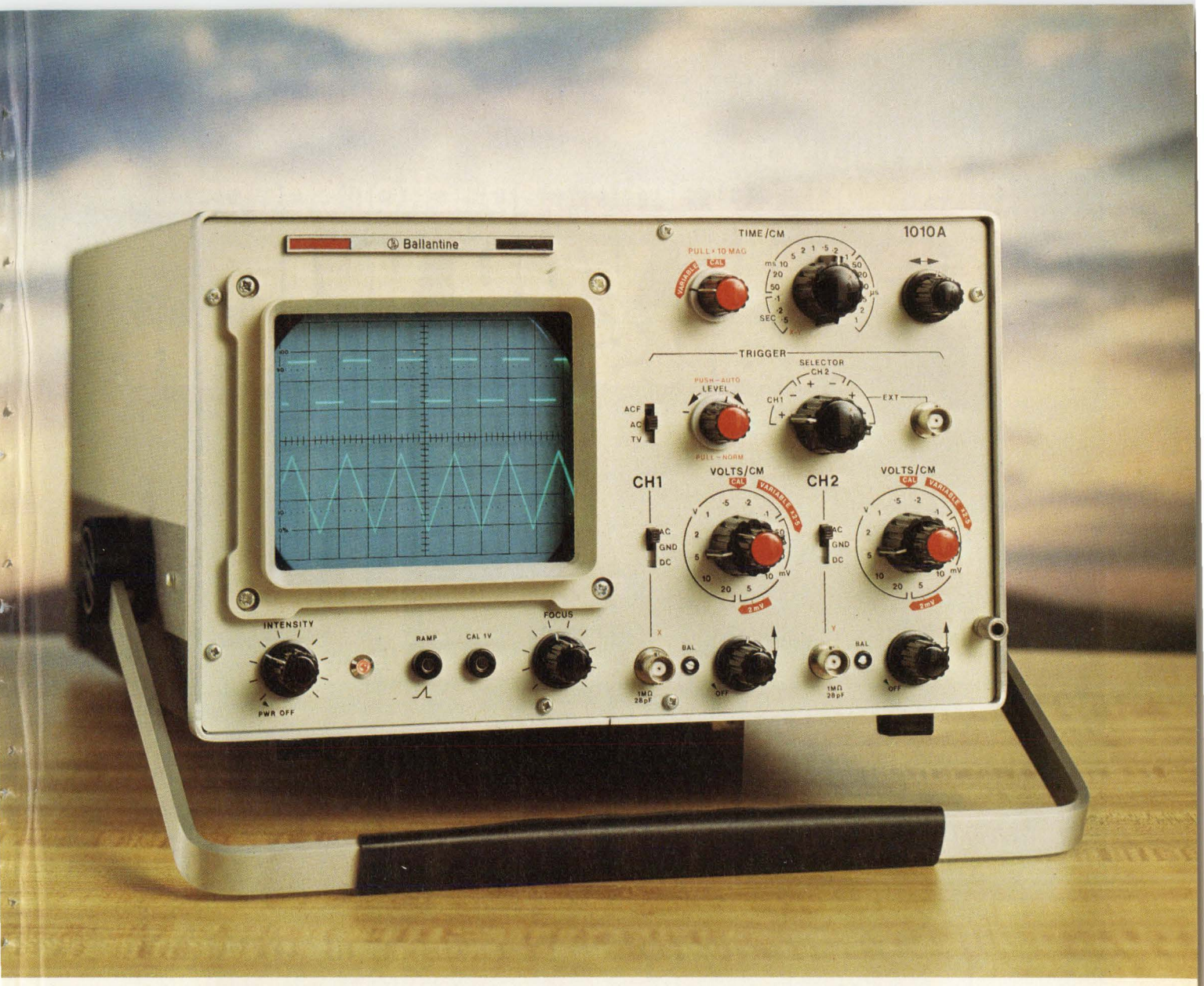
ITT's Cannon Electric division in Santa Ana, Calif., is trying to build a six-fiber optical connector with less than 1-dB repeatable insertion loss. "But there's a five-month extension to the contract at no cost to the Government," says Christian. "The first units didn't work, but we're confident that industry will be there with the connectors that we want when the need and market arises."

Perhaps one of the more significant promises of fiber-optics is potentially lower life-cycle costs, including less expensive repeaters and fewer repairs and spares, as well as lower costs for transporting and storing the smaller and lighter fiber-optic cables.

As for cable costs, "we firmly believe we can get the cost of fibers down to the order of 10 cents per meter for annual quantities of 50,000 to 100,000 kilometers," says Corning's Fairaizl. Adds the Army's Christian, "We had originally anticipated a cost of 40 cents a meter." Cable costs are expected to be about 50 to 60 cents per meter for a 0.25-in.-diameter cable with six fibers and some strength members. □

**Strictly comparable.** These two reels of 26-pair coaxial cable are length for length the equivalent of the single reel of fiber—vivid proof of the latter's small diameter.



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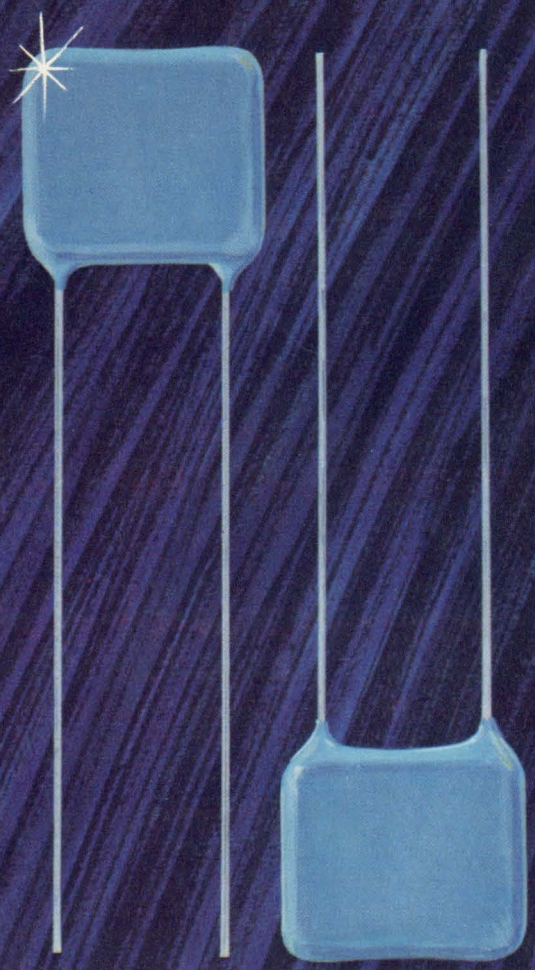

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Communications

# Aiming satellite TV at rooftops

Delegates to ITU conference agree on orbits and allocate frequencies in Eastern Hemisphere for direct broadcasting after mid-1980s

*by Arthur Erikson, Managing Editor, International*

**Telecommunications officials from** around the world are already planning how to beam television broadcasts through communications satellites in geostationary orbit to individual rooftop antennas. While it will be the mid-1980s or later before significant numbers of viewers will be receiving programs that way, the prospect of broadcast-satellite service—or BSS as it's known—already has national radio-TV organizations excited, particularly in highly developed countries where terrestial networks are out of the question.

The tab for full-fledged BSS will run in the hundreds of millions of dollars for most countries, and none yet has a clear idea of how or where to raise the money. Nonetheless, systems planners around the world can go to their drawing boards right now if they want to. The technical parameters for BSS were blocked out by experts from 111 countries during a five-week International Telecommunications Union World Administrative Radio Conference in Geneva that ended in mid-February.

Moreover, channel allocations in the 12-gigahertz band, and satellite positions as well, were worked out for countries in Europe and Africa (ITU Region 1) as well as Asia and Australasia (Region 2). North and South American countries, urged by the United States to postpone detailed planning, assigned no channels but did set aside positions in space for BSS. Channel assignments will come out of a conference by 1982 at the latest. In all three regions, the frequency band of 11.7 to 12.2 GHz (12.5 GHz in Region 1) can be used also for satellite and terrestial services, further complicating the problem of allocations.

**Delay.** U.S. delegates wanted a delay because, as one put it, "we don't want to get locked into 1970 technology." And, although the 25-man U.S. delegation was not fully persuasive, it did convince the representatives of other American countries to set slightly more stringent system parameters—implying better technology—than did the Africans, Europeans, Asians, and Australasians. "We can live with this flexible plan; it's not too bad," says FCC Commissioner Robert E. Lee, who headed the U.S. delegation.

**Carrying the flag.** Heading the United States team at last month's Geneva conference on broadcast-satellite service was FCC Commissioner Robert E. Lee.


By and large, the delegates from the other 110 countries went home satisfied. "This is the first administrative conference I known of where we didn't have to take votes [in plenary session] to settle issues we couldn't get a consensus on," says one ITU official.

For BSS, the conference agreed that the basic broadcast signal would be frequency modulated, although other types of modulation were not ruled out so long as they do not interfere more than straight fm; beam polarization will be circular. In Regions 1 and 3, the power-flux density was set at −103 decibel-watt at the edge of the coverage area (about the same as the half-power contour around the axis of the beams' intersection with the earth). At the −103-dBW level, a receiver with a figure of merit (G/T) of 6 dB/kilometer and an antenna 0.9 meter in diameter will do for individual reception. At the satellite, this level works out to an effective isotropic radiated power (EIRP) of 67 dBW. For systems designed for community antennas, flux density was set at −111 dBW.

**Lower power.** The American countries plan to transmit slightly less power, providing a power-flux density of −105 dBW at the edge of the coverage area for individual reception. This translates into 63 dBW EIRP at the satellite, and a 1-meter will be needed for the

## Probing the news

receiver. This density is higher than the 58 dBW of the U.S./Canadian communications-technology satellite, which uses a record-high-power 200-W traveling-wave-tube amplifier for direct broadcasts.

The American countries also will work with smaller bandwidths than the Region 1 and 3 countries. In their frequency plan, the necessary bandwidth was set at 27 MHz with guard bands of 14 MHz at the lower edge of the band and 11 MHz at the upper edge. Region 2 bandwidths are 8 and 23 MHz, with guard bands of 12 and 9 MHz.

As for the satellites, the plan laid down for regions 1 and 3 presupposes a nominal spacing of 6° between BSS satellites around the equatorial orbit. Lower-powered satellites for telecommunications services can be slipped between them with adequate precautions against interference. After the BSS satellites have been lofted to their assigned stations, they must not be allowed to drift more than ±0.1°. The antenna beam, too, is limited to a deviation of 0.1° in any direction. There is a ±2° limit on angular rotation of the beam unless the beam is circular and circularly polarized.

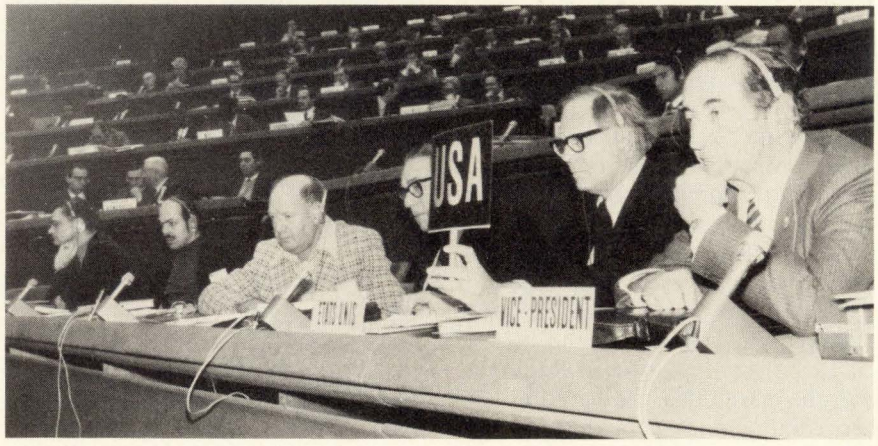
**Allocation.** Region 2 countries set aside two big segments of their share of the equatorial orbit where BSS will rate as a primary service. This allocation assures the Latin-American nations that the skies of the Western Hemisphere won't get filled up with fixed-service satellites put up by the U.S. and Canada before direct broadcasting comes of age. The segments are 75° to 100° west longitude (95° for services to the U.S., Canada, and Mexico) and 140° to 170° west longitude. In addition, each country in Region 2 is assured of getting a minimum of four channels when the region's frequency plan is stitched together in 1982.

During session breaks at the conference, systems costs—although not on the agenda—were on many delegates' minds. For a satellite alone, an official of the National Aeronautics and Space Administration hazarded an estimate of $50 million to $150 million. On top of that outlay come up-terminal costs and more money for receivers.

Receiver cost projections ranged from several hundred to several thousand dollars. Japan's public-broadcasting service, NHK, has developed a front end for 12-GHz color-TV reception that has an antenna only 2 feet in diameter and converts the fm signal from the satellite into an amplitude-modulated signal that can be fed to the antenna terminals of a standard cable-TV set. The target mass-production price is $200.

But, even though the Japanese apparently have half the problem in hand, they are not yet ready to try beaming BSS directly to homes. The experimental system they have scheduled to start up next year will have community receivers with antennas of 1.6 meters diameter at the center of the beam and up to 4 meters at the fringes. □

**In action.** U. S. team at the World Administrative Radio Conference included (from right) Lee, Edward Reinhart, Neil McNaughton, Peter Sawitz, William Jahn, and Francis Urbany.



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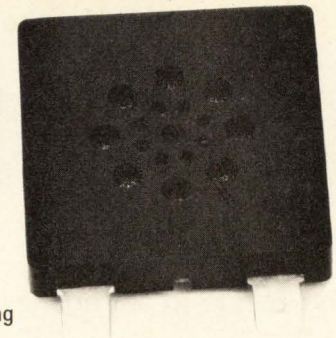

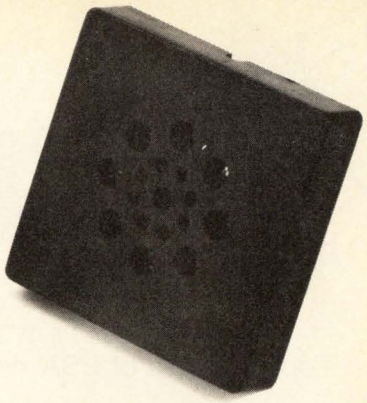

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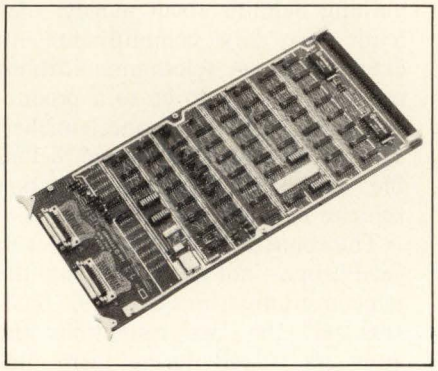

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Line Frequency Clock Module.

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# EUROPE CHARTS SPACE TECH PATH

Space electronics

Top ministers of ESA nations decide to put agency into communications-satellite business as catch-up phase ends

*by Arthur Erikson, Managing Editor, International*

**The Western European** countries now have a pretty good idea of what their place in space will be by the mid-1980s. So far, they've been pressing to acquire the capability to put working satellites into orbit—all too often squabbling among themselves how best to do it. This catch-up phase of their space effort will be largely achieved by the end of this decade, and they have started planning for the "industrial" space era to follow.

To be sure, no one intends to match the programs of the U.S. or USSR. The European Space Agency estimates that spending for space projects by its 11 member countries last year totaled some $750 million. In the U.S., the National Aviation and Space Administration's budget for the current fiscal year runs some $3.7 billion, and the Defense Department also spends heavily for space programs. But the Europeans expect to meet their own needs for satellite systems by mid-decade and also pick up business from the Third World and international groups like Intelsat.

Funded by contributions from its member states, ESA now writes the checks for about two thirds of the European space effort. The agency has budgeted some $500 million this year and wants to hold at that level through 1980. But the spending for the two largest programs—the Ariane launcher and the Spacelab that will ride NASA's Space Shuttle—peaks this year. "We're trying to avoid a slump in funding like NASA had after Apollo," says Andre Lebeau, ESA's deputy director and chief planner.

ESA apparently will get the backing it needs, even though most of its member countries—particularly Great Britain and Italy—are striving for austerity. At a mid-February space ministers' council, the first since ESA was formed 18 months ago by merging the launcher organization ELDO and the satellite organization ESRO, general manager Roy Gibson pitched for a commitment to a budget of a little more than $1.5 billion for the three years ending in 1980. That is more than the ministers want to spend, but their response to the proposal left staff members optimistic.

Although the ministers decided nothing definite about money, they made two key commitments—to extend the ESA telecommunications program and to go on to a production phase for the Ariane launcher. That work must be started before the last of the four qualification vehicles is launched in 1980.

The council directed the agency to get Europe—not ESA itself—into the telecommunications-satellite business. Of the two resolutions the ministers passed during their mid-February meeting, one spelled out guidelines for the agency's role in managing full-fledged operational systems. One of the key clauses limits ESA's operation activities to the launching, placing in orbit, and orbital control of satellites or space-transport systems, and to the provision of technical assistance in the design and exploitation of systems, either to the users themselves or to a body designed by them. The state-run telecommunications administrations will probably operate Europe's future domestic-satellite systems.

By the end of 1980, Europe should be ready to start using Arianes to launch at least two payloads a year. The first four qualification vehicles will go up in 1979 and 1980, and a batch of production models will follow. The first half dozen will be ordered in 1978 from France's space agency, the prime contractor, unless ESA's plans go considerably awry. Four will loft ESA satellites and two Third World satellites. ESA figures the Ariane can put a 900-kilogram payload into a geostationary and 4,000 kg into a low circular orbit. For solar orbits, the payload drops to 400 kg. Improved versions that would up these performance figures are, of course, a good possibility for later in the program.

As for the communications satellites, the first experimental models should be on orbit by mid-year. Known as OTS (for orbital test satellite), it will be followed early next year by a marine-communications version called Marots. A second Marots could well go up in 1979; it is on the list for the extended telecommunications program the ministers in mid-February approved in principle. Delta 3914 launchers will flash these three satellites into orbit. But in 1981, ESA plans to use its own Ariane to launch the first satellite for a European regional comsat system into orbit. □

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Computers

# Encryption standard protects data

## Semiconductor makers expect major market in devices, as Fairchild, Rockwell, and Motorola get early start

*by Ray Connolly, Washington bureau manager*

**As the use** of computers—and the wealth of data they contain—have grown, so have the fears of governments, businessmen, and private citizens that important information concerning their operations or lives would fall into the wrong hands. Now the National Bureau of Standards has moved to allay those fears with the adoption of the first data encryption standard for government and industry use.

Makers of semiconductors and communications equipment see the standard as the source of a major new market when it is officially implemented on July 15. "It will probably be one to two years before a full range of devices is widely available," estimates Dennis Branstad, project leader for the standard. "Then the market will build from there."

Even as NBS and Government computer users detailed plans for implementing the new data encryption algorithm during a mid-February conference, three electronics manufacturers were already moving on the hardware market. Fairchild Semiconductor disclosed plans for using its new, high-speed 9414 Isoplanar integrated injection logic chip [*Electronics*, Feb. 17, p. 82] for the job. Motorola Semiconductor indicates it will employ its M6800 security module, scheduled to become available in small quantities in April, for the task. Rockwell International's Collins Radio is working on yet another large-scale-integrated approach that Branstad describes as "a fully-buffered input, compute, and output device in which the input-output provides simultaneous encryption and decryption."

Fairchild's 9414, which evolved from classified military programs at its Syosset, N.Y., Space and Defense Systems division, is scheduled for sample distribution later this year, says Krishna Rallapalli, advanced products manager. Using what NBS's Branstad calls "a very innovative approach," Rallapalli says the 9414 uses four "identical" bit slices measuring 125 mils on a side to achieve greater reliability and lower cost in production than could be achieved by putting all functions on a single 350-mil chip. Each chip will use two 8-bit shift registers for error detection, while the remaining four will be used for code key.

Motorola's medium-speed M6800 security module for microprocessor interfaces uses a simpler approach, says Branstad, which the company believes will be adequate for the foreseeable market. The 9-by-6-inch board contains the MC6800 microprocessor package plus all buffering and an optional erasable read-only memory for storing keys or smart address control. Keith Warnable of Motorola's Data Security Devices operation says it can be used in block or cipher-feedback modes.

**Origins.** Development of the 64-digit algorithm employed in the standard formally known as FIPS PUB 46 (Federal Information Processing

### Who sets the standards?

While the National Bureau of Standards has employed an IBM concept to develop its new data encryption standard, computer users are already looking for a standard-setter for hardware to guarantee compatibility and interchangeability of parts. Some of those problems are already being addressed by the American National Standards Institute. Government computer users are likely to be the earliest and largest users of the encryption standard, an even larger influence can be expected to come from the Federal Telecommunications Standards Committee, a group that is composed of representatives from diverse agencies.

While the committee is struggling with hardware standards, the Federal Reserve Board's Howard Crumb says it will begin testing devices using the algorithm by mid-1977 with an eye to measuring its operational impact and crypto-key-management and storage approaches. Meanwhile, Jack McDonnell of the National Commission on Electronic Fund Transfers says the commission will recommend technical guidelines for EFT, including implementation of the standard, to the Congress by the end of the year.

One of the earliest tests will come with the standard's use by the Pentagon's Advanced Research Projects agency, whose ARPA network decided to test the encryption algorithm in 1975, long before its adoption, according to Stephen Walker, ARPA's program manager for network security. The Arpanet will employ 13 encryption control units between each terminal used in the test, including the key management facilities. These units, developed by Collins Radio, will use two Digital Equipment Corp. LSI-11 microprocessors for encryption control at each terminal plus a PDP 11/40 for system control and as a key distribution center.

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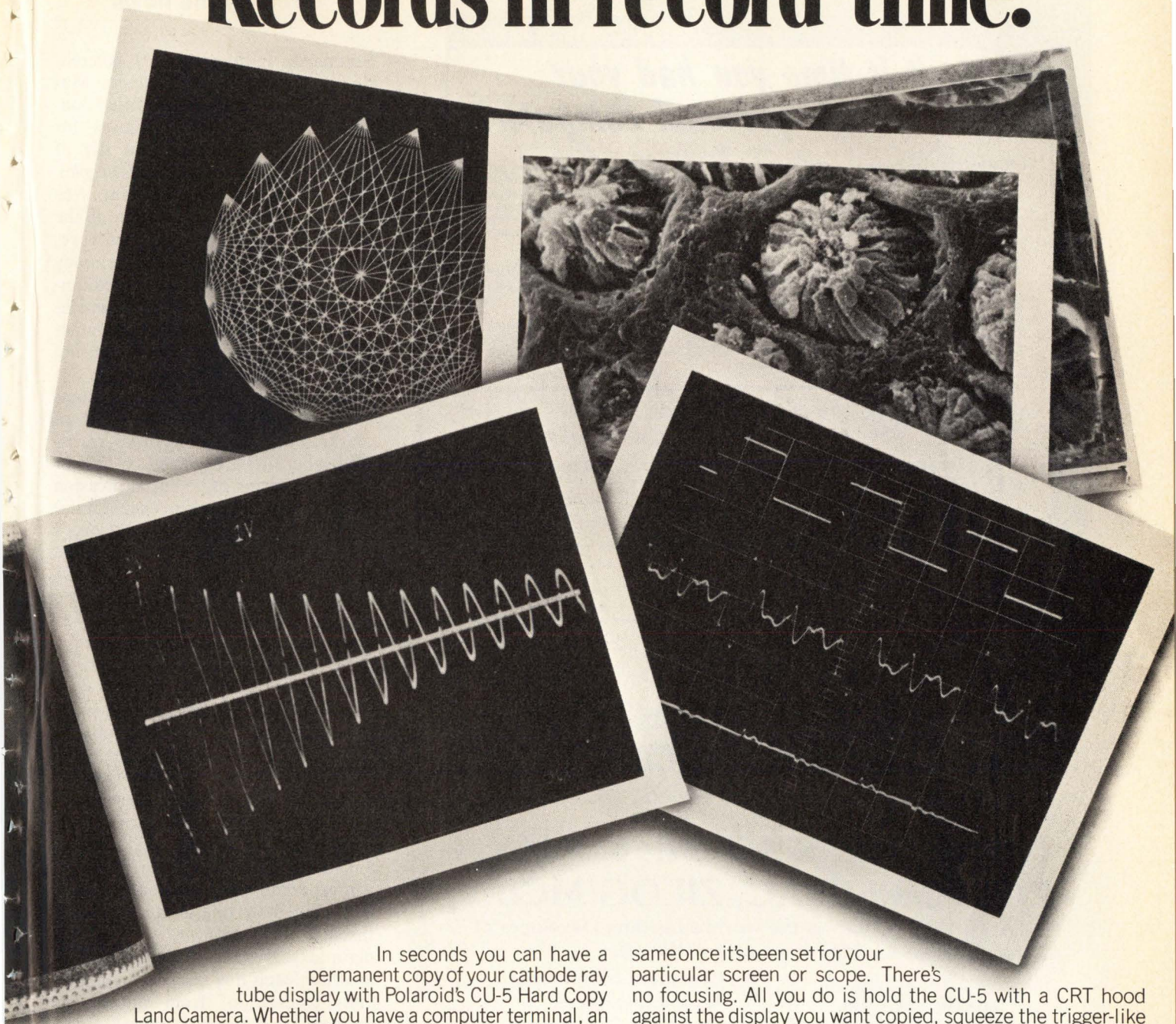

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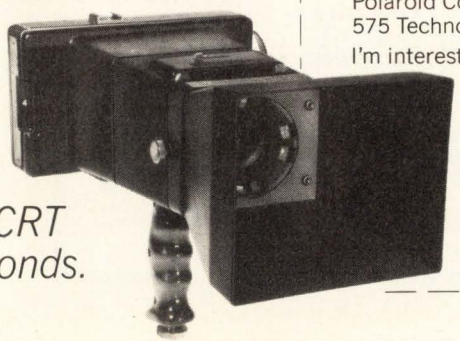

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## Probing the news

Standards Publication 46) is credited to International Business Machines Corp., which has granted nonexclusive, royalty-free licenses for the manufacture, sale, and use of hardware employing it [*Electronics,* Dec. 23, 1976, p. 42]. But NBS specifies that implementation of the standard must be in hardware, rather than software, and employ chips using LSI technology, medium-scale integration components, or other devices such as read-only memories or microprogrammed units using microcode for hardware control.

Bringing the data encryption standard into the workaday world of markets like electronic funds transfer—where it is expected to answer many criticisms of potential invasion of privacy—still requires substantial effort, however. Burroughs Corp.'s Ed Lohse warned the NBS conference that standardization of parts like LSI chip pinouts and power dissipation will be critical to the success of device interchangeability. Similarly, data rates and communications interfaces must be meshed.

**Links.** Levels at which encryption takes place also was a major topic at the meeting at NBS's Gaithersburg, Md., headquarters. Link-by-link encryption, where devices incorporating the algorithm are placed in series with the circuit between a terminal and the communications equipment, is most commonly used today. But it is limited by letting data traffic pass through any node of a system in plain text. Node-by-node encryption, in which each line uses a unique key and "translation" from one key to the next occurs in a peripheral security module is considered promising.

But Interbank Card Association's Carl M. Campbell Jr. believes end-to-end encryption appears to be the obvious choice for systems where conversations are relatively long, as in the military. Such encryption uses a key control center in the communications link that can be reached by each of a system's terminals through its own key. The key control center then verifies a terminal's authority to communicate with others and generates a temporary key for that particular communication. □

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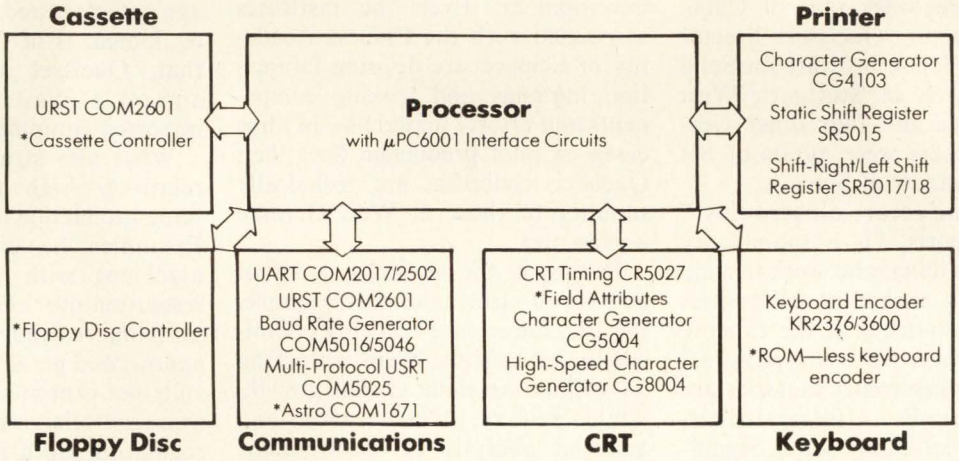


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# 熱烈欢迎西德朋

Electronics abroad

# Chinese put priority on semiconductors

*by John Gosch, Frankfurt bureau manager*

**Although not yet** a factor in world markets, the People's Republic of China is making big strides in electronics technology, particularly in semiconductors. It is producing MOS-memory circuits with good yields and has made semiconductor lasers that can operate at room temperatures for more than 5,000 hours. It is also intensively investigating magnetic-bubble memories and other sophisticated devices.

These observations were made during a three-week tour of China by Hans-Joachim Queisser, director of the Max Planck Institute for Solid State Research in Stuttgart, West Germany. He and four other German researchers were guests of the Chinese Academy of Science.

"Semiconductor electronics," Queisser reports, "is a top-priority endeavor in China, and work in solid state is being pushed at universities and by the academy at the expense of many other fields in physics." Many small electronics factories are producing transistors, integrated circuits, and other components. Significantly, the institutes, universities, and factories cooperate closely, and "there is little duplication of effort at the various facilities," says Queisser, a former associate of transistor co-inventor William Shockley.

So far, a relatively small output, lack of automated techniques, and high component costs have prevented China from entering world markets. But Queisser, for one, does not quarrel with Western sources who put China among the world's top 10 electronics producers and who see the nation of 750 million challenging the Soviet Union and West Germany in a few years. China watchers peg the country's 1974 electronics output at $2 billion.

**No basics.** As for fundamental research, however, "in the western sense it is virtually nonexistent in China," Queisser says. The emphasis is almost wholly on semiconductor development. Even the institutes associated with the Chinese Academy of Science are devising fabrication methods and making components and crystal materials—in some cases on pilot production lines that, Queisser concedes, are technically superior to those at West German universities.

Peking is the center of a lot of activity in electronics. For example, the Chinese science academy's Semiconductor Institute there is working on gallium-arsenide crystal growth, liquid epitaxy, luminescence, and material analysis by spectroscopy, and it has silicon and GaAs microwave diodes as well as MOS devices in pilot production. Then, too, the semiconductor department of the Peking-based Institute for Physics is engaged in solid-state laser work, as well as artificial diamond, spinel, and garnet fabrication and experiments with bubble memories. Tsinhua University, also in Peking, is fully equipped to produce and test MOS devices such as 1,024-bit p-channel memories.

Also active in the MOS field is Nanking University's Institute for Physics, now primarily engaged in semiconductor work. It has charge-coupled devices like shift registers in pilot production and is involved in transistor-transistor-logic device development, material analysis, and experiments with silicon-on-sapphire components.

In Shanghai, at the academy's Institute for Metallurgy, Queisser witnessed work on GaAs materials and components, field-effect transistors, and Schottky diodes.

Canton's Sun Yat-sen University is producing silicon varactors, developing sputtering techniques, and experimenting with nitrides with a view toward metal-nitride-oxide-semiconductor components.

But some areas are neglected in China. Among them are microprocessors, glass fibers, and certain other fields of optoelectronics.

**Equipment.** At the disposal of Chinese development engineers is a large array of production apparatus, instruments, and test equipment: microwave testers, evaporation and sputtering apparatus, multichannel analyzers, oscillographs, and vacuum equipment with helium-leakage detectors and oil-less pumps. All equipment is of Chinese origin, and that, Queisser says, "particularly amazes a West German" used to imported equipment in his own lab.

What also struck Queisser is the relatively high technical level of some production and test equipment. Examples he cites are exposure machines with a $\pm 1$-micrometer resolution over the wafer, dual-trace sampling oscillographs rated at 1 nanosecond per division and 10 millivolts per centimeter, and high-precision controllers said to be capable of regulating diffusion oven temperatures to within $\pm 0.1$°C at 1,100°C.

Hard work at semiconductor facilities seems to be the order of the day. One factory that Queisser visited employs some 800 people in two, and sometimes three, shifts. Work on Sundays is not uncommon, and, what with automated or computer-supported mass-production techniques all but nonexistent, manual labor is very much in evidence. □

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For Bob Cox, Chief Engineer at Threshold, anything less just wouldn't have been enough.

"At first we offered our voice-input terminal using a mini. But that put the price of the system at $18,000 — a price that was way out of line with a lot of applications. So to cut costs, we developed our own micro from chips. Then the LSI-11 came out. Right off, we knew it was the answer.

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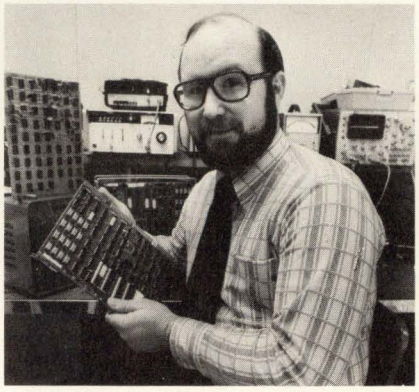

Bob Cox, Chief Engineer at Threshold Technology, Delran, New Jersey

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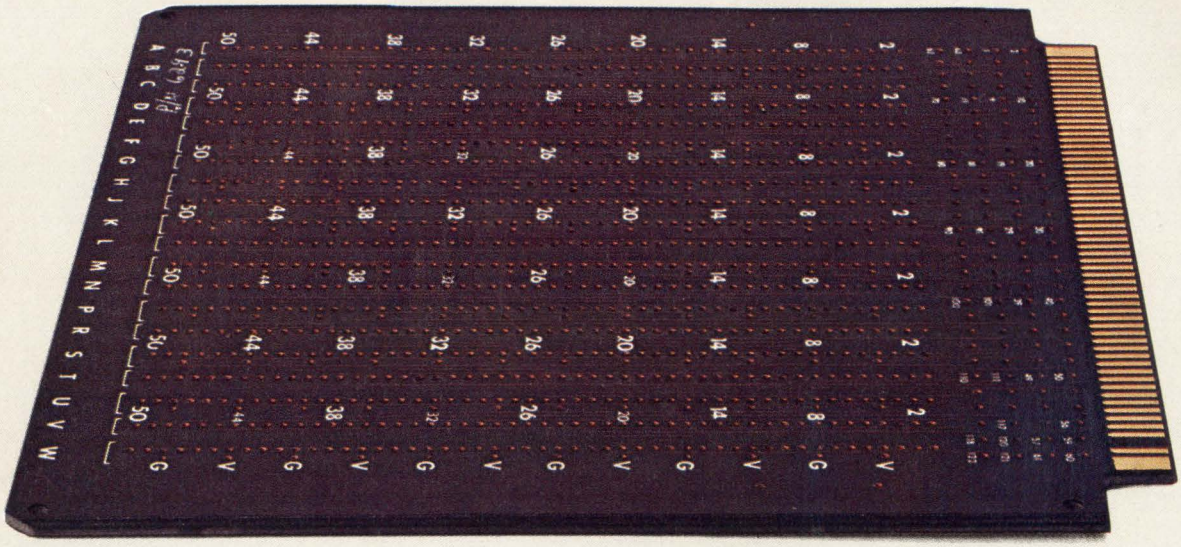
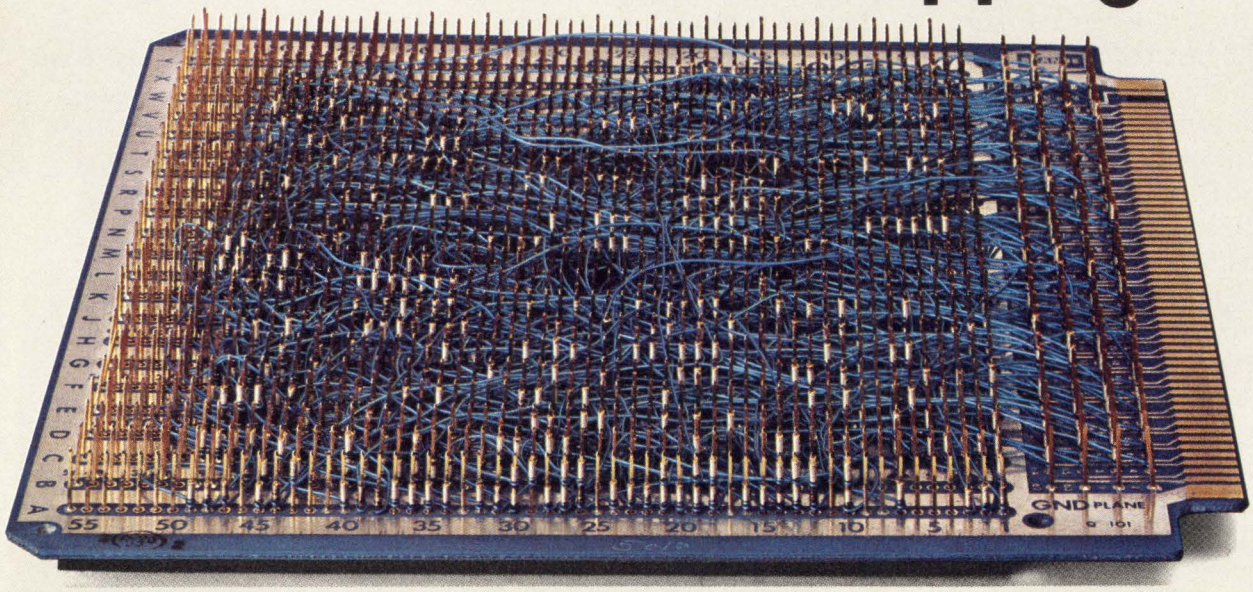
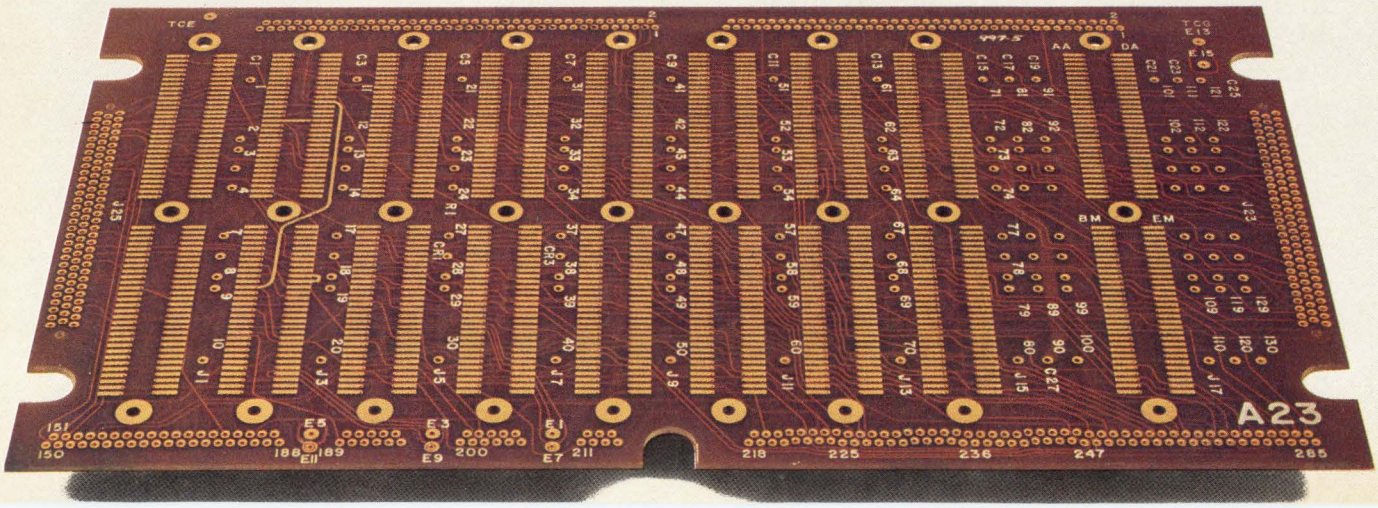


## costs less than wirewrapping...

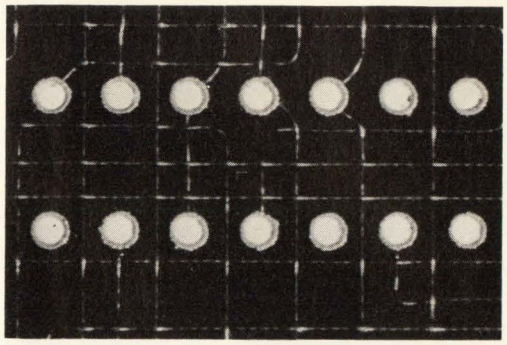


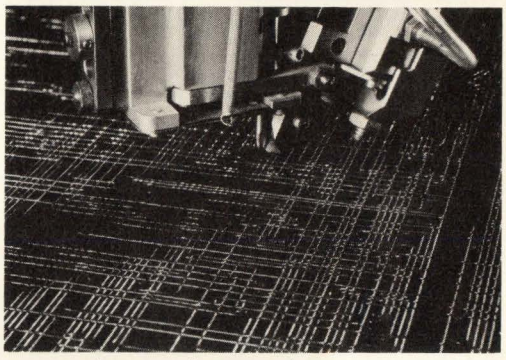

## works better than multilayering.



Two major systems—wirewrapping and multilayering—have been used for complex electronic interconnection in the last 15 years. Despite improvements and refinements, each still has inherent disadvantages. That's why Multiwire was created by Photocircuits. It overcomes the disadvantages of wirewrapping and multilayering.

A Multiwire board is basically a customized pattern of insulated wires laid down on an adhesive-coated substrate by a machine operating under numerical control.





## Multiwire vs. wirewrapping.

Today, interconnection costs are more important than ever. So take a long, hard look at a key advantage of Multiwire panels. They cost much less than wirewrapping in small or production quantities. Multiwire prices also include a 100% continuity check.

But cost is not the only reason for the superiority of Multiwire over wirewrapping. There are also design advantages. For example, Multiwire offers two-dimensional packaging density equal to wirewrapping. But with Multiwire panels, you reduce board-to-board spacing. And Multiwire weighs much less too. So it can contribute substantially toward improving the envelope or three-dimensional package of your product.

Electrically, Multiwire is also superior. The extreme repeatability of the manufacturing process provides much higher electrical reliability as received—this is an important cost-saving factor. In addition, you get the controlled impedance characteristics required without variations.

