JUNE 10, 1976

A MICROPROCESSOR THAT MATES WITH ANY PERIPHERAL FAMILY/101

Cathode-ray: how they make oscilloscopes better/113

Designing efficient amplifiers with FETS/122

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Electronics

CHOOSING SIDES IN WATCH TECHNOLOGY

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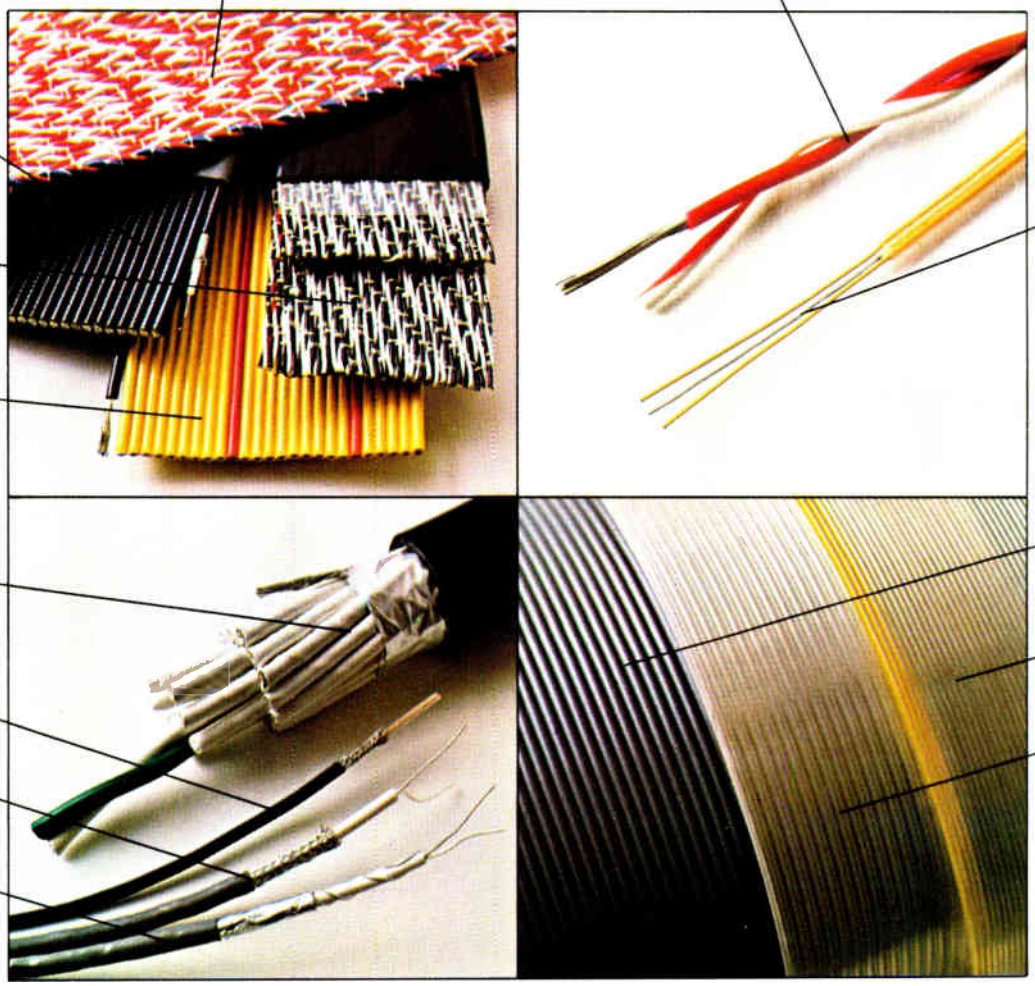

WOVEN RIBBON CABLE. Components PVC insulated twisted pairs

TWISTED PAIR. Components PVC insulated conductors

JACKETED BONDED RIBBON CABLE. Components 95Ω air-spaced miniature coaxial cable

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Teltronics Inc. telephone equipment and components
Brand Rex Ltd. (Scotland) wire and cable

CRTs set the pace for oscilloscopes, 113
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And in the next issue . . .
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Palomar Engineers
Escondido, Calif.

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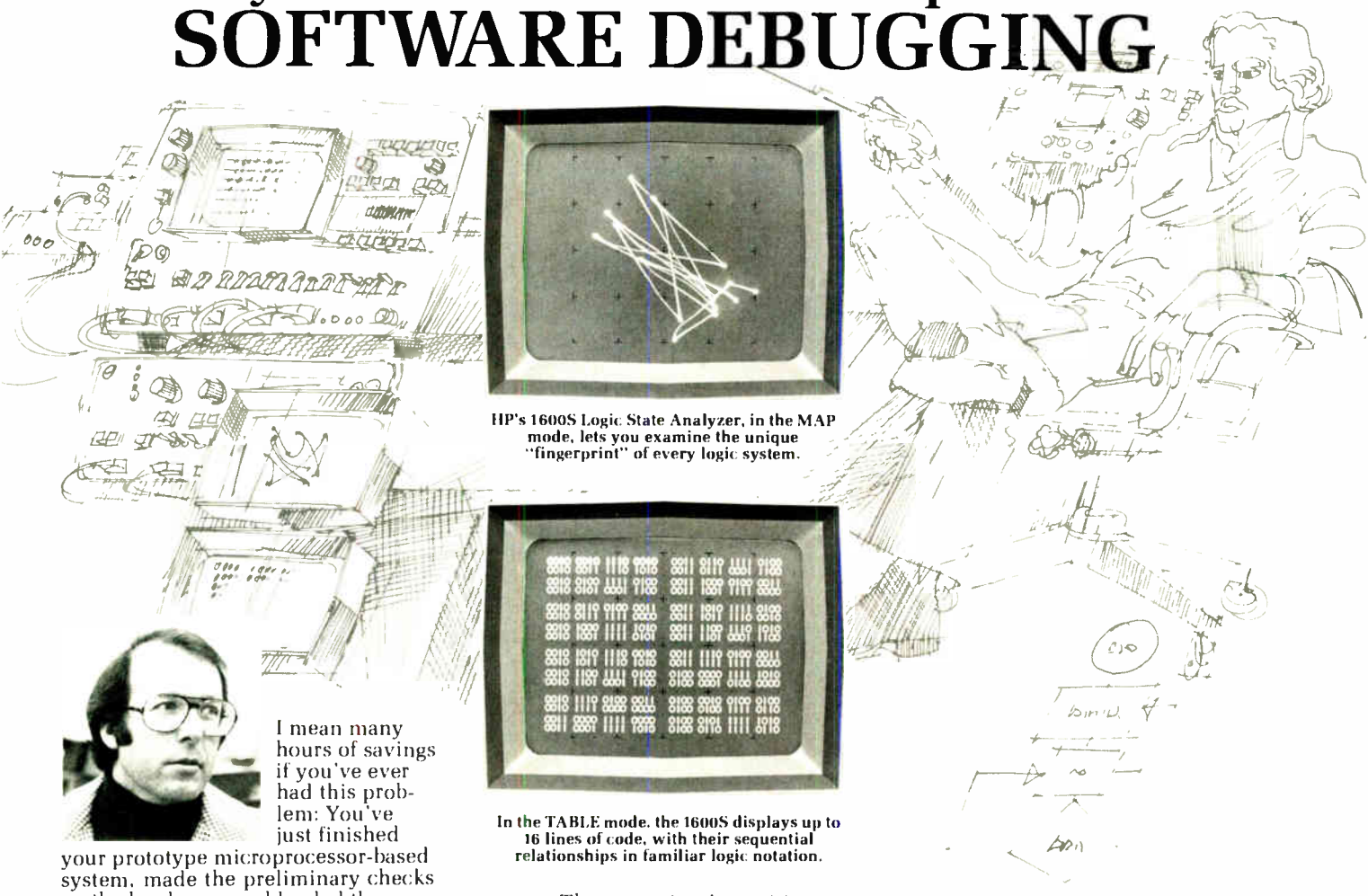
Let's talk about a way for you to save hours in microprocessor SOFTWARE DEBUGGING



HP's 1600S Logic State Analyzer, in the MAP mode, lets you examine the unique "fingerprint" of every logic system.

In the TABLE mode, the 1600S displays up to 16 lines of code, with their sequential relationships in familiar logic notation.

I mean many hours of savings if you've ever had this problem: You've just finished your prototype microprocessor-based system, made the preliminary checks on the hardware, and loaded the program in RAM. You hit the start button. Everything's running smoothly, then wham! You're out of business. Things are out of sequence and the system is doing things you never intended. Now you could be in for hours—or even days—of troubleshooting.

But let me tell you about a much faster way to spot software problems... with HP's 1600S Logic State Analyzer. This instrument lets you look inside your operating circuit—right on the buses and qualifier lines—and see program implementation. That's the fastest way I know to locate software problems in operating circuits. Actually, the 1600S gives you two ways to view program flow:

Mapping. This is a dynamic view of your system's operation...a pattern of dots and lines that are unique for each program. Each dot is a specific data word. It's location indicates binary magnitude, and its brightness indicates relative frequency of occurence.

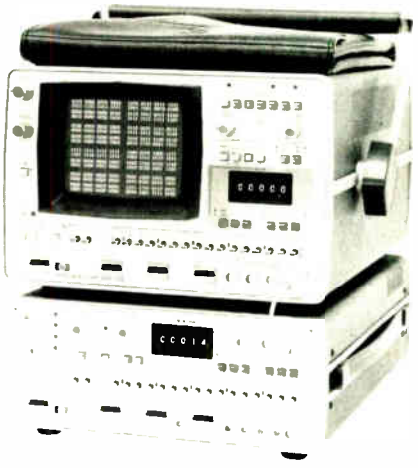
You might call the map a personal fingerprint. It's different for every program. With a little practice, you can easily spot a suspicious pattern and locate the word or group of words that could be the trouble source. Then you simply position a cursor over the word in question and push a front-panel switch to go to the Table display mode.

Table. The CRT now gives you a display of word flow using the word you selected as the trigger point. It displays up to sixteen 32-bit words at one time...in familiar One's and Zero's. You can look at events leading up to, surrounding, or following the trigger word. And even delay up to 99,999 clock cycles beyond the trigger point to view events anywhere in your program.

Suppose your problem is an erroneous data word that causes an unwanted jump. Mapping helps you spot the jump, and the Table mode lets you quickly compare each data word leading up to the jump with your written program.

That's just a simple example. HP's 1600S Logic State Analyzer, priced at $7100*, can speed more complex software debugging problems too. We'd like to tell you more. And HP has arranged a number of seminars to make that possible. Find out how to attend one in your area by calling your local HP field engineer. He can also supply you with complete spec sheets and application notes detailing the use of mapping for troubleshooting minicomputer and microprocessor systems. You'll discover an exciting new concept in digital troubleshooting.

*Domestic U.S.A. price only.



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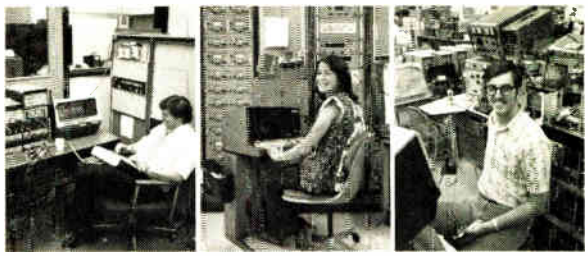
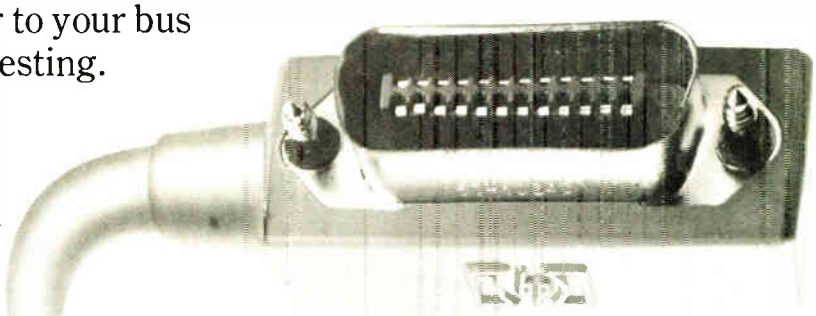
Your powerful connection to easier automated testing.