## Multiwire vs. multilayering.

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| **3 dimensional packaging density** | Medium | High | High |
| **Weight** | High | Low | Low |
| **Ease of changes** | Excellent | Poor | Good |
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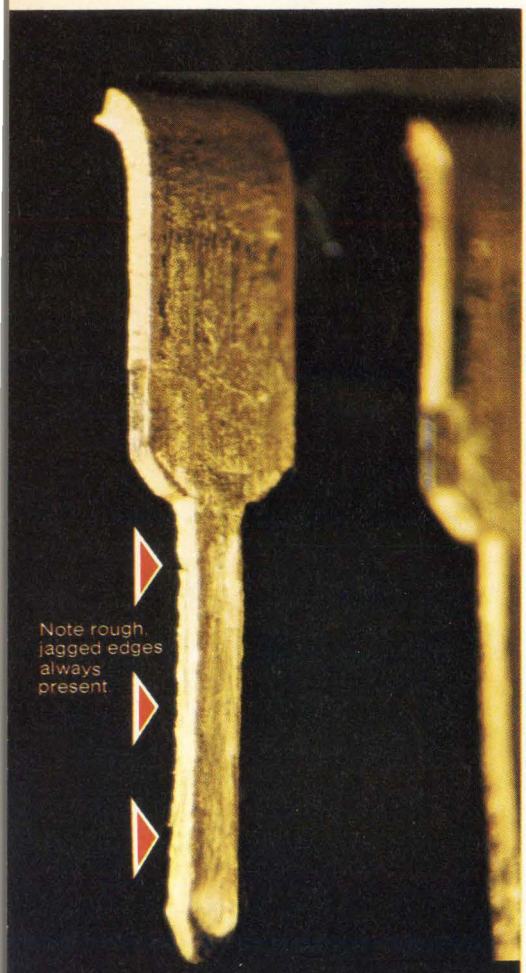
UNRETOUCHED

# MICROPHOTOS




**Your IC lead frames look like this** at 30X enlargement (unretouched). Because they are punched out of metal, the edges are rough, jagged and irregular. In contrast, the flat sides of the lead frame are smooth, even and perfectly plated.

Arrows indicate scars and abrasions made by rough edge of lead frame.

22X magnification, unretouched.

## THEIRS

**An ordinary edge-bearing socket contact** after 5 insertions of DIP lead frame. Contact has been spread apart to show inside faces of contact. Notice how the contact has scars and abrasions from *rough, irregular edge of IC lead frame.* Electrical contact is degraded and resistance is increased. Reliability is obviously reduced.

*Lead frame in place in an ordinary edge-bearing contact.*

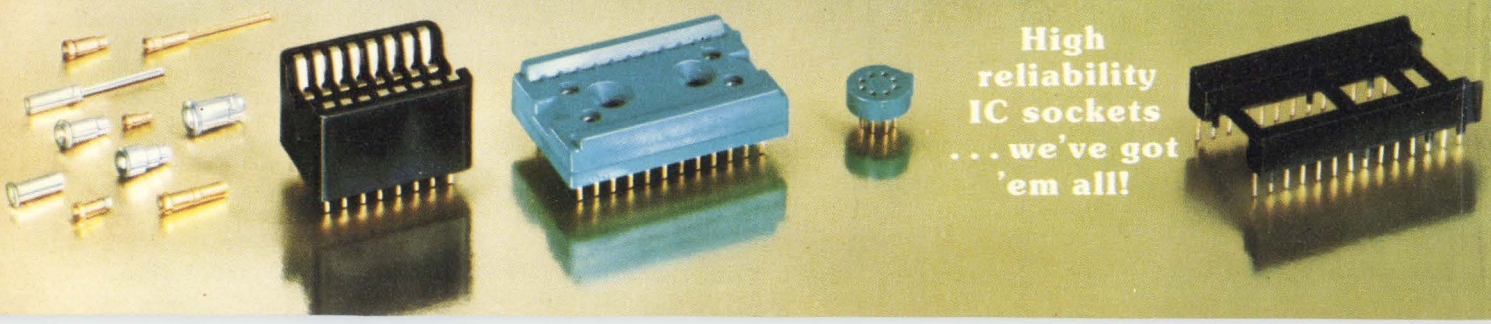
Arrows indicate contact surface still smooth, clean, free from abrasions.

22X magnification, unretouched.

## OURS

**ROBINSON-NUGENT "side-wipe" socket contact** after 5 insertions of DIP lead frame. Contact has been spread apart to show inside faces of contact. See how the RN contact—because it mates with the *smooth, flat side of the IC lead frame*—retains its surface integrity. This 100% greater lead frame contact results in continued high reliability.

*Lead frame in place in RN "side-wipe" contact.*



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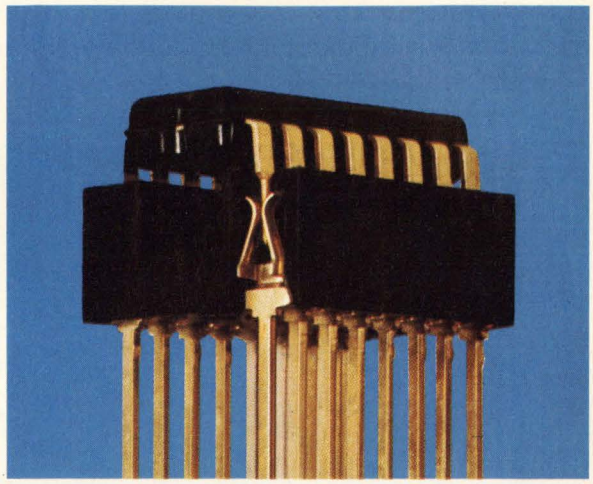

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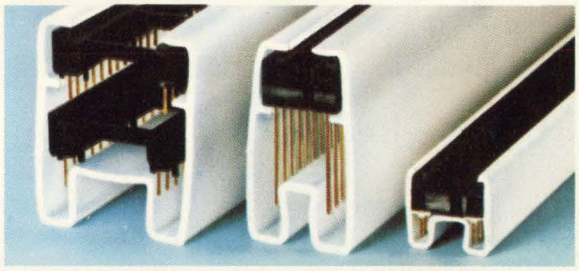

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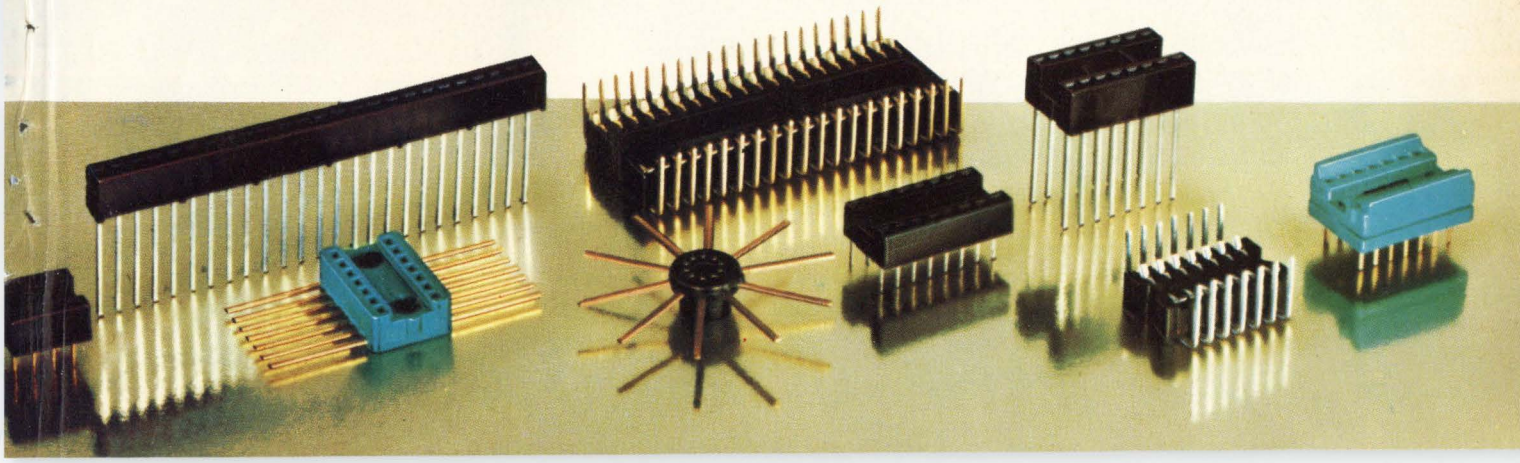
Circle 86 on reader service card



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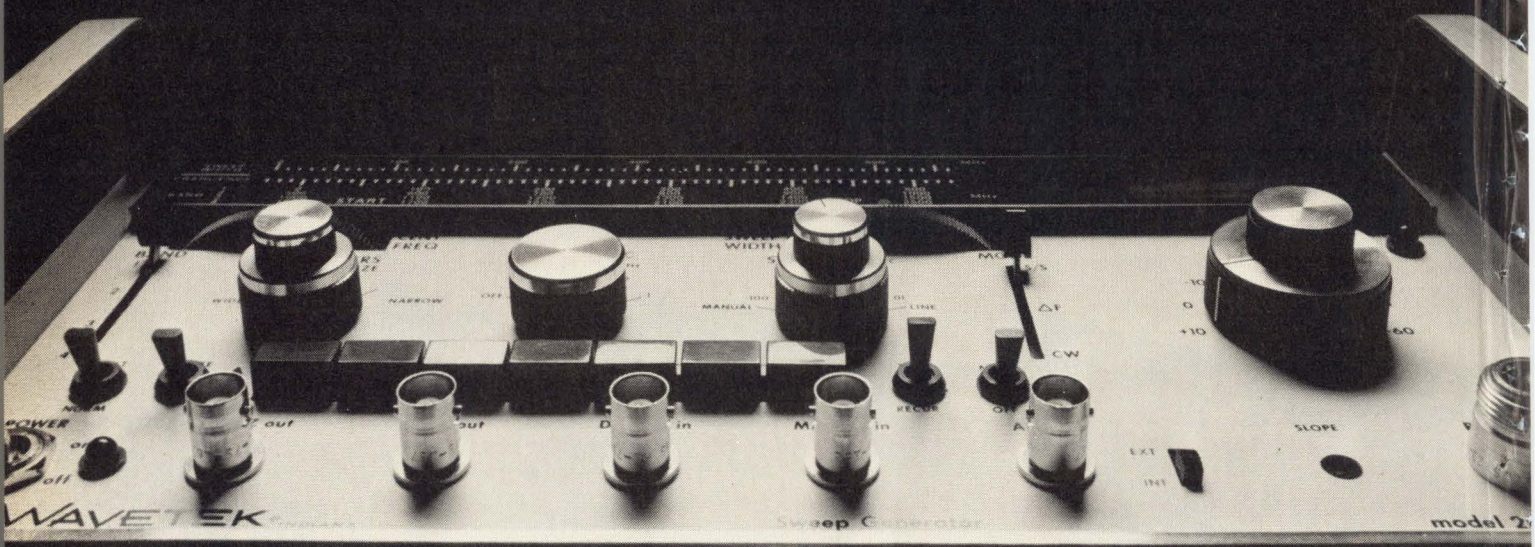
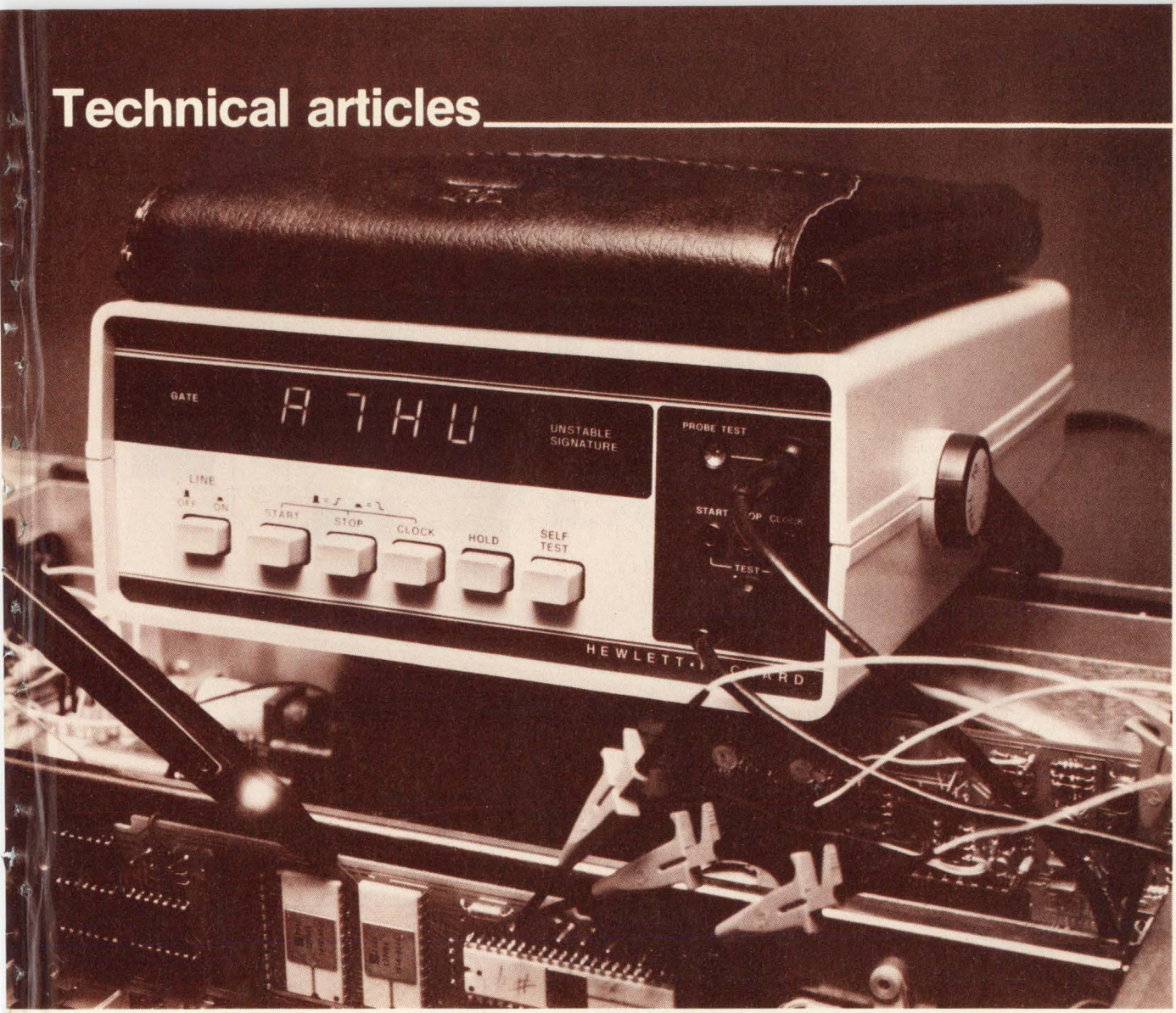



Circle 88 on reader service card



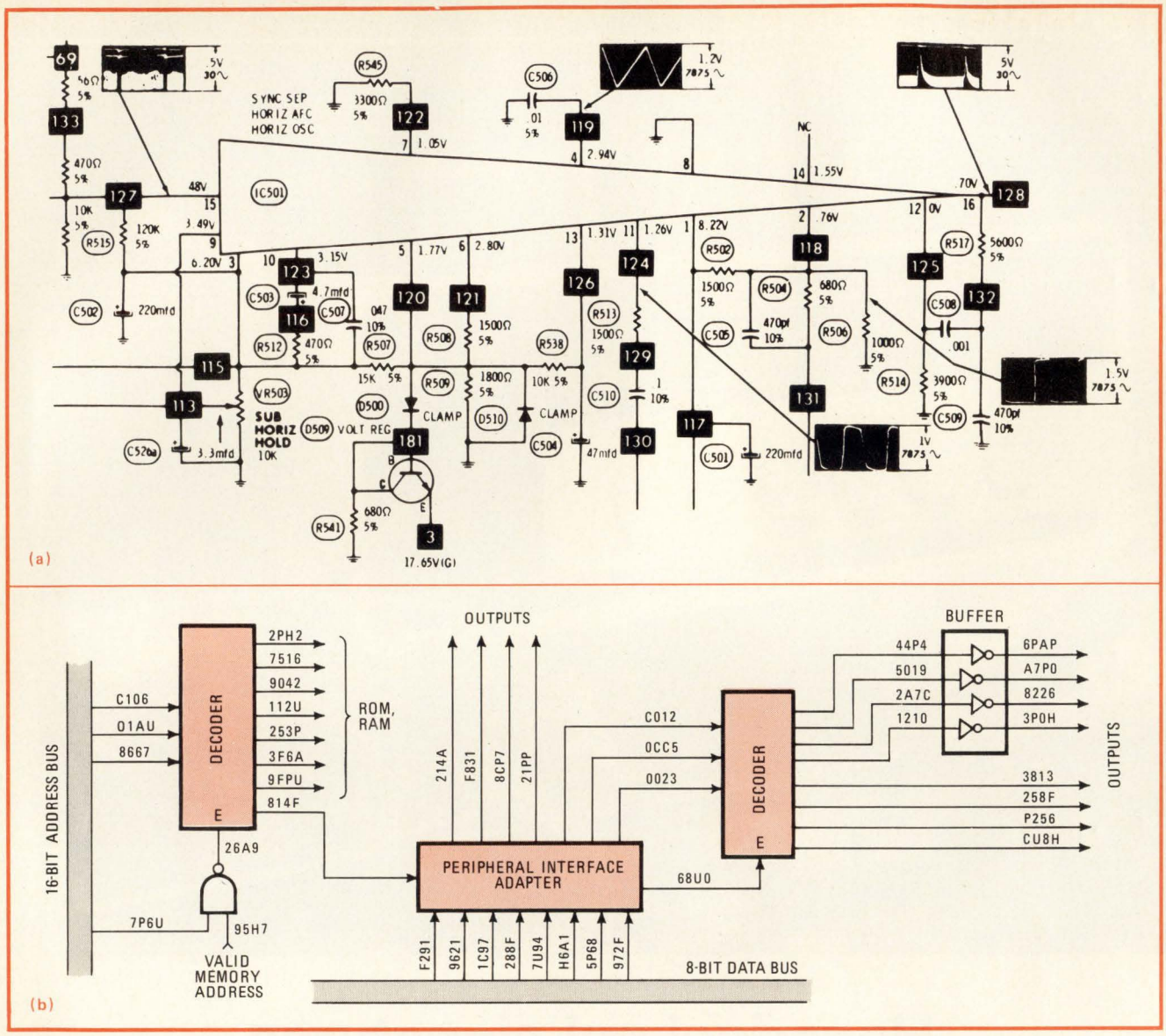

# Hexadecimal signatures identify troublespots in microprocessor systems

by Gary Gordon and Hans Nadig, *Hewlett-Packard Corp., Santa Clara, Calif.*

☐ The number of microprocessor-based products manufactured each month is approaching the total of all installed computers and minicomputers, raising the question: "How will they be serviced?" Traditional digital servicing, in which defective modules are swapped for good ones, creates substantial inventory and handling costs. A much more economical alternative is a new technique called signature analysis, with which a product can readily be serviced down to the component level.

Signature analysis is based on the time-honored technique of signal tracing. When its requirements are designed into a product, a new test instrument can map lengthy bit streams from the product into short four-digit hexadecimal "signatures." These the technician compares with the correct signatures noted on the system's circuit diagram. If a bit stream is faulty, he traces it back through gates and memory elements until he can isolate an element with correct inputs but faulty outputs. The method has a 99.998% certainty of spotting a faulty bit stream, regardless of its length or the subtlety of its faults.

Signature analysis is more than a new measurement technique. It is a wholly new service philosophy, for the decision whether to adopt it requires a thorough evalua-




**1. A new form of digital ID.** Diagrams of analog circuits, as for a television set (a), have voltage levels and waveforms noted on them to aid service technicians (circuit is taken from a Howard W. Sams Photofacts service manual). But in digital circuits, all waveforms look alike, and the schematic shown here (b) is annotated instead with hexadecimal signatures that characterize the bit streams unique to each circuit node. A new test instrument derives actual signatures for the technician to compare with the correct ones on the schematic.

tion of its applicability while a product is still in the development stage.

The final decision will usually be based on economics. On the plus side, the technique:

- Increases a product's value to the customer by lowering his cost of ownership.
- Lowers warranty costs for the manufacturer.
- Lowers production-line troubleshooting costs, because it simplifies the job of isolating the speed-related failures, which cannot be caught by present board testers.
- Lowers materials costs, because the product no longer needs to be divided into replaceable modules.

On the minus side, designing signature analysis into a system does add back some other material expenses and also lengthens development time.

On balance, though, the pluses outweighed the minuses in Hewlett-Packard's first applications of the technique to two digital voltmeters. As will be described later, development time and costs rose roughly 1%. But the return on this investment was substantial. Factory costs dropped, since the 1% or so increase in parts cost caused by adding jumpers and extra read-only-memory space was more than offset by the roughly 5% decrease in other materials costs. As a matter of fact, HP has opted for signature analysis for the majority of its upcoming microprocessor-based instruments and other data products.

## Analog roots

Signature analysis reverts to the advantages of analog-equipment servicing. There, too, the serviceman uses an annotated schematic (Fig. 1a), which clearly shows voltages and waveforms and allows him to make repairs without a detailed understanding of the circuits. By

## How accurate is signature analysis?

For any technique intended to pick up errors in bit streams, it is important to have a measure of the accuracy with which it performs that function. To calculate the accuracy of signature analysis, the first step is to define an error bit stream as a hypothetical sequence related to an erroneous data bit stream in the following way: in the error bit stream, the bit or bits that are in error in the data stream show up as 1s, while bits not in error—regardless of whether they are 1s or 0s in the data stream—show up as 0s. Then, in, say, a 500-bit data sequence, if bit 42 is in error—whether it is a 1 or a 0—bit 42 of the corresponding error bit stream will be a 1 and all 499 other bits will be 0s.

The second step is to invoke the principle of superposition, which is applicable because the feedback shift register is linear. This states that the response of the register to the sum of two inputs is the same as the sum of its responses to the individual inputs. (Note that superposition is used only for this analysis and is not used in the actual instrument.)

From this it follows that if the register input is considered to be the sum (modulo 2) of two sequences—a data bit stream and an error bit stream—then the signature it should display will be equivalent to the sum (modulo 2) of the individual signatures.

Consider this case of summing the two signatures. If there are one or more errors in the data bit stream, the error bit stream will contain 1s in those locations. Then, the sum of their signatures should be different from the signature of the data bit stream itself. It follows that the signature of the error bit stream must be anything but 0 for errors to be detected. This deduction then leads us to examine the conditions under which the signature of the error bit stream becomes 0—the case where errors would go undetected.

With a 16-bit shift register the error bit stream's signature is never 0 for streams of 16 bits or less that contain a 1. This happens because the first 1 to enter the register never has time to leave it before the signature is complete and can never be canceled by a fed-back bit. Thus all errors are caught.

For length 17, one error-bit-stream sequence will be missed; that which starts with a 1, and then has a 1 present at each bit-time where the first 1 is fed back, thus canceling each subsequent error bit. Then, as the 17th bit enters the register, the first and only remaining error bit exits from the register. Thus the signature will be 0 even though there were 1s in the original error bit stream. This means that with 17-bit-sequence inputs, one of the $2^{17}$ possible combinations may be in error and will not be caught. For length 18, three are missed; for length 19, seven are missed; and so on.

In general, the percentage probability of catching an error in a sequence length m with register length n is:

$$100 - 100[H(m-n)][(2^{m-n}-1)/(2^m-1)]$$

where H is the step function (required to make the function zero for sequences of n or less).

In more useful terms, with register length n equal to 16, the error is always less than 1 in $2^{16}$, regardless of m, the length of the input stream (as m gets very large, the error term approaches $2^{-n}$). This gives rise to the certainty of 99.998% that an error, if present, can be spotted.

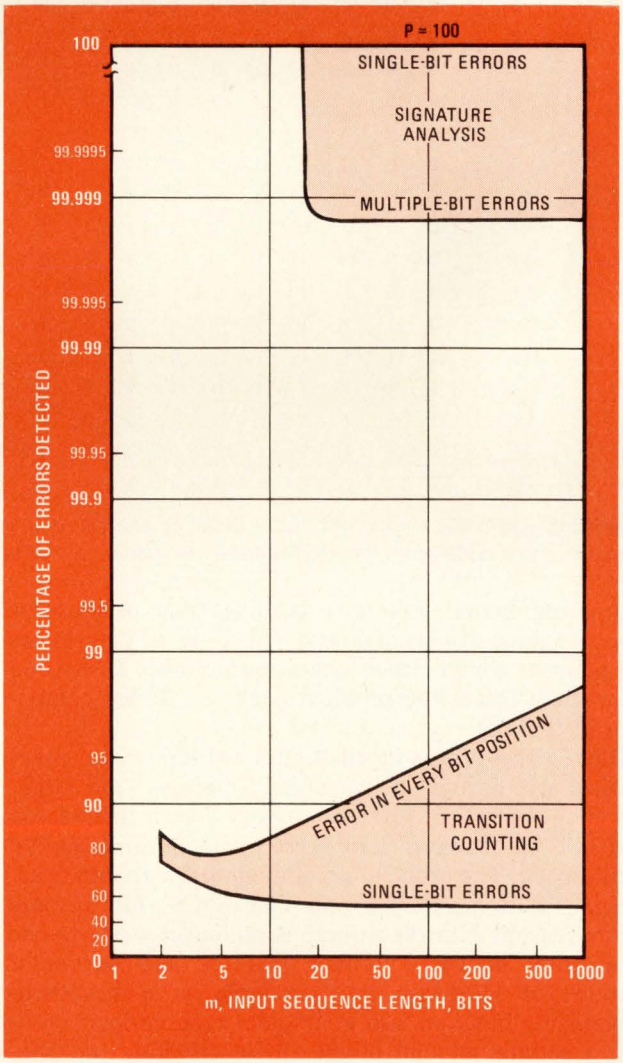
For transition counting, the corresponding probability that it will detect an error in a sequence of length m is expressed by the equation:

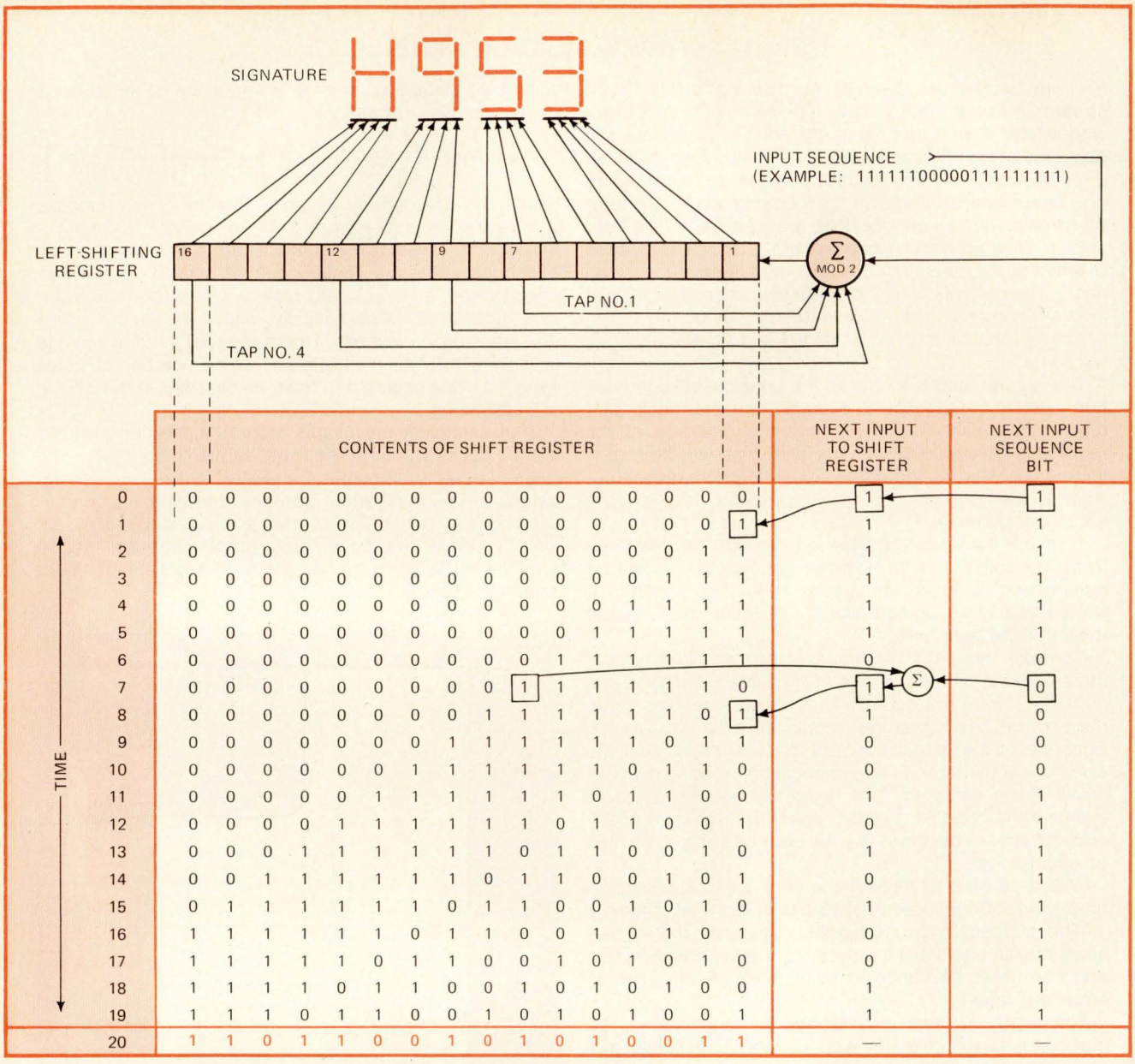
$$P(\%) = 100 - \left[\frac{100}{2^m(2^m-1)}\right] \sum_{r=0}^{m} \left[\frac{m!}{(m-r)!r!}\right]\left[\frac{m!}{(m-r)!r!} - 1\right]$$

where r is the dummy variable. This function increases with increasing m (see graph).

Although these two equations are valid when errors affect the entire bit sequence, that situation is seldom encountered, even in board testers with algorithmic stimulus generators. More typically, digital errors are subtle and affect only a few bits. This is especially true when one is looking for faulty bit streams some number of gates away from the source of a fault, as happens in the course of backtracing.

Thus an equally meaningful figure of merit for signatures is their ability to catch the most subtle of all faults—the single bit error. Signature analysis really excels here, catching every such error. Transition counting, in comparison, misses (m-1)/2m of the errors, nearly 50% for lengthy sequences. Logarithmic graph paper, in fact, is required in the figure to show the formidable superiority of signature analysis.






| | CONTENTS OF SHIFT REGISTER | | | | | | | | | | | | | | | | NEXT INPUT TO SHIFT REGISTER | NEXT INPUT SEQUENCE BIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| 12 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 |
| 13 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| 14 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| 15 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 |
| 16 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| 17 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| 18 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| 19 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 |
| 20 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | — | — |

TIME

**2. Shifting.** The basic component in the signature analyzer is a linear shift register with feedback. This converts the bit stream from a particular circuit node into a four-digit hexadecimal signature. The table shows how a 20-bit input sequence is processed.

comparing actual voltmeter readings and oscilloscope traces to those displayed on the schematic, he determines the point at which circuit operation becomes faulty and from there traces the problem back to a failed component in the unit.

But in the programmed digital world, service schematics are devoid of waveform, voltage, and other service information, for the not very comforting reason that all bit streams look pretty much alike on an oscilloscope. The problem is compounded with microprocessors, state machines, and controllers, for a more subtle reason: with them there is no longer a one-to-one association between product features and particular sections of hardware. For example, if a keyboard-debouncing function fails in an older random-logic product, a service manual might advise checking the integrated circuits that control that function. With microprocessors, on the other hand, key debouncing is more likely a time-shared function tying up the whole processor for a brief moment. When it fails, any one of a large number of ICs could be faulty.

### The price of board exchange

As a solution, subdividing the circuitry into replaceable modules has worked reasonably well till now. For one thing, board exchange places relatively few demands on the technical abilities of the serviceman. For another, it is and will remain the fastest way to make repairs when down time is costly, as in large computers and process-control systems. A further advantage is the economy of scale inherent in centralizing repair at the manufacturing site.

But these advantages carry a price. The economy of scale is offset by substantial administrative and inven-

tory costs. A manufacturer may have up to 5% of his assets tied up in service-module inventory, which includes both replacement-board kits and "float" boards in round trip to the factory or waiting in bins. Administrative and handling costs for such a program can also be quite high, particularly as a product approaches obsolescence in the marketplace.

Also, the problem looms of faulty boards in the loop. "Soft" or system-related failures are difficult to detect at repair centers, some of which have reported "no problem found" on 50% of certain returned boards.

Finally, board-level repair is particularly unattractive for supporting products overseas. Turnaround times for modules stretch way out, and import duties of several times the price of the module are often encountered.

For these reasons, centralized board-exchange programs are being widely reevaluated. A partial answer is to move service closer to the customer. For very high-volume products, where board exchange and automated test remain popular, many companies are moving their repair to outlying depots. For lower-volume products where up time is again critical, signature analysis is viable for depot repair of exchanged boards.

Signature analysis was primarily conceived, however, as a more radical change in service strategy. It is a way to substantially reduce repair costs on microprocessor-based products and ROM-based controllers that can stand a few extra hours of down time. Most instruments, computer peripherals, point-of-sale terminals, desk-top calculators, video games, and future citizens' band and television applications fall into this category. The list also includes equipment for which backups are often available: controllers, communications or military equipment, and some of the newer digital products as diverse as taxi-meter and gas-pump controls.

Here the administrative simplicity and cost savings of signature analysis are quite compelling. Troubleshooting by this method requires only a universal $1,000 test instrument, the HP 5004A signature analyzer (see p. 95), and the service manual of the product, which of course must have been specially designed to contain the necessary modest self-test program.

## Deriving the signature

Everything depends on the signature. A kind of compressed "fingerprint" of the data present on a node, it is compared with the correct signature printed on the schematic of the product (Fig. 1b) so that any discrepancy may be noted and traced to the source. Clearly, the major figure of merit for any such signature must be the accuracy with which it allows faulty bit streams to be spotted.

HP realized some years ago the potential of the signature-tracing method and investigated numerous ways in which bit streams could be compressed or mapped into signatures. Possibilities are transition counts, 1s counts to generate check sums, and even entropy, the communications measure of information. But a linear-feedback shift register, the method eventually chosen, does a superior job in this regard (see "How accurate is signature analysis?" p. 91).

Linear-feedback shift registers have been used as generators of pseudorandom binary sequences in cryptography, mechanical-vibration control, communications channel testing, and digital radar. But for signature analysis, the register is configured as shown in Fig. 2. Bit sequences being measured are summed in modulo 2 with the register feedback. The register is clocked by the same clock as the bit stream under measurement. Input sequences may be any length, but at the end of the measurement only the residue remaining in the register is looked at. These 16 bits, when displayed in a hexadecimal format, comprise the "signature" of the measured bit stream. A nonstandard hexadecimal character set (0123456789ACFHPU) was chosen for easy readability and compatibility with 7-segment displays.

The table in Fig. 2 shows how the register generates a signature from the 20-bit sequence 11111100000-111111111. Initially (time 0 thru 7) the register acts merely as a shift register. At time 7, the first 1 of the input sequence has reached the first feedback tap (tap 1, Fig. 2). It is fed back and mixed with the input 0, with the result that a 1, not a 0, is next clocked into the register (time 8). This behavior continues until the end of the measurement when a residue of 16 bits, 1101100101010011 (time 20), is all that is left from the 20-bit input sequence. (Note the total dissimilarity in appearance between this residue and the original 11111100000111111111 input sequence.) This residue is displayed in hexadecimal format as H953, the signature of the 20-bit sequence.

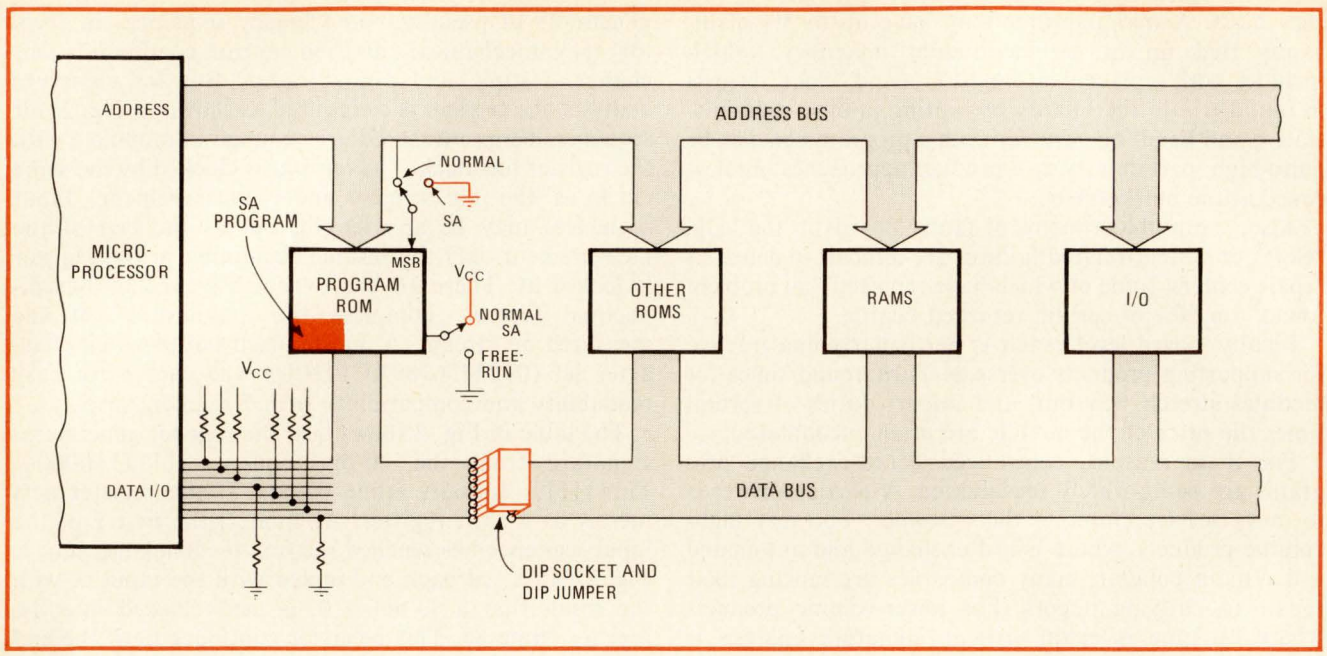
## Designing in signature analysis

In an actual circuit designed to incorporate signature analysis, the bit sequences may be any length, probably much longer than 20 bits. A portion of the circuit's read-only memory—perhaps 5%—contains a special program for stimulating the various nodes in the circuit (Fig. 3). The stimulation serves more to "wiggle" or force a state change on the nodes than to generate meaningful data. Frequently this stimulus program may be merged with the product's performance-verification program. The correct signatures are developed by simply exercising the various parts of a circuit that is known to be good and noting the results on the circuit diagram.

A second requirement, beyond stimulating nodes, is to break feedback paths within the circuit either by using hardware switches, jumpers, or connectors, or by disabling gates with software. This requirement is necessary to prevent a fault from being fed back around and perturbing all data nodes. In practice, adding the ability to break feedback paths incurs an incremental hardware expense of less than 1%. (The cost is more than offset, however, by the savings resulting from no longer needing to subdivide the product into small, replaceable modules.) When these two requirements are met, back-tracing a fault to its source is a straightforward process of tracing faulty signatures.

In using signature analysis, the procedure varies slightly depending on whether the fault lies in the kernel (the minimum configuration of microprocessor and ROM necessary to run the simplest test program) or in the outlying circuitry.

If the fault is in the outlying circuitry (a keyboard or




**3. Adapting the product.** To incorporate signature analysis in a microprocessor-based product, the designer has to add extra program steps to the read-only memory, some switches to put the system into the signature-analysis mode, resistors to force a no-operation instruction when the ROM is disabled, and jumpers that can be removed to isolate portions of the circuit. Here, a 16-pin jumper in a dual in-line package (type AMP 435704-8 or equivalent) is inserted in the data bus.

display scanner, input/output latch, etc.), the field engineer simply switches the circuit to the diagnostic mode. Then, guided by a troubleshooting tree, he uses the test instrument to trace faults back to their source.

But what if the problem lies in the kernel, and even the ROM stimulus program will not run? Here, the microprocessor itself can provide a stimulus if its address counter is allowed to sequence through the address field. To do this it is only necessary to open the data/instruction bus and force the no-operation instruction onto it. This stimulus program checks out all the address lines and the individually enabled ROMs as well. All of these nodes are readily characterized with signatures.

Since signature analysis relies on the ability of a system to control itself in a synchronous manner, asynchronous circuits, like monostables, direct-memory access, dynamic memory, or interrupts, need to be carefully controlled. Generally, simple provisions in the hardware can be made to force them into a synchronous or disabled condition when that is required for a particular test.

## The technique in use

As an example, consider the first HP instrument to use signature analysis—the 3455A system voltmeter from the HP Loveland Instrument division in Colorado. The digital portion is quite extensive. It is microprocessor-controlled and contains a self-test program stored in ROM. If the self-test fails, a jumper inside the enclosure is removed, breaking feedback loops and also enabling the signature-analysis routine which is used now to diagnose the instrument.

The decision to go with signature analysis influenced the design in several ways, all of which make it easier to troubleshoot down to the component level. The whole digital portion is on one board. The elimination of connectors and a multitude of smaller pc subassemblies reduced the production cost and also made all the parts easily accessible for testing without the use of special extender boards.

Naturally, some extra design time, a few more ROM locations, and the extra jumper wire were the price paid for this kind of serviceability. The cost evaluation proved to be interesting: the production cost actually fell, and the extra design time amounted to approximately 1% of the overall development time.

## Manual aid

Besides the design engineer, the writer of the service manual made an important contribution to the successful application of the signature analysis to the 3455A voltmeter. After learning the internal algorithms of the product almost as well as the designer and having no precedent to fall back upon, he developed a number of innovative ideas for the service approach that were enthusiastically received by the field engineers.

The service manual is written in such a way that a person unfamiliar with the signature analyzer can walk up to a sick voltmeter, read the instructions, and within a short time locate the fault. One element in the manual is a troubleshooting flowchart or tree (Fig. 4), which systematically guides the technician through the fault-finding process.

The initial tests may rely very little on signature analysis, yet may allow isolation of the fault down to a specific area. Diagnostic programs cannot carry on from here, since they do not have access to individual nodes, but it is from here on down to the components that signature analysis excels.

At this level, the repairman uses the annotated sche-

## The signature analyzer

The 5004A signature analyzer checks out a compatibly designed digital product by detecting the bit streams at various circuit nodes and displaying them as hexadecimal signatures, which may or may not agree with the correct values noted on the schematic. It is a lightweight, portable instrument, built around the feedback-shift-register circuitry that produces the signatures, and it is equipped with an active probe for data input.

The probe has dual threshold levels that are compatible with transistor-transistor logic. It also serves as a TTL probe, rather like the HP 545A, and in this capacity provides additional troubleshooting information by indicating high, low, bad-level, and pulsing states.

Through an active "pod" on the 5004A's input cable, the product under test supplies the instrument with three gating signals: start, stop, and clock. Start signals the beginning of a measurement window, preparing the shift register to receive information from the data probe. Stop closes the measurement window. Clock is the system clock of the product under test and assures synchronous acceptance of data and gating signals by the shift register. The active edge of each of these gating signals can be selected at the front panel, giving the designer more latitude in applying signature analysis to his product without adding hardware.

The front panel also includes a gate light and an unstable-signature light. The gate light indicates proper start/stop gating operation, remaining on during the measurement window, with stretching to make it visible to the operator during very short on times. The unstable-signature light indicates a difference between signatures in adjacent windows, alerting the user to intermittent faults that may not be apparent from the display.

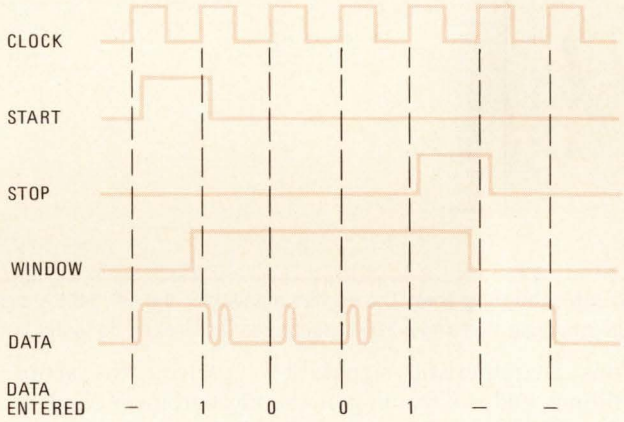
Two useful controls are the hold and reset switches. The hold feature allows observation of single-event (one-shot) signatures, such as a power-on-restart routine. The instrument will display only the signature associated with the first valid window and will hold the display until the probe reset switch is pressed. The hold/reset controls are also useful for taking signatures in awkward locations where it is impossible to simultaneously probe and watch the display.

Since the 5004A is synchronized to the system clock of the product under test (up to 10 megahertz), setup times become important. Setup time is the period during which data must be stable before arrival of the selected clock edge. In the 5004A, the maximum data setup time is 15 nanoseconds (but typically 8 ns). This leaves the balance of the clock cycle for the settling times of components in the product under test. No hold time is required after the selected clock edge.

Any data state changes between clock edges are disregarded. The first data bit accepted during a measurement window is the one coinciding with the synchronized start-signal edge. The last bit accepted is that preceding the synchronized stop-signal edge (see figure).

Tri-state bus architectures are common in many types of equipment and pose the problem of how to interpret the floating state for the purposes of consistent signature detection. Pullup resistors in the circuit under test would force a bus high in the third state, but would slow down the state transitions and possibly cause inconsistent signatures. Instead, the 5004A data probe pulls to the 1.4-volt level, through a 50-kilohm input resistor, and employs hysteresis. This causes the floating state of a tri-state bus to be entered without ambiguity into the signature as the same state (0 or 1) as the most recent valid bit.

To increase the confidence of on-site service, the front panel self-test feature allows a go/no-go checkout of the entire 5004A, including probe, pod, and cables. An internal program exercises the analyzer and displays the result. If this display indicates a malfunction, the 5004A itself can be switched to its own test mode and diagnosed to the component level with another signature analyzer.

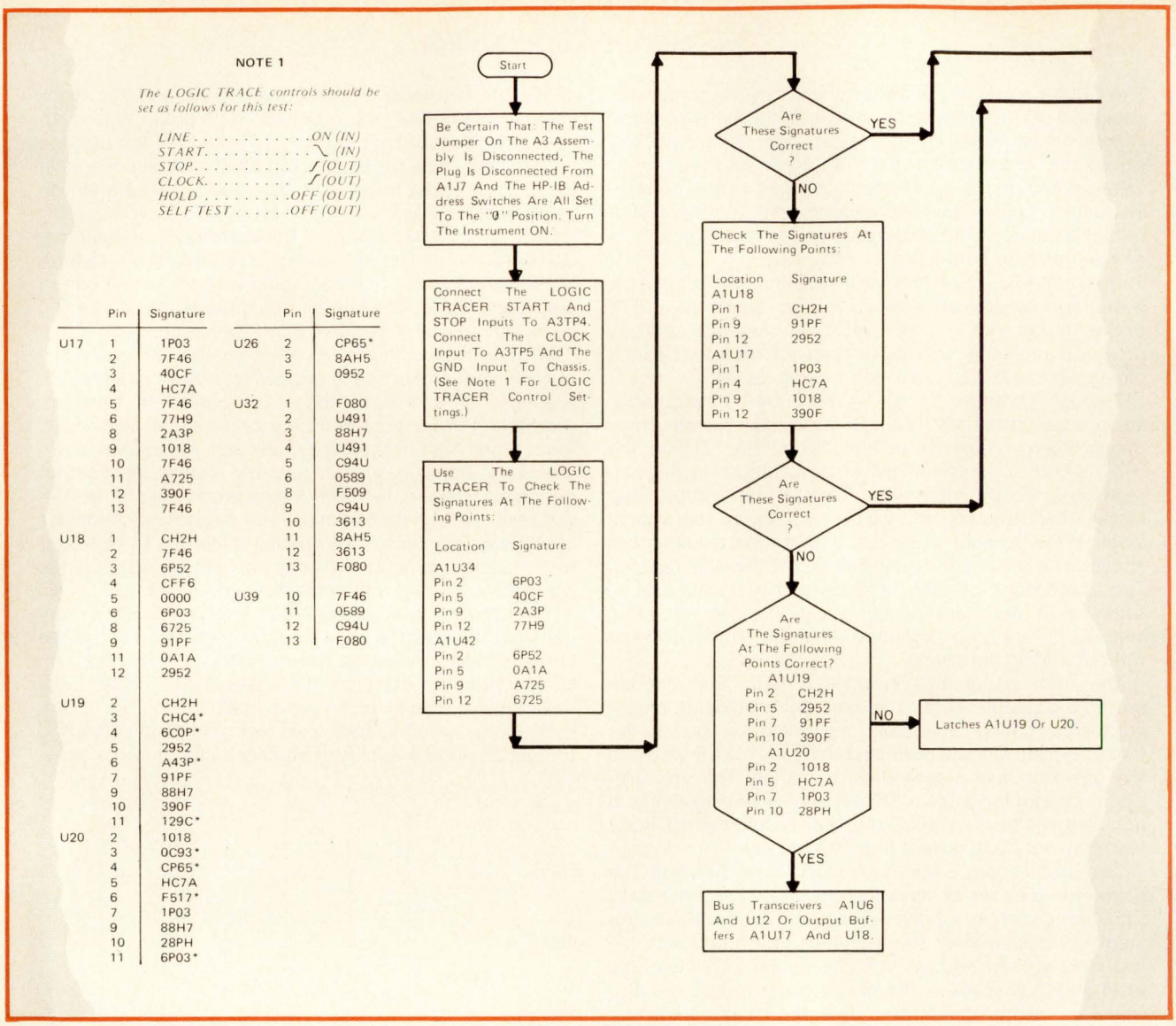



matics and graphs of board layouts, together with the flow chart, to find the bad node. In some cases, the manual includes instructions as to which IC to replace. In other cases the use of a logic probe, which is an integral part of the logic tracer, may be required. A current sensor, such as the HP 547A, helps to find short circuits between traces or to ground and is particularly helpful when bus problems are encountered.

In the case of the voltmeter, the first test checks its kernel, which consists of the microprocessor, the clock circuit, the power supply, and a number of external gates. After the proper functioning of the kernel has been verified, the test setup is changed (one control wire of the logic tracer is moved to another pin in the 3455A), and the remaining portions of the circuit are tested. A special portion of the ROM control loads and reads the random-access memories. Some asynchronous portions require a third test setup. Again, the connection of the start wire is simply moved to the next pin designated for this purpose, and troubleshooting can continue.

Several methods of documentation have been tried successfully. The 3455A service manual shows pictures of the board and defines the setup for each test (Fig. 4). Each picture shows only the signatures related to the particular test, directing the field engineer's effort towards the important areas on the board. The ROM program even simulates interrupt signals, ensuring, however, that they occur predictably at the same spot within a window so that stable signatures result.

The signature analyzer has its own self-check. Each test setup is tested by touching the power-supply voltage with the instrument's probe to input a sequence of all 1s.




| | Pin | Signature |
|---|---|---|
| U17 | 1 | 1P03 |
| | 2 | 7F46 |
| | 3 | 40CF |
| | 4 | HC7A |
| | 5 | 7F46 |
| | 6 | 77H9 |
| | 8 | 2A3P |
| | 9 | 1018 |
| | 10 | 7F46 |
| | 11 | A725 |
| | 12 | 390F |
| | 13 | 7F46 |
| U18 | 1 | CH2H |
| | 2 | 7F46 |
| | 3 | 6P52 |
| | 4 | CFF6 |
| | 5 | 0000 |
| | 6 | 6P03 |
| | 8 | 6725 |
| | 9 | 91PF |
| | 11 | 0A1A |
| | 12 | 2952 |
| U19 | 2 | CH2H |
| | 3 | CHC4* |
| | 4 | 6C0P* |
| | 5 | 2952 |
| | 6 | A43P* |
| | 7 | 91PF |
| | 9 | 88H7 |
| | 10 | 390F |
| | 11 | 129C* |
| U20 | 2 | 1018 |
| | 3 | 0C93* |
| | 4 | CP65* |
| | 5 | HC7A |
| | 6 | F517* |
| | 7 | 1P03 |
| | 9 | 88H7 |
| | 10 | 28PH |
| | 11 | 6P03* |

| | Pin | Signature |
|---|---|---|
| U26 | 2 | CP65* |
| | 3 | 8AH5 |
| | 5 | 0952 |
| U32 | 1 | F080 |
| | 2 | U491 |
| | 3 | 88H7 |
| | 4 | U491 |
| | 5 | C94U |
| | 6 | 0589 |
| | 8 | F509 |
| | 9 | C94U |
| | 10 | 3613 |
| | 11 | 8AH5 |
| | 12 | 3613 |
| | 13 | F080 |
| U39 | 10 | 7F46 |
| | 11 | 0589 |
| | 12 | C94U |
| | 13 | F080 |

**4. Troubleshooting tree.** The service manual for the HP 3455A digital voltmeter, the first instrument to use signature analysis, contains a troubleshooting tree and a list of signatures that should be found at the designated pin numbers of the various devices.

If this characteristic signature is correct, the setup conditions and the framing of the measurement window are verified. Specifically, this tells the user that the switches on the signature analyzer, as well as all the jumpers, switches, and control buttons in front and rear of the voltmeter are correctly set. Thus, the confidence level of the user is very high at the start of a test.

This application of signature analysis went particularly smoothly, because the engineer developing service techniques worked closely with the design engineer. Generally, the design engineer wrote the stimulus routines while the service engineer involved himself with documentation and overall test strategy. This early involvement also ensured that the designer, with the many demands on his time, did not neglect to think about serviceability and, for example, put off allocating read-only-memory space till inconveniently late in the design cycle.

The fact that signature analysis is built into the 3455A voltmeter also made final testing on the production line much easier. A signature analyzer is now a favorite piece of production-line test equipment for the 3455A.

Thus, the signature analyzer promises to have a significant impact on present service costs. With the industry presently spending roughly a billion dollars annually to find the 10 million ICs that fail each year in the field, such a technique is needed. Although IC pretesting and burn-in programs have gone a long way toward weeding out weak devices, changes are nevertheless needed in service strategy as well. The signature analyzer offers a new option for those who are planning service strategies. □

### Closing the loop

*Pending HP's completion of an applications note on how to build signature analysis into new equipment, Gary Gordon and Hans Nadig will be happy to answer readers' questions on their article directly by telephone. They can be reached at Hewlett-Packard's Santa Clara, Calif., division plant at (408) 246-4300 between 9 and 5, Pacific Standard Time.*

# Thin-film magnetic heads excel in packing and moving data

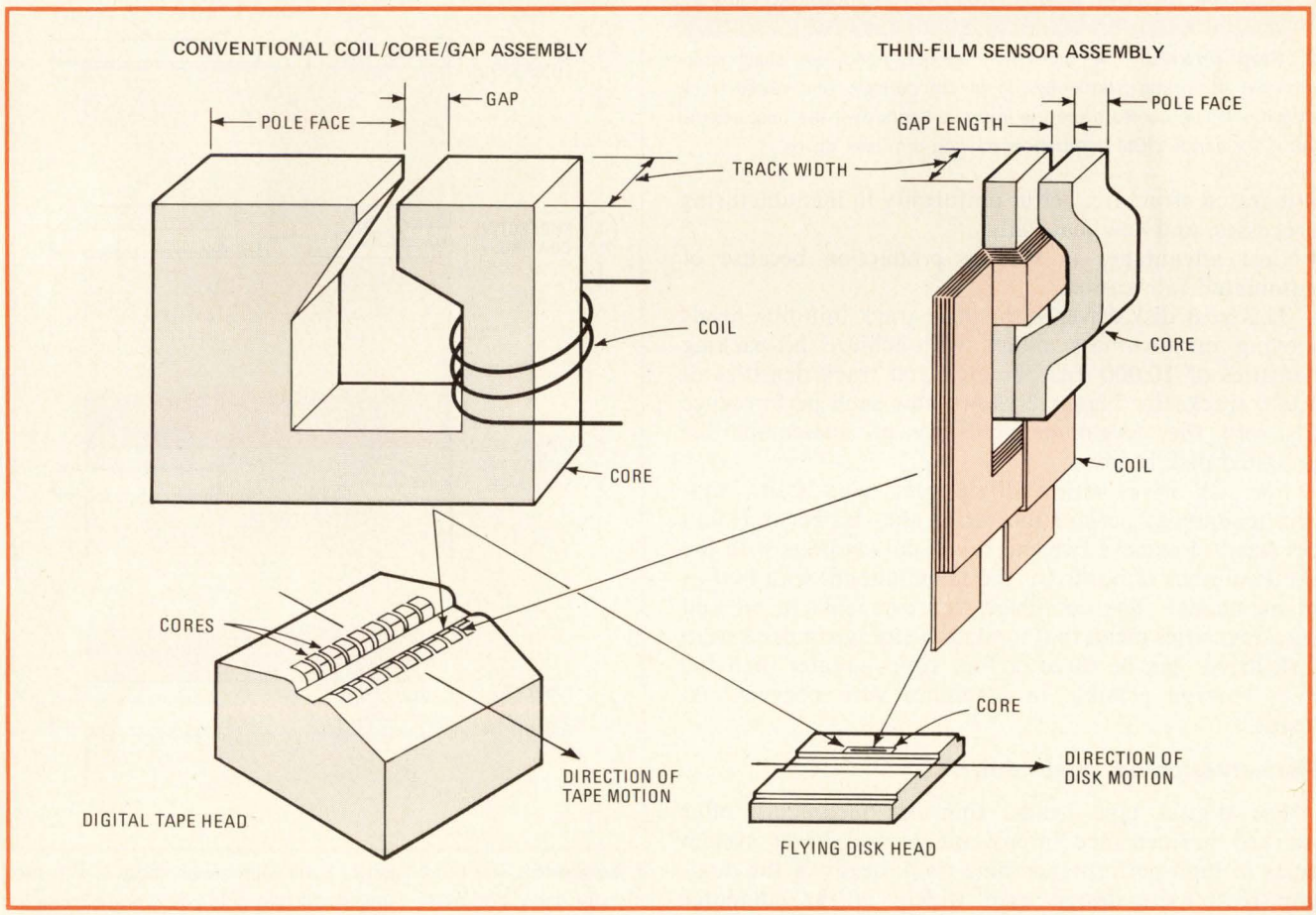
## New approach should spawn computer disk and tape drives with larger storage capacities and higher rates of data transfer

by Thomas A. Roscamp and Paul D. Frank, *Applied Magnetics Corp., Goleta, Calif.*

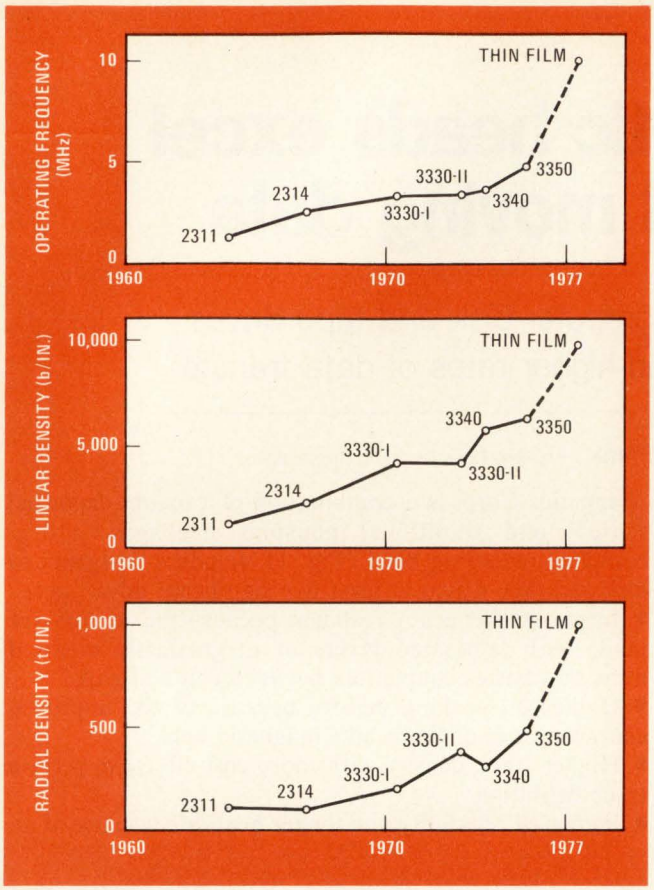
☐ Magnetic read/write heads with sensors of thin-film materials have left the laboratory and are entering the commercial realm. They bring with them the promise of a new generation of computer disk and tape drives with larger storage capacities at lower costs per bit and higher rates of data transfer.

The steady improvements in tape and disk drives have been primarily the result of incremental advances in recording media, reduced head-to-media spacing, and increased head and system reliability. However, thin-film technology represents a breakthrough in head design. A thin-film head being produced by Applied Magnetics Corp. is a combination of vacuum-deposited sensors and traditional housings packaged into a complete recording head (Fig. 1). It offers designers of disk and tape drives at least five significant advantages:

- Improved frequency response because the sensors are made with laminated layers of magnetically oriented films that better couple flux between coil and gap.
- Higher bit-packing density because of the improved characteristics of the head's magnetic field.
- Higher track density with more cost-effective, precise track definition.
- Increased reliability and longer head life because of an




**1. Head to head.** The thin-film sensor used in magnetic recording heads is produced by vapor deposition as a single structure, giving greater control over its characteristics, while the conventional head is produced from separate parts. (The assemblies are not drawn to scale.)




**2. Step upward.** The thin-film magnetic head will significantly improve operating frequency, linear bit density, and radial track density. These curves trace the improvements over the past several years for various IBM-compatible moving-arm disk drives.

integrated structure, better uniformity in manufacturing processes, and new materials.

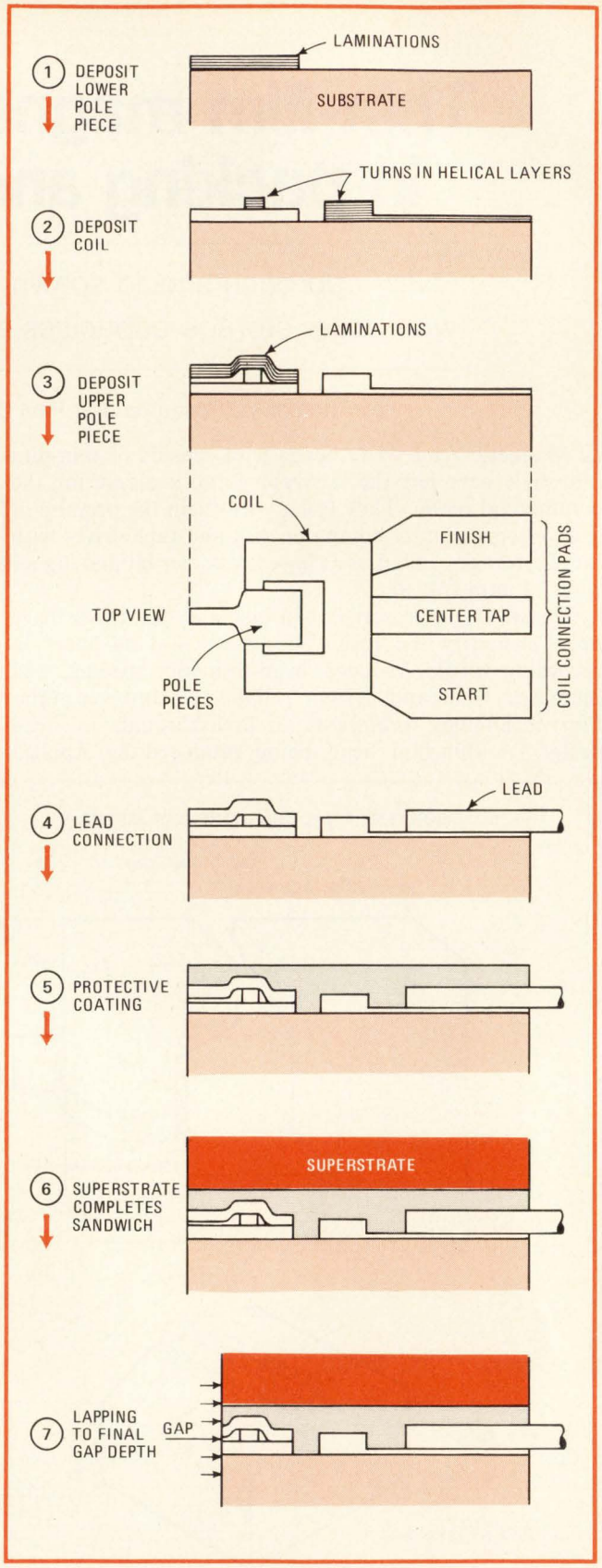
- Cost advantages in volume production because of automated fabrication.

This year disk drives with single-track thin-film heads moving on low-mass sliders will achieve bit-packing densities of 10,000 bits per inch and track densities of 1,000 tracks/in. Figure 2 shows how such performance fits into the development history of IBM-compatible actuated disk heads.

For disk drives with multiple-track fixed heads, thin-film technology permits increasing the number of tracks per head to achieve twice as much data storage with the same number of heads (or the same amount with half as many heads). The combined improvements in bit and track densities mean that total data storage in fixed-head disk drives can be three or four times greater than the data storage possible in machines with conventional heads.

## Performance up, costs down

For digital tape heads, thin-film techniques offer marked performance improvements and lower system costs in high-performance nine-track heads of the dual-gap read/write design used widely in the computer industry. All nine sensors can be produced simultaneously by vacuum deposition. Closer dimensional toler-




**3. Sequence.** The production of a thin-film sensor begins with the vacuum deposition of the laminated lower pole piece and proceeds through depositions of the coil, and upper pole piece. The leads, protective coating, and superstrate are then added.

ances can be achieved, and there is reduced crosstalk and less need for magnetic shielding.

Moreover, a new generation of 18-track read/write heads designed for standard ½-in. computer tape with 10,000 b/in. on each track is feasible. Together with higher track densities, the improved bit-packing densities will make possible as much as three times more data storage than existing tape drives, at a lower cost per byte for the user.

Thin-film technology also looks promising for instrumentation recorder heads that will permit higher data rates. The heads also will be useful for video-recording applications where images are recorded linearly at high tape speeds. However, present limitations on gap sizes and the number of turns of the conductor make unlikely any use soon in diskettes, audio tape recorders, and lower-speed video recorders.

## Making thin-film heads

Once a sensor design has been established, hundreds or even thousands of them can be produced simultaneously during a single vacuum deposition. Thin-film head manufacturing may lend itself to further simplifications, such as deposition of the sensor directly on the air-bearing slider of a disk head or construction of hybrid heads where the read/write circuitry is integrated into the total head package.

The steps in the deposition and packaging of a multiturn thin-film sensor are shown in Fig. 3. The substrate and superstrate may be of a variety of materials, such as special glasses, titanates, ferrites, Fotoceram, or sapphire. Several hundred layers of different materials may be deposited to form the pole piece, coil, and gap required for a particular type of sensor.

In this design, the pole pieces consist of layers of magnetic material with layers of an insulating material deposited between them. The coil consists of multiple turns of a conducting material deposited in a square helical arrangement, also with an insulating layer separating the turns. Figure 4 is a microphotograph of the thin-film sensor as seen through the protective coating. The total thickness of material between substrate and superstrate typically ranges from 0.0005 to 0.003 in.

The design of thin-film heads is considerably more complex than that of their conventional counterparts. The most important design factors in conventional heads are gap length and depth, core material and geometry, and head contour. However, gap length is the primary variable in tailoring the head to an application.

## Computer aids analysis

In thin-film heads, the geometry of the entire pole piece plays as important a role as does gap length. This factor, plus the complex physics of thin-film-head operation, requires a computer-aided design analysis to fit all the variable parameters to system requirements, such as velocity of the medium, packing density and transfer rate of the bits, head-to-media separation (flying height), medium material and thickness, write current, desired playback voltage levels, and characteristics of the read/write electronics.

The table gives a comparison of typical performance characteristics and ranges of operating conditions for conventional and thin-film recording heads. Also included is a comparison of the measured performance of a standard 3330-11 disk head and a thin-film version of the head operating under the same conditions. The differences in performance can be understood by studying the differences in construction.

In the conventional head design, the pole face must be extremely long compared to other important dimensions such as gap length, head-to-medium separation, and medium thickness. It is so much longer, in fact, that in theoretical calculations it is traditionally considered to be infinite. For the thin-film sensor, the length of the pole face is less than a hundredth of that of the conventional pole face, and it is an important design variable.

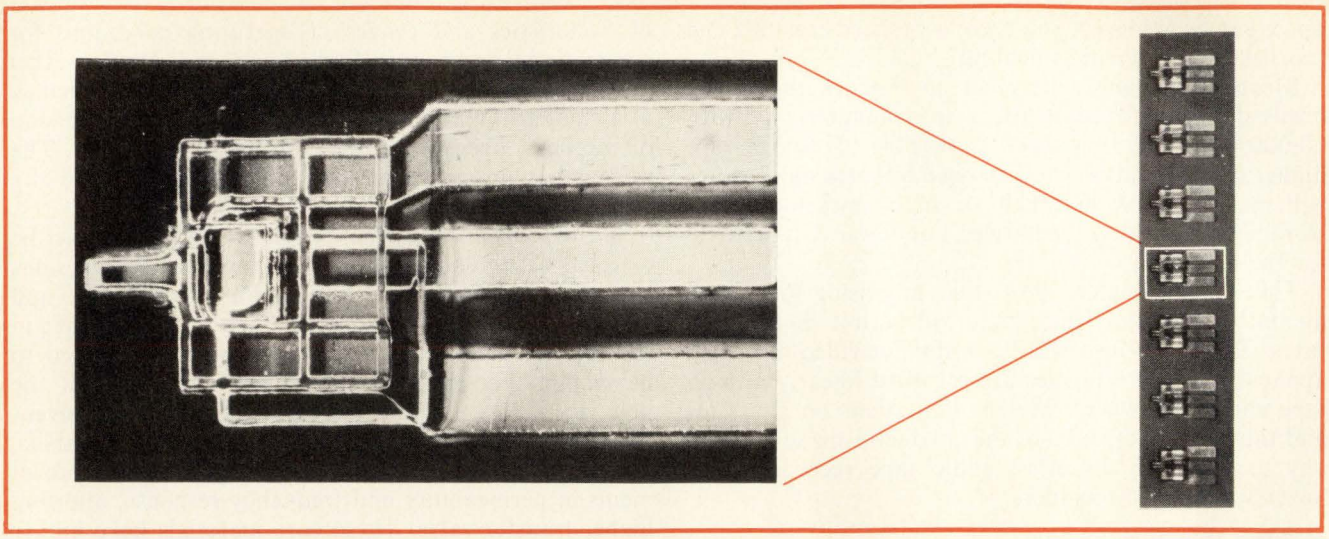
Thin-film core materials offer significant improvements in permeability and frequency response, allowing higher transfer rates. These core materials have higher saturation flux densities than do standard ferrites. This factor allows stronger fields to be used during recording and makes feasible the utilization of newer "high-energy" recording media.

The write current levels and playback voltages produced by these multiturn thin-film designs are generally compatible with conventional read/write electronics. Therefore it is possible to extend the performance of storage systems without significant advancements in electronics technology. An example of this is the improved resolution of the 3300-11 thin-film head, shown in the table.

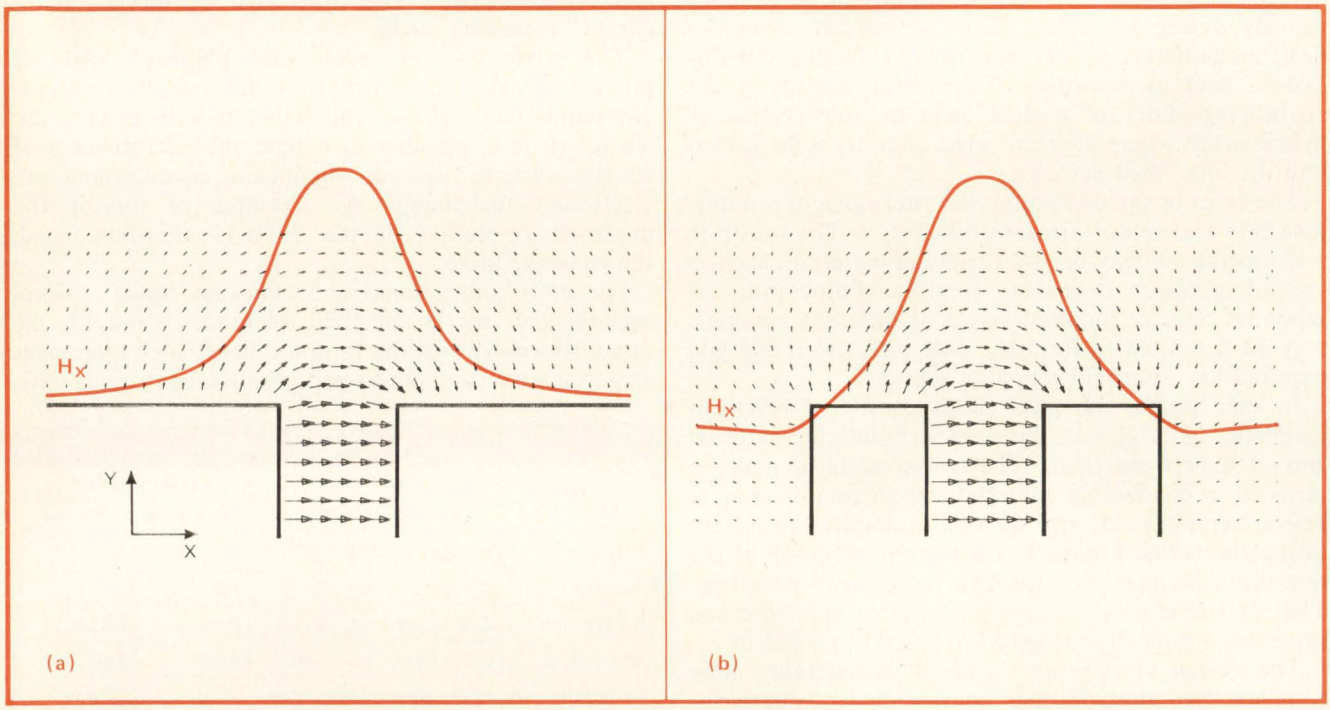
For both conventional and thin-film heads, control over the gap lengths and their tolerances is roughly the same. However, with the thin-film head, such tolerances as gap scatter (the gap-to-gap misalignment in a multi-

TABLE: CONVENTIONAL VS. THIN-FILM HEADS

| Head characteristic | Typical ranges | | 3330-11 disk head | |
|---|---|---|---|---|
| | Conventional | Thin-film | Conventional | Thin-film |
| Coil turns | 10 – 1,000 | 10 – 30 | 50 | 20 |
| Gap length, μin. | 20 – 250 | 20 – 100 | 100 | 100 |
| Pole-face length | 0.030 – 0.300 in. | 50 – 500 μin. | 0.030 in. | 220 μin. |
| Track width, in. | 0.001 – 0.050 | 0.001 – 0.050 | 0.002 | 0.002 |
| Inductance (full coil) | 10 μH – 100 mH | 100 nH – 1 μH | 23 μH | 600 nH |
| Resonant frequency | 100 kHz – 10 MHz | 50 – 200 MHz | 9 MHz | 60 MHz |
| Cable and read-input capacitance | usually critical | usually not important | 15 pF | 15 pF |
| Write current rise time | limited by head | faster: limited by cable and electronics | 62 ns | 13 ns |
| Write current (peak-to-peak), mA | 10 – 200 | 100 – 400 | 150 | 200 |
| Output voltage | 100 μV – 100 mV | 100 μV – 10 mV | 2 mV (40 μV/turn) @ 4,000 b/in., 5 MHz | 1.3 mV (65 μV/turn) @ 4,000 b/in., 5 MHz |
| Resolution | compromised | optimized | 50% @ 4,000 b/in., 5 MHz | 78% @ 4,000 b/in., 5 MHz |
| Permeability | less than 1,000 @ 2 MHz | greater than 1,000 @ 20 MHz | 500 @ 5 MHz | 1,500 @ 5 MHz |
| Core saturation flux density | limits the core field | higher | 3,500 gauss | 10,000 gauss |
| Flying height, μin. | 20 – 100 | 20 – 100 | 40 | 40 |



**4. The sensor.** A single thin-film sensor is shown in a microphotograph as viewed through the protective coating. All sensors in the linear array are deposited during a single series of vacuum depositions, allowing more precise track placement and better gap-to-gap alignment.




**5. Fringing fields.** The gap fringing fields for conventional (a) and thin-film (b) heads show the thin-film head's field has steeper sides and reaches a negative, minimum value before turning upward. Corresponding negative dips for the conventional head are far from the gap.

channel head) can be better controlled, because all the sensors are deposited simultaneously. The manufacturing technology generally allows better control of track widths and locations than would be economically possible with techniques used to produce conventional heads.

## Pulse shape is the key

A vector representation of the gap fringing field for a conventional head (Fig. 5a) shows a longitudinal component $H_x$ in the direction of the medium's motion and a perpendicular component $H_y$ at right angles to the medium's surface. For most digital recording applications, $H_x$ is the component of primary interest because information is recorded longitudinally in the medium.

For a conventional head, $H_x$ reaches its maximum above the gap center and decreases to either side of the gap, appearing to approach zero asymptotically at large distances. This basic shape of the $H_x$ "pulse" is the same for any head-to-medium separation.

For the thin-film head (Fig. 5b), $H_x$ again reaches its maximum above the gap center. However, $H_x$ decreases more rapidly than in the conventional head, passes through zero, dips to a minimum value near the outer edges of the pole pieces, then asymptotically approaches zero from below.

The location of the negative dips in the thin-film head's field is a result of the small dimensions of the pole

face combined with the requirement from Maxwell's equations that the integral of the $H_x$ pulse for any recording head must be zero:

$$\int_{-\infty}^{\infty} H_x \, dx = 0$$

The location of the negative dips close to the gap region means they interact with the gap field to form an $H_x$ pulse narrower and steeper on the pulse edges than is the case with the conventional head. In the conventional head, the negative dips occur at points that lie far from the gap, so they do not play a significant role in the gap fringing field.

For digital recordings, the playback voltage pulse (Fig. 6) for an individual recorded transition (a bit of recorded information) tends strongly to resemble the shape of the $H_x$ pulse. As a result, narrowing the $H_x$ pulse tends to decrease the playback pulse width, thus decreasing crowding of these pulses and allowing higher bit densities to be read. Similarly, the increased steepness of the $H_x$ pulse edge causes a shorter transition to be written on the medium, which gives less crowding of write pulses and allows higher bit densities to be recorded.

### Setting write current

With conventional digital recording heads, one of the usual compromises in setting the write current is between resolution (or playback voltage) and overwrite of old information. As the write current is increased, the depth of penetration into the medium increases, and the playback voltage tends to increase.

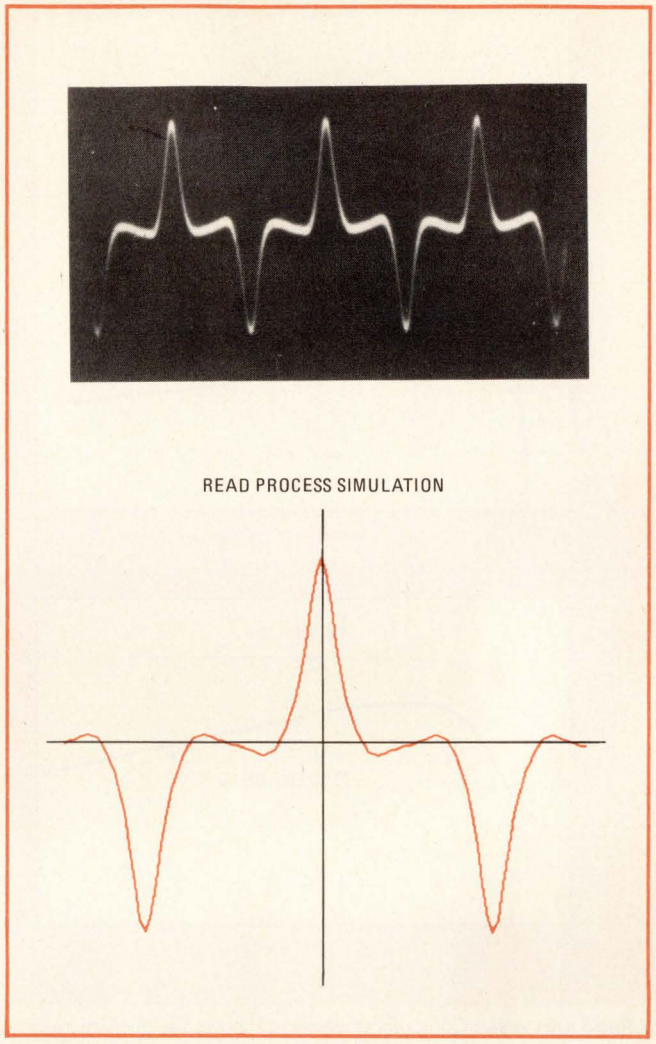
However, as the depth of penetration increases, demagnetizing fields build up in the medium to oppose the transition being written. This phenomenon is often referred to as self-demagnetization. Simultaneously, the steepness of the $H_x$ pulse of the conventional head decreases with increasing write current, which tends to produce a longer transition (Fig. 7a). This degradation of steepness results in what is commonly called recording demagnetization.

Thus, as the write current is increased, the effects of self-demagnetization and recording demagnetization cause a wider transition to be written, increasing write-pulse crowding at typical recording densities and reducing the playback voltage output. The optimum write current is the point on the curve in Fig. 7b where the tendency for increased playback voltage from improved penetration reaches a maximum before it begins to be reduced by increasing demagnetization effects.

Unfortunately, this current is not high enough to give satisfactory overwrite of old information in most applications, because the resulting depth of penetration is too shallow. This forces operation at a write current considerably higher than this optimum value, which means a sacrifice in resolution.

### Reversing recording demagnetization

For the thin-film head, however, the steepness of the $H_x$ field continues to increase with higher write current because of the physical requirement imposed by the presence of the negative dips (Fig. 7a). The effects of recording demagnetization are reversed, and written transitions become shorter.

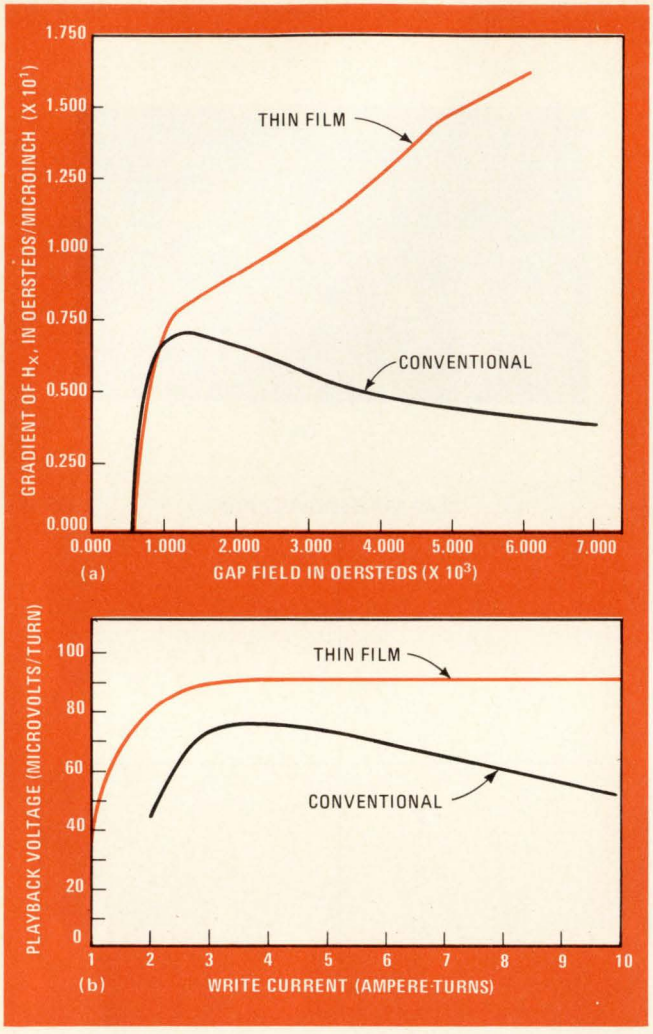



**6. Playback.** The playback voltage pulse for a thin-film head resembles the gap fringing field shape of Fig. 5. The plot shows the results of a computer simulation of the read process that closely models the actual pulse displayed on the oscilloscope.

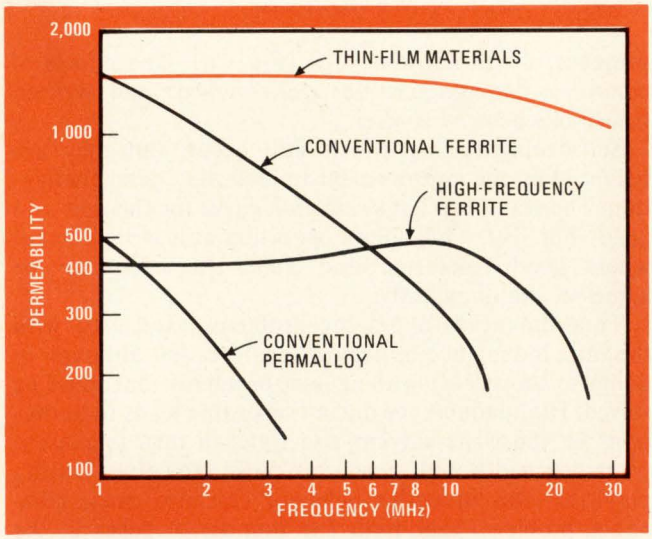
Self-demagnetizing effects still occur, but they are balanced by the improvement in recording demagnetization. The result is a flat saturation curve for the thin-film head (Fig. 7b). This allows operation at a write current where good resolution and good overwrite can be achieved simultaneously.

Thin-film heads avoid the problems associated with the high inductance of conventional heads—although in doing so they develop their own problems that must be solved. High inductance during recording leads to limitations on the write-current rise time, in turn increasing transition width and then write-pulse crowding. During playback, this inductive behavior can also cause resonance problems that limit the number of turns in the coil. These problems also restrict the electronics used for the read process.

The small dimensions of the thin-film pole piece result in inductances typically much less than that for the




**7. Read and write.** Computer analysis (a) shows the thin-film head's steeper longitudinal component of field for a head-medium separation of 40 μin. Saturation curves (b) measured at 3.24 MHz show playback voltage stays flat over broad range.




**8. Permeability.** Thin-film materials maintain superior permeability over a broad range of frequencies, compared with conventional and high-frequency ferrites and conventional permalloy materials. This characteristic translates into higher data-transfer rates.

conventional sensor. These inductances do not present a design limitation.

Unfortunately, the small dimensions of the pole piece can significantly increase core reluctance. If corrective design steps are not taken, this increase would reduce core efficiency (the ability to couple magnetic flux between the coil and the gap).