The Real-Time HP-IB Minicomputer is the best thing to happen to automated testing since the Hewlett-Packard Interface Bus (HP-IB*), which brought order and simplicity to the world of programmable instruments. Now you can apply the power of an HP 21MX minicomputer to your bus for do-it-yourself automated testing.



With an HP-IB/21MX Minicomputer your multi-programming system can run multiple instrument clusters concurrently. And your system also can be generating new programs in Real-Time BASIC, FORTRAN IV or HP Assembler; organizing and analyzing data; and producing timely management reports. All at the same time.

21MX minicomputers can even be easily linked together to form plant-wide networks. And upwards to a central HP 3000 or IBM 360/370.

Real-Time HP-IB Minicomputers. They give you the simplicity of HP-IB interfacing, and the minicomputer power to gain real management control of your automated testing. Prices, with disc and bus interface included, start at about $33,000 in the U.S.

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*Hewlett-Packard's implementation of IEEE Standard 488-1975, "Digital Interface for Programmable Instrumentation."

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Electronics
The International Magazine of Electronics Technology
Vol. 49, No. 12 • June 10, 1976

Highlights

Cover: The toss-up in digital watch technology, 91
Competition between rival logic and display technologies is fierce, and no one can tell whether complementary MOS or injection logic, light-emitting diodes or liquid crystals will come out ahead in this year's digital watches.

Cover design is by Art Director Fred Sklenar.

Quadraphonic sound grows sweeter, 68
A new integrated-circuit matrix system, based on better mathematics, promises sharper four-channel separation and directionality—and greater consumer appeal.

8-bit processor chip focuses on control, 101
The limited processing and memory requirements of electronic scales and other simple controllers are satisfied by a special-purpose microprocessor—a single chip that interfaces with any 8-bit TTL-compatible bus-oriented peripherals.

CRTs set the pace for oscilloscopes, 113
Finer resolution, brighter traces, storage capability, bigger bandwidth—all these advances in cathode-ray-tube design have also benefited oscilloscopes. The next step may well be the all-solid-state display, built out of charge-coupled devices.

And in the next issue . . .
Special report on electronics games . . . MOS moves into high power . . . approaches to microprocessor programing.

Electronics

Publisher's letter

Microprocessors pack a lot of power into a small package, so that they can take on a number of jobs without having to be customized for each one. The resulting volume production translates into a rather phenomenal price/performance ratio.

It had to happen, of course, but that basic strength—all things to all applications—is already considered by some to be a bit of disadvantage. When Electronic Arrays Inc. designed its EA 9002, the emphasis was on specialization.

Let's hear the design philosophy in the words of Electronics Arrays' Bill Wickes, who wrote the technical article that starts on page 101. "A while back some friends of ours, Ed Lee and Matt Biewer of Pro-log, a newly emerging company in Monterey, Calif., specializing in microprocessor applications, approached us with an idea. The idea was that while the 8080 or 6800 are good microprocessors, they are not configured for small, low-cost real-time controller and logic replacement applications. They are too sophisticated, too complex to easily comprehend, an overkill for the job. Electronic Arrays felt the same way and after many joint sessions the specifications for the EA9002 emerged."

Was the design what they had in mind? Yes, according to Wickes. "It was conceived from the ground up as a stand-alone digital process controller capable of interfacing with the real world through an 8-bit parallel TTL-compatible data bus. The timing and control signals allow the use of the individual bus-oriented TTL-compatible devices best suited to an application. It combines the on-board 64-byte scratch-RAM of the F-8, the push-pop subroutine stack of the MCS-4, the simplified timing concepts of the PPS-4, the straightforward peripheral addressing techniques of the 6800, and the general-purpose registers of the 8080, with a simple instruction set and a single +5-v supply."

Digital watches are certainly an idea whose time has come. With shipments in 1975 of some 3.5 million units, sales this year should soar to at least 15 million. And in 1980, estimates have it, more than 90 million should pass into the hands and onto the wrists of consumers.

Right now, a number of semiconductor houses are vying for a piece of the digital-watch action and, as our cover says, choosing up sides in the electronic technology that makes the watches possible.

Our consumer editor, Jerry Walker, who wrote the article beginning on page 91: "It isn't clear whether watches with complementary metal-oxide semiconductor chips or those with integrated-injection-logic chips will be the preferred technology. Both approaches offer advantages, and the two technologies are running neck and neck at the watch-chip level. Watch displays—whether liquid-crystal or light-emitting-diode displays—have not been sorted out, either."

But there is a lot of activity in digital watches and much more to come. You'll find out just what in our digital-watch status report.

June 10, 1976 Volume 49, Number 12
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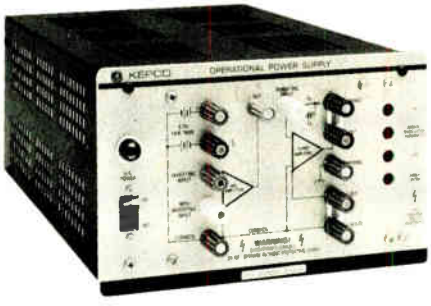

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Faster than a speeding 741...

. . . more stable than a drifty FET!

Say hello to *Superslew*, generally known as PMI's Mild Mannered OP-01 general purpose bipolar monolithic op amp.

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News update

■ In this election year, it should come as no surprise that the progress of Compuvote Corp. in selling its microprocessor-controlled voting machine is "right on target." That's the estimate of Fred L. Carter, the former Los Angeles County election commission chairman who heads the firm. "We've had interest from every major jurisdiction in the country," says Carter. Right now, three cities are close to a decision on whether to buy the machine, says Carter—Denver, San Francisco, and Chicago.

San Francisco is labeled by Carter the best prospect; it will make its decision by July 15. Compuvote, which is based in Beverly Hills, Calif., is still negotiating with the other two cities. Chicago's tentative plan is to change half its voting machines in the first phase, and Los Angeles county plans to field-test the Compuvote system in the November general election.

Only two changes have been made in the hardware since last year [*Electronics*, June 12, 1975, p. 41]. A digital readout has been added to enable the voter in the booth to tell for sure if he has actually punched the correct hole, and C-MOS memory has replaced n-MOS technology because it uses less power and offers more capacity.

■ Cray Research Inc. has sold its first computer system since the Minneapolis company was organized in 1972. The customer is the University Corp. for Atmospheric Research, and the deal is for a Cray-1A system to be installed at the National Center for Atmospheric Research in Denver. The center has not yet decided whether to lease the equipment or purchase it for $8.9 million.

Earlier this year Cray delivered a Cray-1 system to the Los Alamos Scientific Laboratories for test and evaluation. This activity came as the company announced a first-quarter loss of $290,929 on revenue of $14.2 million. Cray Research went public March 13.

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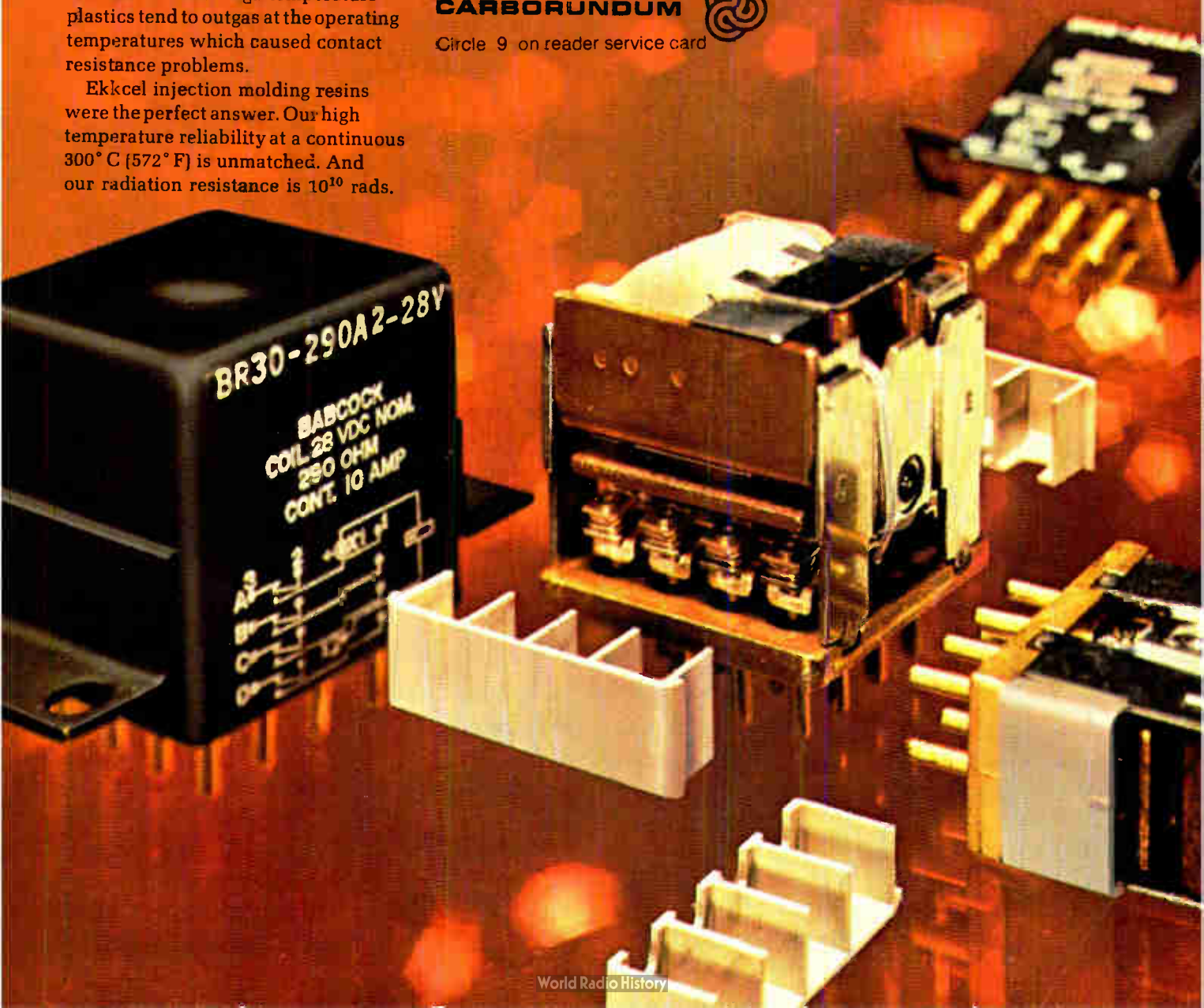

Editorial

Legislating competition out of telecommunications

A bitterly divided telecommunications industry is girding for battle in Congress later this year over the controversial Consumer Communications Reform Act of 1976. First introduced in the House three months ago with virtually no support, there have been 89 similar bills introduced in the House with 125 sponsors—more than a quarter of the membership. On the Senate side, there are two bills with 12 sponsors, 11 of them backing a bill introduced by Indiana Democrat Vance Hartke, now in line to succeed to the chair of the Commerce subcommittee on communications. The rapid growth of support for the bills, which Federal Communications Commission chairman Richard E. Wiley sees as designed "to submerge or destroy" telecommunications competition, is widely credited to intensive and large-scale lobbying in an election year by AT&T, its affiliates, and the members of the U.S. Independent Telephone Association.

The position of the telephone companies, as expressed by AT&T chairman John deButts, is that "the current trend of Federal regulatory policy is adverse to the interest of the public." By permitting selective competition in the carriers' more lucrative markets, deButts believes, the FCC is producing "a Government-imposed allocation of the market, arbitrarily established and artificially maintained."

The opposition sees it differently, particularly in its interpretation of what has come to be known on Capitol Hill as "the Bell bill." Jack Biddle, president of the Computer Industry Association, translates the bill's wording as legislation to prohibit any competition; to let AT&T acquire the companies that have come into being to serve consumer needs that it has so long neglected; and to let it deal only with states on terminal interconnections, since AT&T has been unable to get its way with the FCC, the courts and the White House.

Data Transmission Co. and MCI Telecommunications Corp., two of the largest specialized carriers authorized to compete with the Bell System using microwave networks, have yet to show a profit. And both acknowledge that passage of the legislation would quickly put them out of action altogether. The North American Telephone Association, made up of independent terminal-equipment suppliers, says that accuracy demands the bill be labeled "The Monopoly Protection Act of 1976." To fight the legislation, some opponents have formed ACCT—Ad-hoc Committee for Competitive Telecommunications.