Modern conventional heads also are facing core efficiency problems at higher recording densities. These problems are due to the rapidly decreasing permeability of conventional core materials at the high frequencies required for these densities (Fig. 8).

### Increasing core efficiency

It is possible to increase core efficiency in thin-film heads by constructing the pole pieces from oriented thin films of a doped permalloy material. Such a material has much better permeability at high frequencies (Fig. 8).

An oriented film is a magnetic material that exhibits uniaxial anisotropy, meaning that it has a preferred axis of magnetization called the easy axis. In the thin-film head, it is deposited with the easy axis lying along the track width and perpendicular to the direction of motion (Fig. 9a).

When the head is idle, the magnetization in the pole pieces will lie along the easy axis with a magnitude equal to $M_s$, the saturation magnetization of the material. When the head is operating, the magnetization will rotate out of the easy axis so that it has components along the hard axes: the X axis (parallel to the direction of motion) and the Y axis (perpendicular to the surface of the medium).

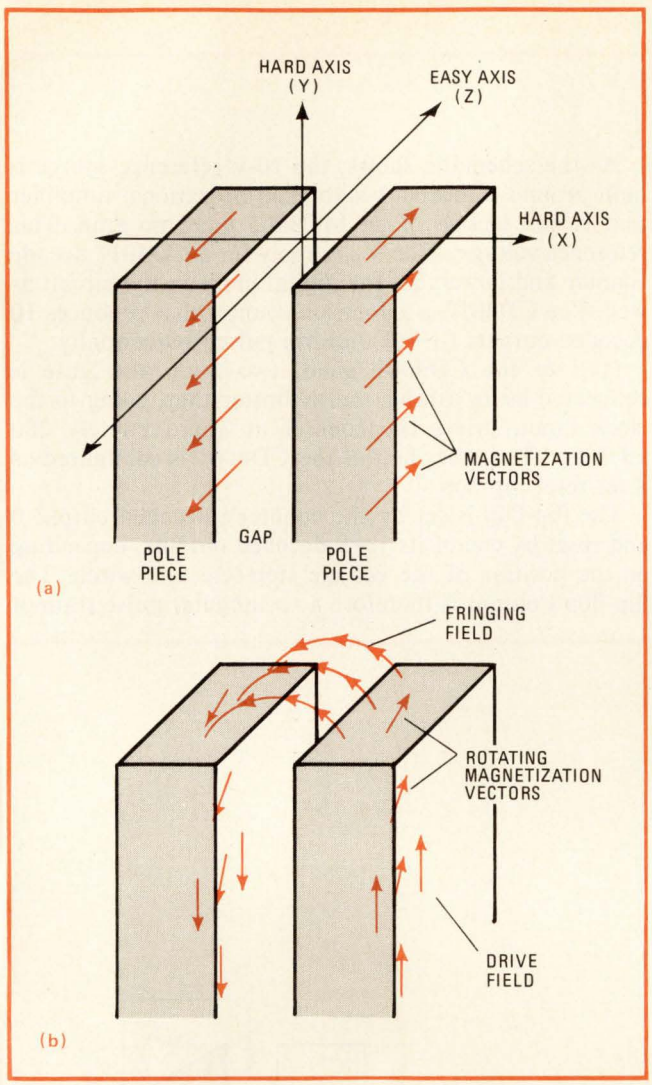
This rotation of the magnetization produces a net flow of flux in the head. As seen in Fig. 9b for the write process, the magnetization tends to rotate into the direction of the field produced by the coil (the drive field). This process—switching by rotation—is very fast, giving high permeability and excellent frequency response.

The drive-field strength necessary to obtain complete rotation is called the anisotropy field, $H_k$. The permeability is proportional to the ratio of $M_s$ to $H_k$. Using proper magnetic materials, it is possible to produce oriented films with high $M_s$ and low $H_k$, thus yielding high permeability.

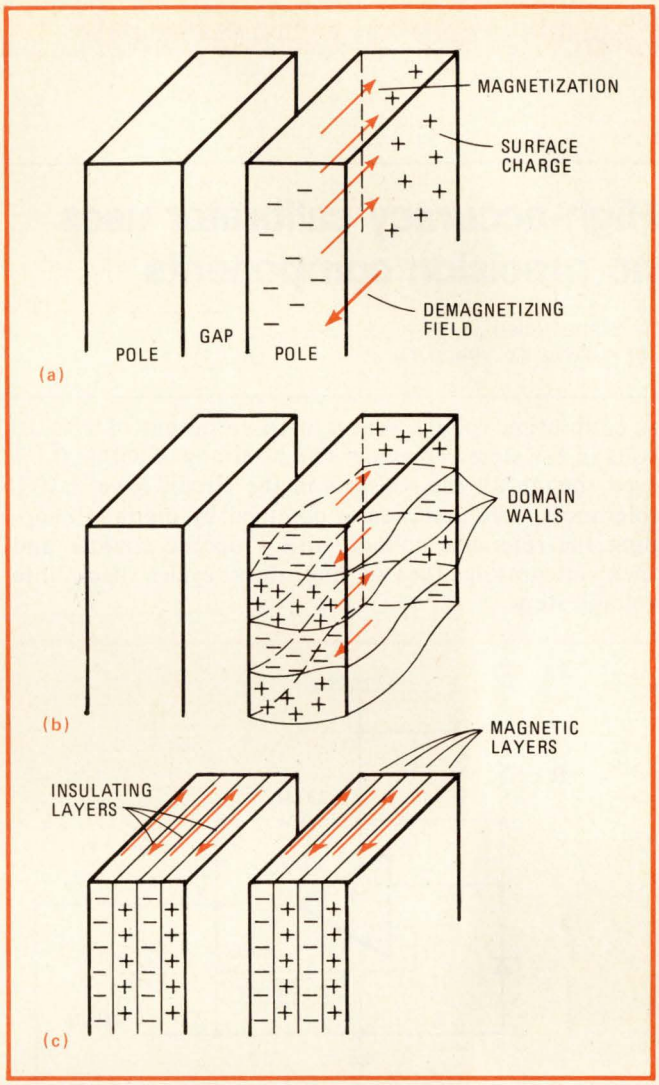
Along the easy axis, the films are inherently bistable since the magnetization can lie in either direction. The magnetization will remain unchanged until a large enough field is applied in the opposite direction along the easy axis to switch it 180° into its other stable state. The drive-field magnitude necessary to produce this switching of the magnetization is called the coercive field, $H_c$.

### Overcoming domain formation

Reliable recording heads cannot always be made with pole pieces consisting of single-layer oriented films. Such heads are likely to experience severe problems with Barkhausen noise during the playback process because of the presence of numerous magnetic domains in the film. The problem stems from the behavior of oriented films as permanent magnets in the absence of a drive field. This behavior causes a demagnetizing field inside




**9. Fast switching.** When the thin-film head is idle, magnetization vectors lie along the direction of the easy axis, perpendicular to the direction of motion. During operation, the magnetization rotates, producing a component along the hard axis that causes a flux flow.




**10. Domains.** Without a drive field, films behave as permanent magnets causing demagnetizing field (a). In narrow films, domain walls form (b). Lamination of the films (c) makes layers single domains with alternating magnetizations.

the film opposed to its first magnetization (Fig. 10a).

The demagnetizing field is due largely to magnetic surface charges that occur whenever the magnetization is not parallel to an edge or surface of the film. When the films are limited in width, as with a narrow-track recording head, the demagnetizing field may become larger than $H_c$, causing an unstable condition.

In this unstable situation, magnetic domains with reversed magnetizations will form (Fig. 10b). Switching is no longer strictly by rotation, but also by movement of domain walls, which tends to occur in jumps rather than smoothly—causing what is known as Barkhausen noise.

Of the several ways to avoid domain formation in the pole pieces, there is one that does not compromise the permeability, design flexibility, or track density: lamination of the pole-piece structure (Fig. 10c). The magnetization in each successive layer alternates in direction along the easy axis, with each layer essentially a single magnetic domain. In effect, there are no domain walls.

At the same time, the demagnetizing fields of the successive layers also alternate in direction, so that the demagnetizing fields cancel one another to a large extent. Moreover, this structure minimizes the possibility of eddy-current losses in the permalloy core, because each lamination provides only a very small cross-sectional area where the currents might flow.

Applied Magnetics Research has been working with several makers of computer peripherals on applying thin-film heads to tape and disk drives. Such cooperation is essential because the parameters are numerous and complex enough to require computer analysis based on data inputs from the peripheral designer as well as from the magnetic-head engineer.

Such cooperation between the peripheral designer and the head manufacturer has already provided results. This year will see the beginning of a new generation of peripherals using thin-film heads for greater data capacity, higher transfer rates, and improved track-to-track uniformity. It promises better peripherals and more cost-effective computer systems. □

# High-accuracy calibrator uses no precision components

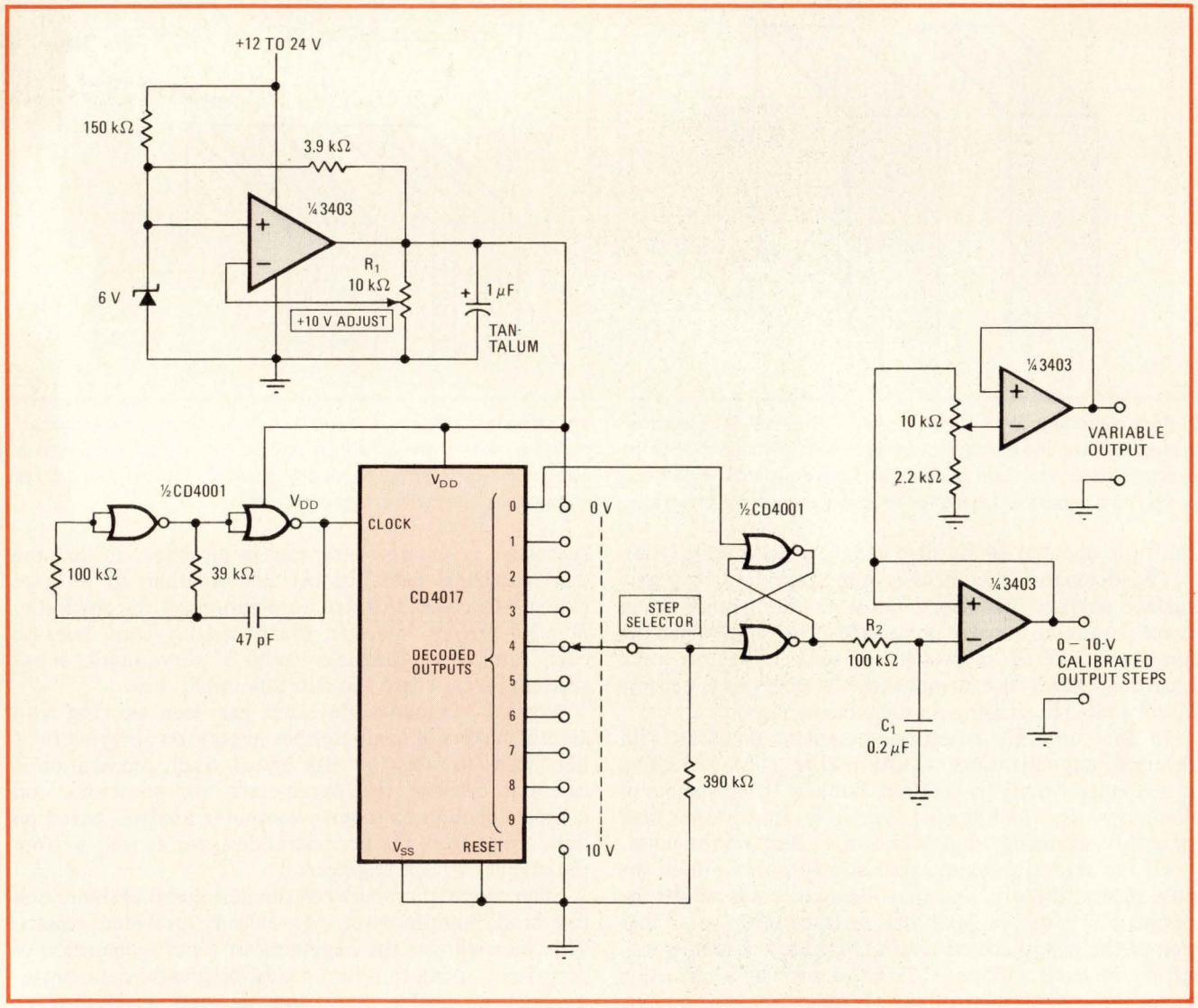
by Walter Allen
*The Audichron Co., Atlanta, Ga.*

A calibrating voltage source with an output of 1 to 10 volts in 1-v steps can achieve an accuracy of within 0.1% even though all the resistors in the circuit have ±10% tolerances. The precision is obtained by digitally chopping the reference voltage with a decade counter and then integrating the varying duty cycles back into voltage steps.

As the schematic shows, the 10-v reference source is built around a feedback-stabilized operational amplifier that is one section of an MC3403 quad op amp. This reference voltage is the $V_{DD}$ supply for a CD4017 decade counter and powers all the digital chips in the circuit as well. The CD4017 is a Johnson counter that produces 10 decoded outputs (0 – 9) that are pulsed sequentially.

Half of the CD4001 quad, two-input NOR gate is connected as an astable multivibrator that, going to the clock input, drives the counter at approximately 200 kilohertz. The other half of the CD4001 is configured as a set-reset flip-flop.

The flip-flop is set by the counter's decoded output 0 and reset by one of its 1 – 9 decoded outputs, depending on the position of the voltage step-selector switch. The flip-flop's output is therefore a rectangular pulse train of




**Digital division—analog accuracy.** Changing the duty cycle of the pulse train is the key to accurate voltage division. Frequency and duty cycle of clock at left do not affect output, since decoded counter outputs accurately determine duty cycle.

approximately 20 kHz that has a duty cycle varying from 0% to 100% by 10% steps.

The signal is then integrated by the RC low-pass network and buffered by another section of the MC3403 quad op amp for output. An adjustable divider and additional op-amp follower provide stable voltages between steps.

The MC3403 quad op amp is used for its high current capability—up to 30 milliamperes—and also for its ability to swing down to within a few millivolts of the negative supply rail.

Potentiometer $R_1$ sets the 10-v reference voltage. When this is precisely adjusted, the 1-v switch-selectable output steps are accurate to within 0.1% with any loads up to 20 mA. The adjustable output tracks between steps with high linearity, and the 20-kHz ripple component in the output is less than 1 mV.

The capacitor in the integrating network should be a high-quality, low-leakage unit, though its value is not critical since it determines only the step response time. With the value of 0.2 microfarad shown, the response time is about 100 milliseconds. A 1.0-$\mu$F tantalum capacitor would give better filtering characteristics, but its response time is on the order of 0.5 s. □

## Inductive kick gates SCR motor crowbar

by Buck Postlewait,
*Instrumentation Specialties Co., Lincoln, Neb.*

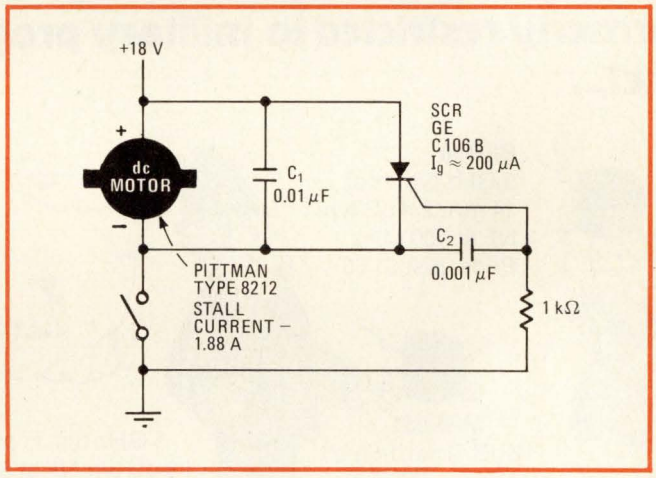
A dc motor can be made to stop itself with a little help from an SCR. Applying a "crowbar," or direct short, across its terminals will prevent the motor from coasting. Using a silicon-controlled-rectifier crowbar permits gating by the inductive kick of the motor's collapsing fields and stops rotation of the armature within 50 milliseconds.

As shown in the figure, the switch controlling the motor is in the negative supply lead. When it opens, the tank circuit formed by capacitor $C_1$ in parallel with the motor's windings will ring with a damped sinusoidal waveform. The negative transition of this waveform, plus the windings' back emf (which is the same polarity as the supply voltage) drive the voltage at the motor's negative terminal below ground.

Since the SCR's gate is tied to ground through the 1-kilohm resistor it is then forward-biased with respect to the cathode. The SCR fires, slowing the motor abruptly. The rectifier remains in conduction until the current flowing through it drops below the holding value—but by this time the motor is nearly halted.

This circuit is used in a motorized rotary valve system, where the desired valve opening is obtained by running the motor for a specific amount of time; thus, quick stopping is a must. However, the crowbar can brake any small dc motor. The only design considerations would be the SCR current rating, which must be greater than the stalled current drawn by the motor, and the value of $C_1$, which may have to be adjusted for optimum response. □

Designer's casebook is a regular feature in *Electronics*. We invite readers to submit original and unpublished circuit ideas and solutions to design problems. Explain briefly but thoroughly the circuit's operating principle and purpose. We'll pay $50 for each item published.




**Quick crowbar.** Opening the motor circuit generates an induced voltage which, added to signal in tank circuit formed by windings and $C_1$, gates the SCR. The rotation of the armature is thus crowbarred to a halt within 50 ms. Capacitor $C_2$ prevents false triggering.

## Comparator switches regulator for foldback current limiting

by R. H. Richardson
*Melbourne, Fla.*

The three-terminal regulator, while easing the design of regulated power supplies, does limit the adjustability of their output parameters. Here is a circuit that couples a comparator with a National LM317 adjustable, three-terminal power regulator to provide independent control of output voltage and current limiting.

The power supply shown in the figure was designed as a 9-to-16-volt, 20-ampere bench regulator for automotive transceiver applications. It therefore employs high-power regulating transistors, but the technique of comparator-controlled current limiting in the output is adaptable to any power range. In this case, the current limit of the supply can be set from 1 to 20 A, independent of the output-voltage setting.

The circuit employs a foldback type of current limiting; that is, once the current limit is exceeded, the output voltage drops nearly to zero. The LM311 comparator,

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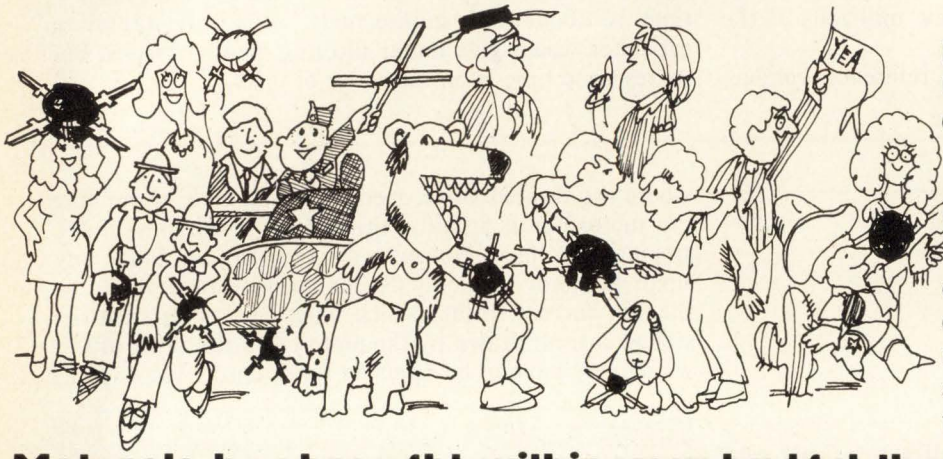


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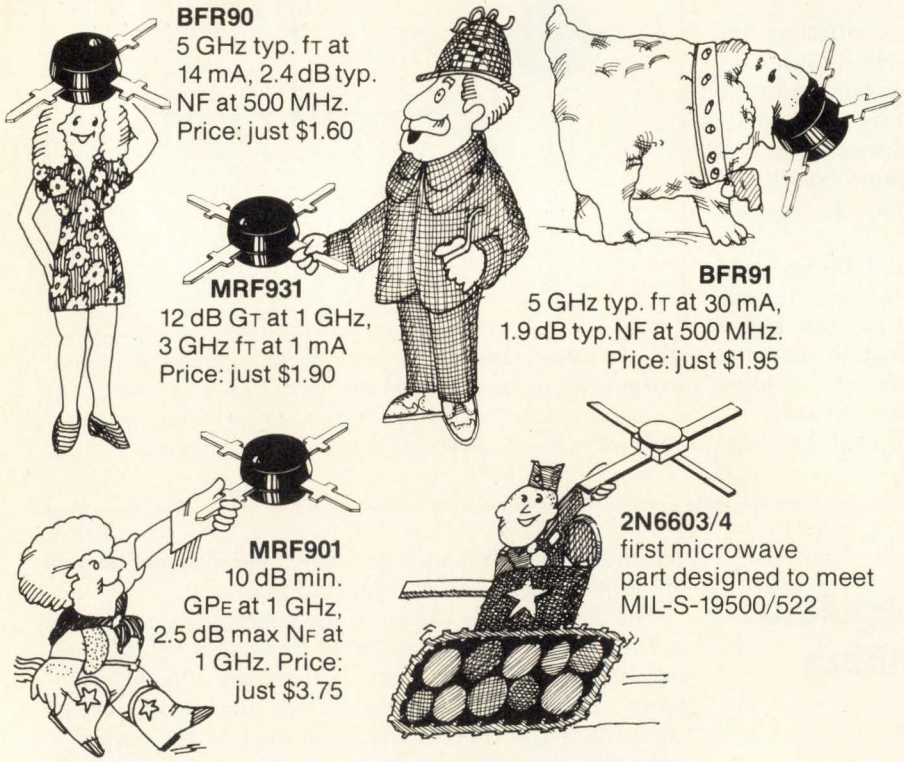

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monitoring the current flow, switches the supply into the limiting mode.

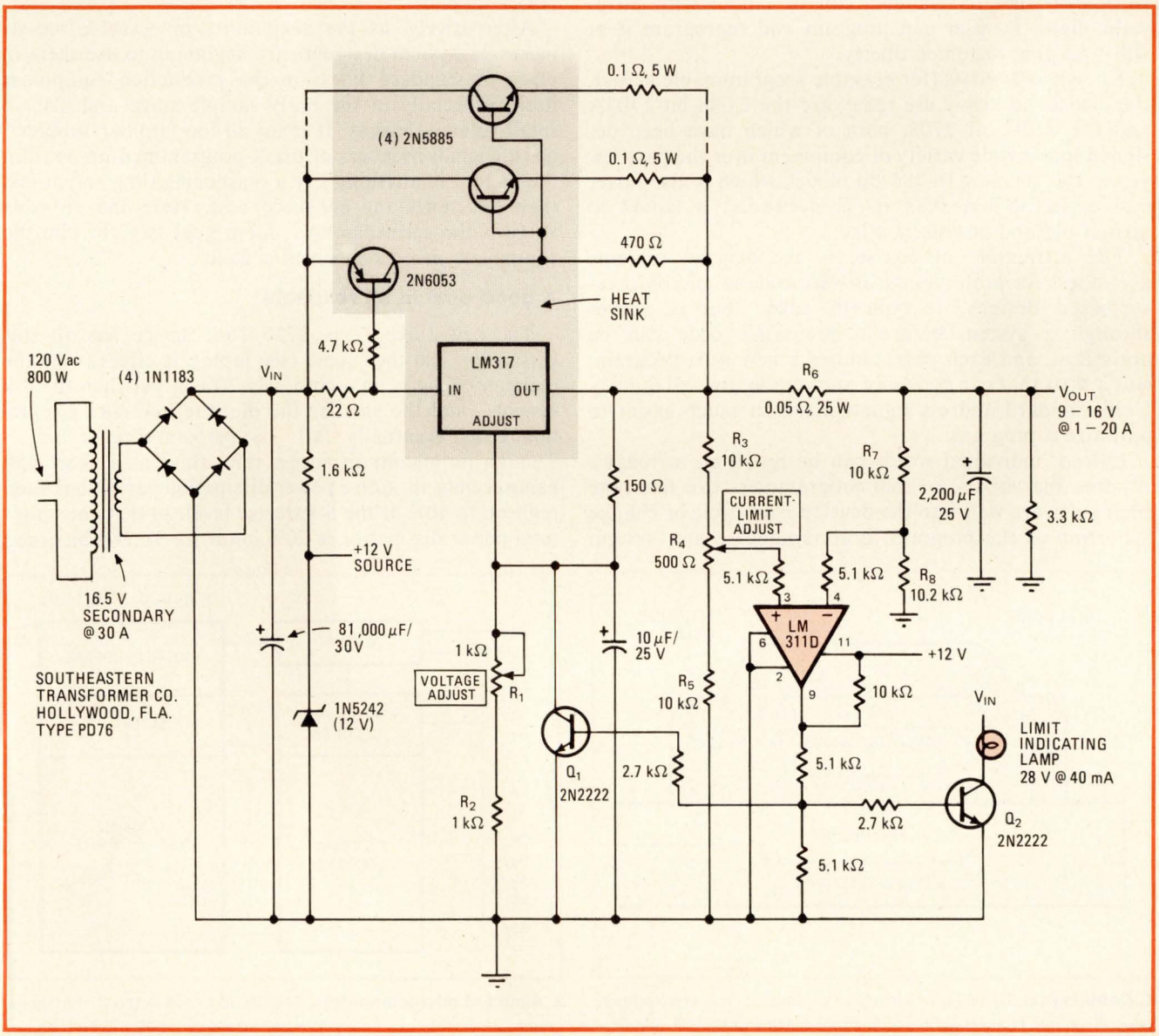
The output of the comparator goes high whenever the voltage drop across the current-sense resistor, $R_6$, exceeds the bias level set by the limit control, $R_4$. A high level at the output of the comparator turns on transistor $Q_1$, which in effect shorts out the voltage-adjusting resistors $R_1$ and $R_2$, thus dropping down the output voltage.

The design has an inherent hysteresis: in the limiting state, just enough current flows through the sensing resistor $R_6$ to keep the comparator turned on. Therefore the circuit does not oscillate as many other limiting regulators do—the output voltage remains near zero until the overload is removed. The action of the comparator also provides automatic recovery from the foldback point, since the circuit cannot latch in the current-limiting mode.

Transistor $Q_2$ turns on an incandescent lamp to indicate the limiting state. Since the value of the current-sensing resistor $R_6$ is not critical, the device may be replaced with the internal resistance of a 0- to 20-A meter, if desired.

The dial of the current-limiting control can be calibrated with known output loads at a set output voltage. Control of the limiting function is primarily dictated by the biasing resistors surrounding the comparator, $R_3 - R_8$. Designs for output voltages and currents in other ranges may employ the same basic configuration of regulator and comparator, with only the biasing components needing to be changed.

The LM317 adjustable regulator, available in either TO-3 or TO-220 packages, is capable of driving loads up to 1½ amperes without the aid of power-transistor followers. In the supply shown, five power transistors—four 2N5885s and a 2N6053—are required to handle the 20-A loads. All power transistors and diodes, as well as the regulator, must have adequate heat sinking. □




**Foldback current-limiting supply.** This supply, which has an output voltage adjustable from 9 to 16 V and provides independent current limiting from 1 to 20 A, uses a comparator to drop output voltage when the current limit set by potentiometer $R_4$ is exceeded.

# The biggest erasable PROM yet puts 16,384 bits on a chip

Using just one 5-V supply, the ultraviolet-erasable device is interchangeable with 16-k read-only memories—a boon to designers of microprocessor systems

by Robert Greene, George Perlegos, Phillip J. Salsbury, and William L. Morgan, *Intel Corp., Santa Clara, Calif.*

☐ In just two or three years, from being barely on the edge of visibility, a field-erasable read-only memory has blazed its way to prominence in the system designer's world. Because its contents can be erased with ultraviolet light, its user can program and reprogram it at will—an unaccustomed liberty.

Known as EPROMs (for erasable programmable ROMs), the devices in heavy use today are the 2,048-bit 1702A and the 8,192-bit 2708, both of which have been designed into a wide variety of equipment over the past few years. But the new 16,384-bit model, which is also faster and easier to use than its predecessors, is bound to attract old and new users alike.

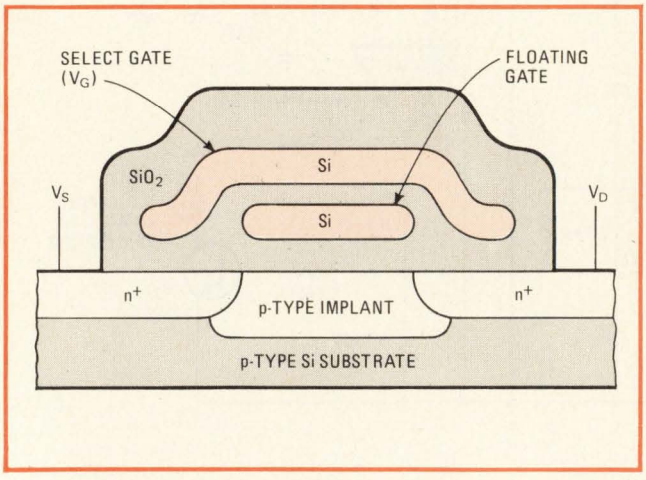
The attraction, of course, is the devices' extreme usefulness for prototyping software code in microprocessor-based designs. It typically takes tens of passes through a system before a program's code can be optimized, and each pass requires a new ROM program. But a ROM that can be erased and reprogrammed quickly from standard address signals makes it much easier to optimize a program.

Indeed, individual words can be rewritten in today's UV-erasable PROMs, so that programmers can fine-tune their software well into the development cycle or change a portion of the program to accommodate new system features. Then, once satisfied with the program, the user can switch into production with factory-programmable ROMs that have identical pin assignments and use similar power supplies.

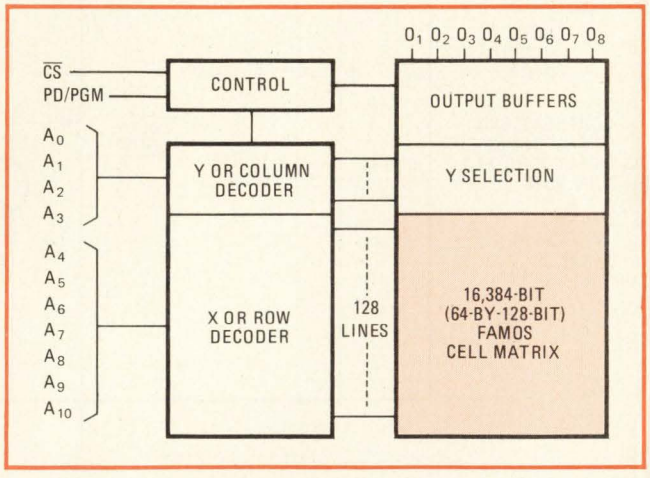
Alternatively, as the availability of erasable PROMs increases, system designers are beginning to use them in place of standard ROMs in the production equipment itself, especially in the early sample stage and also in small-volume designs. It is an all-too-familiar problem, getting small numbers of mask-programmed ROMs from the factory in anything like a reasonable time and at less than an exorbitant per-piece cost. Here the erasable PROM is the perfect answer, for it goes straight into the equipment once its program is fixed.

### A good deal in all respects

The new Intel Corp. 2716 16-k device has all this versatility, and then some (see table). It offers twice the memory capacity on a chip only 20% larger than the 8-k version—and the smaller the die, the lower its production costs eventually fall. Its performance is better. Though its maximum access time stays at a short 450 nanoseconds, its active power dissipation per bit has been reduced to 40% of the 8-k device level, so that the chip's total power dissipation is 20% lower for 16,384 bits than




**1. Doubling up.** By using two levels of polysilicon, this stacked-gate version of the floating-gate avalanche-injection MOS cell occupies half the area of earlier Famos cells. As a result, the 16,384-bit 2716 chip is only 20% larger than the 8,192-bit 2708 devices.




**2. Aimed at microcomputers.** The 16,384 cells in the 2716 device are organized into two 64-by-128-cell arrays or 2,048 8-bit words, an arrangement that makes the device useful for byte-oriented microcomputer designs and also compatible with 16-k ROMs.

| ULTRAVIOLET-LIGHT-ERASABLE PROGRAMMABLE ROMs | | | |
|---|---|---|---|
| Year | 1972 | 1975 | 1977 |
| Model | 1702A | 2708 | 2716 |
| **Basic features** | | | |
| Technology | p-MOS | n-MOS | n-MOS |
| Organization | 256 X 8 | 1,024 X 8 | 2,048 X 8 |
| Chip area (mil$^2$ equiv.) | 134 | 160 | 175 |
| Package pins | 24 | 24 | 24 |
| **Read performance** | | | |
| Access time (max) (ns) | 650 | 450 | 450 |
| Power dissipation (mW) | 700 | 730 | 500 |
| " " per bit (mW) | 0.4 | 0.1 | 0.04 |
| Standby power (mW) | * | * | 125 |
| " " per bit (mW) | * | * | 0.006 |
| Power supplies (V) | +5, −9 | +5, +12, −5 | +5 |
| TTL compatibility | yes | yes | yes |
| **Programming requirements** | | | |
| Supply voltages (V) | +12, −35, −48 | +26, +5, +12, −5 | +25, +5 |
| " " pulsed, $V_P$ | yes | yes | no |
| Program control levels (V) | 0/−48 | 0/+12 | TTL |
| Address and data inputs (V) | 0/−48 | TTL | TTL |
| Duty cycle (%) | 20 | 80 − 100 | 80 − 100 |
| **Programming performance** | | | |
| Programming time of all words (s) | 120 | 100 | 100 |
| " " per word (s) | 0.4 | 100 | 0.05 |
| Single-pulse programming | no | no | yes |
| Single-location programming | yes | no | yes |
| Erase time of all words (minutes) | 10 − 20 | 10 − 30 | 10 − 30 |

*Power dissipation can be reduced by clocking power supply or turning off during deselect

it was for 8,192 bits. In fact, the 2716's speed-power product, at 450 ns and 500 milliwatts, puts it on a par with standard high-density ROMs. Moreover, the chip's low standby power mode, in which it dissipates only 125 mW, affords further power savings at the system level.

Equally important, the 2716 works off a single 5-volt power supply, in contrast to the earlier multiple-supply 1702A and 2708 devices. This change is vital for today's designs, since it allows the device to be used with the new, more powerful 5-V microcomputers. In fact, another device using the same basic cell concept, the 8755, has been designed with special input/output ports and control lines to work directly with the 5-V Intel 8085 microcomputer, as well as with other types of 5-V microprocessor systems.

In applying the new 16-k 2716 in microprocessor-based systems, the system designer not only replaces two 2708 packages with one 2716, but he or she can also eliminate the 1-of-4 decoder chip that is needed with the two earlier devices. Indeed, when hooking up the 2716 to single-chip microcomputers such as Intel's 8048, only a standard, commercially available 8212 latch is used, as with the 2708 configuration, and nothing else. All other control signals and address signals are supplied by the processor.

Finally, the new devices are easier to program than the earlier ones. They need only two programming supply voltages (+25 and +5 V) instead of three and four different voltage levels (some as high as 48 V) typical of UV-erasable PROMs. Moreover, the program voltage $V_P$ need not be a low-duty-cycle pulse, so that program time is greatly reduced—from 100 seconds to 0.05 s per bit—even while control levels and address and data inputs are kept at straight 5-V transistor-transistor-logic levels.

All these improvements flow from a new n-channel stacked-gate cell that uses just one transistor. This cell is fabricated with a dual-layer silicon-gate process that closely resembles the one used in today's 16-k dynamic random-access memories. As the cross section in Fig. 1

## The Famos principle

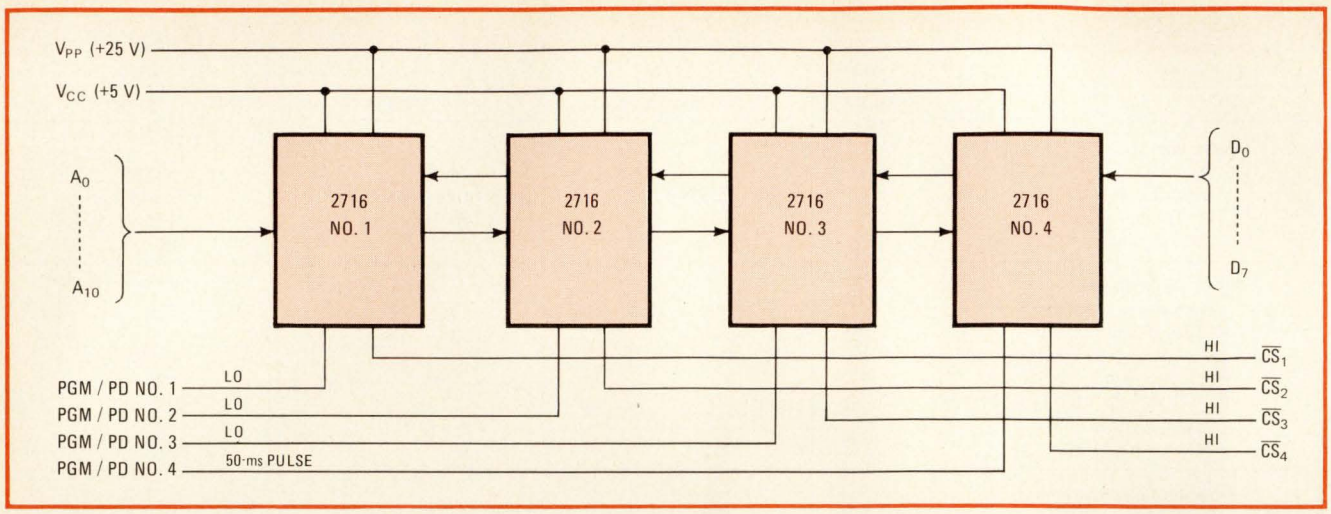
Famos describes the floating-gate avalanche-injection metal-oxide-semiconductor transistor that Dov Frohman-Bentchkowsky developed at Intel Corp. in 1971.

The Famos device is essentially a silicon-gate MOS field-effect transistor in which no connection is made to the floating silicon gate. Instead, charge is injected into the gate by avalanches of high-energy electrons from either the source or the drain. A voltage of -28 volts applied to the pn junction releases the electrons.

Data is stored in a Famos memory by charging the floating-gate insulator above the channel region. The threshold voltage then changes, and the presence or absence of conduction is the basis for readout.

The Famos cell has generally been considered more reliable than nitride storage mechanism used in reprogrammable metal-nitride-oxide-semiconductor memories. In MNOS memories, carriers tunnel through a thin oxide layer into traps at the oxide-nitride interface. But a partial loss of stored charge during readout limits the number of readout cycles to approximately $10^{11}$.

In Famos memories, on the other hand, there is no loss of charge due to reading. Moreover, over time, the loss of stored electrons is negligible, less than one per cell per year. and information retention is excellent.




**3. Picking and choosing.** The 2716 erasable PROM has a program inhibit mode, to allow the designer of a multipackage system to program some of the devices and not others. Only those devices that receive a TTL-level pulse on the PGM/PD pin will be programmed.

shows, a lower floating gate stores the cell's charge, and an upper control or select gate operates the cell. Being stacked one over the other, the gates create an extremely compact structure—the smallest cell of any UV-erasable PROM in production. Including decode, address, drive, and sense circuitry, the entire memory fits on a chip well under 40,000 $mil^2$ in area.

As for the cell's operation, the fact that it has a fairly complicated stacked-gate configuration is completely transparent to the user. Unlike the 1702A erasable-PROM floating-gate cells (see "The Famos principle," p. 109), the stacked-gate cell is programmed by means of hot electrons injected from the channel through the oxide to the floating gate. This injected charge raises the threshold voltages at the top or select gate, so that a charged cell has a higher select voltage than an uncharged cell. The overall charge pattern, then, as seen from the select gates, duplicates the pattern of a standard mask-ROM.

Once programmed, the charge retention of the new 16-k UV-erasable PROM is as good as in the original Famos devices. Reliability studies of standard production runs indicate that 95% of the devices can be expected to retain their memory for 100 years at 70°C. Charge removal from the stacked-gate cell occurs with its exposure to ultraviolet light, just as in both the earlier UV-erasable devices.

## Using the 2716

The array of 16,384 Famos cells, which are formed into two 64-by-128-cell matrixes (Fig. 2), is organized as 2,048 8-bit words, giving the 2716 a byte orientation that is useful in microcomputer applications. Because of this arrangement, the device operates almost exactly like the 2708 8-k erasable-PROM. The only differences are that on the 2708 device the power-supply voltages $V_{DD}$ and $V_{BB}$ are on pin 19 and pin 21 respectively, whereas on the 2716 device the address $A_{10}$ is on pin 19 and the program voltages (+25 V for programming, 5 V for reading) are on pin 21.

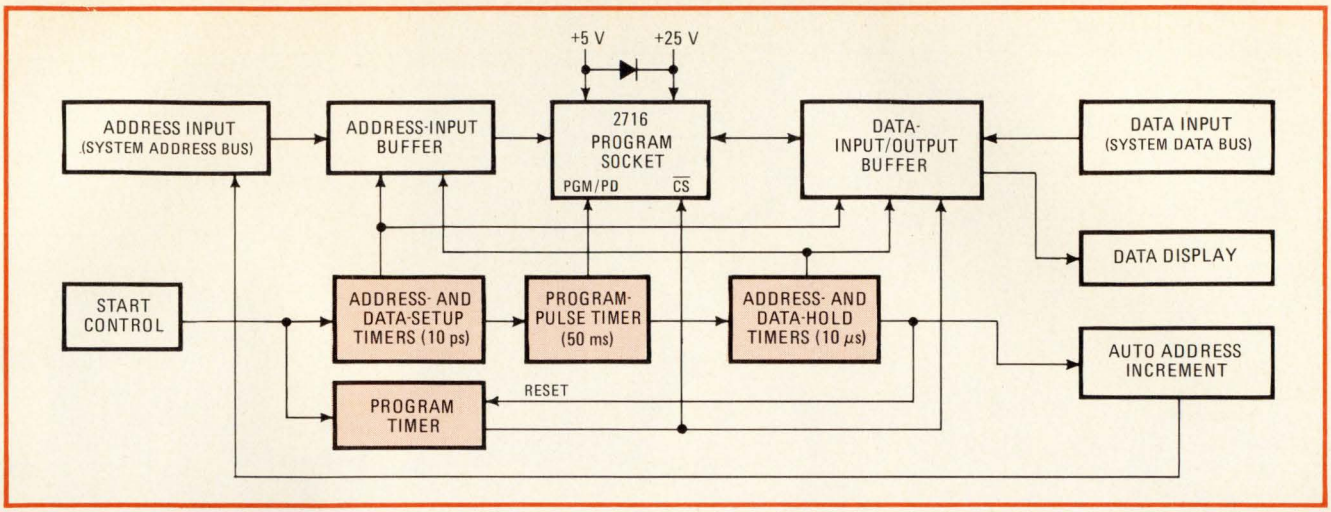
Otherwise, complete data and power-supply compatibility exists between the familiar 2708 and the new 2716: they plug into exactly the same sockets, having exactly the same standard 24-pin package and the same pin assignments (except for those mentioned above). The one change in designing a board with a 2716 is that programming it requires a +25 V power supply and reading it takes a 5-V supply instead of the 26-V pulses needed for programming and the ±12 V, +5 V, and −5 V supplies needed for reading the 2708.

As for ease of use, the 2716 compares well with ordinary ROMs. The seven highest-order address bits, $A_4$ to $A_{10}$, select the rows, while address bits $A_0$ to $A_5$ select the columns and operate on eight 1-of-16 decoders, such that one of 16 column lines is gated to each of the eight output buffers.

Sensing is the same as in the 2708 devices. The charge on the selected column line is monitored. Unprogrammed cells will have a low threshold and will discharge the column line when selected, while the threshold of programmed cells will have been raised to an impedance level that is high enough to keep the column line charged.

To read the 2716, the chip-select input is the only control input required. Lower this input to a transistor-transistor-logic 0 and the device reads; raise it to a TTL 1 again and the device stops reading—is deselected. When deselected, this chip-select input causes the outputs to go into the high impedance state within about 120 ns, a time short enough to allow a designer to OR-tie several 2716s in parallel yet still retain the maximum 450-ns access times of individual devices. On the other hand, since chip select is really an enabling signal, if only one or two 2716s are being used in a system, they may be left low during all cycles, allowing a designer to exploit the typically faster access times of any individually selected devices.

Writing and erasing are no big chores, either. Initially, and after each erasure, all bits of the 2716 are in the logic 1 state (output high). Data is written by selectively programming 0s (output low) into the desired bit locations. To set up the 2716 for programming, the program power supply, $V_{PP}$, is raised to 25 V, and the chip-select is raised to the input high-voltage state ($V_{IH}$) or 2.2 V




**4. Programming made easy.** In this setup, the user need only observe the appropriate setup times for the programming operation to succeed. The start control signal gets the timing chain moving, and from then on things are practically automatic.

minimum. The data is then presented, 8 bits in parallel, on the data output lines ($O_1$ to $O_8$ in Fig. 2), while the corresponding address is presented to the address inputs.

After the address and data setup times have elapsed, a program pulse is applied to the programming PGM/PD pin. This pulse is a TTL-level signal that serves to gate the program power supply, $V_{PP}$, into the array. It must be present for at least 50 milliseconds to ensure long-term retention of the programmed data. When this program is completed, the $V_{PP}$ pin should be returned to +5 V.

Finally, erasing the 2716 is the same as for all UV-erasable PROMs. The user places it under an UV lamp and exposes it to the equivalent of 15 watt-seconds/cm$^2$. Although there is no evidence that extended exposure harms the device, the lamp should be placed on a timer and shut off after 30 minutes to prevent unduly long (overnight and over-weekend) accidental exposure.

A useful feature of the 2716's program design is its program-inhibit mode. In multipackage systems, this mode lets the designer ignore some of the devices on a given board and only program or reprogram the rest. The setup is shown in Fig. 3. All inputs and outputs are tied together except for PGM/PD. Only those devices that receive a TTL-level pulse on the PGM/PD pin will be programmed. In the setup shown, device No. 4 is being programmed with a 50-millisecond pulse on this pin, while the address contents of the other three devices are unaffected.

The programming schemes devised for the 2716 are easier than for previous UV-erasible PROMs, as may be seen from the example diagrammed in Fig. 4. In this scheme, the addresses and data may be derived from a microcomputer system bus. Alternatively, the user can generate both manually, employing toggle switches for control and a counter for address input. However, when manual operation is performed, a provision must be made for automatic incrementing of the address pulses.

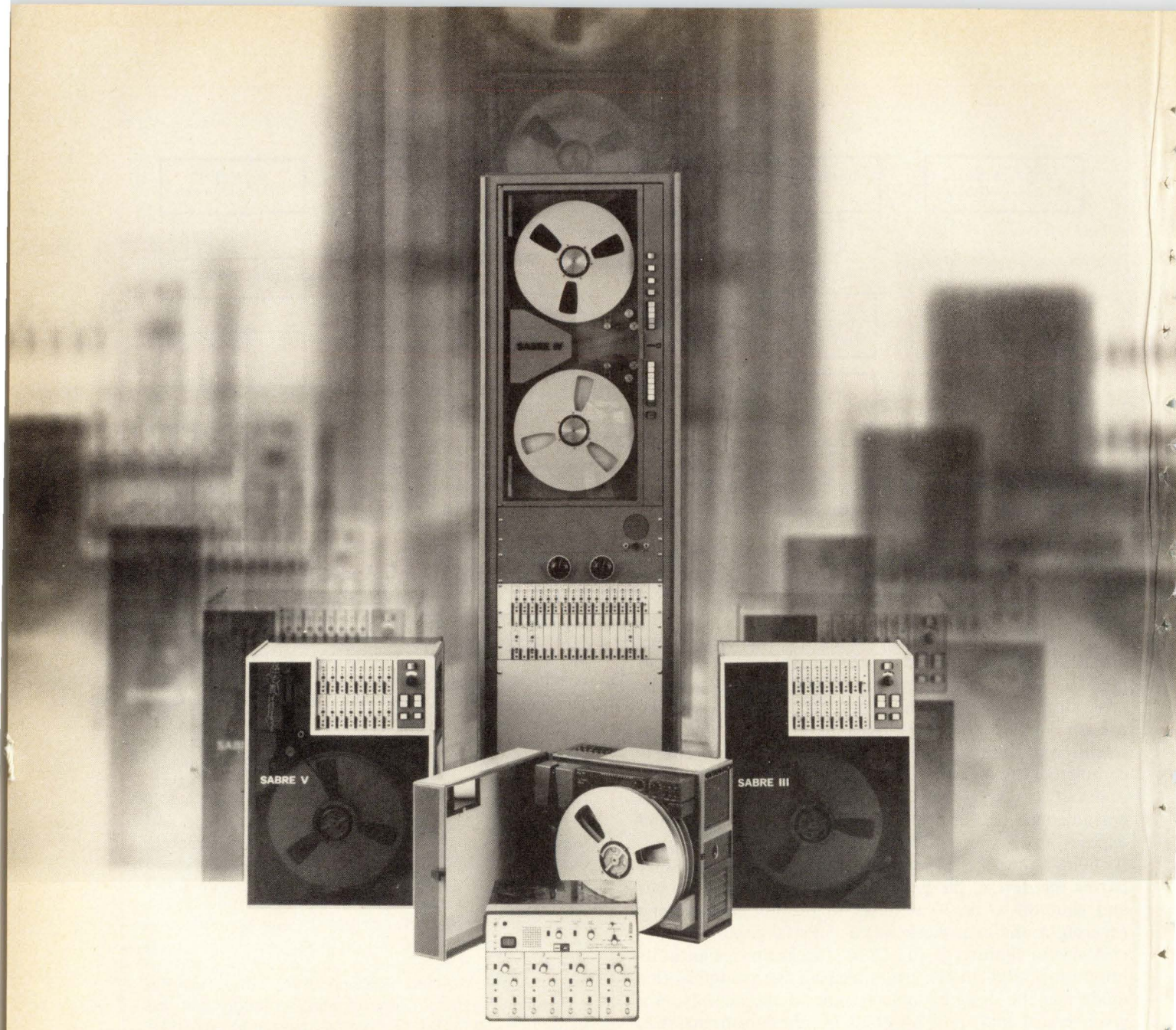
In either case, a start control signal enables the timing chain shown in Fig. 4, assuring that the appropriate setup times are observed. This signal also enables the program timer, which controls the 2716 chip-select signal, and places the data input/output buffer in the input mode. The program timer must be reset after the address and data hold times have passed.

Once started, the address and data-setup timers enable the program pulse timer, which applies the required TTL pulse to the 2716 PGM/PD pin. This pulse, in turn, on its falling edge, enables the address- and data-hold timers. After they have finished, the auto-address-increment timer does one of two things. Either it advances the address-input counter on a manual programmer, or it resets a not-busy flag on a microprocessor. The program timer is then reset, placing the data I/O buffer in the output mode for data verification. Note that the $V_{PP}$ (+25-V) supply does not have to be turned off or switched during program/read transitions. However, it should be lowered to $V_{CC}$ for nonprogramming operation to reduce power dissipation. □

## From PROM to final ROM—fast

Since the UV-erasable 16,384-bit 2716 user-programmable ROM is pin-compatible with the 2316E mask-programmed 16-k ROM, designers can debug systems with the 2716 and, as soon as the data pattern is firm, order read-only memories to plug directly into the 2716/2316E socket. In fact, the initial system can be shipped with erasable PROMs and fitted with ROMs in the field when they become available. Also, the 2716 can be used as the master for transmitting the desired data pattern back to the factory without all the hassle of tape formats.

This direct interchangeability between the 2716 and the 2316E can also speed up implementing code changes. In the past, even when systems were successfully prototyped with UV-erasable PROMs and released to production using mask ROMs, the slightest code change forced the end user to wait while the new code was implemented on the prototype system, then translated into a ROM pattern, and only then placed in the production system. But when the 2316E is used in production systems, any change in code can be performed in a matter of a few hours by programming a 2716 with the custom pattern and plugging it in.

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# Hybrid transformers prove versatile in high-frequency applications

## At frequencies up to 1 MHz, they can be used for duplexing, proximity-sensing, or making intermodulation measurements

by Tom Gross, *T. A. O. Gross & Associates, Lincoln, Mass.*

☐ Most hybrid transformers—the three-winding type used for telephone applications—do not operate beyond the voice-frequency band. However, if their frequency range is extended, they can easily perform a number of other tasks. Among these applications are:

- Duplexing a single transducer for both transmit and receive functions in ranging systems and ultrasonic detectors for camera focusing and intrusion alarms.
- Measuring intermodulation distortion when a device must be driven by several signal sources that should not interact.
- Coupling several transducers to common drivers so that the harmonics generated in one transducer are not reproduced in another one.
- Making return-loss measurements in the frequency domain.
- Proximity sensing of metallic objects.

The transformers used for all of these applications can be made with standard materials without the need of special winding machinery. If the turns ratio is unity, the winding may be a simple trifilar structure, which gives excellent coupling and winding symmetry. In fact, this construction may be used for operating frequencies as high as 1 megahertz with the popular termination impedance of 50 ohms.

### Ins and outs of the hybrid transformer

The hybrid transformer is valuable for many applications because it can couple circuits to a common terminal without coupling them to each other. The device consists of three closely coupled windings, two of which are connected in series-aiding fashion (Fig. 1a). In general, the two series-connected coils have an equal number of turns, so that $N^2 = Z_4/Z_3$, where Z is the termination impedance, and N is the ratio of the number of turns of the "floating" winding to the number of turns of one of the series windings.

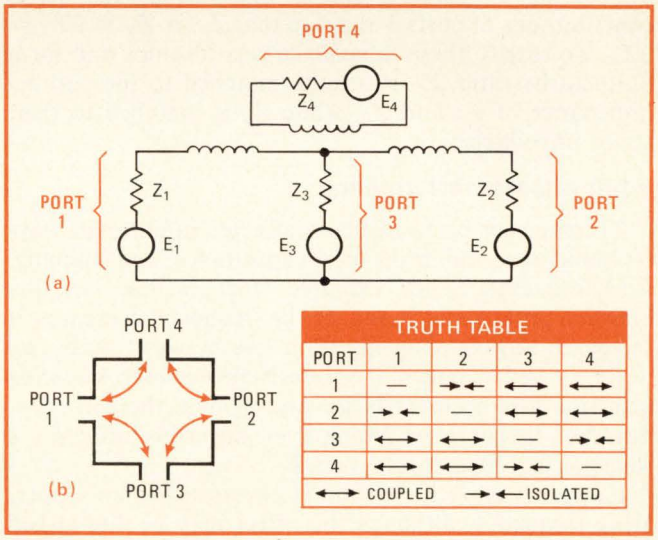
When each port is terminated properly, this configuration yields a four-port device having the truth table of Fig. 1b. Ports 1 and 2 are both coupled to ports 3 and 4, but they remain isolated from each other. Similarly, ports 3 and 4 are connected to ports 1 and 2, but not to each other.

Hybrid transformers tend to differ from conventional coupling transformers in the care exercised to achieve winding symmetry, high magnetic coupling, and high shunt reactance over the operating-frequency range. However, most ordinary power transformers having three windings may be used as hybrids over limited ranges of operating frequencies and termination impedances. The special coupling properties of the hybrid transformer result from bridging of external impedances, rather than arcane processes inside the device.

### How the isolation works

The operating action of the hybrid transformer may be explained readily by mesh equations, but an intuitive understanding is more helpful for applying the device. A simple assumption helps to explain the operating principle: Let each of the three windings have N turns (unity turns ratio), and let all the termination impedances be equal so that $Z_1 = Z_2 = Z_3 = Z_4$.

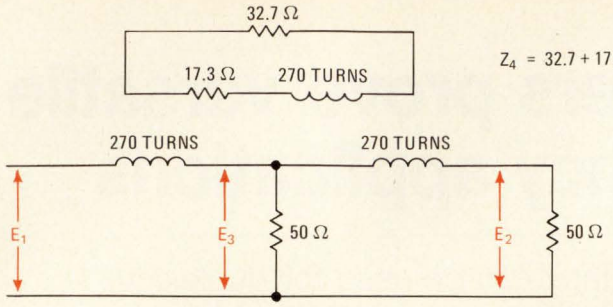
The isolation between ports 3 and 4 is easiest to understand. If all the voltage sources except $E_3$ are shorted, the current generated by $E_3$ divides equally, flowing in opposite directions in the series windings. No net flux is produced in these windings to induce a voltage in the winding of port 4. To port 3, ports 1 and 2 appear




| TRUTH TABLE | | | | |
|---|---|---|---|---|
| PORT | 1 | 2 | 3 | 4 |
| 1 | — | →← | ↔ | ↔ |
| 2 | →← | — | ↔ | ↔ |
| 3 | ↔ | ↔ | — | →← |
| 4 | ↔ | ↔ | →← | — |

↔ COUPLED →← ISOLATED

**1. Basics.** Hybrid transformer (a) is a four-port device formed by three windings, two of which are connected in series. As the truth table (b) shows, ports 1 and 2 are coupled to ports 3 and 4, but isolated from each other. Likewise, ports 3 and 4 are also isolated.




| TEST RESULTS | |
|---|---|
| Frequency (Hz) | $E_1/E_2$ (dB) |
| 50 | 22 |
| 100 | 28 |
| 500 | 41 |
| 1,000 | 49 |
| 40k | 50 |
| 100k | 45 |
| 500k | 34 |
| 1,000k | 22 |

CONSTRUCTION DETAILS
Coil resistance: 17.3 ohms
Inductance: 220 mH at 1 kHz
Core: Magnetics Inc. G42616-UG or Ferroxcube 26/16-3B7
Bobbin: two-section 26/16
Winding: 270-turn trifilar, 135 turns on each bobbin section of three strands of gauge-36 film-insulated wire, twisted approximately one full turn of 3 strands per inch

**2. Simple structure.** Hybrid transformer for ultrasonic applications may be built with standard materials and without special winding machinery. The core is a ferrite cup, and each coil consists of 270 turns of a trifilar winding of film-insulated wire.

to be connected in parallel; therefore, if $E_4$ is the source, a current circulates in the series-windings' loops, yielding equal but opposite voltages that cancel at port 3.

The isolation between ports 1 and 2 is a bit harder to grasp, but it can be illustrated by assuming that $E_1$ is the only active source and that the other three sources are shorted. If no current flows in $Z_2$, the only impedance reflected in the left side of the tapped winding is that of $Z_4$, which has been presumed to be equal to $Z_3$, as well as $Z_1$. So, if $E_1$ were 3 volts, 1 v would appear across $Z_1$ and 1 v across $Z_3$. Also, 1 v would be induced across $Z_4$ and 1 v across $Z_2$. Since this latter voltage is equal and opposite to the 1 v across $Z_3$, no net voltage would be present at port 2.

Although $Z_3$ must exactly equal $Z_4$ to preserve the isolation between ports 1 and 2, impedances $Z_1$ and $Z_2$ may have any value from zero to infinity without impairing the isolation of their respective ports. But if power matches are desired—as they usually are—the impedance of ports 1 and 2 must equal the series contributions of ports 3 and 4 so that $Z_1 = Z_2 = 2Z_3 = 2Z_4$. To satisfy these impedance relationships and for a unity turns ratio, $Z_3$ is usually matched to the parallel impedance of $Z_1$ and $Z_2$, while $Z_4$ is matched to their series impedance.

## What affects performance

Transformer performance is affected in different ways by inductance, coil resistance, capacitance, and coupling. Low inductance, for example, reduces the isolation between ports 1 and 2, and, as the frequency decreases, it increases the coupling insertion loss between these two ports, as well as port 4. If coil resistance is high, coupling insertion loss becomes large, and drift in the coil resistance of the port-4 winding even adversely affects the isolation between ports 1 and 2.

Excessive capacitance limits the transformer's operating frequency, although this effect may be diminished by low termination impedances. Capacitance symmetry, another important factor, may be aided by floating the port-4 winding and termination impedance above ground. Insufficient coupling, the principal fault of ordinary power transformers pressed into hybrid service, limits the maximum operating frequency, as well as the highest usable values of the termination impedances.

Despite these possible hindrances, the performance needed from a hybrid transformer for broadband operation is quite easily obtained, so long as the application involves a fairly high minimum operating frequency and low-value termination impedances. If the transformer is not to operate at low frequencies, it need not have a large number of turns, and a broad variety of commercially available ferrite pot cores may be used for the construction of the transformer.

## Building one is not difficult

Above mid-audio frequencies, ferrite-cup cores, which come with convenient coil bobbins, are appropriate. Standard off-the-shelf hybrids for 600-ohm telephone use may be employed well below voice frequencies with a proportionate reduction in terminating impedances. For close coupling and broad bandwidth, trifilar windings may be used at frequencies up to about 1 MHz. However, at termination impedances higher than 50 ohms, a trifilar construction may prove troublesome because it produces considerable interwinding capacitance.

Several different constructions are suitable for a high-frequency hybrid transformer. Figure 2 shows one for applications at ultrasonic frequencies. This structure provides excellent isolation between ports 1 and 2 over the range of 500 hertz to 500 kilohertz. Its low-frequency performance can be improved by wrapping more turns of a smaller-diameter wire, but this causes insertion loss to go up. Also, connecting the useful load to port 3 rather than port 4 halves the insertion loss caused by coil resistance, and the load may be driven down to dc. Of course, when the load must be floated above ground, port 4 is appropriate.

Furthermore, termination impedance $Z_4$ may be absorbed entirely into the coil resistance at port 4 by simply winding the coil with smaller-diameter wire. This leaves more room for using larger-diameter wire for the other two coils, thereby reducing insertion loss. However, such a modification may cause excessive transformer heating in power applications so that hybrid balance drifts with temperature. Using nichrome or

Manganin wire for the port-4 winding will ensure hybrid balance over a wide range of temperature.

Since this particular transformer design is intended for ultrasonic applications, a ferrite-cup core is the optimum technical choice. Because such a transformer structure can accommodate frequencies much lower as well as much higher, it is ideal whenever a single unit must be put together in a hurry. As a rule, a laminated-metal core is the better choice for low-frequency transformers slated for production volumes and a ferrite core for rf applications.

## Applying the hybrid transformer

For duplexing operations, a hybrid transformer is hard to beat for its extreme simplicity and excellent coupling properties. The transmitter and the receiver are connected to a common transducer, as shown in Fig. 3a for a sonar system, in which the isolation between ports 1 and 2 prevents receiver overload.

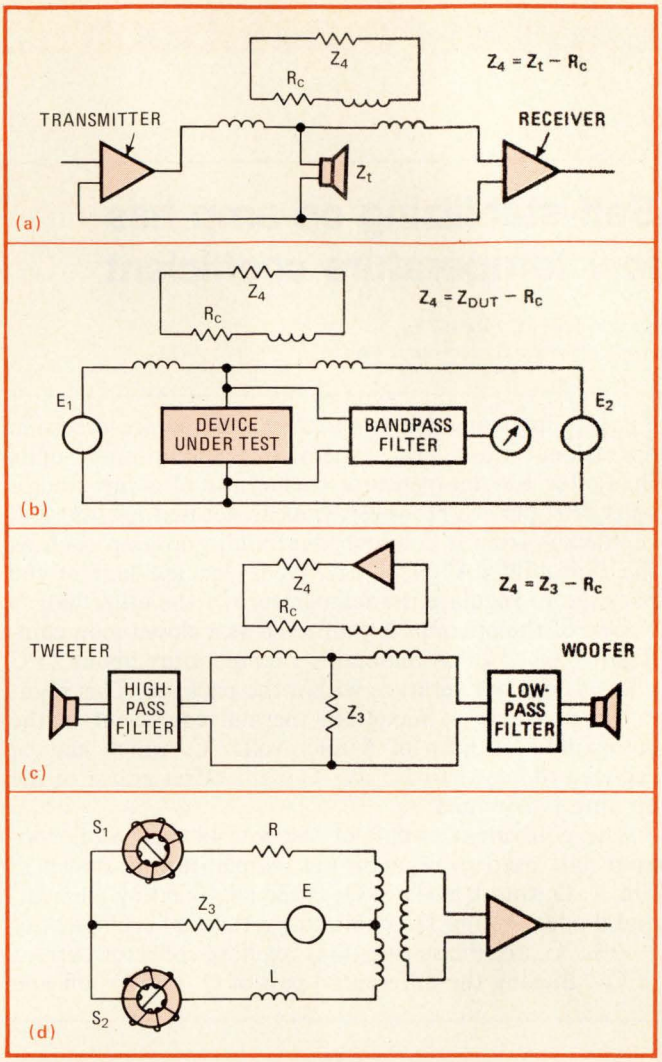
To avoid the loss in port 4 of half of the transmitted signal energy, as well as half of the received signal energy, the terminating impedance of this port is set equal to the impedance of the transducer minus the coil resistance of the port-4 winding; in other words, the coil resistance becomes part of that port's termination. The coil resistances of the other two windings have no first-order effects on isolation or termination impedance.

Return loss may be measured with the identical set-up—simply replace the transducer at port 3 with the device to be tested. Return loss is usually measured in the time domain (by pulsing the device under test and monitoring its response with the receiver). However, a hybrid transformer enables return loss to be measured in either the time or frequency domain.

Yet another application is measuring intermodulation distortion. In the circuit of Fig. 3b, the hybrid transformer is coupling two signal generators to the device under test at port 3, thereby eliminating spurious intermodulation between the generators, and the use of ports 1 and 2 for the signal sources permits coupling down to dc. Isolation between these two ports is lost when the winding reactance is no longer large, compared to the impedance of the device under test. However, in many applications, this loss in isolation at low frequencies can be tolerated.

A hybrid transformer can also couple two transducers together while isolating each from undesirable harmonics generated in the other. For example, in a hi-fi system, a hybrid transformer can prevent harmonics caused by woofer nonlinearities from passing through the high-pass section of the crossover network and being reproduced by the tweeter. The transformer isolates the tweeter from the woofer while both are driven by a common source, as illustrated in Fig. 3c. However, with this circuit, applying the negative feedback needed for woofer damping is difficult because of the high value required for $Z_4$, the amplifier's output impedance.

In the final and perhaps most intriguing application, the hybrid transformer may be operated as a proximity sensor to detect the presence of metallic objects. In fact, a proximity sensor based on a hybrid transformer provides greater sensitivity than most other circuits




**3. Versatile.** Besides telephone applications, the hybrid transformer may be used as a duplexer (a) in sonar systems, for intermodulation measurements (b) with coupling down to dc, as a woofer-tweeter isolator (c) in hi-fi systems, and as a proximity sensor (d).

because it permits high-gain amplification at port 4 for canceling noise sidebands of the oscillator signal.

Figure 3d shows a typical setup. Toroid $S_1$ is wound to minimize the effects of external fields, while toroid $S_2$ is wound to maximize ulterior effects. Since the Q and inductance of $S_1$ are higher than those for $S_2$, the resistor and inductor are needed to balance the impedances at ports 1 and 2 (when no metallic targets are present). A conducting object near $S_2$ causes this toroid's Q to drop and its inductance to change, thereby varying the impedance at port 2 and producing a signal at port 4. (Below oscillator frequencies of about 15 kHz, ferrous objects generally increase $S_2$'s inductance.) □


**Bibliography**

K. S. Johnson, "Transmission Circuits for Telephonic Communication," Van Nostrand, N.Y., 1925.

A. A. Albert, "Electrical Communication," John Wiley & Sons, 1950.

Pender and McIlwain, "Electrical Engineers Handbook: Communication—Electronics," 4th ed., pp. 6–12, John Wiley & Sons, 1950.

A. J. Eisenberg, "Telephone Coupling Transformers," Microtran Co. Inc., Valley Stream, N.Y., Engineering F232, 1975.

T. A. O. Gross, "Super Toroids with Zero External Fields," Electronic Design, Sept. 1, 1976, pp. 110-112.

# Self-stabilizing op amp has low temperature coefficient

by Joseph M. Gorin
*Hewlett-Packard Co., Loveland, Colo.*

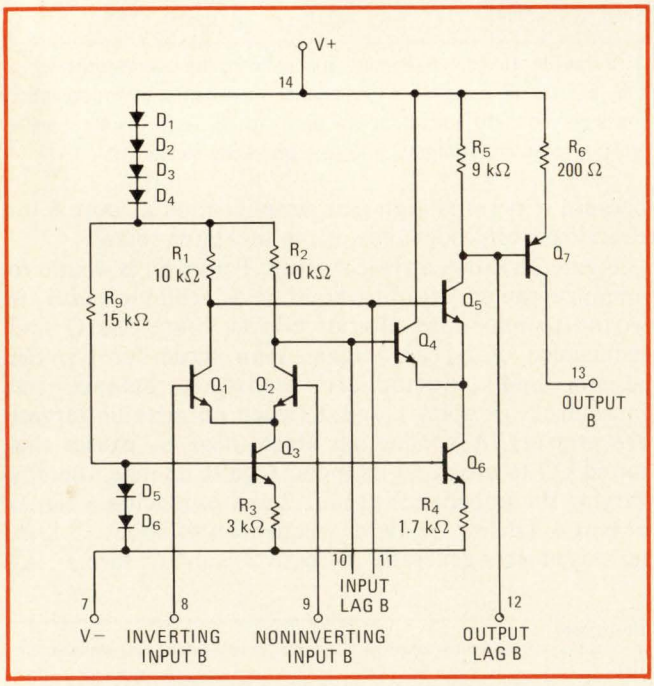
Circuits involving precision references require precision operational amplifiers—expensive, premium-grade units that offer low temperature coefficients of a few microvolts drift per °C. However, you can get that low thermal coefficient from a common dual audio op amp such as the Fairchild μA739 or μA749, if you use half of the package to regulate the temperature of the other half.

One of the op amps is connected as a closed-loop chip-heating system that maintains a temperature about 25°C above room temperature within the package. This regulation produces a maximum thermal coefficient in the companion op amp of 6 microvolts/°C, which can be reduced to less than 1.5 μV/°C if the offset adjust of the op amp is trimmed.

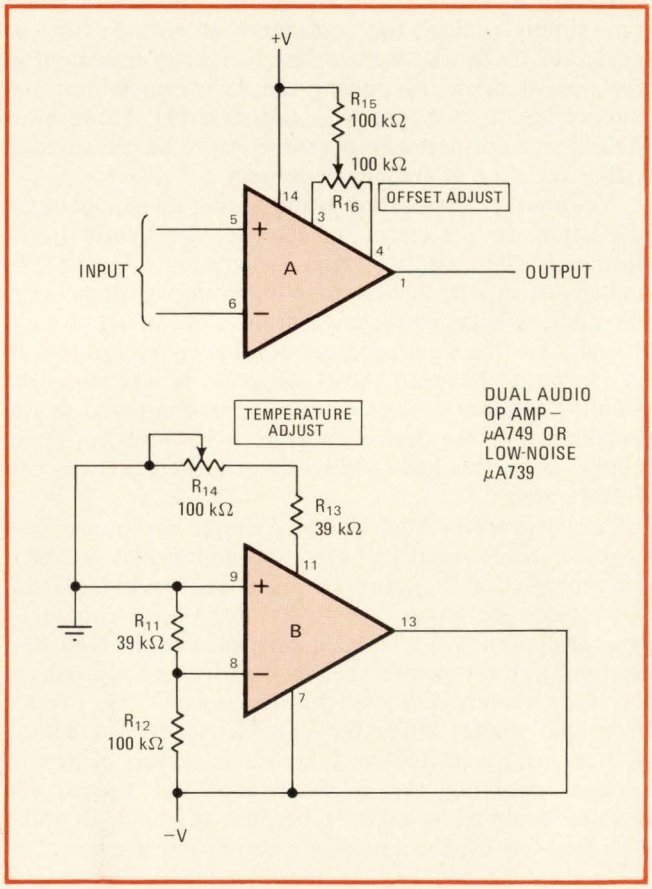
The equivalent circuit of the μA749 dual audio op-amp half used to regulate the temperature is shown in Fig. 1. Output transistor $Q_7$ is the chip-heating element, and diodes $D_5$ and $D_6$, exhibiting a thermal coefficient of −.3%/°C, are the sensors that regulate collector current of $Q_3$. Biasing the differential pair of $Q_1$ and $Q_2$ off and on, respectively, directs all of $Q_3$'s collector current through $Q_2$ and produces a thermally dependent voltage across $R_2$. The variation is about 7 mV/°C, but the thermal coefficient of $R_3$ opposes this with about 2 mV/°C. The voltage change is amplified by the $Q_4$-$Q_5$ differential pair that controls the current through $Q_7$ and hence the chip temperature.

For example, as the chip gets warmer because of a rise in the ambient temperature, the collector current of $Q_3$ gets smaller and the voltage drop across $R_2$ decreases. Since the upper end of $R_2$ is clamped, the lower end sees a rise in voltage, increasing the base voltage of $Q_4$. The differential signal unbalances $Q_4$ and $Q_5$, reducing the drop across $R_5$ and thus the current in $Q_7$. The chip is heated less, and its temperature decreases.

The system is shown in Fig. 2. Op amp B is the heater that stabilizes A. Resistors $R_{11}$ and $R_{12}$ bias the differential input ($Q_1$ and $Q_2$ in Fig. 1), and $R_{13}$ and $R_{14}$ determine the temperature of the chip by setting a reference voltage for the second differential pair ($Q_4$ and $Q_5$ in Fig. 1). Potentiometer $R_{14}$ permits adjustment of the chip temperature to about 25°C above ambient. If




**1. Half a μA749.** This circuit is equivalent to one audio amp in a dual package. Transistor $Q_7$, used as a chip-heating element controlled by the thermal dependence of $Q_3$, stabilizes other amp in the package, producing a thermal coefficient rivaling precision units.




**2. B regulates A.** Using op amp B as a chip-heating system reduces thermal coefficient of op amp A to less than 6 μV/°C. Trimming offset voltage by adjusting $R_{16}$ can cut drift to 1.5 μV/°C. $R_{14}$ adjusts chip temperature; set it to produce 1.6 V between pins 12 and 14.

$R_{14}$ is adjusted so that 1.6 v appears between pins 14 (positive supply) and pin 12, the companion op amp will exhibit its rated thermal coefficient over a range of about ±25°C around the ambient.

Potentiometer $R_{16}$ is the offset adjust for the stabilized op amp. Setting this to produce a minimum offset voltage at the output (pin 1) will trim the thermal drift of op amp A to about 1.5 μv/°C. □

# Logic tester has unambiguous display

by S. Jayasimha Prasad and M. R. Muralidharan
*India Institute of Technology, Madras, India*

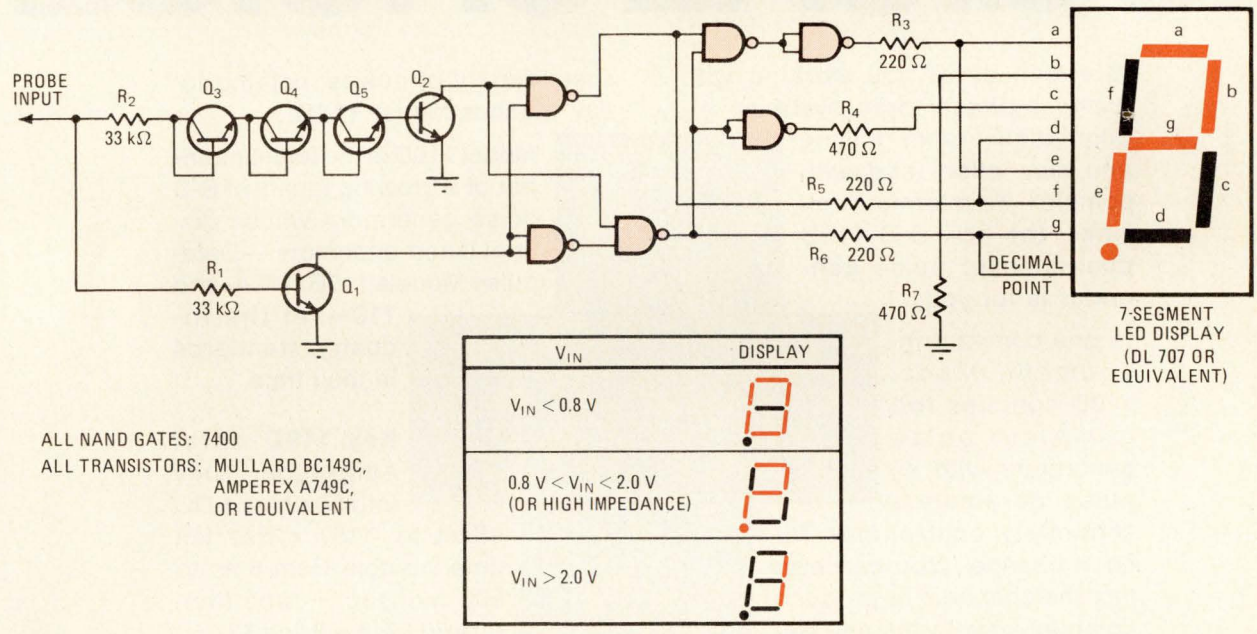
It usually takes a little time to interpret the display of most logic probes. But this tester flashes a totally unambiguous 0 or 1 or ? on its seven-segment display, the question mark indicating any voltage level not within the logic thresholds.

The circuit, built around transistor-transistor logic NAND gates, is shown in the figure. The output character display is controlled by the logic of input transistors $Q_1$ and $Q_2$. If an input of less than 0.8 v is encountered, both transistors are off and the display is gated to indicate a 0. For an input greater than 2.0 v, both transistors are on, and the display indicates a 1.

For an input that lies between 0.8 v and 2.0 v, $Q_1$ is on while $Q_2$ is off, and the NAND gating causes a question mark to be indicated on the display. A high impedance at the input registers a similar output.

The logic thresholds, being set by the voltage drops of the transistors, can be tailored to suit other needs. Transistors $Q_3$-$Q_5$, which determine the logic-1 threshold, may be replaced with an appropriate number of diodes, and diodes may even be added in the base circuit of $Q_1$ to raise the logic-0 threshold.

Resistors $R_1$ and $R_2$ limit the input current, and $R_3$-$R_7$ limit the currents to the display, which may be any low-power seven-segment light-emitting-diode unit. □



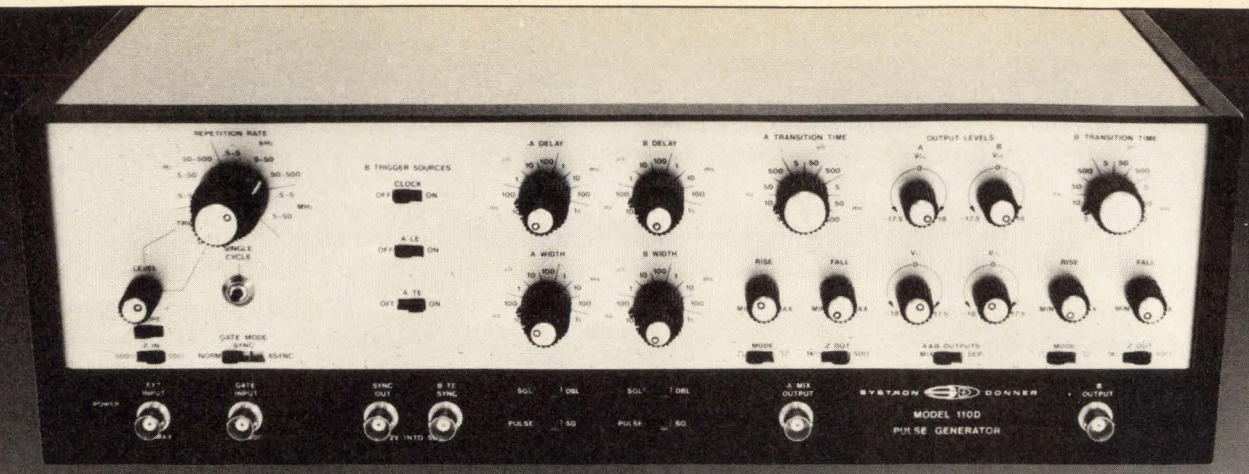

**Unquestionably logical.** TTL tester displays 0 for low level, 1 for high level, and ? for an open circuit or illogical level, as shown in table. Thresholds are set by transistors in the input circuit and may be changed to suit particular needs.

# Chart aids selection of optimum LED driver

by William A. Palm
*Minnetonka, Minn.*

There is no single best way to drive a light-emitting diode from a transistor-transistor-logic output. Fanouts, polarities, and circuit loading must all be considered in choosing a drive configuration. The table lists eight different arrangements along with their respective characteristics and tradeoffs.

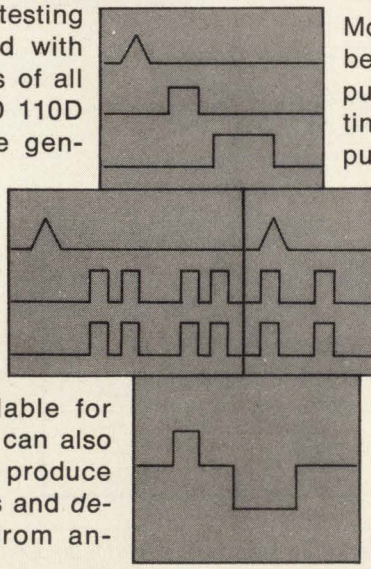
In methods 1, 2, and 3, the TTL outputs drive the LEDs directly and because of fanout limitations cannot drive




## S-D's new dual channel ±18v pulse generator

# THE LOGICAL CHOICE

Attention all of you working with 2 and 4-phase logic systems, bipolar logic, radar testing and simulation, and with complex waveforms of all types: the new S-D 110D dual-channel pulse generator is for you.



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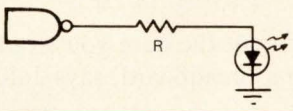
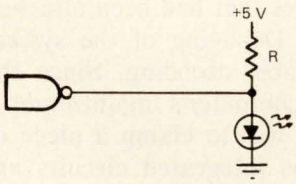
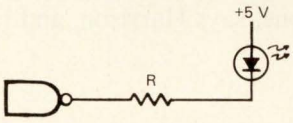
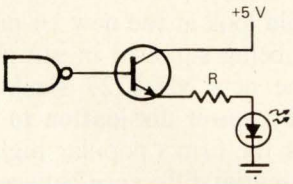
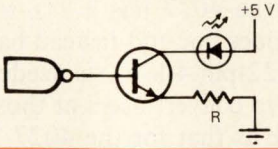
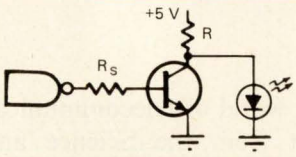
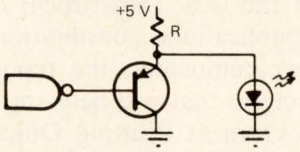
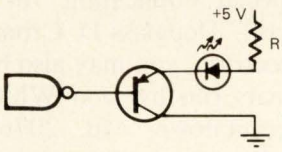
SYSTRON DONNER

any other inputs. The remaining five arrangements employ drive transistors to avoid loading the outputs. When both pnp and npn transistors are readily available, method 4 may be used to light the LED with a logic 1 output, while method 8 indicates a logic 0. If it is desirable to have a single driving scheme, then inverters can be added to indicate both logic levels.

Need for low power consumption rules out methods 6 and 7, since they consume more power with the LED off than on. The on current in method 1 depends greatly on the chip's internal pull-up resistor. Logic levels other than TTL must be handled differently and are not considered in the table. □

Engineer's notebook is a regular feature in *Electronics*. We invite readers to submit original design shortcuts, calculation aids, measurement and test techniques, and other ideas for saving engineering time or cost. We'll pay $50 for each item published.

**EIGHT METHODS OF DRIVING LEDs FROM TTL OUTPUTS**

| | Method | Output that turns on LED | Circuit loading | | Comments |
|---|---|---|---|---|---|
| | | | Output high | Output low | |
| 1 |  | high | $I \approx (5 - 1.7)/R$ | negligible | • Do not use output to drive logic inputs |
| 2 |  | high | negligible | $I = 5/R$ | • Do not use output to drive logic inputs<br>• Use open-collector outputs only<br>• Consumes power when LED is off |
| 3 |  | low | negligible | $I \approx (5 - 1.7)/R$ | • Do not use output to drive logic inputs<br>• Can use open collector or active output |
| 4 |  | high | negligible | negligible | • Use active output only |
| 5 |  | high | negligible | negligible | • Use active output only |
| 6 |  | low | negligible | negligible for $R_S > 5\ k\Omega$ | • Consumes power when LED is off<br>• Use active output only |
| 7 |  | high | negligible | negligible | • Consumes power when LED is off<br>• Can use open collector or active output |
| 8 |  | low | negligible | negligible | • Can use open collector or active output |

Use R = 200 Ω OR 300 Ω

# Engineer's newsletter

**UV-erasable read-only memories to drop in price**

If you've been shying away from the ultraviolet-light-erasable programmable ROMs because they're so expensive, you can look forward to a sharp decrease in unit price. Several new suppliers are jumping into the market, and higher-density (16,384-bit) devices are coming out. The chip in big demand at present is the Intel 8,192-bit 2708, which users we've spoken to say they are **now buying for $50 to $75 in small quantities. Watch for its price to drop at least in half** between July and December and make it even more popular for prototyping microprocessor-based systems.

**Conductive foam clamps ringing on computer bus line**

Here's a fix for ringing on computer bus lines. It's not the cure you would ship with a product, but it will do a quick job on a breadboard, says John M. Harrison, Concord, N.H.

The problem was in 8-foot bus-extension cables that had been attached with no terminators to a microcomputer bus. Debuging of the system revealed that ringing was the cause of unreliable decoding. Since the system would eventually operate within the computer's mainframe, a permanent fix was not important. The solution was to **clamp a piece of conductive foam (the black type in which MOS integrated circuits are frequently supplied) around the flat cable,** using simply a large paper clamp. The spurious decoding was completely gone, says Harrison, and he could then continue to debug "real" problems.