If the telephone industry's bill is, as its opponents contend, so blatantly monopolistic and contrary to the public interest, it will never get out of committee. Why, then, the intense concern? Kevin Hannon, NATA executive director, suspects AT&T never believed the bill would pass at all, but may already be on the way to achieving its goal of putting its competitors out of business by indirectly denying them access to capital in the financial community.

"This is a capital-intensive industry," Hannon explains. "They only want the publicity that will scare off the financial community. Once they have done that, all other questions become moot. No money, no industry, no competition."

Whether the threat is direct or indirect, however, one thing is clear. Competition in telecommunications can only bring benefits—to the equipment makers, to the carriers, and, most important, to the public. We hope, after hearings are held, that Congress will reject limitations on telecommunications competition. For those engineers and managers whose livelihood depends on telecommunications competition, the issues raised by AT&T's lobbying efforts cannot be ignored.

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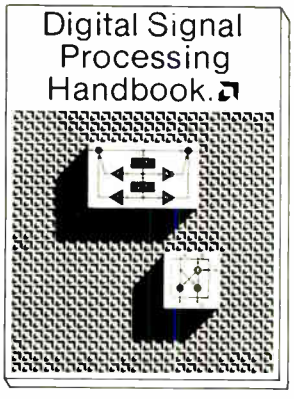

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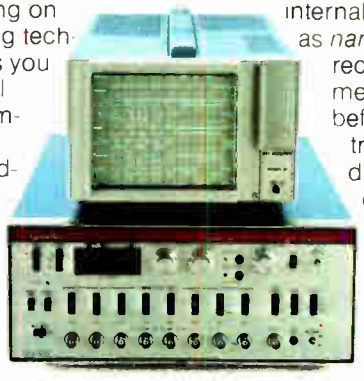

• Ideal companion for your 2-trace portable scope • Portable and self-contained • 8 channel • 50 MHz • Digital delay for precise trigger control • Accepts synchronous clock input (0° or 180° phase) • Provides internal clocking • Catches glitches as *narrow* as 5 ns • Pre-trigger recording • 512 bit per channel memory • Captures 512 words before, after, or around the trigger • Expanded and mixed display • Constant brightness expand to X20 • Combinational "true" trigger • "Any-change" trigger • Built-in delay (4 digit) • Latch mode (catches single pulses) • Adjustable threshold levels for channels 1-4 and 5-8 • Step-and-wait cursor control • Steps through data one bit at a time • Price: $3575. • Delivery 30 days A.R.O.

What next?

If you want to see a demo, right now, of our new 851-D or any of our digital logic analyzers (we have both less expensive and more powerful models), pick up the phone and call (408) 255-9500. Ask for Roy Tottingham at ext. 851.D. Or circle the reader service number and we'll send data. Biomation, 10411 Bubb Road, Cupertino, CA 95014

(851-D shown actual size.)

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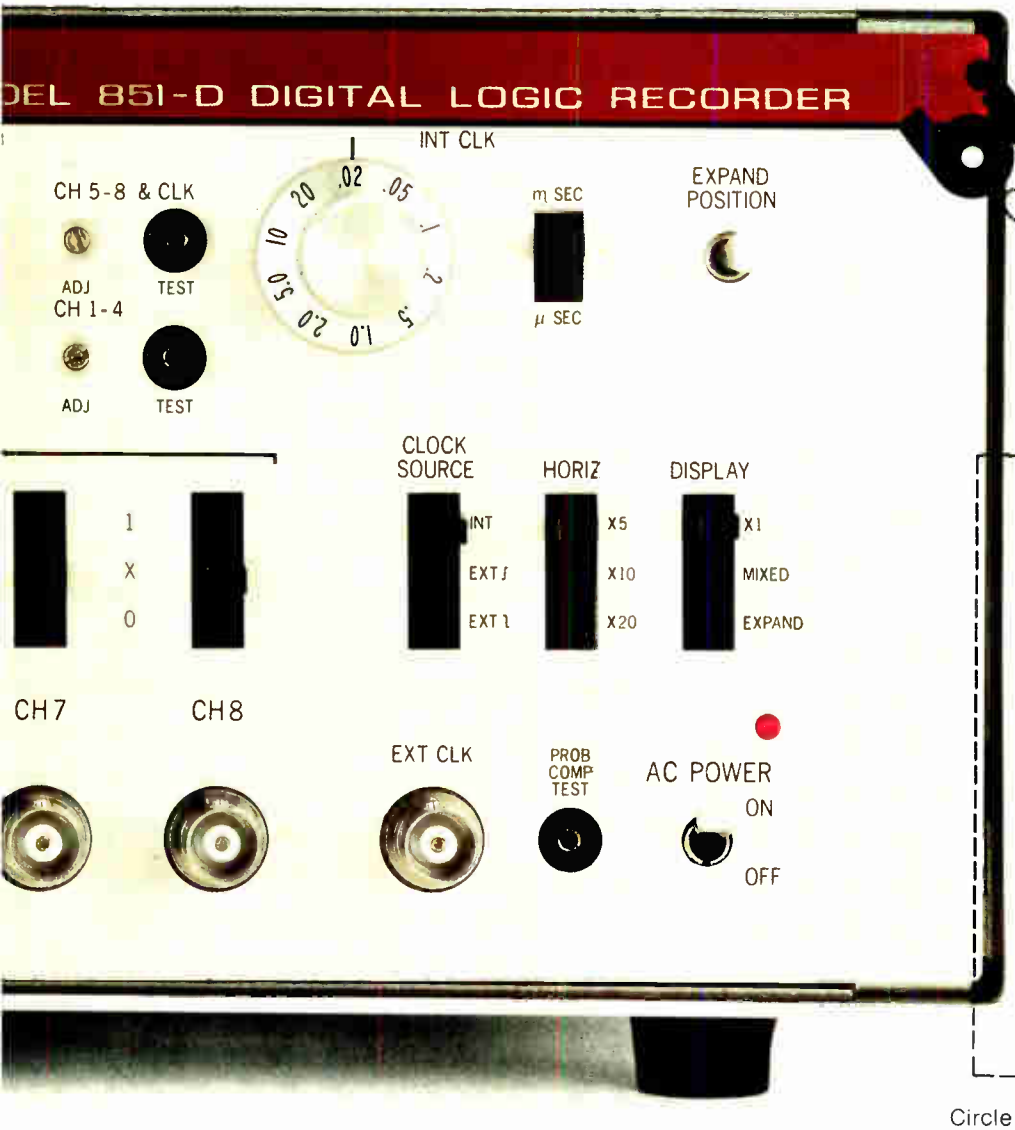
Creating tools for technology



- [ ] Sounds great, but I don't know what all of the features actually do. Please send more information
- [ ] Send information on your complete digital logic analyzer line

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Biomation
10411 Bubb Road Cupertino CA 95014. (408) 255-9500.
TWX 910 338 0226

Circle 13 on reader service card 13

People

Now at National, Ebertin sees calculator growth

Even though the calculator market, especially the low-priced end, appears to be approaching saturation, don't expect it to go away. What's more, the complex MOS LSI chips that created it are sure to be used in a number of creative ways to generate products markets with growth potentials just as dramatic as calculators.

In addition to those expectations, 39-year-old Michel Ebertin predicts that his new employer, National Semiconductor Corp., will continue to be a large factor in calculators and a leader in the new calculator-spawned markets. Formerly director of calculator product marketing at Rockwell International, Ebertin just a few weeks ago moved to National as operations director for calculator, game, and microcontroller products.

"When transistor radios first came out," says the 6-foot, 2-inch French-born, but Brooklyn-raised engineer, "it was said that once everybody had one and the market was saturated, the market would go away. Well, everyone is not only still buying transistor radios, they're buying bigger and better ones." Just as developing expertise led to new growth markets for transistor radios, he says, so, too, will it benefit calculators.

National's just-introduced calculator-chip-based microcontroller family [*Electronics*, May 27, 1976, p. 146] is a good example, says Ebertin, of the way calculator makers such as the Santa Clara, Calif., company will attack a number of new markets.

"One new market area that is particularly exciting to me is personal electronic games," says the man who was not only prominent in launching Rockwell into the calculator and microprocessor business but was instrumental in defining devices in both areas that have become industry standards. "I don't mean video Pong-type games. I'm talking about calculator-based games an individual can play either all alone or against someone else."

At play. Michel Ebertin predicts big gains for calculator-based games.

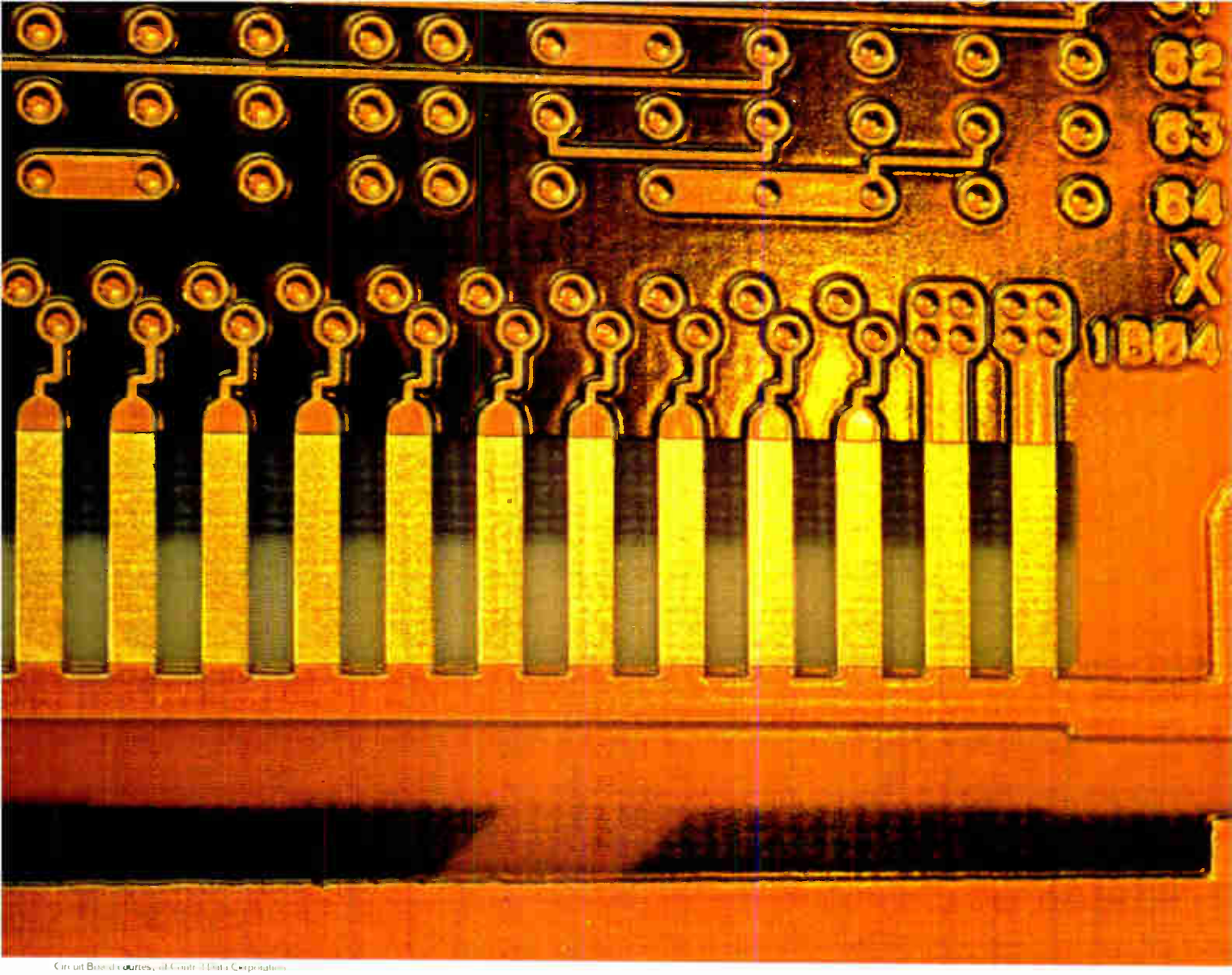
National's first effort in this direction, he says, will be with Quiz Kid II, introduced at the Consumer Electronics Show. On it children can play arithmetic games alone or against each other. "And that's just the beginning. The possibilities are endless and profitable."