**4-k RAM has low standby power**

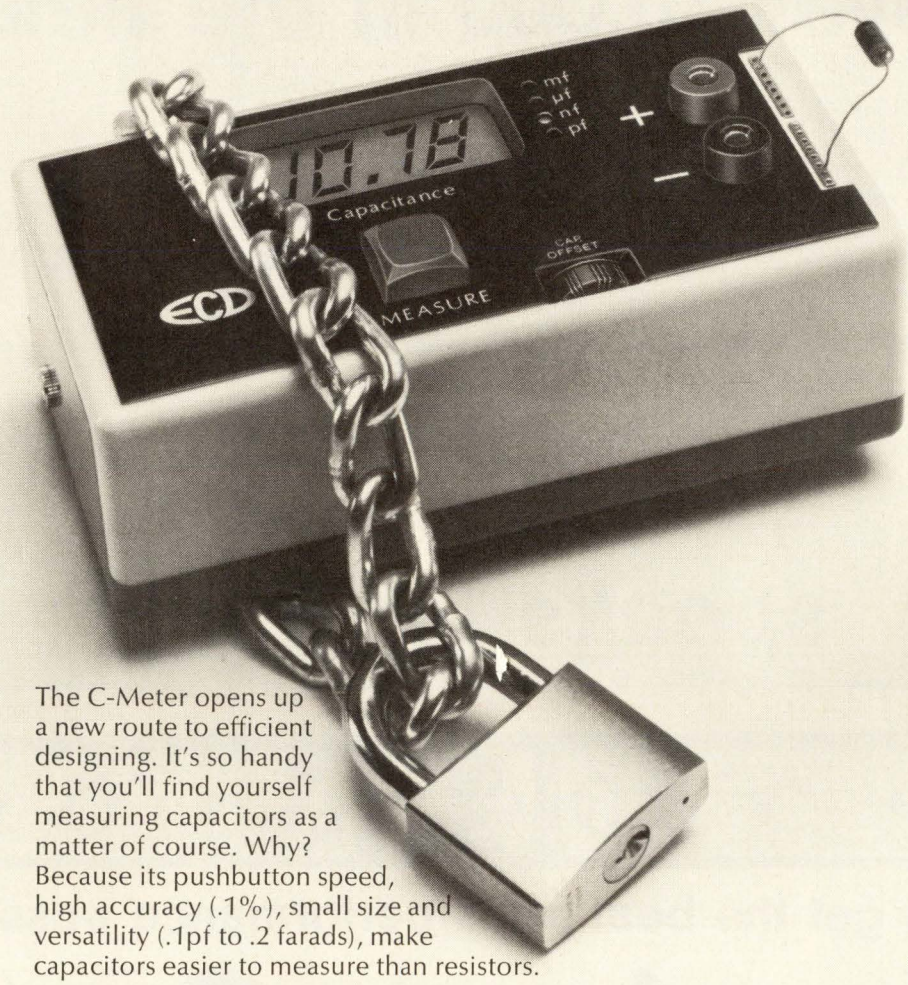
Memory-system designers who want to keep standby power as low as possible—for battery backup, for example—should look at the new 16-pin 4,096-bit dynamic random-access memory now being supplied in sample form by Mostek Corp., Carrollton, Texas. The new MK4227 **slashes standby current to 100 milliamperes and standby power dissipation to a mere 1.3 milliwatts,** compared to the 27 mw for the firm's popular high-performance 4-k dynamic RAM, the 4027. The essential difference between the two chips concerns the row-address strobe—the 4027 has a TTL-to-MOS level converter on the strobe, while the 4227 does not and instead has to use a high-level clock. Actually, early 18- and 22-pin 4-k RAMs needed the very same high-level clock, and Mostek hopes to convert users of those devices, too. Access time for the 4227 is the same as that for the 4027—150, 200, or 250 nanoseconds.

**Postscripts**

If you're looking to play a role in the exploding world of telecommunications, you'll be interested in a recent report from the Science and Technology Telecommunications Task Force of the U.S. Department of Commerce. Based on review of more than 100 publications, consultations with 17 industrial firms, and visits to 39 other companies, the report attempts to identify Government and industry actions that will help apply new technologies. Send $3.25 to the U. S. Government Printing Office, Washington, D.C. 20420, and ask for OT Special Publication 76-9, "Lowering Barriers to Telecommunications Growth," Douglass D. Crombie, editor. . . . With the increasingly crowded spectrum, you may also be interested in a new series of RFI-EMI-EMC seminars run by Don White Consultants Inc., 14800 Springfield Road, Germantown, Md. 20767 (301) 948-0028. There's a catalog that includes a complete course description and calendar.

**Stephen E. Scrupski**

# Borrow my coffee cup... but never my C-Meter.




The C-Meter opens up a new route to efficient designing. It's so handy that you'll find yourself measuring capacitors as a matter of course. Why? Because its pushbutton speed, high accuracy (.1%), small size and versatility (.1pf to .2 farads), make capacitors easier to measure than resistors.

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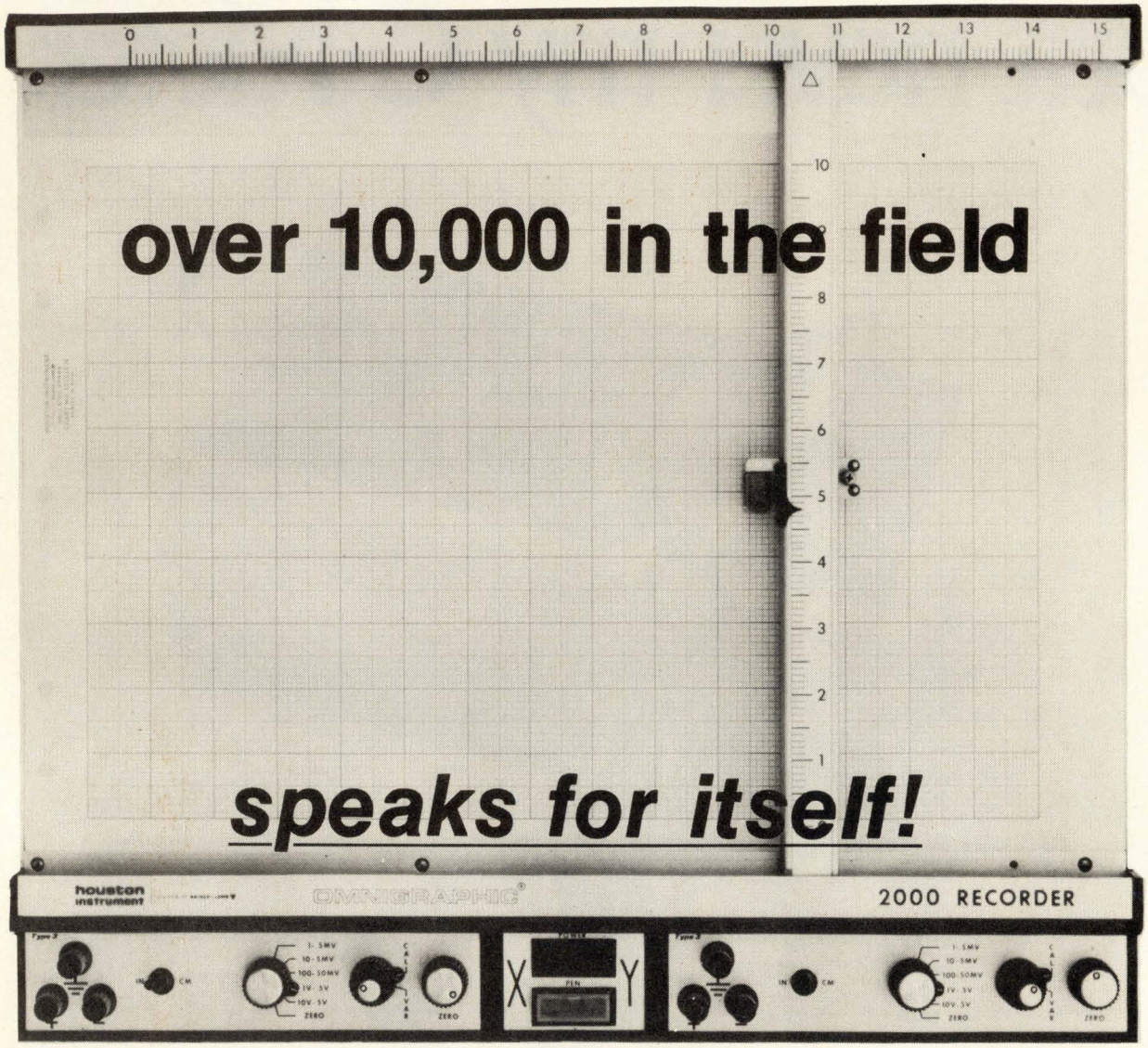
Circle 121 on reader service card

# Omnigraphic® Series 2000 X-Y recorders

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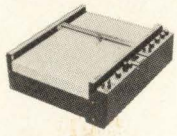
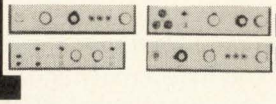
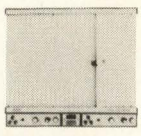
**1**  **+1**  **= 3** 

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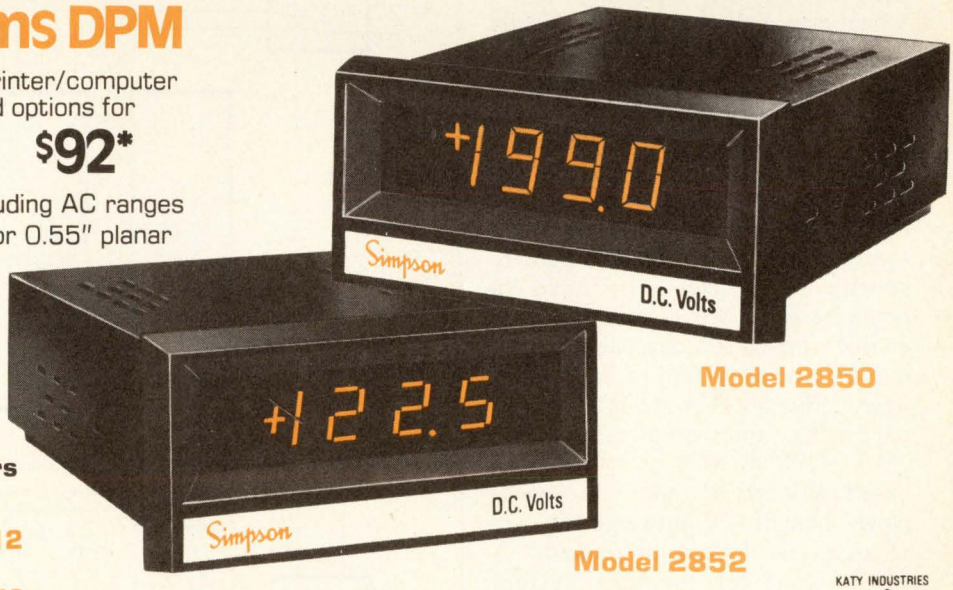


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# 4-k static RAM uses dynamic features

Mostek device boasts 200-ns maximum access time, 340-ns cycle time with low power requirements and no external refresh circuitry

*by Larry Armstrong, Midwest bureau manager*

**Of the many** 4,096-bit static random-access memories to be introduced in the coming months, Mostek's promises to be a little different. By borrowing features of dynamic RAMs, the Carrollton, Texas, MOS house has reduced the chip size and eliminated the high power requirements of fully static memories without requiring the external refresh circuitry and multiple power supplies of dynamics.

The MK4104, organized as 4,096 by 1 bit, is the first of the firm's 4-k statics to reach the market. Mostek says it has a better speed-power product than known competitors. Maximum access time is 200 nanoseconds, and read or write cycle time is 340 ns. Power consumption depends on the frequency: at 4 megahertz, active power is typically 80 milliwatts and standby power is 8 mW, but at 1 MHz, power dissipation drops to 35 mW.

The 4104's memory array is static, but it is controlled by a clocked interface that allows the use of a dynamic differential sense amplifier that reduces cell size and improves speed. "The user will have to generate a negative-going edge to enable the chip," concedes Derrell Coker, memory-applications manager. "But most systems that this part will go into will already have a clock, such as any microprocessor-based system. If not, the speed-power benefit will outweigh the cost of an external clock by tenfold." A 16,384-by-8-bit memory system made of 4104s, for example, would dissipate less than 3 watts, he points out. Power-supply and cooling costs are $1 to $1.50 per watt, he says.

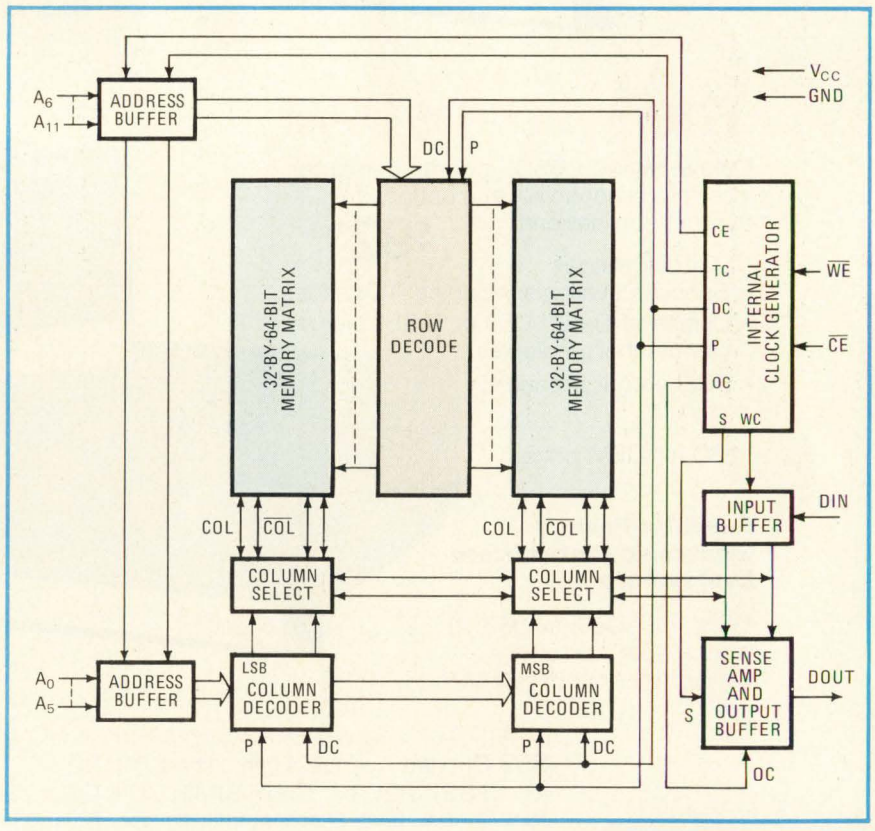
Besides the already low "automatic" standby power dissipation—effective whenever the chip is deselected—the 4104 has another low-power mode. Lowering the part's single 5-volt supply to 2 V cuts power drain to 0.8 mW.

Mostek has kept the chip size to about 24,000 square mils, small for a static RAM. Although the device is based on a six-element cell, active transistor pull-ups have been replaced by a pair of passive polysilicon resistors. That change pares cell size to 2.75 mil$^2$, compared with the conventional 5-mil$^2$ static-memory cell. Output data is valid as long as the chip is enabled, and if its early-write mode is used for all write operations, the data-input pin can be tied to the pc board's data-output pin without additional circuitry.

Mostek plans to start shipping samples in May of the 4,096-by-1-bit MK4451 with common I/O capability. Samples of the 1,024-by-4-bit MK4404 will be available next month.

The MK4104P-3 will go into production this month in the industry standard 18-pin ceramic package. The price in quantities of 100 or more will be $18.75 each.

Mostek Corp., 1215 W. Crosby Road, Carrollton, Texas 75006 [338]



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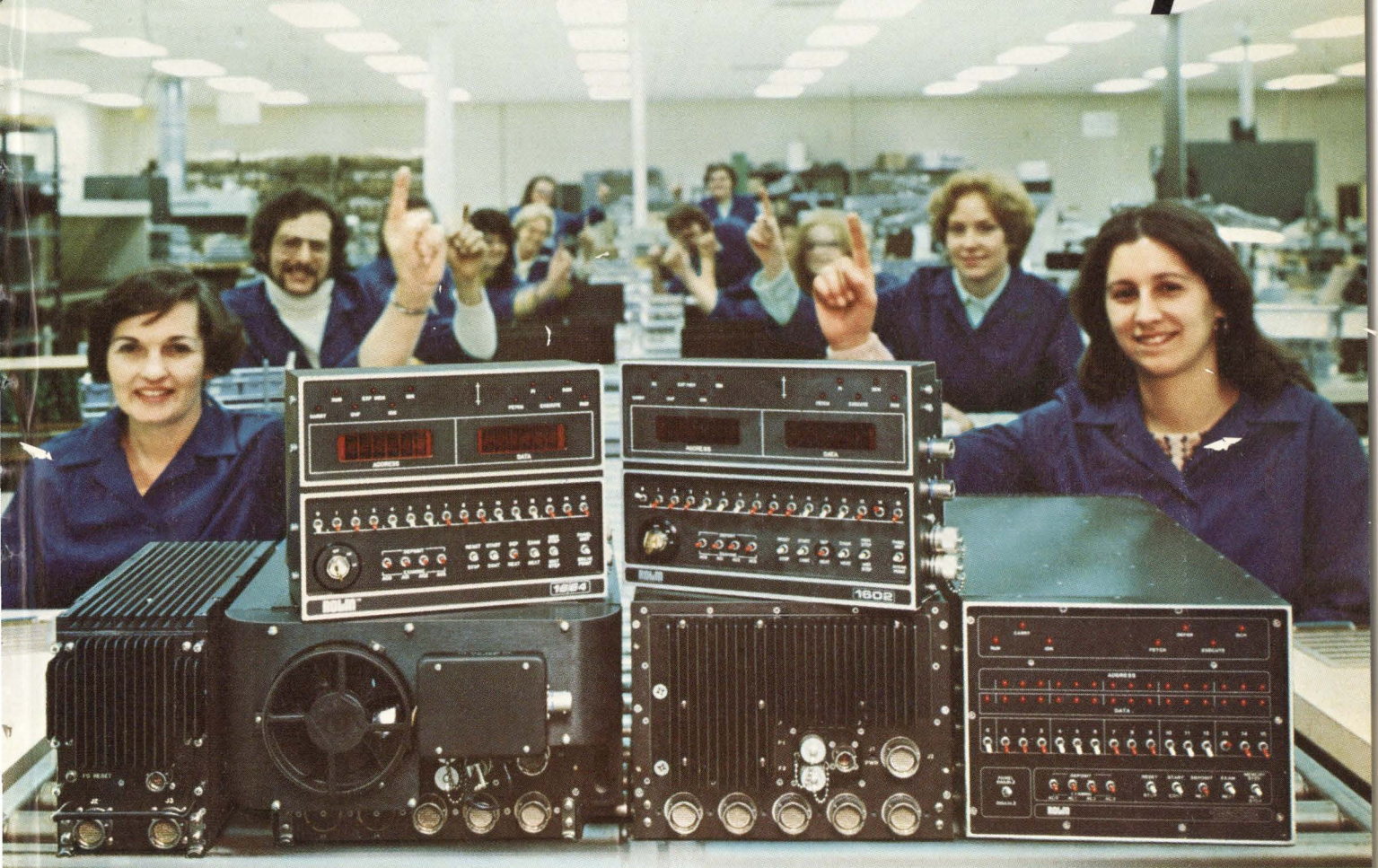

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Circle 125 on reader service card

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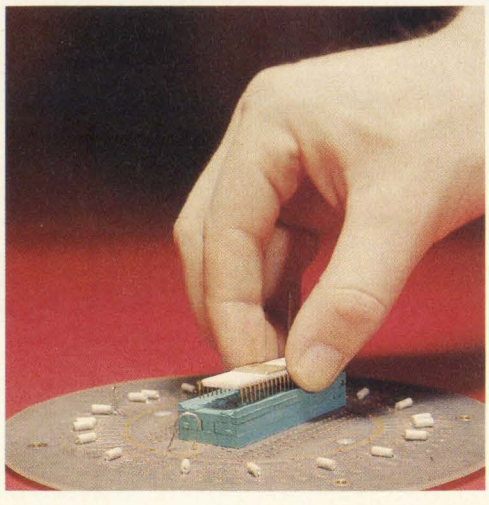

At Tektronix, new product designers team up with specialists in IC technology and testing known as Component Evaluation Engineers. Using their combined expertise, the team compiles information on the devices that seem to fit the application and then narrow the list to a few good candidates. Now, Component Evaluation Engineers begin their most important function; thoroughly evaluating the performance and reliability of each candidate device.

The evaluation process begins by investigating those device parameters and functions most critical to the intended application. This sometimes leads to a complete device characterization, a process that requires exhaustive testing.

When an IC is characterized, every measurable parameter and function is tested, actual limits of performance are determined, and then device behaviour is documented for all the various sets of input conditions in all their combinations and permutations. That's a lot of testing and it can quickly build mountains of test data. A system that performs accurate and reliable tests is not enough. The Component Evaluation Engineer must also have the tools to reduce the data mass into a usable form. For device characterization, the engineer needs a combination general purpose IC test system and a data processing system—a totally integrated package that both acquires and processes test and measurement data.

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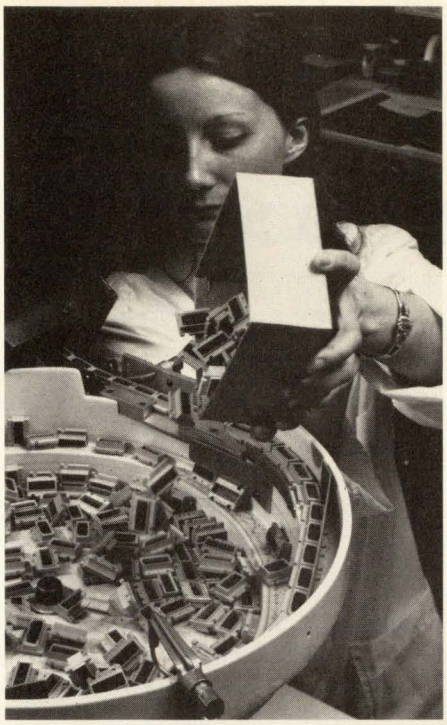

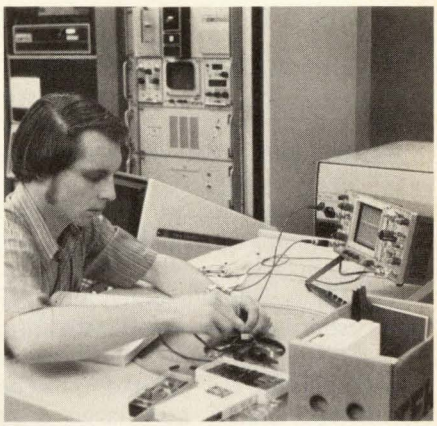

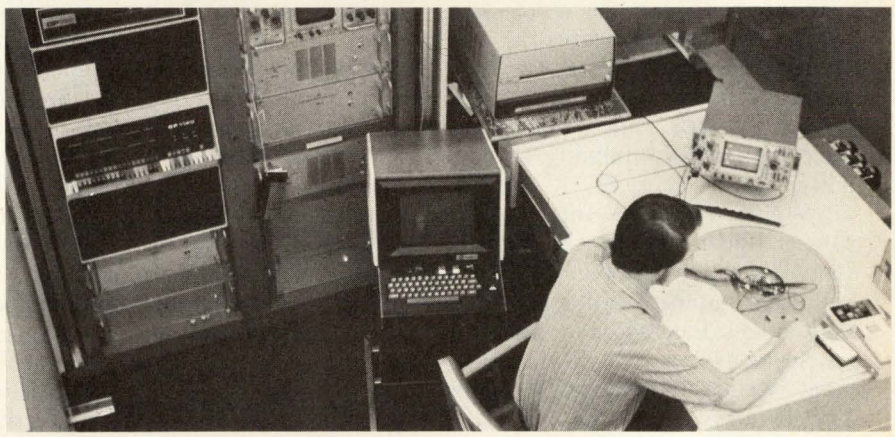

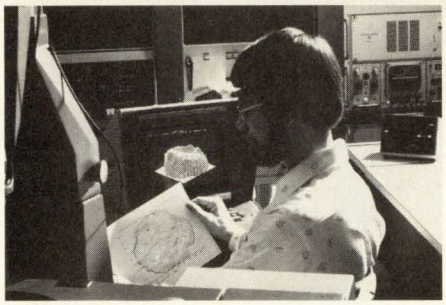

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# Recorders get facelift, C-MOS logic

Leeds & Northrup's redesigned Speedomax machines also replace inkpad-and-wheel printers with thermal type and feature digital readouts

*by Raymond P. Capece, Industrial Electronics Editor*

**An old favorite** in the industrial recorder market, Leeds & Northrup's Speedomax line is getting a facelift as well as updated multipoint recorder units. A new thermal printing system eliminates the mess and maintenance of inkpad-and-wheel printers, and a new large digital readout that can be read from several feet away indicates the point number being logged. But the big change is inside: utilization of complementary-MOS logic circuits with their high noise immunity and low power drain.

"We've replaced the complex cam-and-gear system required for synchronization between the pens and point numbers with C-MOS logic that makes the recorder inherently synchronous," explains Ralph Hartman, product applications specialist. The logic system is also more flexibile. A programming board behind the front panel lets the user select the frequency of the printing of the point number next to its plot or permits him to skip channels with no pause required for the skipped point. Other switches log on alarm only, permit manual advance of point-number cycling, select holding on a single point, and give indication without printing.

The new machines' names—the 165 and the 250—indicate their chart width in millimeters. The capacities of the new series are 25% greater than earlier models and most other recorders. Up to 30 points can be accommodated on the Speedomax 250, as opposed to 24, and up to 15 points on the Speedomax 165, rather than 12 on other recorders with comparable chart widths. This higher density is made possible by the more flexible point-number identification, which can be set on the programming board anywhere from once every dot to once every 99 dots.

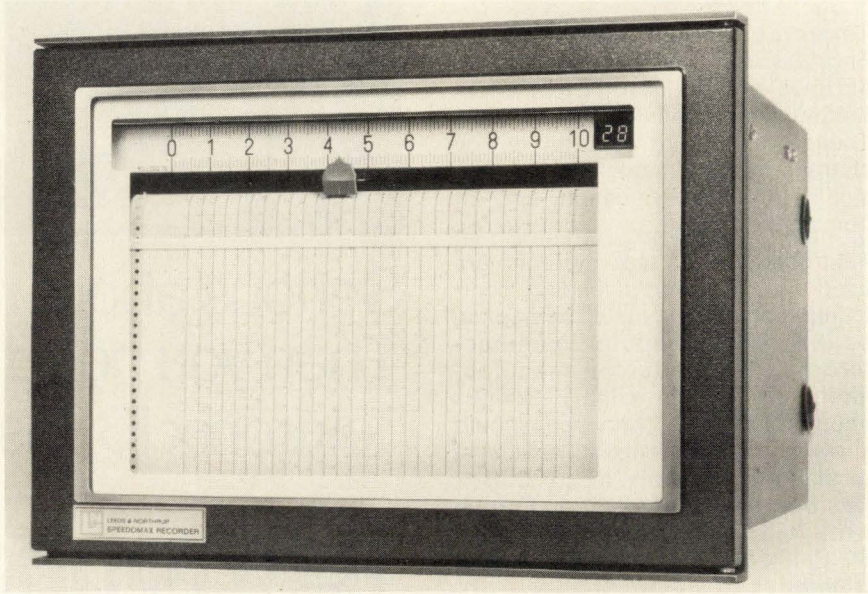
A wide range of options is available on the digitally controlled recorders. The 250 is available with as many as five chart-drive speeds, from 1 to 60 inches per hour, while the 165 is available with as many as four speeds. Individual synchronous motors are supplied for each speed.

Another user option is a time-marking feature that prints the correct hourly time on the left-hand margin of the chart paper independent of chart speed. In addition, a fail-safe option prints points in the right-hand margin. "Our customers find this feature most desirable," Hartman says. "If a thermocouple is open-circuited, the point is clearly printed offscale, rather than somewhere on the chart. The user then knows immediately that a sensor has failed."

The recorders, designed for tough environments, are housed in gasketed, cast-aluminum enclosures and feature such refinements as an easily removable door panel and an overhang lip to keep dust from falling in when the door is opened. They operate from 120, 220, or 240 volts ac and, through interchangeable circuit-board cards, accept a wide range of inputs. Delivery time is eight weeks.

The Speedomax ink recorders will continue in production, but the firm thinks the price differential of a few hundred dollars for the new models—pegging the low end at just under $1,000—will seem insignificant in view of the added flexibility of the 165 and the 250.

Leeds & Northrup Co., Sumneytown Pike, North Wales, Pa. 19454. Phone (215) 643-2000 [339]



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| Covers frequency range of 50 to 520 MHz, using a scaling ratio of 4. Sensitivity is 15 mV rms (AGC). Maximum allowable input is 5 V rms (fuse protected). VSWR less than 2:1 into 50 ohms for levels less than 1 V rms. |
| 1000 MHz Prescaler |
| Covers 50 to 1000 MHz using a scaling ratio of 8. Sensitivity is 15 mV rms, and maximum allowable input is 5 V rms (fuse protected). VSWR less than 2.5:1 50 ohms for levels less than 1 V rms. |
| 1250 MHz Prescaler |
| Covers 50 to 1250 MHz using a scaling ratio of 8. Sensitivity is 20 mV to 1000 MHz, increasing to 40 mV rms at 1250 MHz. Maximum input 5 V rms (fuse protected), and VSWR less than 2.5:1 for levels less than 1 V rms. |

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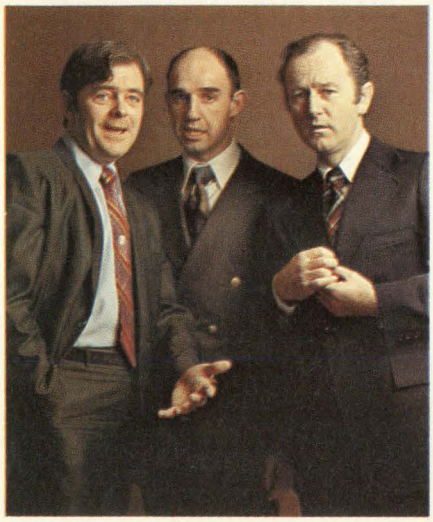

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But you can see. Take a look at the unit pictured in this ad—you're going to see a lot more on the front panel.

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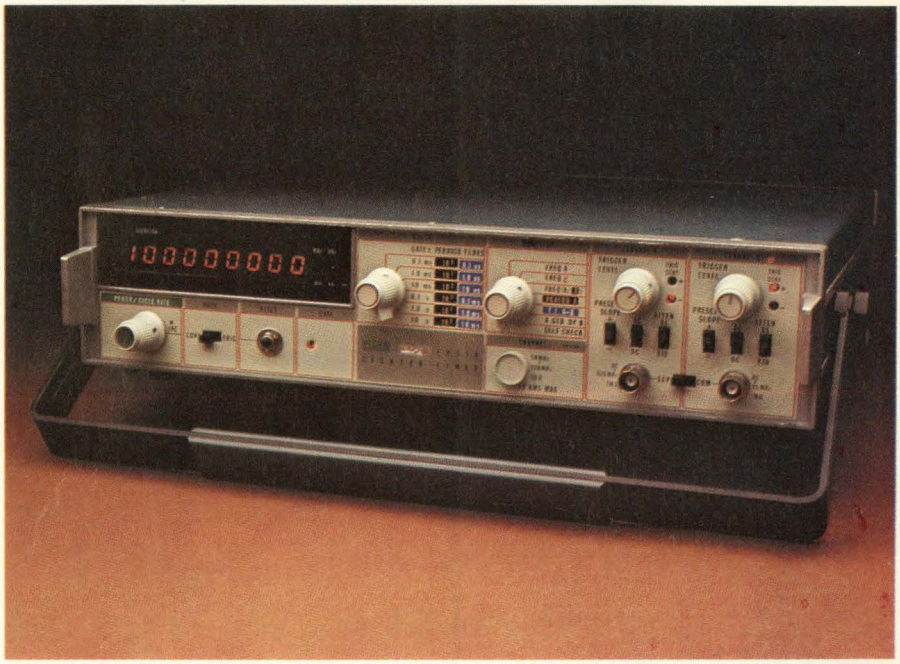

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# Relays overcome big weaknesses

Designed for ac operation devices are immune to noise, don't trigger on false pulses

Solid-state relays for ac applications—even zero-crossing devices—still have two weak points. An inductive load, such as a motor or transformer, can fool the zero-crossing type into generating radio-frequency interference when it turns on, and line transients can falsely trigger any solid-state relay made to date. Theta-J Relays Inc. gets around both weaknesses with its TA1201Q line of quiet-switching units. They will initially be rated at 140 volts at 0.75 ampere, go to 2A very soon, and eventually reach the 10-A range.

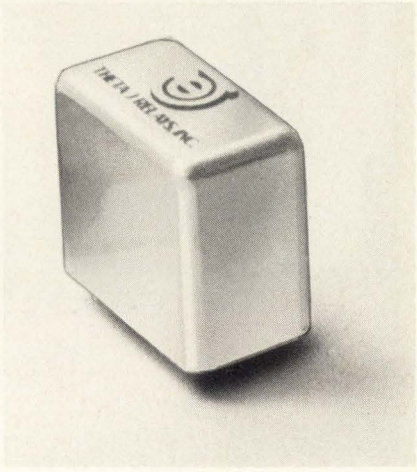
Edward T. Rodriguez, chairman and technical director, maintains that the relays are totally immune to noise on the output and will not trigger on false pulses. "Using them is just like using a rheostat or potentiometer at turn-on," he says. "You get smooth switching with absolutely no noise."

Rodriguez says the biggest difference between the TA1201Q line and conventional zero-crossing relays is that Theta-J combines its photocell optical-coupling approach [*Electronics*, Aug. 5, 1976, p. 120) with a tailored power transistor as the output switching device. "The power transistor has no snap action," he says, so that it cannot be falsely triggered by the current from an inductive load—a common problem, he says, even in zero-crossing relays that use triacs designed to fire at the sine wave's zero-crossing point in voltage. The triac is also what makes conventional solid-state ac relays susceptible to line transients, according to Rodriguez.

Because the devices are immune to false turn-on by any rapidly rising load voltages, they can safely switch load voltages at frequencies well above 1 kilohertz, compared with about 400 hertz for today's best devices implemented with triacs, he says. The combination of photocell and power transistor also assures switching in greater than 1 millisecond instead of about 1 microsecond for conventional units. This is further assurance that the relay can neither create nor respond to transients.

The TA1201Q series is expected to be used in logic-oriented applications requiring quiet switching, including telephone switch-gear to accommodate the ac ringing signal, in computer peripherals and point-of-sale terminals. The relays are packaged in a 16-pin power dual in-line package. Price for the 0.75-A device is $9 each in quantities of 1,000, and delivery takes six to eight weeks.

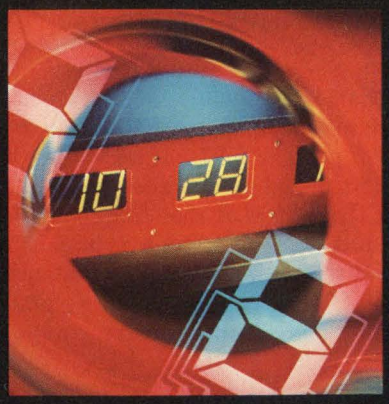
Theta-J Relays Inc., One DeAngely Drive, Bedford, Mass. 01730. Phone (617) 275-2575 [341]

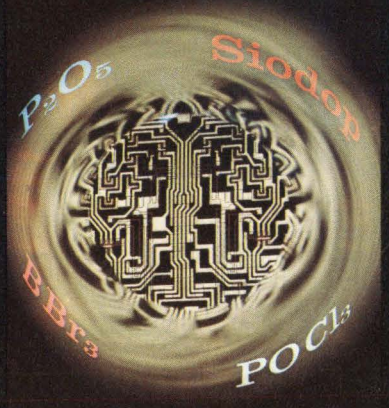


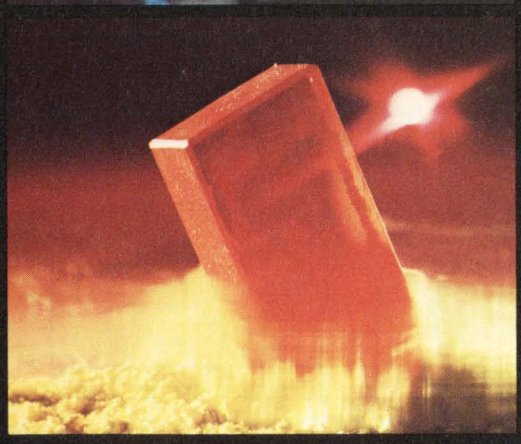
## Tiny trimmer capacitor withstands 3,000 g of shock

An ultraminiature trimmer capacitor with a Teflon fused-film dielectric can be used in a variety of applications to frequencies beyond 5 gigahertz. The sliding portion of the capacitor is so light compared with the force required to move it that the unit can withstand more than 3,000 g of shock.

Two versions of the capacitor are offered. The CP2 covers the range from less than 0.1 picofarad to more





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Circle 131 on reader service card

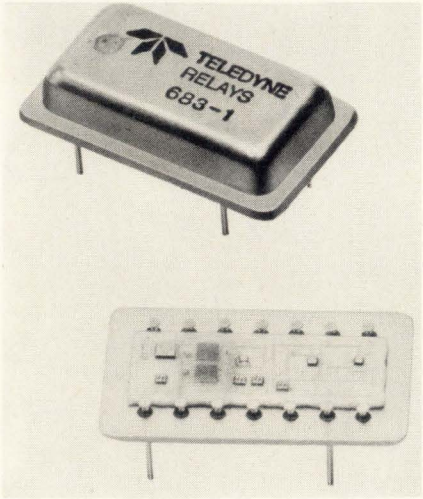
than 2.5 pF, while the corresponding numbers for the CP10 are 0.5 and 9.0 pF. The CP2 has a Q of 1,000 at 250 megahertz, while the Q of the CP10 is 500 at that frequency. Both units have a voltage rating of 150 volts dc, an insulation resistance of 50,000 megohms at 10 v, and an operating temperature range of −55°C to 125°C.

The capacitors are available on pre-aligned high-temperature tape, which can be used to hold them in place during soldering. They are also provided in assembled form, aligned and soldered to alumina substrates. These latter units can be handled as conventional chip devices, but the substrate adds approximately 0.3 pF to the minimum capacitance.

Voltronics Corp., West St., East Hanover, N.J. 07936 [343]

### Hybrid solid-state relay meets MIL-R-28750

Constructed like a hybrid integrated circuit and hermetically sealed in a metal dual in-line package, the




model 683-1 dc solid-state relay meets the requirements of MIL-R-28750. It operates over the range from −55°C to 115°C, generates no electromagnetic interference, and turns on and off very quickly—in at most 50 microseconds and 150 μs, respectively.

The relay employs a proprietary

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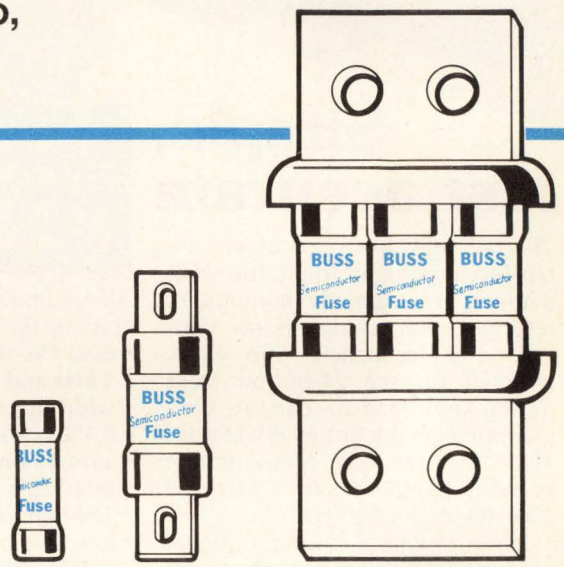


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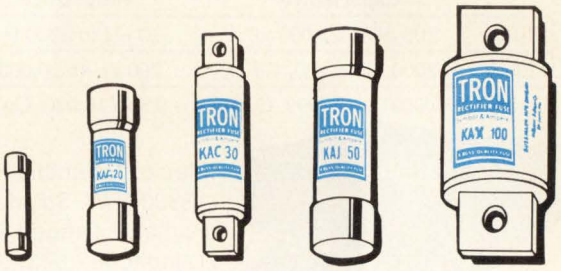


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## New products

constant-current microcircuit for a TTL- and HiNIL-compatible input control range of 3 to 15 v dc. Positive-feedback circuitry gives it a snap action that prevents damage from slowly ramped inputs. Priced at $16.50 each in thousands, the relays have a delivery time of four to six weeks.

Teledyne Relays, 3155 W. El Segundo Blvd., Hawthorne, Calif. 90250. Phone (213) 973-4545 [344]

### Long-lived, highly linear pots sell for only $2.95

A line of semiprecision conductive-plastic potentiometers offers linearity within 1%, a rotational life of 5 million cycles, and a low-volume price of $2.95. In lots of 10,000 pieces, the price drops to $2.50 each.

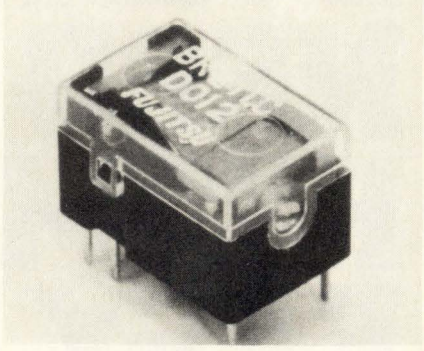
The single-turn Econopot MKIII has precious-metal contacts, 303 stainless-steel shafts, and thermoset plastic terminal supports. In addition, of course, they provide the infinite resolution and the low noise characteristic of conductive plastic.

Delivery time for the MKIII is from stock to two weeks, depending upon the resistance required.

New England Instrument Co., Kendall Lane, Natick, Mass. 01760. Phone James Dyne at (617) 873-9711 [346]

### 3-ampere relay weighs less than 1/6 ounce

Although it measures only 0.4 inch high and weighs less than ⅙ ounce, a



# Guildline Introduces the only 14 Million Count DVM on the Market Today


Guildline's radical 7-1/2 digit precision digital voltmeter, Model 9577 features standards laboratory accuracy and stability. The 9577 is equally at home on the work bench or in a system application via programmable BCD or IEEE Standard 488.

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## Guildline Instruments, Inc.

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## New products

new micro relay is available with contact ratings as high as 3 amperes dc and 24 volts dc. Intended for printed-circuit-board applications requiring high-density mounting, the single-pole double-throw relays have DIP terminals spaced on 0.1-in. centers and come with four contact variations. Their electrical life is more than half a million operations. The relays sell for $1.08 each in thousands.

Impact Electrical Products Inc., 7 Westchester Plaza, Elmsford, N.Y. 10523. Phone Harry Hopper at (914) 592-2880 [347]

### 10-ounce lithium battery puts out 1 A for 30 hours

A lithium battery that weighs 10 ounces and is 5.5 inches long by 1.64 in. in diameter has a capacity of 30 ampere-hours at a drain of 1 ampere. With a nominal operating voltage of 2.8 v, the model 660-5A Eternacell has an energy density of 134 watt-hours per pound. Its shelf life is greater than five years, and it can operate at −65°F. It is available with a positive button terminal or positive and negative solder tabs. Pricing on the 660-5A is less than $10 each in large quantities. Delivery is from stock to two weeks.

Power Conversion Inc., 70 MacQuesten Parkway South, Mt. Vernon, N.Y. 10550. Phone Stewart Chodosh at (914) 699-7333 [345]

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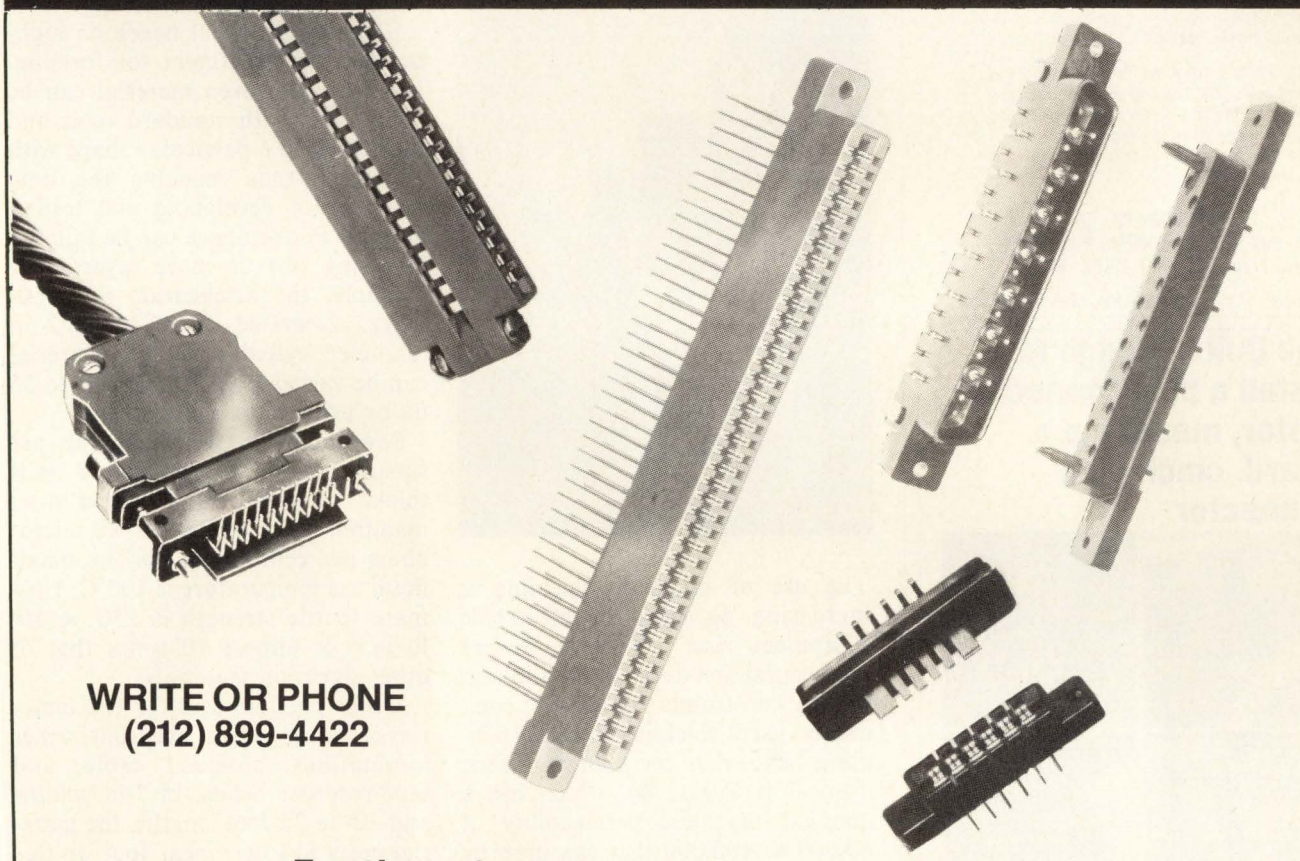

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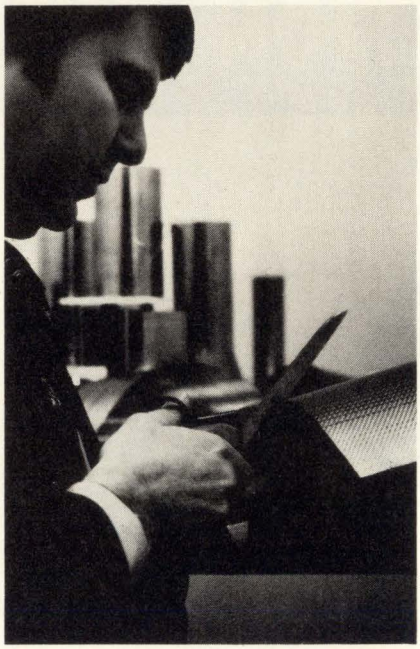
## New products

Materials

# Magnetic shield can be shaped

Woven metal glass retains its magnetic permeability after rolling and stamping



The use of magnetic shielding is increasing as sales of electronic equipment rise, the trend toward miniaturization accelerates, and regulatory constraints tighten. But commonly used shielding creates handling headaches for manufacturers. Typical is Permalloy, which has a nominal magnetic permeability of 60,000 to 100,000 that can drop by as much as 50% when the material is wrapped in a cylindrical form. And annealing the material to restore its permeability is an expensive and time-consuming step.

Now Allied Chemical has come along with Metshield, made of Metglas 2826, a soft-magnetic metal glass that boasts excellent stability during the handling and shaping operations. The material, which has a nominal composition of $Fe_{40}Ni_{40}P_{14}B_6$, permits a manufacturer to use simple fabrication methods to make its own shields.

The Metglas alloy is formed into 2-by-70-mil ribbons and crosswoven into 7-inch widths of a fabric called Metshield. It is then epoxy-coated, and the resulting fabric can be formed into complex shapes without altering performance.

Its nominal permeability is at least 60,000. In a laboratory test, the permeability of an unshaped strip of Metshield was measured; then it was rolled into a cylinder from which small strands were cut. The strands proved to have the same permeability as the original fabric.

The new material needs no high-temperature treatment for forming. Instead, the woven material can be cut to size with standard tools and fabricated to a particular shape with adhesives, thus reducing the time and cost of developing and testing designs. Performance can be tailored by using one or more layers. For example, the attenuation of a 60-hertz, 2-oersted field on a 2-in. diameter cylinder of this material can be varied from 20 decibels to 35 dB by using one to four wraps.

Metshield weighs 1.2 pounds per square yard and is about 8 mils thick. It can be wrapped on a ¼-in. mandrel. Its resistivity is 180 microohms per centimeter, and its maximum use temperature is 100°C. Ultimate tensile strength is $250 \times 10^3$ lb/in.$^2$, or almost 10 times that of other shielding materials.

Other possible uses for the material or its derivatives are transformer laminations, shielded cable, and tape-recorder heads. In 7-in. widths and 10- to 25-foot lengths, the material costs $14 per linear foot. In this quantity, delivery is off the shelf.

Allied Chemical Metglas Products, 7 Vreeland Road, Florham Park, N.J. 07932. (201) 455-4031 [371]

## Blue epoxy coating cures quickly under UV radiation

A blue epoxy coating material, which can be used as a solder mask for hard printed-circuit boards or as

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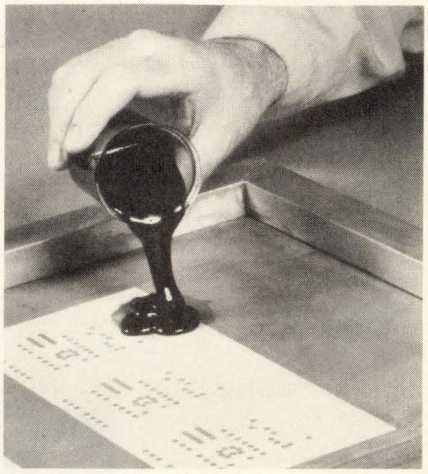
## New products

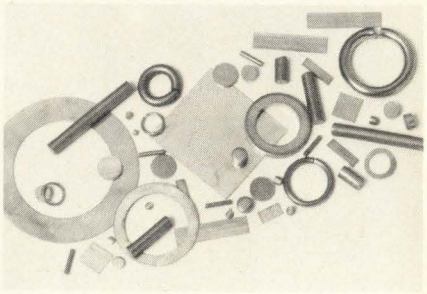


a protective coating for flexible circuits, cures in seconds when exposed to ultraviolet radiation. Because it substitutes a short exposure to ultraviolet radiation for a prolonged heat treatment in an oven, the material is said to use as little as 10% of the energy required by conventional inks. It also eliminates racking and unracking steps, further reducing processing costs. Called ultraviolet cure epoxy 1301, the one-part material has a shelf life of one year.

3M Co., Dept. EP6-32, P.O. Box 33600, St. Paul, Minn. 55133 [373]

### Solder preforms come with or without multicore flux

Solder preforms in virtually any size or shape are available in any soft solder alloy with or without multiple flux cores. The flux cores may be of type R (nonactivated), RMA (mildly activated), or RA (activated) rosin. Among the standard shapes are rings, washers, disks, rectangles, squares, pellets, and strips of tape



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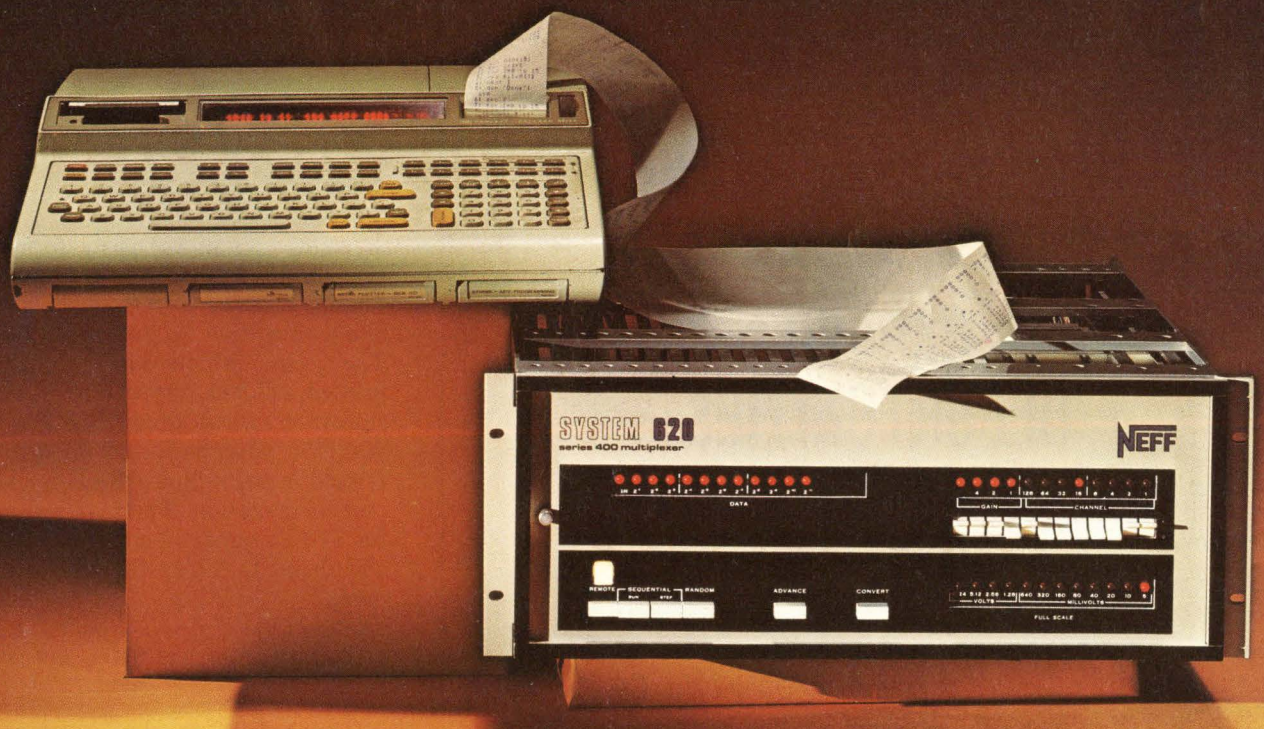



Circle 141 on reader service card

## New products

either cut to precise lengths or wound on reels as continuous ribbons.

Multicore Solders, Westbury, N.Y. 11590 [374]

### Rubber pyramid arrays absorb microwaves

A flexible microwave absorber molded as an array of pyramids is useful at frequencies of 2.4 gigahertz and higher. Available in silicone rubber (Eccosorb RMP-S-75) or vinyl rubber (Eccosorb RMP-V-75), the absorber has a nominal reflectivity of −17 to −20 decibels. The silicone version, which is reinforced with fabric, is recommended for high-temperature, high-power, and airborne applications. The vinyl product, which is the more rugged, is useful for outdoor applications such as on ship masts and decks. The material can be bent easily and may be readily bonded in place. It can be cut with scissors or knife.

Sold as squares measuring 1 foot on a side, the absorbers are priced, in quantities of 51 to 100 square feet, at $46.90 per square foot for the silicone material and $33.10/ft$^2$ for the vinyl. Delivery is from stock.

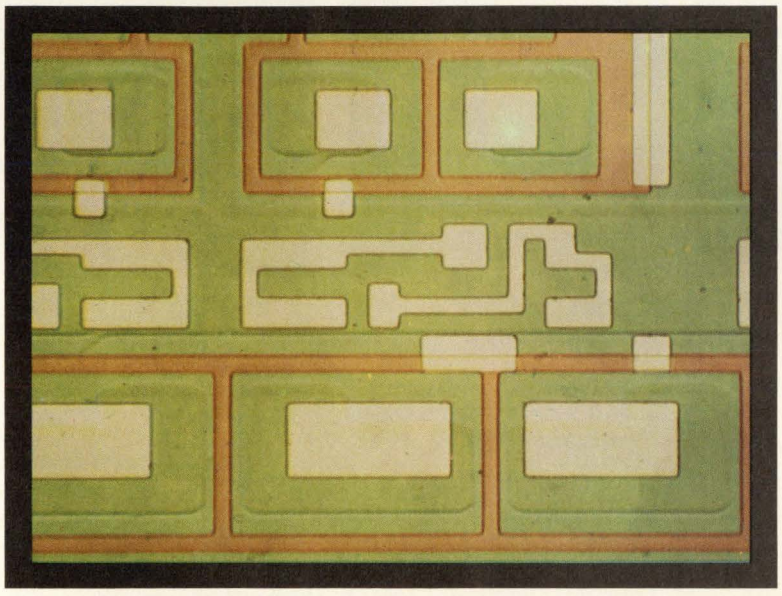
Emerson & Cuming Inc., Canton, Mass. 02021 [376]

### Thick-film nickel paste resists solder leaching

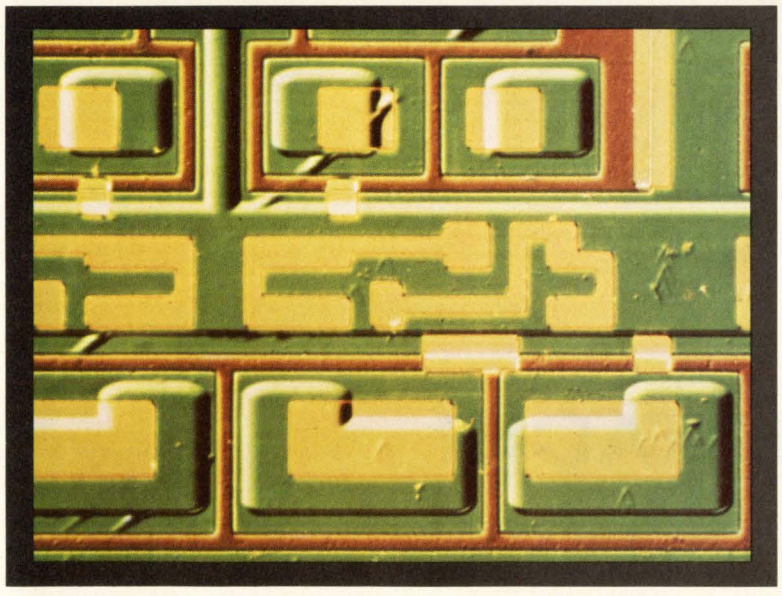
A conductive nickel paste formulation for thick-film hybrid circuits is readily soldered with tin-lead solders and is resistant to solder leaching. The paste, which can be screen-printed, adheres very well to alumina substrates when fired at 800°C to 900°C in nitrogen for 15 minutes. It is used in thick-film hybrids for low-cost metalization. The material sells for $10 an ounce in small quantities and drops to $7/oz for 100 oz and more.

Transene Co. Inc., Route 1, Rowley, Mass. 01969. Phone (617) 948-2501 or (617) 948-2811 [377]

# If this is all you're seeing,



# this is what you're missing



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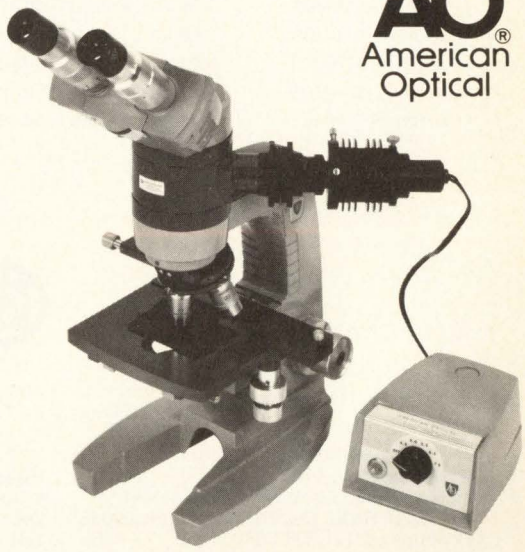

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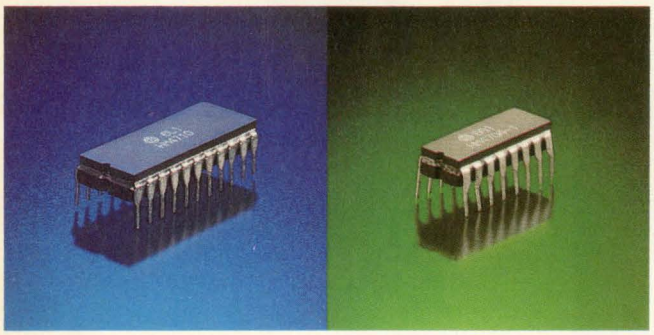


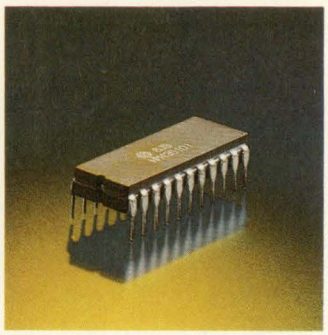
**HM4710**

High speed 22pin 4K Dynamic RAM
Access Time
ECL Output 100ns max HM4710
TTL Output 130ns max HM4711-1

**HM4704-1**

High Speed 16pin 4K Dynamic RAM
Access Time
TTL Output 200ns max HM4704-1

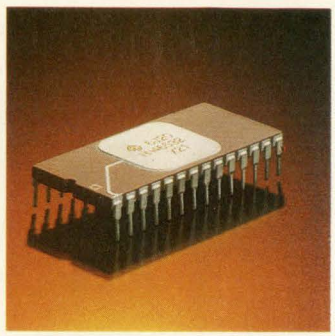
1K STATIC (C MOS)



**HM435101V**

Wide supply voltage margin
(Vcc=5V±10%)
All input and output are
TTL compatible
Access Time
650ns max HM435101V

MOS ROM



**HN46532**

32K bits MOS ROM (4kW x 8b)
Access Time
650ns HN46532

**DYNAMIC RAMs**

| Type | Process | Organization (word x bit) | Access Time (max) | Package | Replacement |
|---|---|---|---|---|---|
| HM4704-1 | NMOS | 4096 x 1 | 200ns | 16DIP | Mostek MK 4027 |
| HM4704-2 | NMOS | 4096 x 1 | 250ns | 16DIP | |
| HM4710 | NMOS | 4096 x 1 | 100ns | 22DIP | |
| HM4711-1 | NMOS | 4096 x 1 | 130ns | 22DIP | |
| HM4711-2 | NMOS | 4096 x 1 | 150ns | 22DIP | |
| HM4711-3 | NMOS | 4096 x 1 | 200ns | 22DIP | Intel 2107B |

**MOS ROMs**

| Type | Process | Organization (word x bit) | Access Time (max) | Package | Replacement |
|---|---|---|---|---|---|
| HN35600P | PMOS/Mask | 256 x 8 | 930ns | 16DIP | Intel 4001 |
| HN35800P | PMOS/Mask | 1024 x 8 | 930ns | 28DIP | Intel 4308 |
| HN351702A | PMOS/E.P | 256 x 8 | 1000ns | 24DIP | Intel 1702A |
| HN46532 | NMOS/Mask | 4096 x 8 | 650ns | 28DIP | |
| HN46830A | NMOS/Mask | 1024 x 8 | 500ns | 24DIP | Moto MCM46830A |
| HN462708 | NMOS/E.P | 1024 x 8 | 450ns | 24DIP | Intel 2708 |

**STATIC RAMs**

| Type | Process | Organization (word x bit) | Access Time (max) | Package | Replacement |
|---|---|---|---|---|---|
| HM435101 | CMOS | 256 x 4 | 650ns | 22DIP | Intel 5101L |
| HM435101V | CMOS | 256 x 4 | 650ns | 22DIP | |
| HM435101-1 | CMOS | 256 x 4 | 450ns | 22DIP | Intel 5101L-1 |
| HM452102-3 | NMOS | 1024 x 4 | 350ns | 16DIP | Intel 2102A |
| HM452102-4 | NMOS | 1024 x 4 | 450ns | 16DIP | Intel 2102A-4 |
| HM46810A | NMOS | 128 x 8 | 450ns | 24DIP | Moto MCM6810A |

**BIPOLAR RAMs**

| Type | Family | Organization (word x bit) | Access Time (max) | Package | Replacement |
|---|---|---|---|---|---|
| HM2110 | ECL | 1024 x 1 | 35ns | 16DIP | F.C 10415A |
| HM2110-1 | ECL | 1024 x 1 | 25ns | 16DIP | |
| HM2510 | TTL | 1024 x 1 | 70ns | 16DIP | F.C 93415 |
| HM2510-1 | TTL | 1024 x 1 | 45ns | 16DIP | F.C 93415A |

**HITACHI**

**Hitachi, Ltd. Electronics Devices Group**
6-2, 2-chome, Otemachi, Chiyoda-ku, Tokyo 100
Telephone: Tokyo (270) 2111 Cable Address: "HITACHY" TOKYO
Telex: J22395, 22432, 24491, 26375

**For inquiry write to:**

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Chicago Office, Electronics Department
2700 River Road, Des Plaines, Illinois 60018
Telephone: (312) 298-0840 Telex: 72-6353

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Deutschland Telephone: 0211-353073～353077
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**Hitachi Electronic Components (U.K.) Ltd.**
Hitachi House, Station Road, Hayes,
Middlesex, UB3 4DR Telephone: (848) 8787
Telex: 936293 (HITELECTRO HYES)

Subassemblies

# A-d converters miss no codes

Military model guarantees all output codes over full −55°C to +125°C range

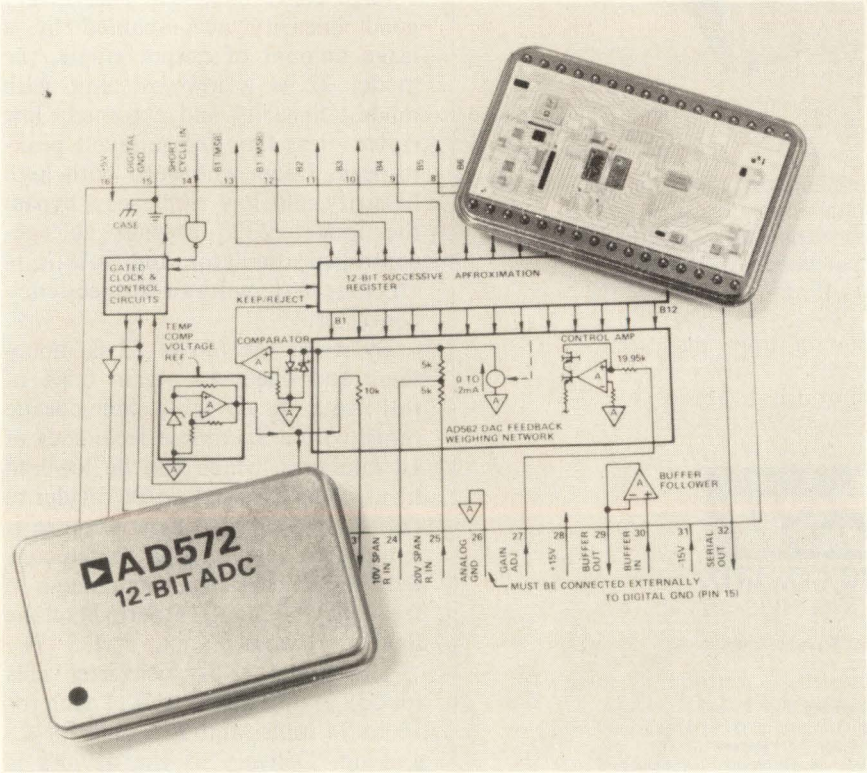
For users of analog-to-digital converters who want to be sure that the device's output corresponds precisely to its input, designers at Analog Devices have come up with the AD572 series of hybrid 12-bit successive-approximation a-d converters. The company guarantees the units will have no missing output codes over all or most of their operating temperature ranges.

Indeed, one of them, the AD572S, aimed at military and aerospace applications, is guaranteed for this and all other performance specifications over the full −55° to +125°C range. The two others are specified for −25° to +85°C, the 572B being guaranteed to have no missing codes over the entire range and the 572A being guaranteed for 0° to +70°C.

Stan Harris, director of marketing at the Microelectronics division, maintains that for their price, these a-d converters are the most accurate available in terms of performance over temperature. In quantities of 1 to 24, the 572A sells for $95 each, the 572B for $125, and the 572S for $250.

Maximum conversion time for all three devices is 25 microseconds. The other key specs, says Harris, are nonlinearity accuracy, low power consumption, and low temperature coefficients. All three have a maximum nonlinearity of 0.012% and consume 900 milliwatts. Maximum gain tempco for the 572C is ±25 ppm/°C over the full military temperature range (±15 ppm/°C from −25° to +85°C), and reference tempco is ±10 ppm/°C maximum.

Gain tempco for the 572A is ±30 ppm/°C, and ±15 ppm/°C for the 572B. Reference tempcos are ±20 ppm/°C and ±10 ppm/°C for the 572A and B, respectively. All three contain, in addition to the analog switch array and laser-trimmed resistor network, an internal buffer



amplifier, comparator, clock, and a precision reference—a zener chip plus operational amplifier rated at 10 volts, ±5 millivolts. Harris says the reference can be used for applications on a printed-circuit board external to the converter.

All three versions are in a welded, hermetically sealed 32-pin dual in-line package. Welding was chosen as the sealing method, Harris says, because with soldering solder balls or flux might get inside the package and contaminate the device. Further, the metal package shields the converter from electrostatic and radio-frequency interference, which can interfere with its accuracy and cause false or missing output codes.

Delivery is from stock to four weeks.

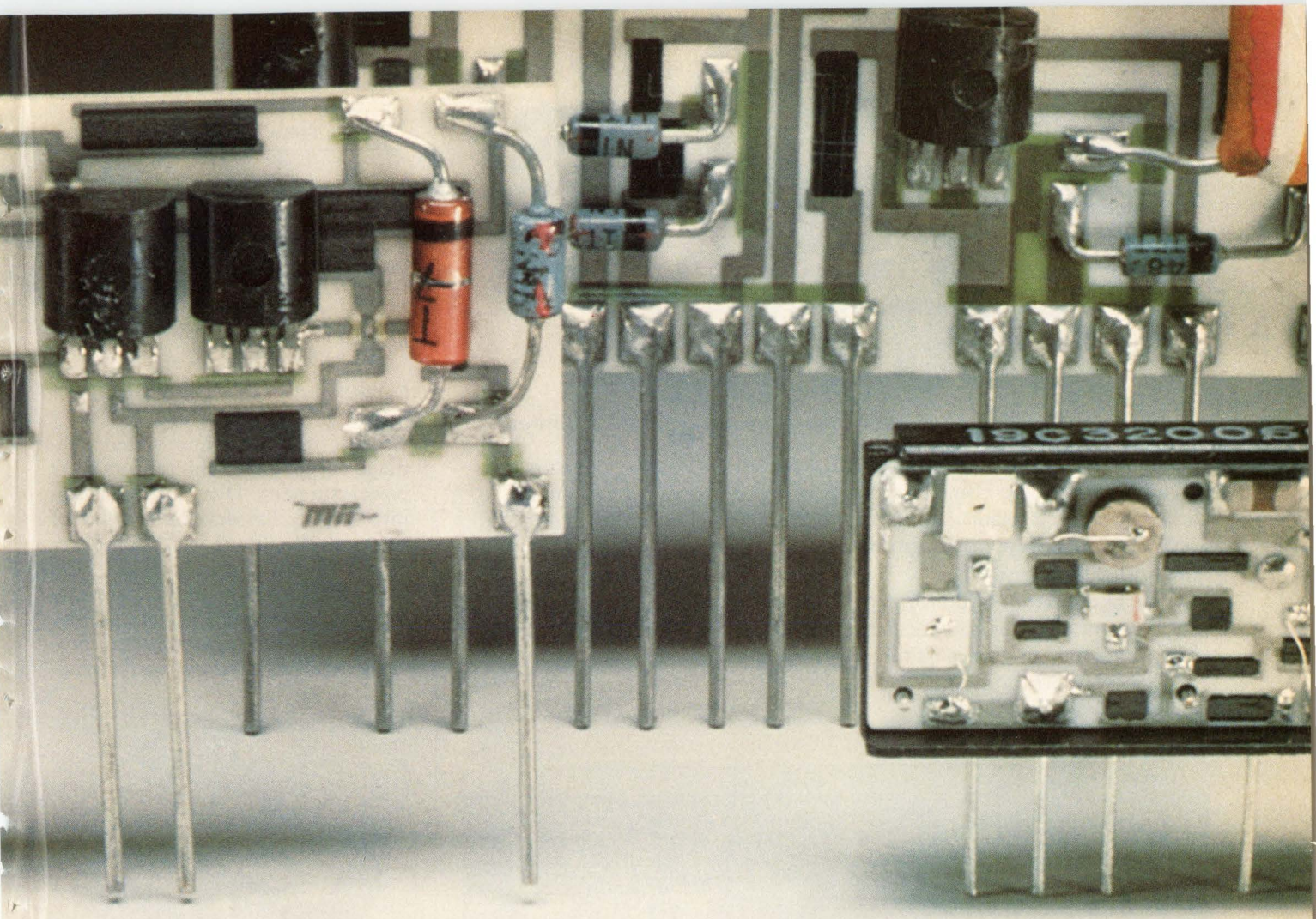
Analog Devices Inc., Box 280, Route 1 Industrial Park, Norwood, Mass. 02062. Phone Lowell Wickersham at (617) 329-4700. [381]

### F-v converter has low output ripple, modest linearity

Unlike most existing frequency-to-voltage converters, which have very good linearity accompanied by a large amount of output ripple, the model 22 is a low-cost unit with modest linearity and extremely low ripple—less than 0.5 millivolt peak-to-peak. Users who need both high linearity and low ripple can bypass the model 22's internal voltage-controlled oscillator and substitute an external voltage-to-frequency converter.

By itself, the model 22 is monotonic and linear to within 0.5% of full scale. It covers a four-decade range with a maximum frequency of 10 kilohertz, which can be lowered by using an external C-MOS divider to reduce the VCO frequency before it enters the converter's phase detector. Settling time after a step change in frequency is about 15 periods of the final frequency.

The model 22 f-v converter sells for $39 in unit quantity, $34 each for 10 to 24 units, and $29 each for 25 and up. Delivery of the devices is



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| Pt/Au 9596<br>Pt/Au 9885 | 10 Sn/90 Pb 8520<br>60 Sn/40 Pb 8522 |
| Au 9791<br>Au 9910 | 88 Au/12 Ge 8513<br>80 Au/20 Sn 8511<br>50 Pb/50 In 9567 |

If you manufacture or assemble thick film hybrid microcircuits or passive components, come to Du Pont Electronic Materials Division, the systems people in thick films. Write the Du Pont Company, Room 25451, Wilmington, DE 19898.

## Electronic Materials Division

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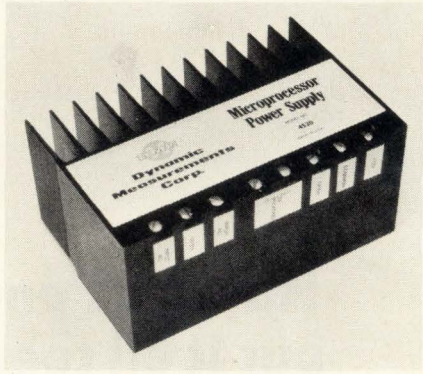
Electronics

Circle 147 on reader service card

from stock to about four weeks. D-B-Developments, 7709 Kilbourne Rd., Rome, N.Y. 13440. Phone Dave Manzolini at (315) 339-1265 [383]

## Potting increases power-supply reliability

Because microcomputer systems demand very high reliability from their power supplies, Dynamic Measurements Corp. has developed a line of premium supplies that are completely encapsulated in hard epoxy. The solid molding, which the company explains is extremely unusual for supplies in the 30-watt range, provides excellent thermal conductivity,




and permits operation without derating in ambients up to 40°C.

Measuring 6.1 by 4.25 by 3 inches, the supplies are available in single-, double-, and triple-output versions. Total regulation (line plus load) is within 0.03% for the 5-volt output and within 0.01% for the 9-, 10-, 12-, and 15-v outputs. Tracking between positive and negative outputs is within 100 ppm/°C, and maximum output voltage error is between 0 and +1%. Standard functional options include Faraday shielding, 5-v overvoltage crowbar, and various input-voltage ranges.

Single-unit pricing is $130 for the single-output supplies, $140 for the double, and $155 for the triple. Delivery is from stock to four weeks.

Dynamic Measurements Corp., 6 Lowell Ave., Winchester, Mass. 01890. Phone (800) 225-1151 [384]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The two models (see schematics) are standard size and pin-spaced for automatic insertion. Series 698-1 comes in 17 stock resistance values; Series 698-3 in 20 stock values. And these parts can be coupled, in series or parallel, to obtain other values in gain-setting, summing and feedback circuit applications.

The 1,000-piece price: just 65¢ for the 698-3 (8 resistors), 81¢ for the 698-1 (15 resistors). Compare with discretes!

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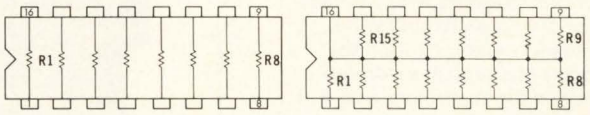


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Microprocessors

# Data board fits Intel computers

16-channel system includes 12-bit a-d converter, sells for only $495

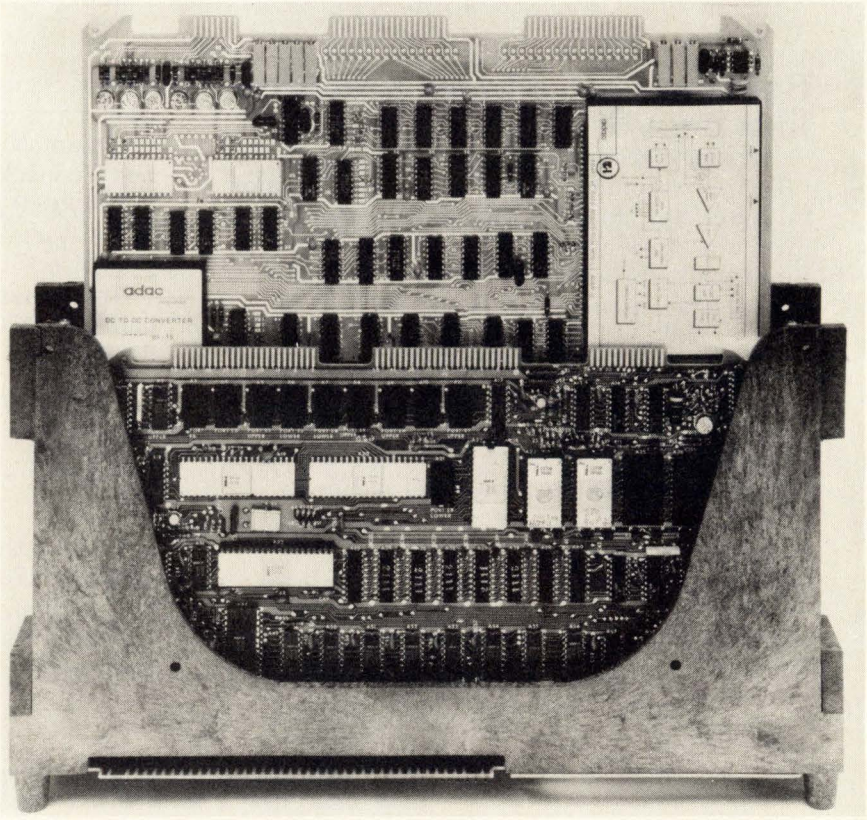
The series 735 one-board data-acquisition systems plug directly into the same card cage as the Intel SBC-80/10 and SBC-80/20 microcomputers and the MDS-800 microcomputer-development system. Priced at only $495 in lots of 1 to 9, the basic 735 provides 16 single-ended or 8 differential input channels, a sample-and-hold module, a fast 12-bit analog-to-digital converter, and logic circuitry to interface with the computer bus.

Options include up to two 12-bit digital-to-analog converters, a software-programmable input amplifier, and a dc-to-dc converter for the analog circuitry. This converter is needed if the 735 is to be used in a system where ±15-volt power is not available.

The amplifier allows a choice of one of four gains for each input channel, and two sets of four are available: 1, 2, 4, and 8, or 1, 2, 5, and 10. The system throughput rate is 35 kilohertz. In the voltage-output mode, there is an optional third-wire sense for the d-a converters. It adds $20/channel to the converter price of $125 for one, $215 for two.

To enhance flexibility, the 735 series bus interface offers a choice of program control or program interrupt through software and choice of memory-mapped input/output or isolated I/O by means of a jumper. When the interface is structured as a memory-mapped I/O, the microprocessor treats the data-acquisition system as a number of memory locations. Of course, memory-mapped I/O is preferred for new designs. But with older designs, simply moving the jumper permits isolated I/O points.

Delivery time for the 735 is four



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☐ I am interested. ☐ I am serious.

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Company Title

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City State Zip

Circle 151 on reader service card

CALCOMP

Circle 207 on reader service card

## New products

weeks. Some units are available immediately from stock.
Adac Corp., 15 Cummings Park, Woburn, Mass. 01801. Phone A.L. Grant at (617) 935-6668 [401]

### Fast microcomputer sells for $595 in kit form

Built around a high-speed version of the Z-80 microprocessor, the Z-2 microcomputer is a low-cost machine with a 250-nanosecond cycle time. Its price of $595 in kit form or $995 assembled includes a microprocessor card, a 21-slot motherboard, a


heavy-duty power supply that can put out 30 amperes at 8 v dc and 15 A from ±18 v dc, and a front panel. The kit includes one card-socket and card-guide set, while the assembled unit includes all 21 sockets and set of card guides.

The computer is configured to allow the user as many as eight independent banks of memory, each with a capacity of up to 64 kilobytes. This memory capacity, coupled with the computer's speed, allows it to handle real-time operations formerly handled by larger machines.
Cromemco Inc., 2432 Charleston Rd., Mountain View, Calif. 94043. [403]

### One-board computer includes 16 kilobytes of RAM

Priced at only $995 in small quantities, a one-board microcomputer called the SDB-80 is supplied with 16 kilobytes of random-access memory. Built round the Z-80 micropro-

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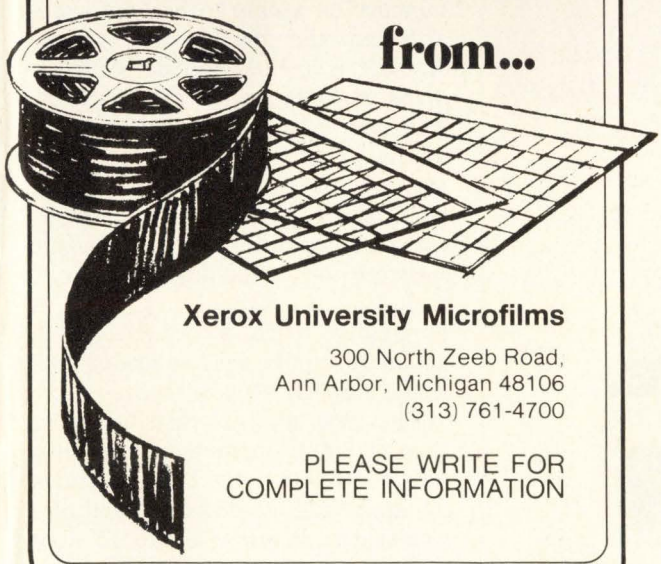

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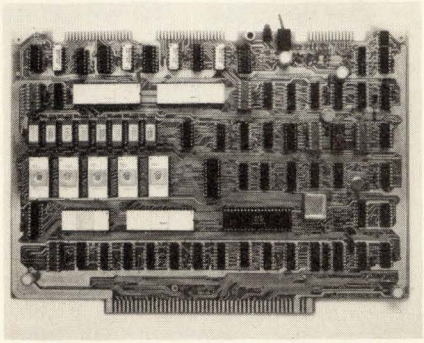
Circle 209 on reader service card

## New products



cessor family, the Software Development Board may also be purchased with a complete package of system firmware, which is contained in five on-board 2-kilobyte read-only memories. This firmware package allows the user to generate, edit, assemble, execute, and debug Z-80 programs.

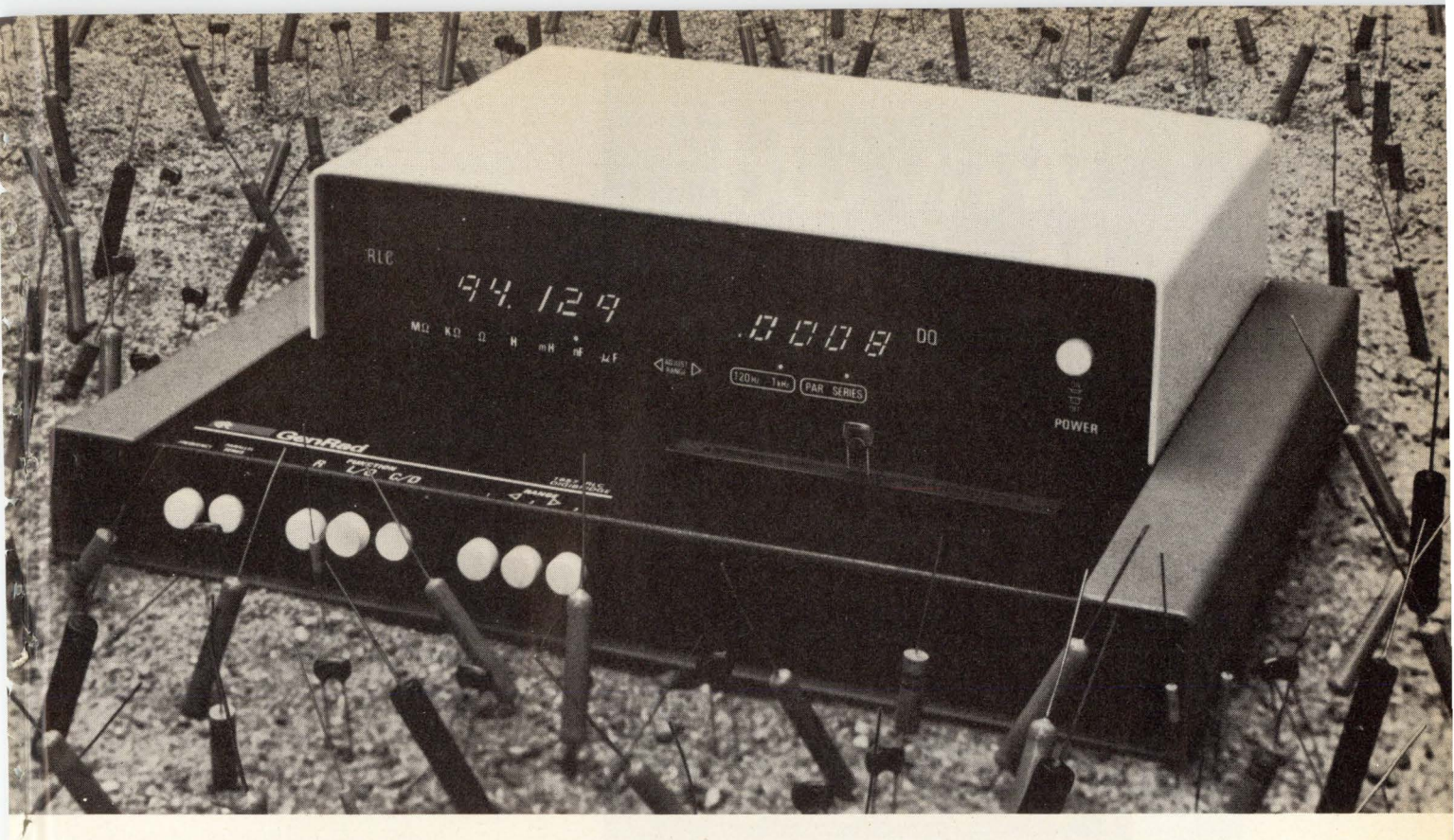
Because the development software is contained in the ROMs, all of the RAM space is available for user programs. With the firmware, a set of interface cables for RS-232 terminals and model 33 Teletypes, and complete documentation, the SDB-80 is priced at $1,395. If the RAM is reduced from 16 kilobytes to 4 kilobytes, the price drops to $1,195.