Bourns's Entrekin plans intensified market research

Being named president of $100 million Bourns Inc., succeeding company-founder Marlan E. Bourns, gives Guy B. Entrekin Jr. obvious pleasure. But it also poses some questions for a man of his reflective nature. Uppermost is how to continue the company's healthy growth. "That's a hard act to follow," he remarks.

Sales of the Riverside, Calif., company doubled from 1966 through 1975, with profits nearly keeping pace until the recession and other problems triggered a sharp decline last year. Entrekin served as executive vice president and chief operating officer since 1974, moving up through the hierarchy after joining the firm in 1963.

One way Entrekin plans to capture continued growth is to put even



Circuit Board courtesy of Control Data Corporation

How much gold can new RISTON* Phototape save you?

Perhaps, quite a bit. We call RISTON Phototape "the gold-saver" because it eliminates wasteful plating of busbars and robber's edges. And that means less gold for the reclaiming process.

RISTON Phototape also makes more sense, since it uses the same equipment as your RISTON dry-film process. With a minor modification of your RISTON HRL-24 Laminator, you can increase productivity and reduce the operating cost of your yellow room.

Ask your RISTON Technical Representative to show you just how much gold you can save with RISTON Phototape. And you'll get an obvious bonus in high-quality board work with the sharpest lines of demarcation.

RISTON Phototape—another innovation from Du Pont—brings the accuracy of dry-film photo-imaging to your plating operation. It's part of Du Pont's commitment to bring increased productivity and higher reliability to your board-making systems.

Call your Du Pont RISTON Technical Representative today. Or write: Du Pont Company, Room 25007, Wilmington, Delaware 19898.

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RISTON Division

DU PONT

Electronics

People

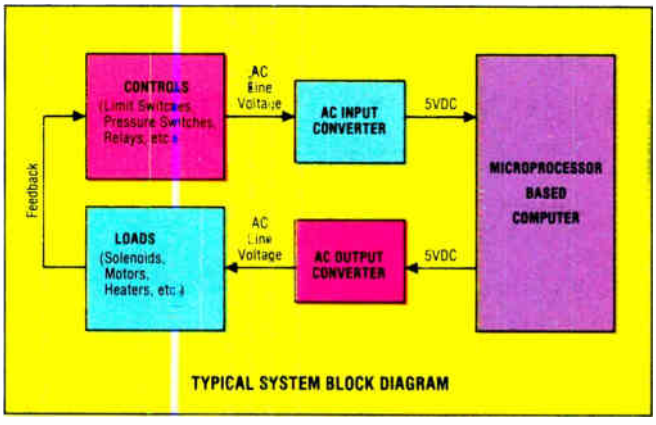
more push into the planning, development, and marketing of Bourns's major product lines: trimming potentiometers. Here, the usually cautious Entrekin flatly asserts, Bourns is number one in the field. "Our basic concepts and philosophy remain the same—making the best possible potentiometers." However, he confesses to a plan to tinker with the success formula—"to do an intensified job of market research and see how big a need exists before we build a product."

Bourns' biggest headache right now comes from a French manufacturing subsidiary, Ohmic, which is piling up sizable monthly losses because of the depressed European market for components. Bourns wants to sell Ohmic, but hasn't found a buyer, and to reduce the work force, but the French government won't allow it. Bourns is continuing to negotiate, and Entrekin is optimistic about bringing the situation under control.

Another matter that has caused Bourns no end of trouble is litigation concerning its efforts to buy out all shareholders and return to being a private company. Entrekin, reiterating company policy, says that this plan has been dropped. While the company might buy more shares, there are no plans to do so at present.

Strategy. New president of Bourns, Guy B. Entrekin says basic concepts will remain.

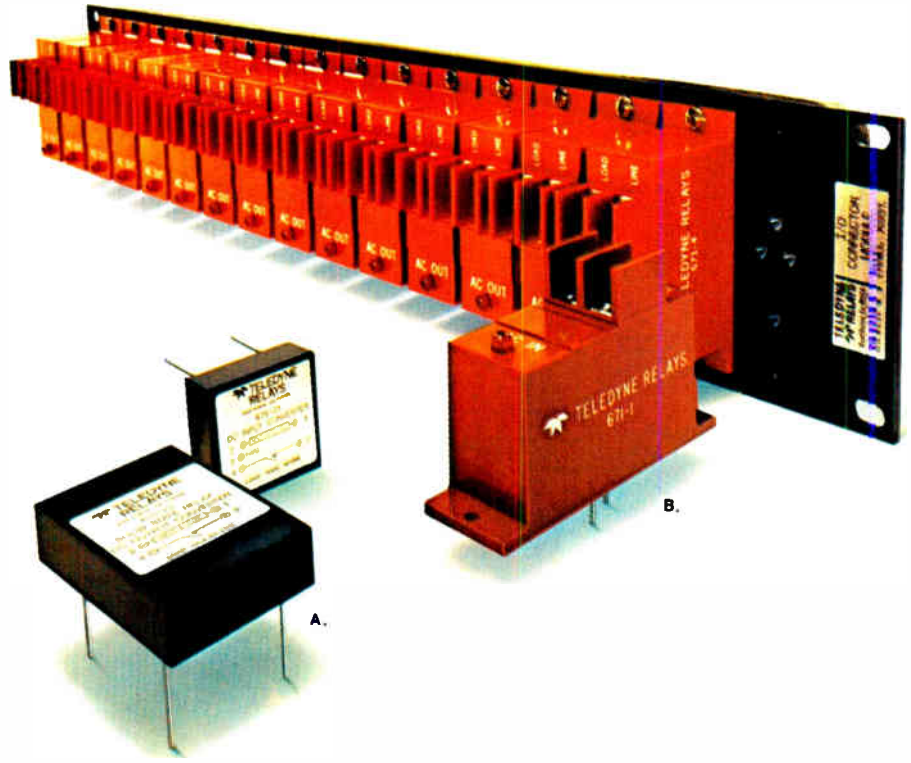
Microprocessors take control with Teledyne I/O converters



TYPICAL SYSTEM BLOCK DIAGRAM

Modular packaging of input/output interface circuitry. That's what Teledyne I/O Converter Modules provide microprocessor based industrial controls for maximum I/O flexibility and expandibility. This single circuit modular concept features all-solid-state circuitry, 1500V optical isolation, and high noise immunity. Our 671 Series modules plug directly into a low cost custom-designed mounting panel, which physically isolates service wiring from logic connections. For pc boards, we offer the same circuitry in our 675 Series low profile package. Both series include ac and dc input/output converters.

So for the best in I/O interface circuitry for microprocessor based industrial controls, contact the people who know the "ins and outs" of this business — Teledyne Relays.



A. 675 Series — Low profile I/O converter modules for pc board mounting

B. 671 Series — Panel mounted I/O converter modules (with integral LED status indicators)

C. 671P Series — Custom-designed mounting panel

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The Battle of the 80's

Think of your next microcomputer as a weapon against horrendous inefficiencies, outrageous costs and antiquated speeds. We invite you to peruse this chart.

Features:	8080A	Z80-CPU	Features:	8080A	Z80-CPU
Power Supplies	+5, −5, +12	+5	Instructions	78	158*
Clock	2Φ, +12 Volt	1Φ, 5 Volt	OP Codes	244	696
Standard Clock Speed	500 ns	400 ns	Addressing Modes	7	11
Interface	Requires 8222, 8228 & 8224	Requires no other logic and includes dynamic RAM Refresh	Working Registers	8	17
			Throughput	Up to 5 times greater than the 8080A	
Interrupt	1 mode	3 modes; up to 6X faster	Program Memory Space	Generally 50% less than the 8080A	
Non-maskable Interrupt	No	Yes	*Including all of the 8080A's instructions.		

Announcing Zilog Z-80 microcomputer products. With the next generation, the battle is joined.

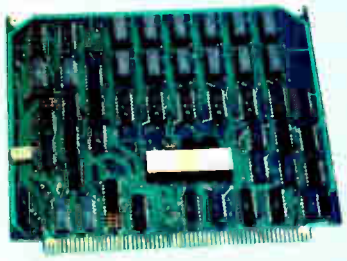
The Z-80: A new generation LSI component set including CPU and I/O Controllers.

The Z-80: Full software support with emphasis on high-level languages.

The Z-80: A floppy disc-based development system with advanced real-time debug and in-circuit emulation capabilities.

The Z-80: Multiple sourcing available now.

Your ammunition: A chip off a new block.



A single chip, N-channel processor arms you with a super-set of 158 instructions that include *all* of the 8080A's 78 instructions with *total* software compatibility. The new instructions include 1, 4, 8 and 16-bit operations. And that means less programming time, less paper and less end costs.

And you'll be in command of powerful instructions: Memory-to-memory or memory-to-I/O block transfers and searches, 16-bit arithmetic, 9 types of rotates and shifts, bit manipulation and a legion of addressing modes. Along with this army you'll also get a standard instruction speed of 1.6 μs and all Z-80 circuits require only a single 5V power supply and a single phase 5V clock. And you should know that a family of Z-80 programmable circuits allow for direct interface to a wide range of both parallel and serial interface peripherals and even dynamic memories without other external logic.

With these features, the Z80-CPU generally requires approximately 50% less memory space for program storage yet provides up to 500% more throughput than the 8080A. Powerful ammunition at a surprisingly low cost and ready for immediate shipment.

Mighty weapons against an enemy entrenched: The Z-80 development system.

You'll be equipped with performance and versatility unmatched by any other microcomputer development system in the field. Thanks to a floppy disc operating system in alliance with a sophisticated Real-Time Debug Module.

The Zilog battalion includes:

- Z80-CPU Card.
- 16K Bytes of RAM Memory, expandable to 60K Bytes.
- 4K Bytes of ROM/RAM Monitor software.
- Real-Time Debug Module and In-Circuit Emulation Module.
- Dual Floppy Disc System.
- Optional I/O Ports for other High Speed Peripherals are also available.
- Complete Software Package including Z-80 Assembler, Editor, Disc Operating System, File Maintenance and Debug.

On standby: Software support.

All this is supported by a contingent of software including: resident microcomputer software, time sharing programs, libraries and high-level languages such as PL/Z.

On standby: User support.

Zilog conducts a wide range of strategic meetings and design oriented workshops to provide the know-how required to implement the Z-80 Microcomputer Product line into your design. All hardware, software and the development system are thoroughly explained with "hands-on" experience in the classroom. Your Zilog representative can provide you with further details on our user support program.

Reinforcements: A reserve of technological innovations.

The Zilog Z-80 brings to the battlefront new levels of performance and ease of programming not available in second generation systems. And while all the others busy themselves with overtaking the Z-80, we're busy on the next generation—continuing to demonstrate our pledge to stay a generation ahead.

The Z-80's troops are the specialists who were directly responsible for the development of the most successful first and second generation microprocessors. Nowhere in the field is there a corps of seasoned veterans with such a distinguished record of victory.

Signal us for help. We'll dispatch appropriate assistance.

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Meetings

International Microwave Symposium, IEEE, Cherry Hill Inn, Cherry Hill, N.J., June 14–16.

Electrical Insulation International Symposium, IEEE, Queen Elizabeth Hotel, Montreal, Que., June 14–16.

ICC '76 International Conference on Communications, IEEE, Marriott Motor Hotel, Philadelphia, June 14–16.

Joint MMM-Intermag Conference, IEEE and AIP, Hilton Hotel, Pittsburgh, June 15–18.

Fault-Tolerant Computing Conference, IEEE, Chatham Center, Pittsburgh, Pa., June 21–23.

Device Research Conference, IEEE, University of Utah, Salt Lake City, June 21–23.

Electronic Materials Conference, AIME, University of Utah, Salt Lake City, June 23–25.

13th Design Automation Conference, ACM and IEEE, Rickey's Hyatt House, Palo Alto, Calif., June 27–29.

Conference on Precision Electromagnetic Measurements, IEEE, NBS, and URSI, NBS Laboratories, Boulder, Colo., June 28–July 1.