Mostek Corp., 1215 W. Crosby Rd., Carrollton, Texas 75006. Phone (214) 242-0444 [404]

### Read-only memory contains 32,768 bits

Believed to be the largest read-only memory on a chip to become available on the market today, the A66XX is a 32-kilobit device organized as 4,096 words of 8 bits each. The new ROM is expected to lower microcomputer costs by reducing the number of chips required for a particular application. For example, the basic operating and diagnostic software for an intelligent terminal, including a cathode-ray tube, a floppy-disk drive, a printer, and a keyboard, can be easily encoded on a single A66XX ROM.

The new ROM consists of more than 18,000 transistors and elements on a 156-by-242-mil chip. It features dynamic address-decoding and device-select circuitry. Up to 16 ROM

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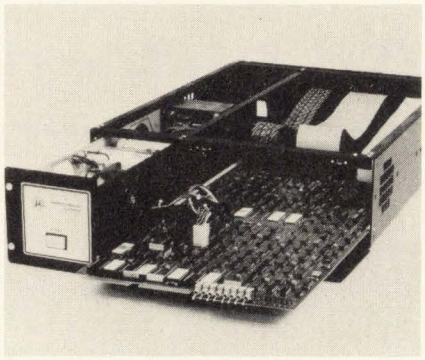
## New products

circuits can be directly selected with the device's 12 address and 4 chip-select inputs. As with all Rockwell PPS microprocessor circuits, the A66XX is priced as part of a system or microcomputer.

Rockwell International, Microelectronic Device Division, 3310 Miraloma Ave., P.O. Box 3669, Anaheim, Calif. 92803 [405]

### Disk controller supports PDP-11 systems

The MSC-1000 is a microprocessor-based controller that supports storage module devices with capacities from 25 to 300 megabytes per spindle. Its microprogrammed design suits it particularly well for use with Digital Equipment Corp. PDP-11



minicomputers. The controller can issue memory reference requests on the Unibus, making it unnecessary for the central processing unit to send the entire command through the host-adapter (interface-card) registers. Instead, the host CPU simply passes the address of the head of a chained command list to the controller. As commands are completed, control and status information is posted in interrupt-driven mailbox registers within the host adapter. Its microprogrammed design permits the MSC-1000 to respond as an RK11 or RP11 for bootstrapping purposes, says the manufacturer. The base price for the controller/formatter and a single host adapter is $7,900.

Microcomputer Systems Corp., 440 Oakmead Parkway, Sunnyvale, Calif. 94086. Phone (408) 733-4200 [406]

# Amperex 70/100-mil ceramic stripline transistors give you $f_T$ from 1 to 14 GHz.

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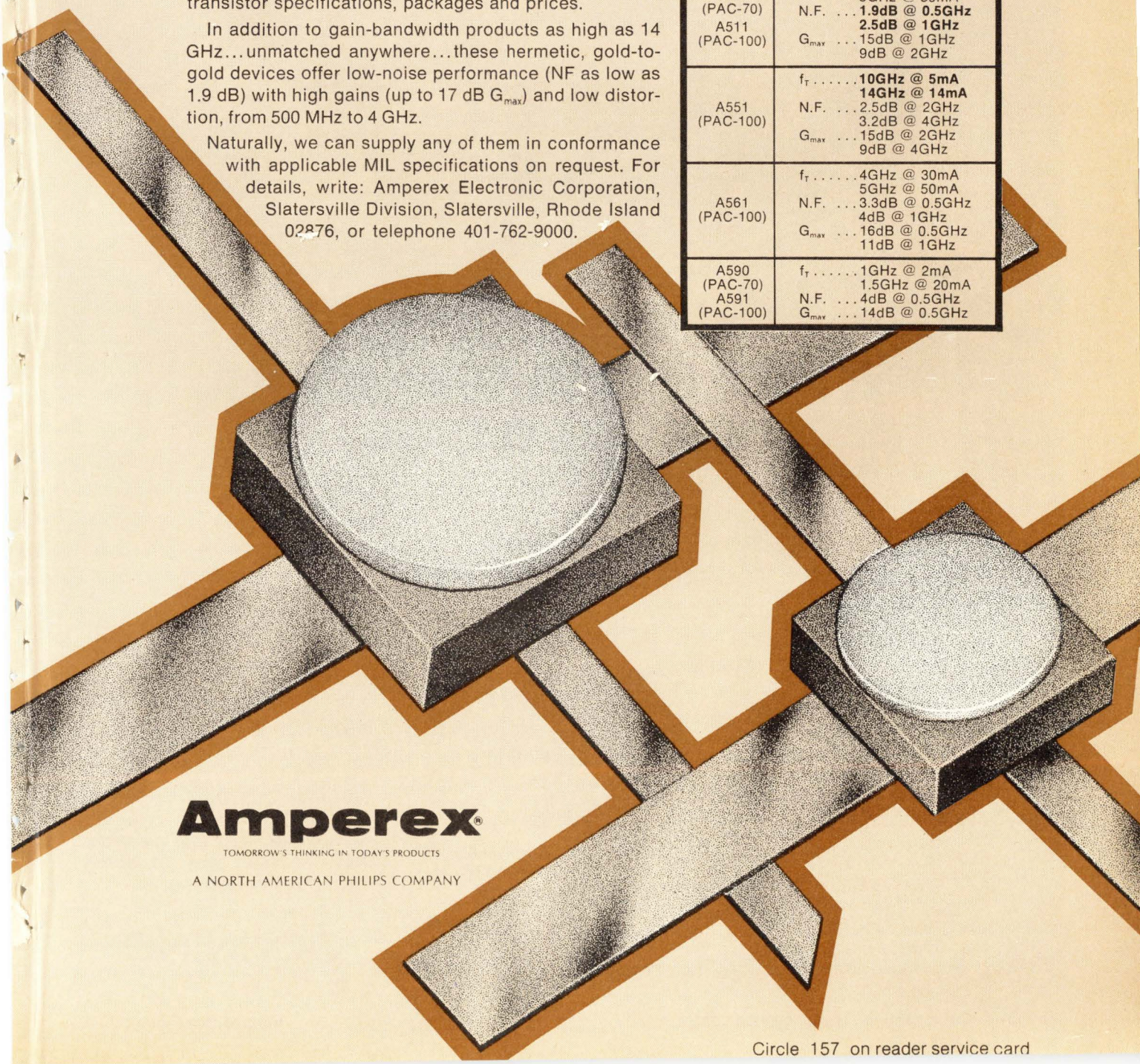
| Type | Typical Characteristics |
|---|---|
| A500 (PAC-70) A501 (PAC-100) | $f_T$ . . . . . 4GHz @ 5mA<br>5GHz @ 14mA<br>N.F. . . . 2.5dB @ 1GHz<br>3.8dB @ 2GHz<br>$G_{max}$ . . . 17dB @ 1GHz<br>11dB @ 2GHz |
| A510 (PAC-70) A511 (PAC-100) | $f_T$ . . . . . 3.5GHz @ 10mA<br>5GHz @ 30mA<br>N.F. . . . **1.9dB @ 0.5GHz**<br>**2.5dB @ 1GHz**<br>$G_{max}$ . . . 15dB @ 1GHz<br>9dB @ 2GHz |
| A551 (PAC-100) | $f_T$ . . . . . **10GHz @ 5mA**<br>**14GHz @ 14mA**<br>N.F. . . . 2.5dB @ 2GHz<br>3.2dB @ 4GHz<br>$G_{max}$ . . . 15dB @ 2GHz<br>9dB @ 4GHz |
| A561 (PAC-100) | $f_T$ . . . . . 4GHz @ 30mA<br>5GHz @ 50mA<br>N.F. . . . 3.3dB @ 0.5GHz<br>4dB @ 1GHz<br>$G_{max}$ . . . 16dB @ 0.5GHz<br>11dB @ 1GHz |
| A590 (PAC-70) A591 (PAC-100) | $f_T$ . . . . . 1GHz @ 2mA<br>1.5GHz @ 20mA<br>N.F. . . . 4dB @ 0.5GHz<br>$G_{max}$ . . . 14dB @ 0.5GHz |



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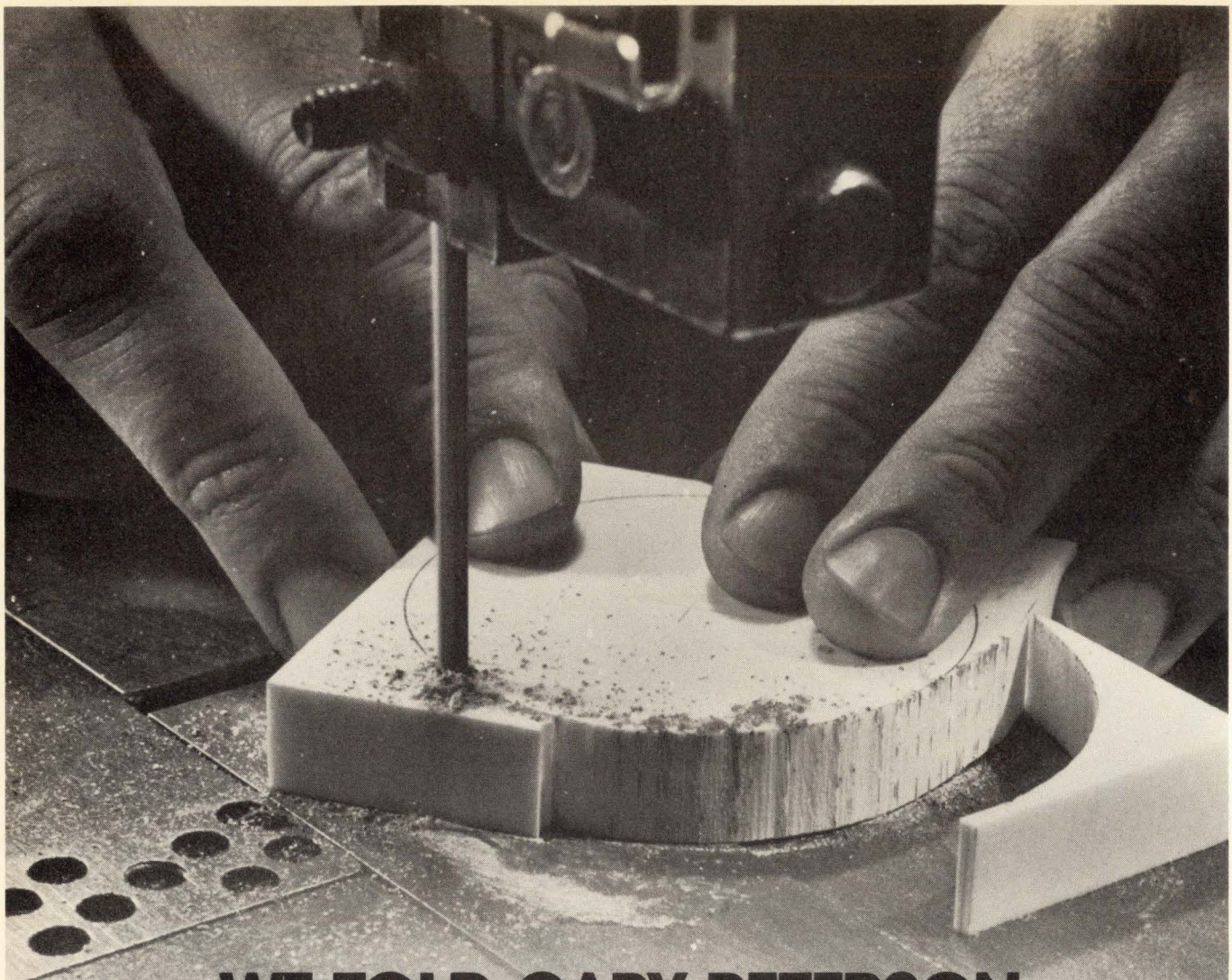

# WE TOLD GARY PETERSON TO CUT IT OUT.

Design engineer Gary Peterson chose MACOR machinable glass-ceramic instead of alumina or beryllia for the 2½ inch diameter circuit base that is the heart of a new angle transducer manufactured by Hewlett-Packard.

In the past, such parts might have been made from alumina or beryllia in a time-consuming, costly process that involves casting or pressing in a mold, then grinding and polishing to desired flatness.

Parts made from MACOR machinable glass-ceramic can be cut from bar stock with ordinary metal-working tools in one-tenth the time. Says Peterson: "MACOR enabled us to develop a product with minimum tooling."

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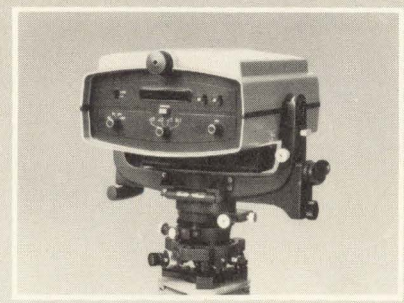

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CORNING

## New products

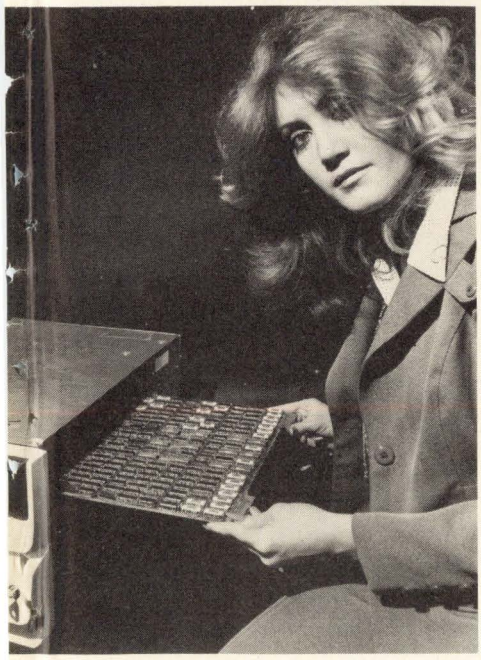
Data handling

# Signal processor on plug-in board

Floating-point array device for Nova, Eclipse offers speed and $10,000 price tag

By eliminating programming capability, Computer Design and Applications Inc. is able to sell a floating-point array-signal processor for only $10,000 each in lots of 25, and delivery time is 60 days. This compares with the $35,000 to $100,000 price tag on devices that perform voice processing, mechanical-design calculations, image enhancement, vibration testing, and similar data analyses. The more expensive parts are actually computers that have all the hardware necessary for loading and debugging programs.

CDA's MSP-2, built on a single plug-in board only 15 inches square, operates with Data General Corp.'s Nova and Eclipse minicomputers. The device maker claims its processor, which works with standard programs, can perform array calculations 10 to 50 times faster than minicomputers programmed for such applications.



"To date, all signal processors of this kind have been minicomputers with weird architecture," says CDA president Robert Caspe. "They allow for user programming, and that's an expensive design. We've taken the approach that a processor need not be programmable in the classical sense."

The firm programs the MSP-2 from its standard array library for the OEM customer. Operations defined in the library can be executed either by Fortran subroutine calls or by straightforward input/output instructions in assembly language from the host computer. All boards, which are driven by programmable read-only memories, can be reprogrammed by CDA to accommodate changes in applications.

"By eliminating the parts for general programming, we've cut down the price considerably," Caspe notes. "Ninety percent of our customers won't be reprogramming anyway."

The MSP-2 reads and operates on input-data arrays stored in the host-computer memory. The board contains 2,048 words of high-speed block floating-point memory. Caspe points out that the use of 24-bit data words minimizes the digital error rate in highly iterative operations. For example, the MSP-2 can perform a 1,024-point fast Fourier transform including input/output transactions on data in the Nova memory in 6.7 milliseconds. It can execute a 512-point complex FFT in the same time span. Users can increase computing power by plugging in additional boards.

The processor is made predominantly of low-power Schottky and static complementary-MOS circuits. It operates within a temperature range of 0° to 70°C.

"Our intention is to come out with a spectrum of processors that will be attuned to a laboratory environment for real-time calculations," Caspe says. This spring, the company will introduce its model MSP-1, which will be compatible with Digital Equipment Corp.'s PDP-11 mini-

## New products

**computer, notes CDA's president.**
Computer Design and Applications Inc., 375 Elliot St., Newton Upper Falls, Mass. 02164. Phone (617) 964-4320 [361]

### Teletype uses 9-wire printer for better looks and life

The model 43 Teletype teleprinter, priced below $1,000, has a nine-wire matrix printhead mechanism that

improves printing quality and increases service life. Compatible with systems that support the popular model 33 teletypewriter, the 43 prints both upper- and lower-case characters at rates up to 30 characters per second. A receive buffer and the printer's capability to run at "catch-up" speed make for a true-throughput rate of 30 characters per second.

Operator controls include switches to select half- or full-duplex operation, 10 or 30 characters per second, parity on/off, and a printer test. The teleprinter accommodates up to three-ply fanfold paper on which it can print up to 132 columns across an 11-inch width.

Teletype Corp., 5555 Touhy Ave., Skokie, Ill. 60076. Or call Terminal Central at (312) 982-2000 [363]

### Processor module includes LSI-11 microcomputer

Aimed at educational and small-business applications, the Terak 8500 series minicomputer is a modular tabletop system. Its nucleus is a self-contained disk-based model 8510 data processor, which contains

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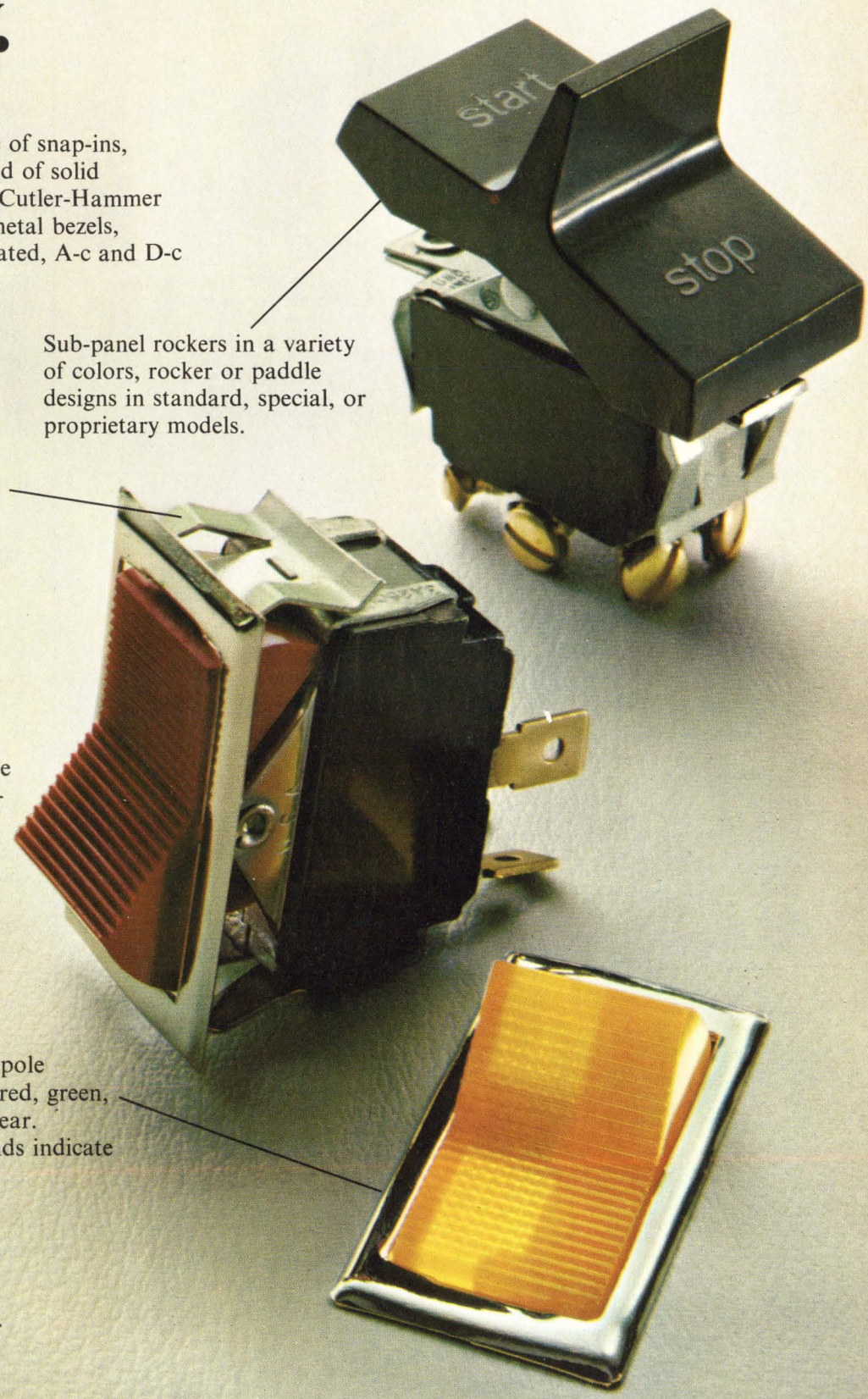


CUTLER-HAMMER
SPECIALTY PRODUCTS DIVISION, Milwaukee, Wis. 53201

Switch to No.1

Circle 161 on reader service card

## New products

a 16-bit Digital Equipment Corp. LSI-11 microcomputer. The processor has a flexible-disk drive that is compatible with the IBM 3740 format, a disk controller that can handle up to four drives, single serial interface circuitry with RS-232-C and 20-milliampere-current-loop signal levels, power supplies, and from 4,096 to 20,480 words of complementary-MOS read/write memory.

Other modules available are the 8512 flexible-disk subsystem, the 8530 data terminal equipped with a keyboard and a 12-inch cathode-ray-tube display, and the 8540 series of line printers. A complete small-business system sells for $16,465. This includes a processor with 20 kilowords of memory, dual flexible-disk drives, the display terminal, an 80-column printer that operates at 300 lines per minute, a disk operating system, and Basic software.

Terak Corp., 14425 N. Scottsdale Rd., Suite 100, Scottsdale, Ariz. 85260. Phone Daniel Clark at (602) 991-1580 [364]

### Disk formatter/controller fits on one chip

The only external logic that must be added to the FD1771 to form a complete floppy-disk formatter/controller is a clock/data separator on the input side and chip-select-decode logic on the output side. Everything else required to interface an off-the-shelf floppy-disk drive with a computer interface bus is contained on the chip.

As a controller, the FD1771 enables the user to seek any track, restore to track zero, step one track in either direction, and read single or multiple sectors. As a formatter, it can emulate IBM 3740 formatting or it can set up non-IBM formats.

The n-channel silicon-gate MOS device, housed in a 40-pin dual in-line package, sells for $80 in small quantities. In hundreds, the price drops to $60 each.

Western Digital Corp., 3128 Red Hill Ave., Box 2180, Newport Beach, Calif. 92663. Phone (714) 557-3550 [365]

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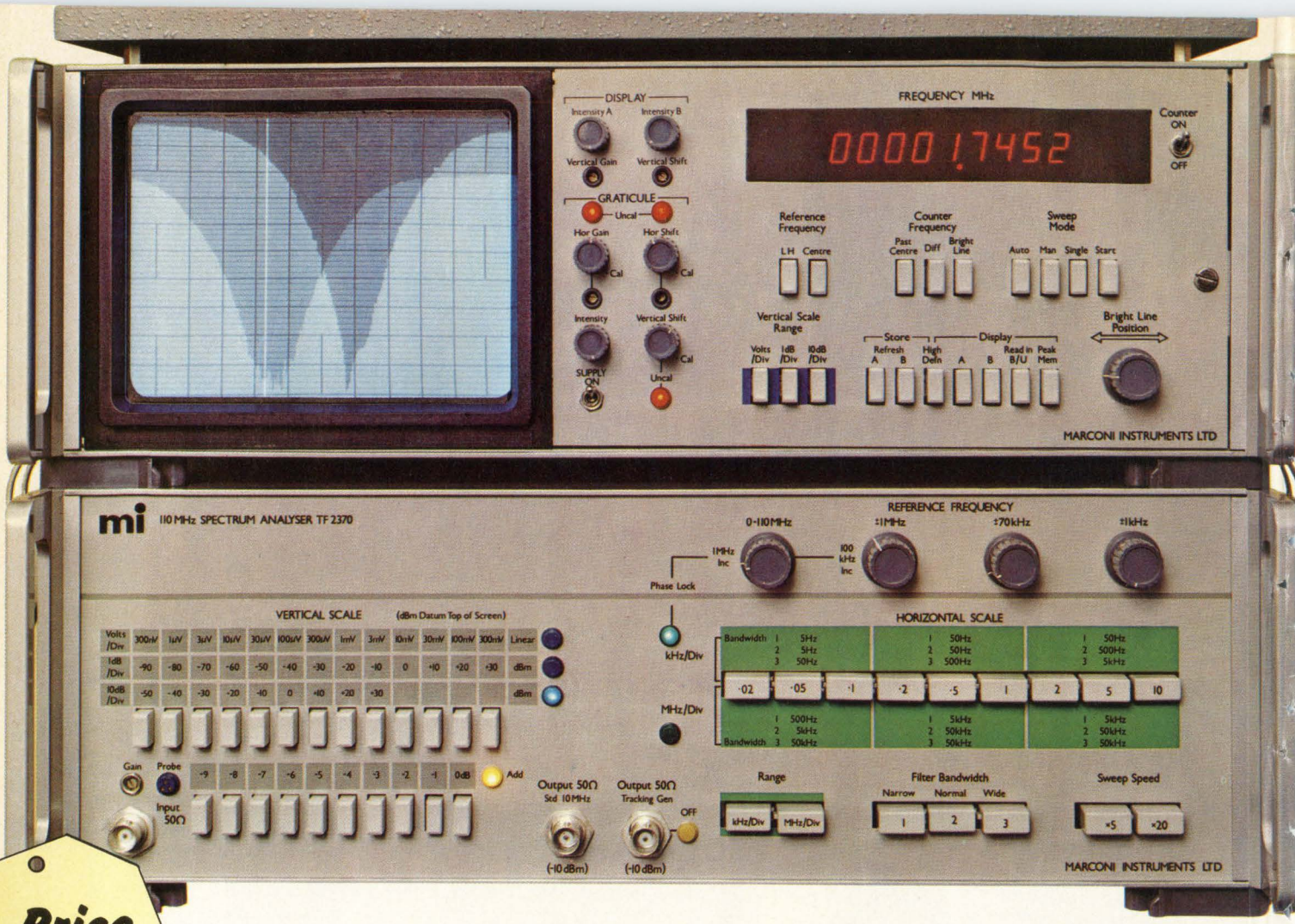


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Packaging & production

# Bonder puts chips on strips

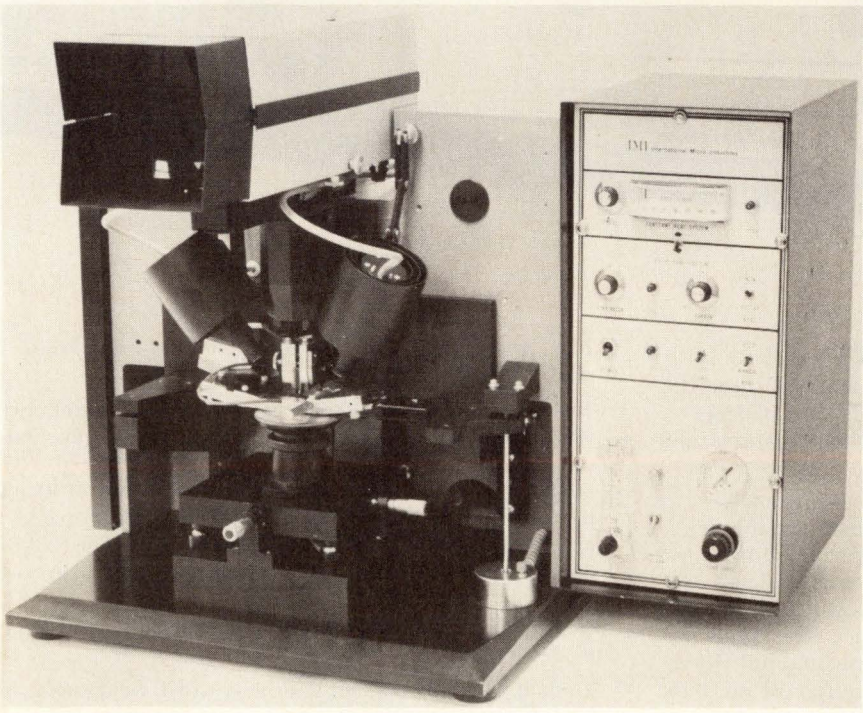
Manual machine is aimed at thick-film hybrid fabrication

More and more makers of thick-film hybrid circuits are using the film-carrier method of manufacturing, in which chips are bonded to copper patterns on nonconductive film. Ideally, a hybrid house would buy strips of tape and bumped chips and put the chips on tape. Then these and their patterns would be removed from the tape and bonded to a substrate. But small and medium-sized companies have discovered a stumbling block: there has been no commercially available low-cost bonder for applying small quantities of chips to tape.

International Micro Industries, a manufacturer of tapes and bonding machines, decided to close that gap with its model 200 manual inner-lead bonder. It is designed specifically to put bumped chips on tapes 6 to 12 inches in length. The machine is equipped with a manual tape advance that fits 8-millimeter, Super-8, 16-mm, 32-mm, 35-mm, and 70-mm tapes. Bonding force is adjustable from 1.5 to 100 pounds, and a pulse or a constant-heat bonding head is available. The bonder can handle 200 to 400 chips per hour, regardless of the number of chip leads.

The system comes with either of two chip holders: one for loose chips, the other for a sawed wafer. It also offers a choice of three viewing methods: cable television, microscope, or a high-resolution viewing projector. But, says Thomas Angelucci, company president, the projection viewer is best because it gives a true color image (the TV is monochrome), has a better depth of focus than the TV screen, and eliminates the operator fatigue of the microscope.

Solid-state controls with photocell switching are used in the bonding system. In an actual operation using a strip plus chips, the operator would first align the chip to the reticle in the viewing system, then use the X/Y controls to manipulate the tape fingers over the integrated circuit's







bonding pads. Finally, he pushes a button to automatically bond. After visual inspection, he advances the tape to the next site.

The machine is designed to be upgraded to a semi- or fully automatic version capable of doing 3,000 chips per hour. It measures 36 by 24 by 21 in. and weighs 250 lb. A basic machine costs $5,950, and the projection viewer costs $1,450. A pulse heat head costs $2,450, and the constant temperature head is $875.

International Micro Industries, P.O. Box 604, Cherry Hill, N.J. (609) 424-3112 [391]

## Unit checks out analog, digital, and mixed circuitry

Thus far, the Capable 4000 line of automatic test systems has been able to handle only digital-circuit boards. Now an option called the model 4707 Analog Capability allows the testers to handle analog and hybrid (mixed analog and digital) circuitry as well.

The model 4707 is a package of hardware and software that can be added to all existing Capable 4000 testers except the model 4050. Or it can be included as part of a new system. It consists of an IEEE-compatible bus for interfacing analog instrumentation, a four- or five-bus-by-32-pin switching-matrix module, an instrumentation matrix (connecting up to 10 instruments to the analog bus), and a software package that controls both the stimulus and measuring analog instrumentation.

The 4707 system can operate simultaneously in its digital and

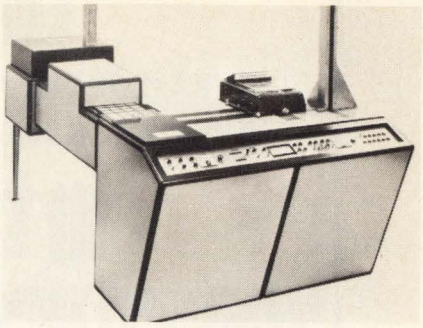
analog modes to perform parametric tests on digital circuitry. A dynamic probe is included in the system for guided fault isolation.

The price of the 4707 Analog Capability, not including instrumentation, is $17,450. Available standard instruments include a multimeter, a 100-megahertz two-channel counter/timer, a function generator, various voltage sources, and a dual load-resistor module.

Computer Automation, 18651 Von Karman, Irvine, Calif. 92713. Phone (714) 833-8830 [393]

## System prepares ceramic substrates automatically

The DEK Autofeed 4000 is a completely automatic system for handling, printing, and drying ceramic substrates for hybrid circuits. It works continuously by maintaining reservoirs of substrates at each of its work stations. The substrates are magazine-fed, positioned, printed, ejected, collated, placed on a moving belt, dried or fired, removed from



the belt and replaced in a magazine at a recommended production rate of 1,200 cycles per hour. In addition to

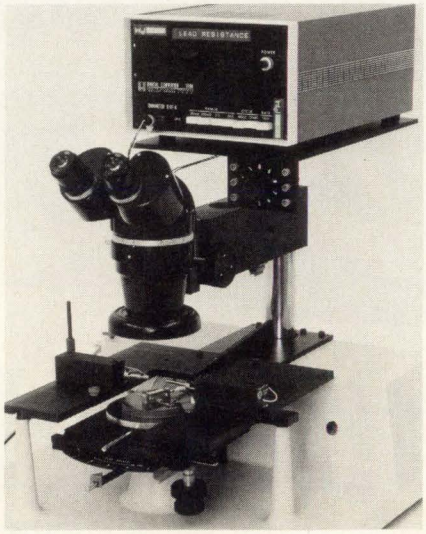
printers, the system, which is manufactured in Great Britain, can feed and take up substrates from such other process equipment as bonders, trimmers, reflow solderers, and component-attachment equipment.

Browne Corp., 203 Chapala St., Santa Barbara, Calif. 93101. Phone Michael Ditmore at (805) 963-0371 [394]

### Precision ohmmeter resolves 0.1 milliohm

Designed for both incoming-inspection and production-line applications, the model PS43PRM precision resistance measuring machine uses a Kelvin circuit configuration to make accurate measurements down to 0.1 milliohm. It is designed to null out lead resistance to make accurate measurements on single- and multiple-layer hybrid circuits, resistor chips, and the like.

The machine can be fitted with a



variety of probe cards and micro positioners. It also contains a vacuum chuck 4.25 inches in diameter that can be fitted with special adapters for holding dual in-line packages. The unit comes equipped with a Kelvin-connected rotary switch for selecting Kelvin-connected probe pairs. Pricing of the PS43PRM depending on configuration ranges from $2,000 to $7,000. Delivery of the PS43PRM is from

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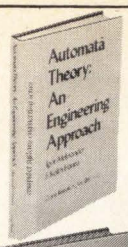

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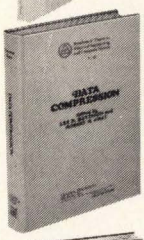

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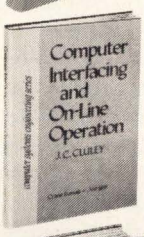

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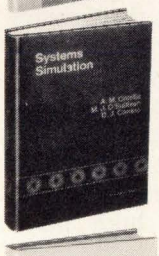

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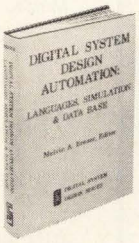

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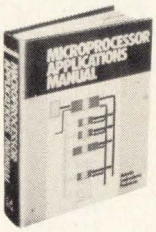

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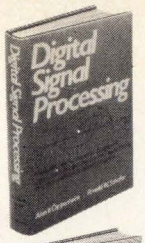

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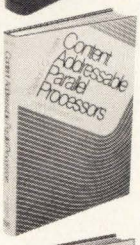

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The panels, which can handle all ICs, from 8-pin to 42-pin, are priced from $350 each in lots of 10 pieces. Frame prices, for similar quantities, start at $16 each.
Mupac Corp., 646 Summer St., Brockton, Mass. 02402. Phone (617) 588-6110 [396]

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AMP Inc., Harrisburg, Pa. 17105. Phone (717) 564-0100 [397]

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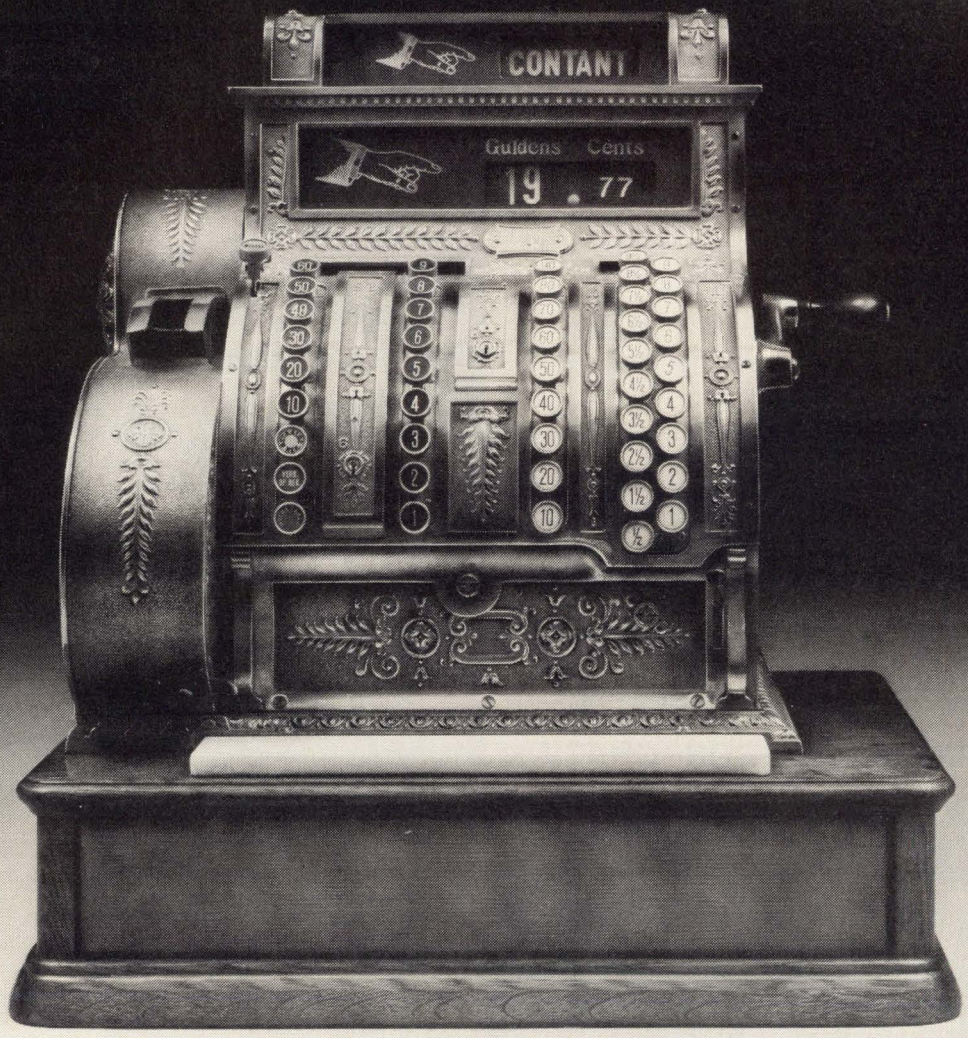


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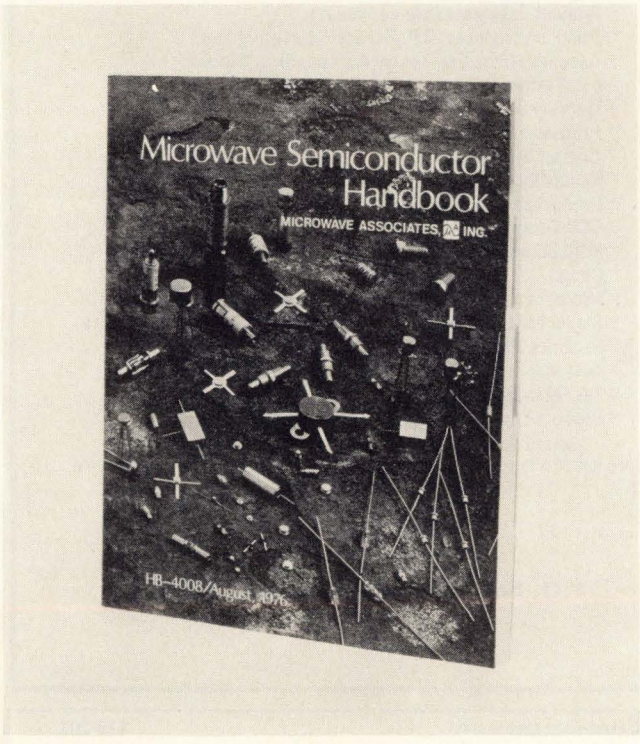
**Switch approvals.** Designed to give international marketers a working knowledge of switch-testing methods in various countries, a 16-page handbook covers such topics as specifications, markings, creepage, clearance distances, and electrical-life requirements for snap-action switches. Copies of *A Handbook of International Switch Approvals* may be obtained by sending $2 to F. Amendola, Cherry Electrical Products Corp., P.O. Box 718, Waukegan, Ill. 60085.

**Solid-state relays.** A comprehensive applications handbook for solid-state relays includes circuits and block diagrams for a wide variety of commercial/industrial and military-aerospace subsystems. Copies of the 24-page handbook may be obtained from Teledyne Relays, 3155 W. El Segundo Blvd., Hawthorne, Calif. [423]

**Microwave semiconductors.** The line of receiving diodes, control diodes, power-generating devices, and amplifying




devices made by Microwave Associates Inc. is covered in a 256-page handbook that can be obtained from the company on South Ave., Burlington, Mass. [426]

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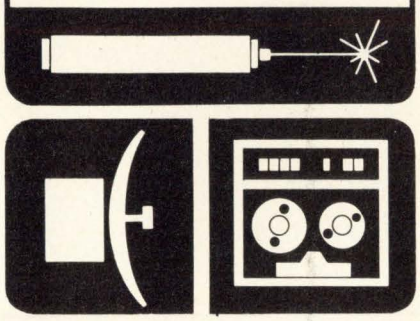

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