Symposium on Frequency Standards and Metrology, NBS and URSI, Copper Mountain, Colo., July 5–7.

Summer Computer Simulation Conference, IEEE *et al.*, Sheraton Park Hotel, Washington, D.C., July 12–14.

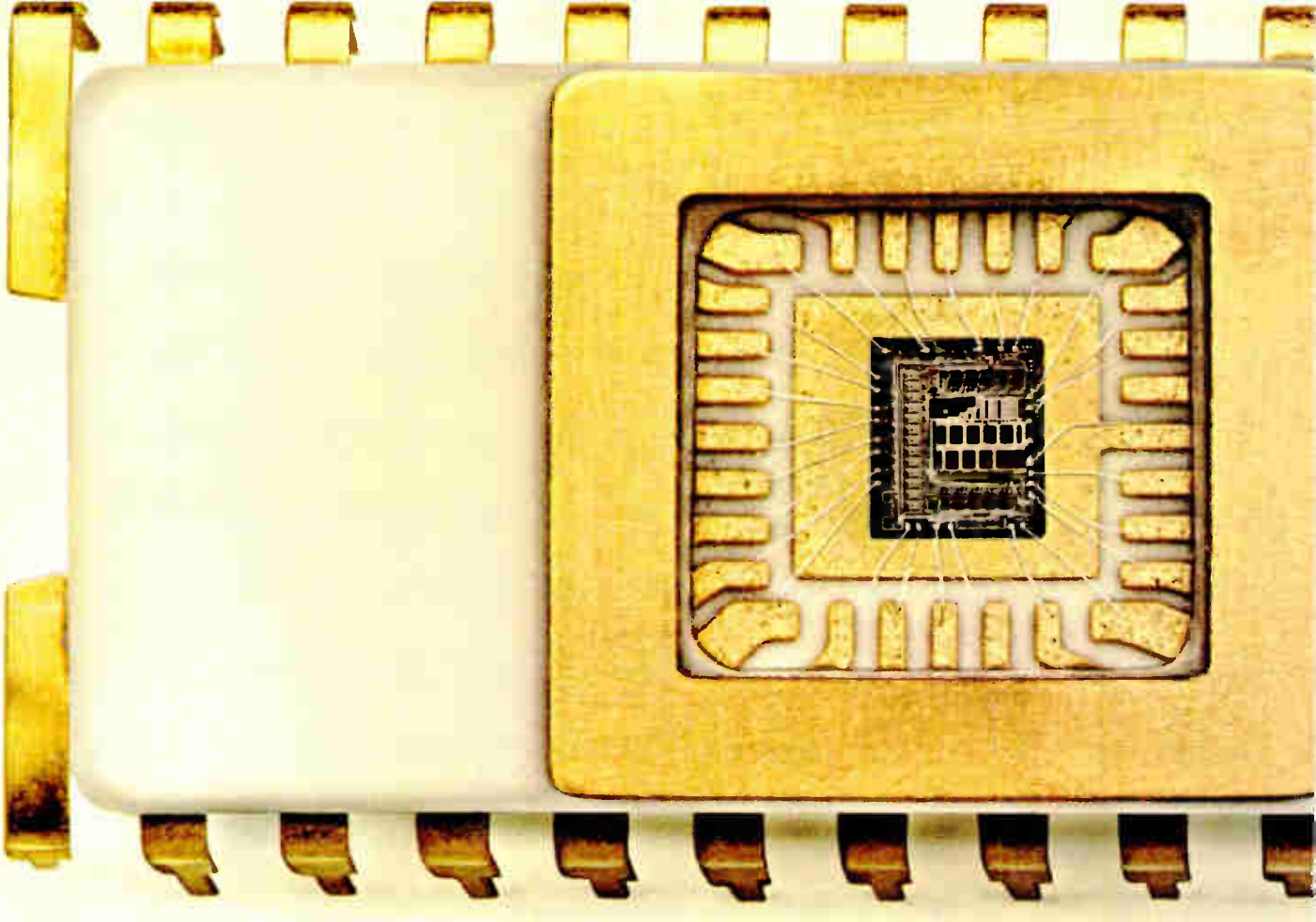
Power Engineering Society Summer Meeting, IEEE, Portland Hilton Hotel, Portland, Ore., July 18–23.

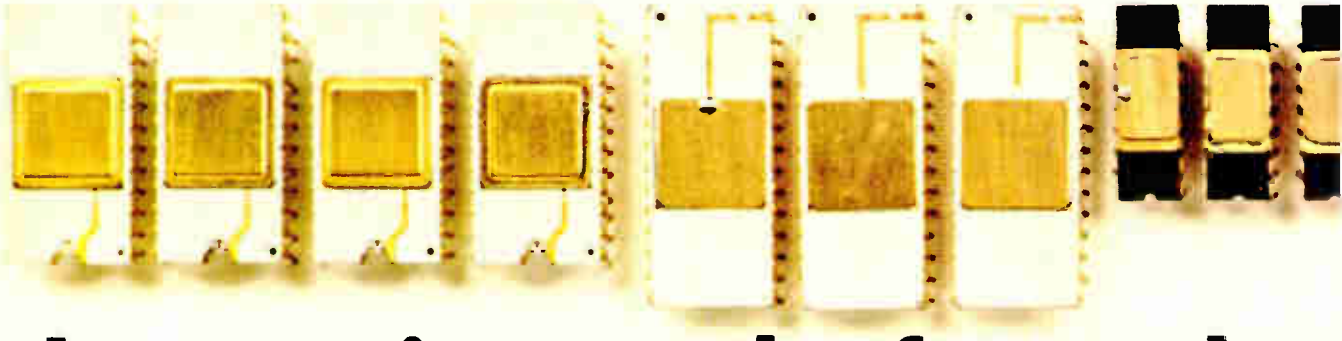
Nuclear and Space Radiation Effects Conference, IEEE, University of California, San Diego, July 27–30.

International Microwave Power Symposium, International Microwave Power Institute, (Edmonton, Alberta, Canada), Louvain, Belgium, July 27–30.

Some companies call two IC Converters a complete line.

Now if they only had the one you wanted.





Analog Devices. We're for real.

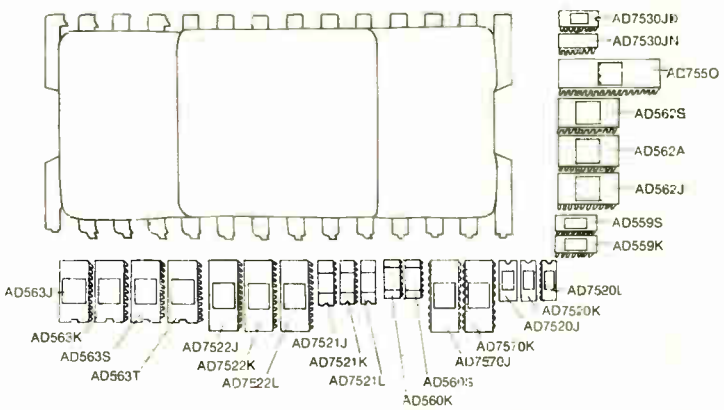
It's hard to tell what's real and what's make believe nowadays. With all the claims and counterclaims about IC Converter capability.

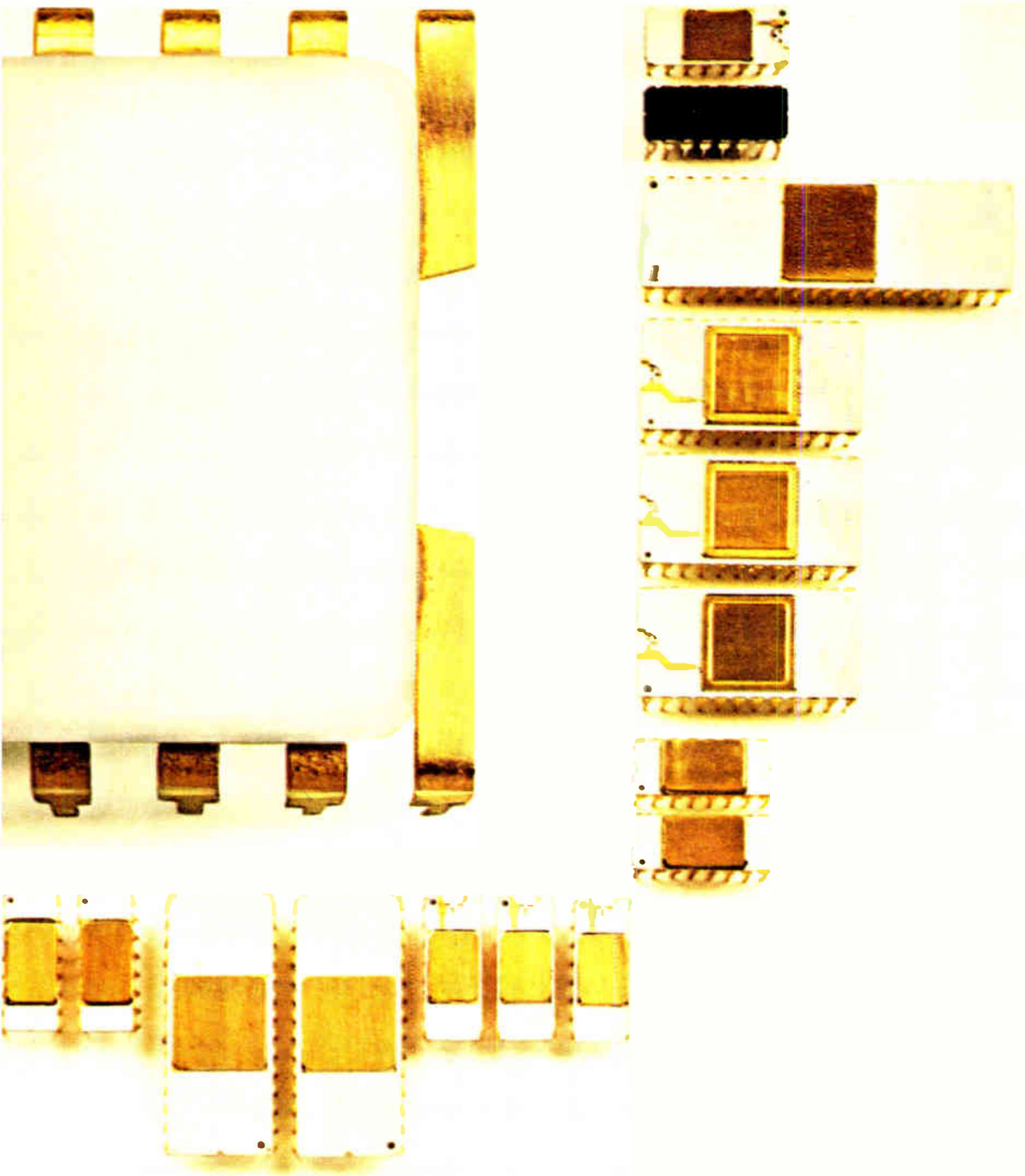
We want to set the record straight.

The Analog Devices IC Converter expertise is more than talk. More than product. More than potential.

It's our ten years experience in data converter technology. It's the support and characterization of our family of IC Converters. It's the assessment of market needs, the implementation to meet those needs. It's the reality of a worldwide technical sales force that knows the IC Converter business from design through application. It's helping our customers solve their problems more efficiently.

The real world. Real products are the first measure of leadership. We have more than twenty bona fide IC Converters for immediate delivery in quantity. A dozen or so more are in the wings which boast the advantages of low power CMOS and high stability bi-polar construction. Analog Devices IC Converters





give you the solution to the very real problems of cost, reliability and performance.

From the 10-bit CMOS DAC, AD7520, to the 12-bit laser trimmed DAC's, the AD562 and AD563, and the microprocessor compatible 13-bit CMOS A/D Converter, AD7550, you'll find the right IC Converter to meet your specific needs. They're all available in a variety of performance and package options.

Making it real. IC production technology at Analog Devices is what separates us from our competition. Carefully controlled processes ensure the highest possible yield even on the most difficult chips. Add the fact that our IC Converters are true IC Converters specifically designed to maximize the advantages of bi-polar and CMOS technology with a minimum number of chips. Plus our exclusive laser trimming to guarantee IC Converter performance and our policy of 100% testing for complete stable final characterization of each device make us your best source of IC Converters. We're the real company in precision measurement and control.

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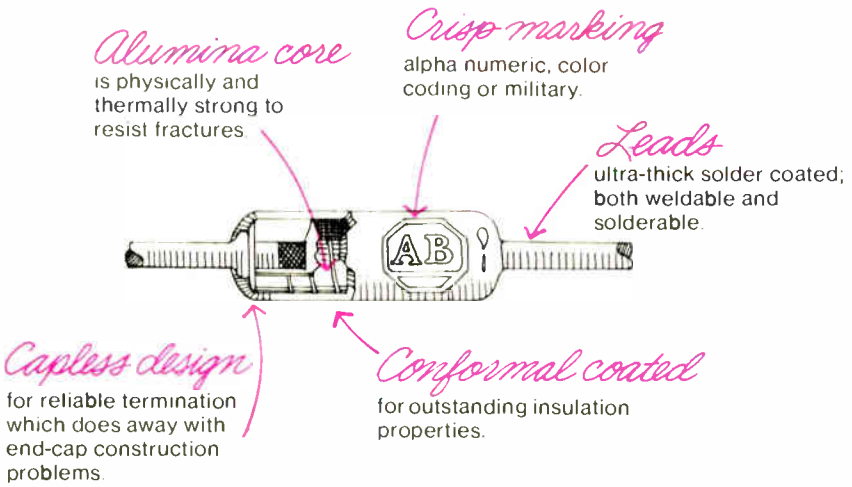
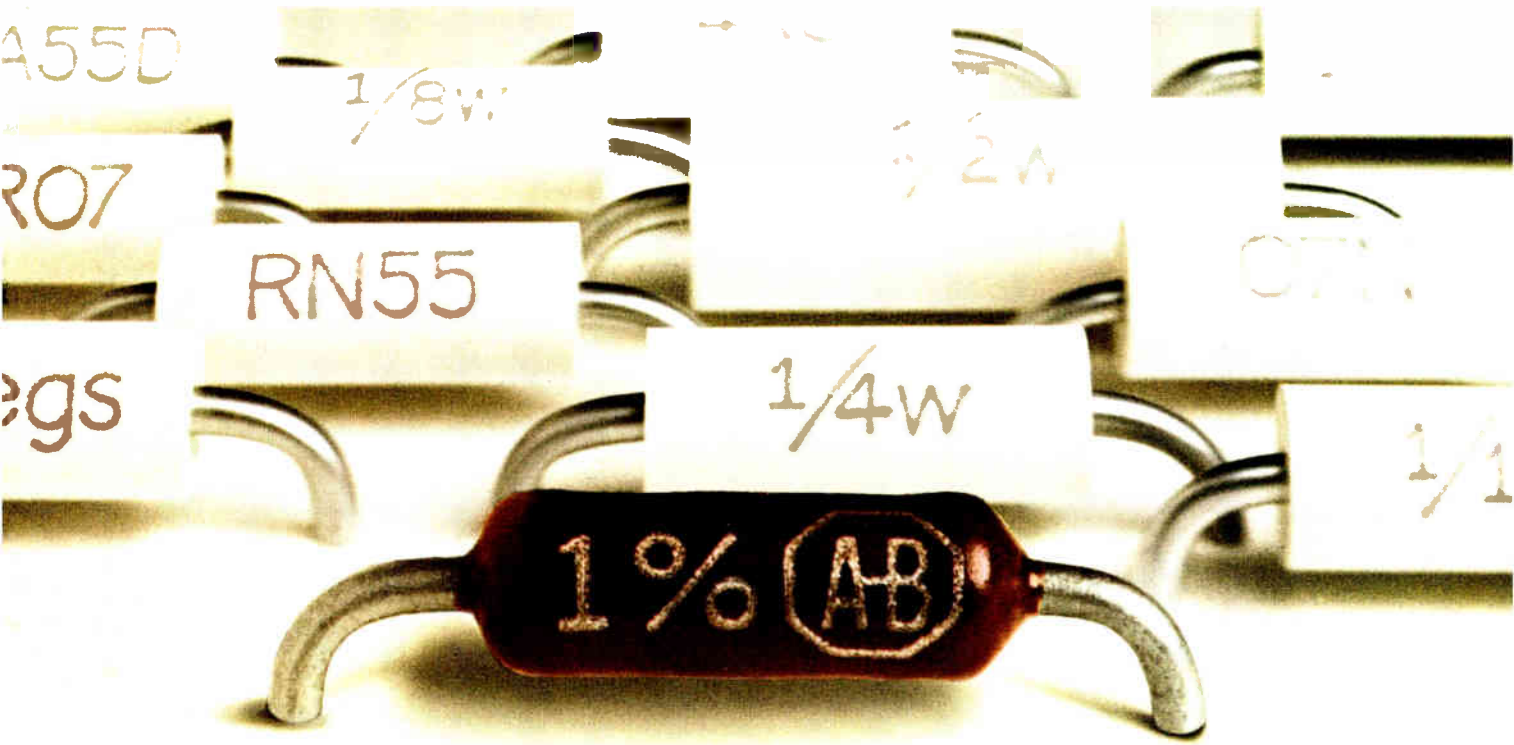
Here's a way to cut the daylights out of your fixed resistor inventory. Standardize on our Type CC cermet. It's sized like a ¼-watt but you get performance that ranges from ⅛-watt at 125°C to ½-watt at 70°C (250 volt max.) Tolerance is 1% over the complete resistance range of 10 ohms to 22.1 megs or 0.5% from 10 ohms to 499K. TCR is as low as ± 50 ppm/°C. The one resistor for all reasons: industrial, RN55C, RN55D and RLR07 needs to 1% and 2% tolerance. We have what you need; our distributors have it when your need is now. Ask for Publication EC33.





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EC129

Electronics newsletter

Bumped film carrier handles most ICs

A new bumped film carrier developed by Pactel Corp. of Westlake Village, Calif., may make it possible **to assemble hybrid ICs with the film-carrier or beam-tape automated method.** Up to now, the need to have the bumps—extra metalization—built up over a chip's normal aluminum pads has limited film-carrier packaging mainly to high-volume digital ICs in dual in-line packages. The bumps protect the chips from the heat of thermocompression bonding.

Developed by Pactel for General Dynamics, the new tape chip carrier has copper IC patterns on one side of a polyimide tape, just like the conventional film carrier. However, the inner leads of the new type tape patterns are in electrical contact with specially metalized, 3-mil-high bumps on 8-mil centers on the other side of the tape. **This eliminates the need for special wafer metalization,** with its attendant costs, yield losses, and reduced chip availability. What's more, it is compatible with virtually all IC chips.

Prime first to use commercial 16-k RAMs in system

It appears that the first computer manufacturer to announce a memory based on the new **commercially available 16-kilobit random-access memory chips** is Prime Computer Inc., Framingham, Mass. Four-Phase Systems, Cupertino, Calif., had previously announced a computer using its own 16-k RAM chips [*Electronics*, Nov. 27, 1975, p. 36]. Prime says it is demonstrating a memory using Intel chips and packing 256,000 bytes on a board measuring 16 by 18 inches. The memory plugs into the company's new model 400 computer [*Electronics*, Feb. 5, p. 92] and allows the computer to be expanded up to 8 megabytes of directly addressable memory.

Price of the board will be $35,000 says Prime, but deliveries will be on a system-by-system basis until the company is satisfied that it can get enough 16-k chips to assure regular deliveries. That announcement probably will be made in September.

Mostek shipping samples of its 16-k RAM

Mostek Corp. has begun to ship sample quantities of its 16-k RAM, the MK 4116. Close to a dozen major customers have seen parts; **access times are all faster than 200 nanoseconds.** Mostek is the third vendor to sample a 16-pin 16-k RAM, following the Intel and Texas Instruments versions released earlier this year [*Electronics*, Jan. 8, p. 27]. Like TI's, and unlike Intel's, Mostek's requires 128 refresh cycles and uses unlatched outputs. The firm expects to build production steadily, reaching as many as 10,000 a week by January.

Displays combine maps, computer data

Control Data Corp. and Litton Display Systems are expected to receive this month several million dollars each to develop what are perhaps the largest displays ever built with their respective and competing technologies. As the second phase of its Interactive Computer Presentation Panel project to combine standard maps and computer-generated information, the Army is paying for two approaches: **Control Data's transparent plasma panel over standard paper maps, and Litton's transparent maps over a light-emitting-diode display.** Two years from now, the firms will compete head-on for the program's engineering development phase.

Electronics newsletter

Under an initial study contract completed early this year, Control Data built a 16-by-16-inch transparent display. It plans to demonstrate that display with a backlighted map in a battlefield scenario at this month's Armed Forces Communications and Electronics Association show in Washington, D.C. Litton will be there, too, to demonstrate its display, which is designed around 392 edge-stackable plug-in LED modules.

IEEE presidential race shifts into earnest campaigning . . .

Both candidates-by-petition for president of the IEEE now claim to have the **signatures of enough members to get on the fall election ballot** and to have their campaign statements plus rebuttals appear in the August issue of the institute's monthly publication, Spectrum. While the submitted signatures were being validated, Irwin Feerst reported a count of more than 3,300 and Robert Rivers, more than 1,600. Both exceed the 1,448 signatures required to make the ballot and run against the candidate nominated by the board of directors, Robert Saunders. And Carlton Bayless has collected enough signatures to challenge Robert Buskman for executive vice president.

. . . and a campaign statement runs into trouble

The main objective of getting the required number of signatures validated early this month, even though it is possible to continue collecting names until the end of July, was to provide time for Spectrum to prepare the candidates' statements and rebuttals for August publication. However, the procedure may be interrupted by **a squabble between candidate Feerst and the IEEE headquarters.**

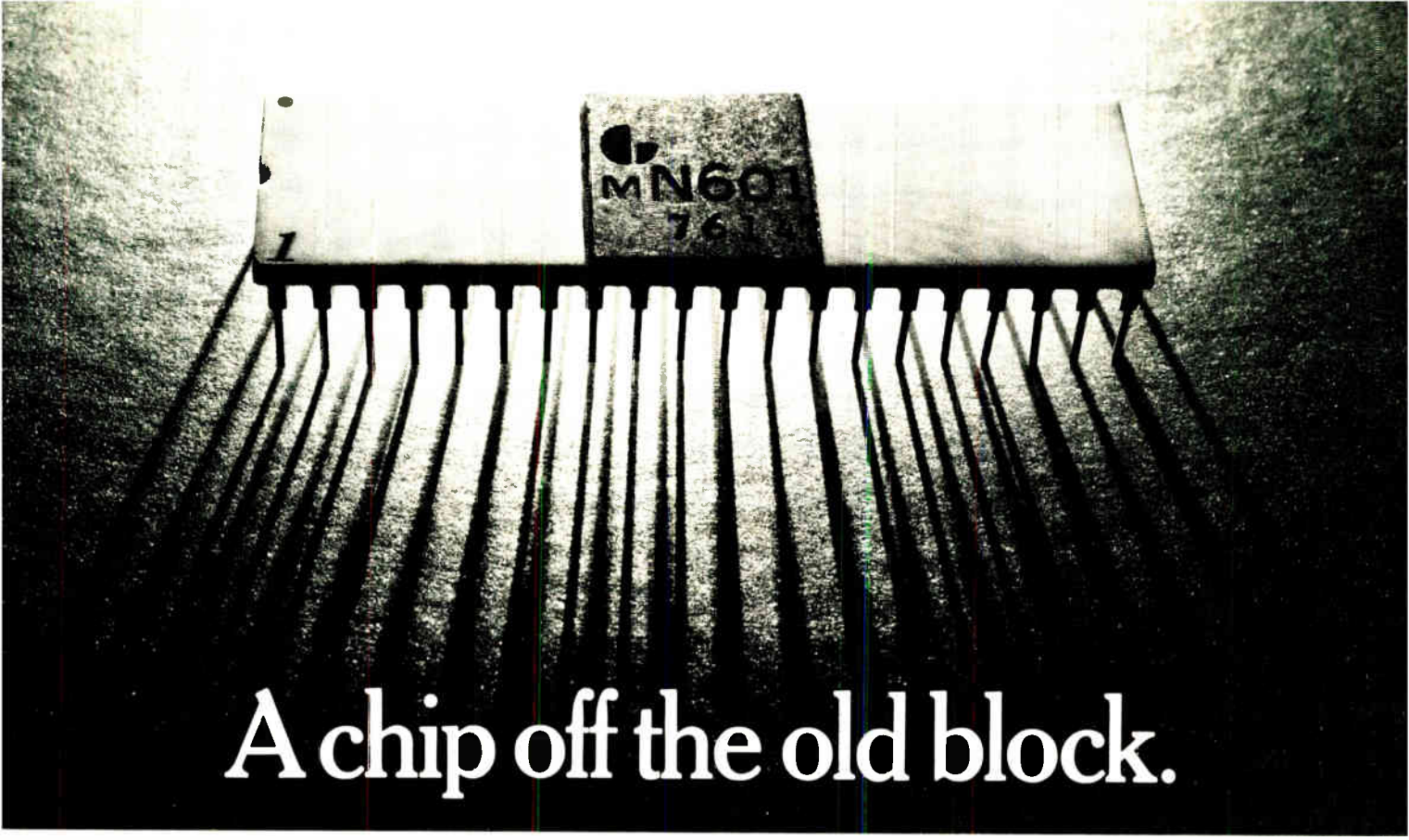
Feerst submitted his statement in the form of a flow chart, similar to a computer decision-block diagram, which was rejected as not fitting the format stipulated by the magazine. Spectrum is editing the diagram to follow the usual candidate statement style, in order to avoid delaying publication, but Feerst is not satisfied, because, first, notification of rejection came from IEEE general manager Herbert Schulke, rather than the Spectrum editor, and second, the magazine uses flow charts in other articles.

Auto makers looking at 80-cent temperature sensor

Dale Electronics has started sending to the auto firms samples of a wirewound nickel, bobbin-type temperature sensor that it will sell for 80 cents each in large quantities. **The barebones unit, suitable for measurements of air temperature, has a response time of 7 seconds,** compared to the 35 seconds response time of the firm's $2.75 molded sensor, now used to sense air and water temperatures for the Bendix fuel-injection system in Cadillac Sevilles.

Canada's air-traffic system ready to be tested

The Canadian government's highly automated air-traffic-control system **will begin performance-evaluation tests later this month or early next.** Called JETS, for joint en-route terminal system, the concept uses CRT terminals linked to Interdata minicomputers in a distributed-processing system, and was designed by Sanders Associates, Nashua, N.H. Sanders has licensed CAE Industries in Ottawa, Ont., to build a large part of the display. When phase one of the contract is completed, seven en-route and two terminal centers will be equipped, requiring 140 systems in all.



A chip off the old block.

As you can see, this chip is housed in ceramic and mounted in a forty pin, dual in-line package.

As you can't see, it's a NOVA® computer.

Inside that packaging sits a full 16-bit, silicon gate, NMOS microNOVA CPU. The mN601.

The mN601 is the first microprocessor designed and manufactured by a minicomputer company. And it's the highest performance NMOS microprocessor on the market. With our 160 nanosecond RAM, it has a memory cycle time of 960 nanoseconds and the fastest instruction times going. Like an Add of 2.4 microseconds. And a Load of 2.9 microseconds.

The mN601 has the 16-bit NOVA instruction set including hardware stack for easy programming. And 16-bit data for efficient memory use.

It also has hardware multiply/divide for fast program execution. Integral data channel logic for easy interfacing to high performance peripherals. Control and timing for high density RAM memories. Integral hidden refresh logic that overlaps instruction execution timing. Plus a unique I/O encoding scheme for efficient easy interface design. Even the real-time clock is included. All of which reduces the chip count.

And all that computer is in a single chip.

And because the mN601 is a NOVA, it uses the most mature, field-proven software you can get with any micro. So you can cut back on development time and cost by using compatible software like our diskette-based Disc Operating System and our Real-Time Operating System.

Also, the mN601 comes with the full documentation support you'd expect from a minicomputer company like Data General.

If you want more than a chip, you can get it. There's a whole chip set, a 4K computer-on-a-board and a fully-packaged 9-slot microNOVA MOS mini. And there's more.

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Sign up for a technical seminar on the microNOVA. They'll be held in major cities around the country from New York to Los Angeles. They'll last a half-day. And they're free.

For more information call our toll free number, 800-225-9497 (Unless you're in Massachusetts. In which case, call 1-617-485-9100 Ext. 2509.)

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Circle 27 on reader service card

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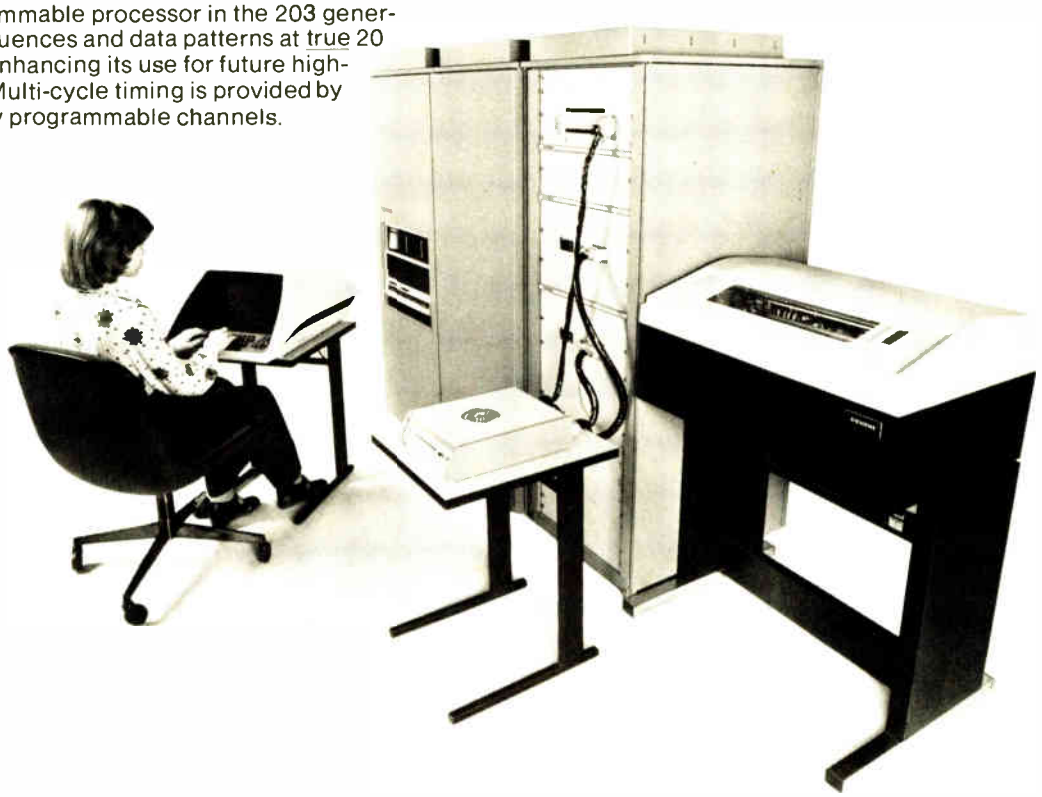


National's scientific calculator has long-term all-semiconductor memory

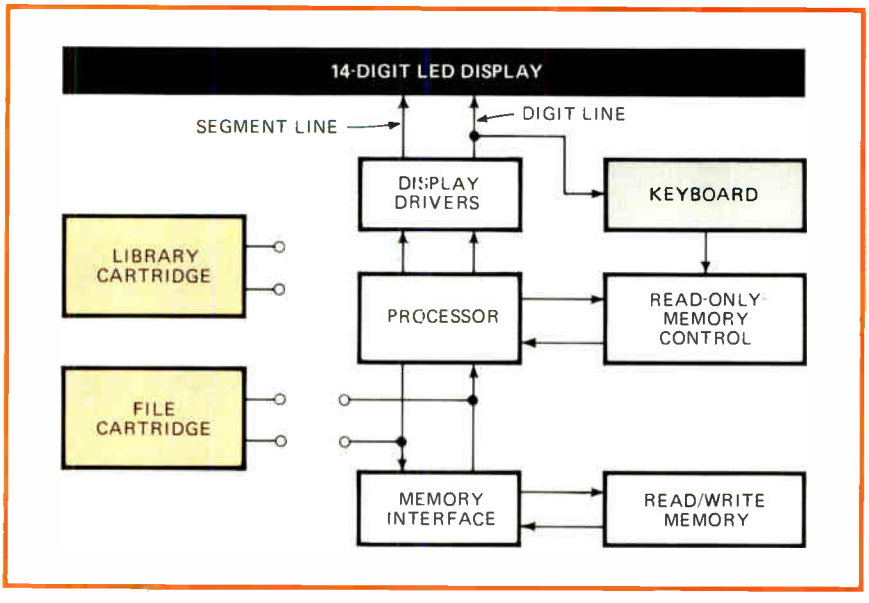
C-MOS, MNOS, and p-MOS memory elements, plug-in program units help 7100 handle 4,240 program steps

The permanent-program-storage end of the hand-held-calculator market has so far been the exclusive domain of the $795 HP-65 and the $395 SR-52. Both Hewlett Packard and Texas Instruments, though, will have to move over and make room for a powerful new member of the club from National Semiconductor Corp.—the all-semiconductor-memory 7100, which will be ready for this Christmas season.

With the all-semiconductor approach taken with the 7100, according to Robert Johnson, director of advanced calculator development at the Santa Clara, Calif., firm, three different types of memory are used to achieve nonvolatility. Present calculators, including the HP-65 and the SR-52, use standard p-channel metal-oxide-semiconductor random-access memories that lose their data when the power is turned off. The 7100 will be the first to feature complementary-MOS RAMs that in the standby mode retain information indefinitely using only a battery's trickle current.

Then, instead of preprogramed magnetic cards, the 7100 features factory-preprogramed plug-in "library" cartridges containing a 16,384-bit p-MOS mask-programmable read-only memory. Finally, instead of another set of blank magnetic cards on which a user can permanently store his own specially developed programs, there is a user-alterable plug-in file cartridge containing two 1,024-bit nonvolatile metal-nitride-oxide-semiconductor RAMs, capable of retaining data for years without power. These cartridges will cost about $20 apiece.

According to Kris Graham, 7100 product-marketing manager, the heart of the $395 calculator is a 1.5-by-2.5-inch printed-circuit board containing 11 chips essential to the system: four 1,024-bit C-MOS RAMs, three p-MOS read-only memory control elements organized as 32 pages of 64 eight-bit instruction words each, the p-MOS memory and processor element, a RAM-interface chip, and two bipolar interface chips to the 14-digit LED display.



Overpowering. The fact that the preprogramed plug-in ROM acts as an integral part of the system, says Graham, makes it unnecessary to "dump" it into working registers and frees the internal memory, giving the 7100 a number of capabilities that simply overpower the competition. Internally, for example, the calculator has 240 merged-program steps and 32 user-available data-storage registers, compared with 224 steps and 20 registers for the SR-52 and 100 steps and 9 registers for the HP-65. "In addition," Graham says, "use of the factory-recorded programs in the library cartridges as subroutines to the program in the mainframe memory brings the total program step capacity to 4,240."

If the user develops a program that is greater than the 240 merged steps in the internal memory, another 240 steps can be stored on the MNOS file cartridge and used as a subroutine. By comparison, to store 4,240 steps in the SR-52 would require 21 cards and in the HP-65, 43

Electronics review

cards. "And in neither case would the steps be available as subroutines to the internal memory," says Johnson. The 7100 has four subroutine levels and eight program flags, versus 2 and 5 for the SR-52 and 1 and 2 for the HP-65 as well as 66 keyboard functions versus 51 for the HP-65 and about 80 for the SR-52. However, the 7100 has 23 key functions for programing.

Other features include backspace, insert, single-step, delete, and pack capabilities for debugging, editing, and reviewing programs; symbolic labeling; conditional and unconditional branching; and decrement and branch of zero. Unlike the HP-65 with its reverse-Polish notation, the 7100 uses straight algebraic logic and has only 3 levels of parentheses versus the 9 for the SR-52.

The comparatively low cost of the 7100, says Johnson, comes not only from the elimination of the motor-driven card reader, but also from the use of standard chips. "Except for the 16-k ROM in the library cartridge, which was designed specifically for this calculator application, and the MNOS RAMs supplied by an outside vendor, everything is available from one of several standard National families of devices."

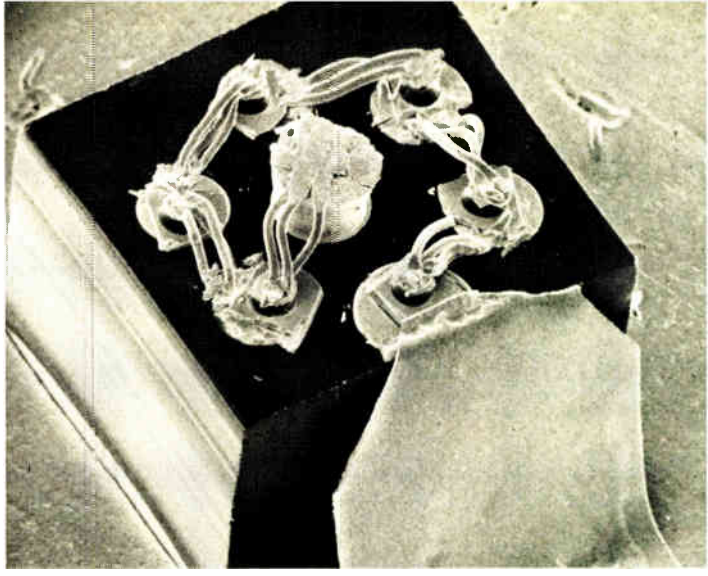
Johnson expects to be in production with the 7100 in time for the Christmas season. Supplied with the calculator will be two file cartridges, a library cartridge with a 75-program mathematics package, a battery pack, carrying case, charger, and instructions. Financial, statistical, and engineering cartridges are in development. □

Solid state

Six Trapatts yield 35 W at 7.5 GHz

In the search for high-power solid-state sources for long-pulse radar transmissions, researchers have tried to connect Trapatt diodes in series to increase power. The trouble is, in experiments so far, the diodes' thermal paths were also in series, which made continuous-wave or long-pulse operation impossible.

Now engineers at the Georgia Institute of Technology have applied computer simulation to the circuit characterization of the Trapatt diode, including mounting parasitics. The resulting packaging guidelines, coupled with much experimentation, has led them to a remarkably efficient structure: six Trapatt diode chips on a diamond substrate. While the chips are mounted electrically in series, thermally they are in parallel.



Real jewel. Six mesa Trapatt diodes, surrounding copper post used to contact center conductor of coaxial transmission line, are mounted on 0.03-inch-square, 0.20-inch-high diamond substrate.

With the diamond substrate specially selected for good thermal conductivity and measuring only 0.03 inch square by 0.02 in. high, the circuit produces 35.5 watts at 7.5 gigahertz. Other combinations of two, three, and four chips provided 12, 14, and 21 W at about 8.7 GHz. All circuits achieved nearly 100% combining efficiencies.

Parallel operation. Walter Cox, head of the solid-state sciences division of Georgia Tech's Engineering Experiment Station, says that parallel operation is a must. Pulse widths of 50 microseconds look like cw operation to the diodes because for those time intervals, the diode approaches thermal equilibrium. Efficiently series-combining the diodes increases the rf impedance of the combination, easing matching.

Initial experiments in the project, which had support from the Naval Electronic Systems Command, were conducted at 2 GHz. The diode chip was mounted on a diamond substrate along with an alumina capacitor on a copper slug, and a gold wire was attached to the capacitor and to the top of the diode chip. Various package capacitance values were made by changing capacitors, and diode lead-inductance variations were made by adjusting the number and length of contact wires.

There was a drastic change in conversion efficiency for capacitance values greater than 1 picofarad, yet variations in lead inductance had little effect. Above a maximum value of package capacitance, which is related to the diode depletion-layer capacitance, the characteristic Trapatt voltage waveform is lost.

Packaging. Further computer simulation and experiments showed that at 7 GHz, the location of the diode on a metalization pad used to mount it to the diamond substrate and the point where the grounding strap contacts the pad significantly affected performance. When using small metalization pads not much bigger than the diode itself and a small quartz standoff for contacting to minimize package capacitance, the efficiency of two diodes in series just about equals that of a single diode chip at frequencies up to 9 GHz.

Omitting either of these conditions results in a 50% drop in combining efficiency. "Although some sensitivity of diode performance to higher-order harmonics was expected, a 50% reduction was not," says Cox. "The apparent significance of these harmonics was surprising and had been previously overlooked."

"It doesn't appear as if six devices is the limit," says Cox, "but too many devices will have to be spread out for thermal considerations and this will affect package parasitics." □

Oceanography

Smart hydrophone tracks currents

Ocean-research sonic buoys are normally tracked by moored hydrophones and the information sent by cable to a land station, perhaps 20 miles away—an expensive procedure. If the information can be stored for up to a year, though, the hydrophone's location is not limited by cable length.

However, fitting a year's worth of data onto a limited amount of magnetic tape requires a "smart" data-collection package. What's more, besides having to identify valid signals and discard noise, "this data package is limited to a 200-milliwatt power drain, so practical design demands a low-power complementary-MOS microprocessor," says its developer, Albert Bradley, research associate at Woods Hole Oceanographic Institute.

The package, to be moored 2,000 meters deep, will be used in a Navy-sponsored program to track ocean currents. By timing signals from up to 200 free-drifting sonic buoys, the system can track buoy movement. Surprisingly little is known about ocean currents, and the Navy is interested in their effect on sound propagation, while biologists want to follow the transport of nutrients.

Operation. In the Woods Hole system, each buoy transmits the same narrow-band frequency sweep, which is picked up by the hydrophone. Its output voltage is amplified and fed into a double-conversion superheterodyne receiver—a double mixing operation that reduces the signal frequency to approximately 1–2 hertz.

After filtering to remove ambient sea noise, the low-frequency output is hard-limited, removing all amplitude information and leaving only the polarity. The result, essentially, is a series of pulses, which are sampled at 10 Hz by an RCA 1802, 8-bit C-MOS microprocessor. It stores 800 successive samples in random-access memory. Every 1/10 second, the 800-bit stack is compared with an ideal transmission.

To reduce power drain, the microprocessor is operated at slow speed, and the high-speed bit comparison is performed predominantly in a simple module, hung on the processor bus, which contains two 8-bit registers. The microprocessor transfers the ideal transmission and the stored samples from memory into these registers, 8 bits at a time. If a predetermined number of bits agree, the signal is stored in stack.

"This is a crude cross-correlation," explains Bradley, "but it is good enough for our purposes, since there is no information in the signal. We are merely trying to identify the signal in a noisy background."

In operation, only the four largest signals that arrive during each 10-minute interval are saved. The buoys operate on a real-time clock and their launch time is precisely known. They are spaced out so that only two transmit within a 10-minute interval. By storing the four largest signals, the two valid transmissions are sure to be captured.

When the tape is retrieved, the scientists can identify which two of the four signals represent buoy transmissions. Since they float very little in the 8 hours between transmission, by lining up 10-minute windows, the signals closest in transmission times will be buoy signals. □

Military

Dual radar spots mortars, artillery

Convinced that two radar beams are better than one for detecting and tracking hostile mortar and artillery fire, engineers at Raytheon Co.'s equipment division came up with a dual-beam system that's undergoing tests at the Army's Yuma Proving Ground in Arizona. An even tougher test comes next month, though, at Fort Stewart, Ga., where the Hostile-Weapons Location System will face shell fire in a rainy, radar-clutter environment.

The Yuma and Fort Stewart tests, although using Army facilities and including Army observers, are being conducted by the Naval Electronic Systems Command and Marine Corps, for which Raytheon developed the system. Raytheon officials would like the Army to take a close look at it, though, claiming their system can do the same job for which the Army is developing two radars. These are the AN/TPQ-36 counter-mortar system and the AN/TPQ-37

Weapons-location competition heats up

Hughes officials, fresh from winning out over Sperry's Gyroscope division in the artillery-locating TPQ-37 competition, report the Army "elated" with the performance of both the Hughes and Sperry systems. Herbert Cox, marketing manager for weapons-locating radars at the Hughes Ground Systems group, Fullerton, Calif., says further that the counter-mortar TPQ-36 encountered no blind speed problems in its Yuma tests, already completed. He says the difficulty can be avoided by varying the pulse-repetition frequency to cover any blind spots.

When asked to discuss results with both their TPQ-36 and TPQ-37, Army officials deferred to Cox, who terms the Yuma tests of the TPQ-36 very successful. Regarding costs, Cox says Hughes has received a number of incentive awards for meeting cost targets for both systems. The unit production costs were established at the outset of both programs. The TPQ-36 is to cost $534,000; the TPQ-37 is targeted at $1.1 million—both in fiscal 1973 dollars.

Cox points out that the TPQ-36 is being readied for its trials in Fort Stewart's rain—ahead of Raytheon's HWLS—and that while a narrow L-band beam has an advantage over X band in rain, the HWLS fan beam illuminates such a large area that its advantage in rain is negated.

artillery-detection radar [*Electronics*, Oct. 30, 1975, p. 71], both of which are being built by Hughes Aircraft Co.

Raytheon has support from the Directorate of Defense Research and Engineering in alerting the Army to the system's capability. In February, during congressional testimony, Malcolm R. Currie, DDRE director, said, "It is not clear that all of these systems are required, and a series of comparative tests will be made to assess the relative performance of these systems."

Two radars. Officials at the Sudbury, Mass., Raytheon division are confident that their system, which combines on one pedestal an L-band search-and-detection radar with an X-band tracking unit, will vindicate their approach because of results already in hand. The system faced more than 2,000 rounds of mortar and artillery fire even before the Yuma tests began. In those earlier tests, "HWLS successfully located multiple weapons with excellent accuracy over a 180° sector," claims Edward F. Hudson, marketing manager for counter-weapon radar systems at the division. What's more, they were "firing simultaneously at high rates."

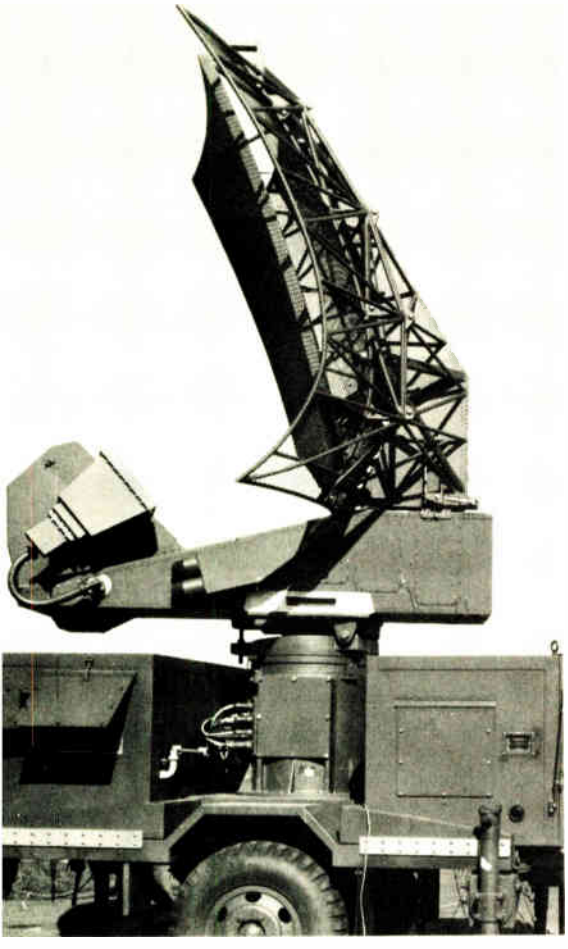
Hudson and Albert Bachman, Raytheon's HWLS program manager, say the L-band fan beam from the continuously rotating antenna gets around the "blind speed" problem of X-band in detecting high-velocity artillery projectiles. Radar can be blind to a target at certain combinations of target velocity with detection system wavelength and pulse-repetition frequency.

These variables can combine to hide the target in the clutter because the target's doppler velocity cannot be determined. Although L band does eventually encounter blind speeds, "you have to go to many multiples of X-band blind speeds before you reach the first L-band blind speed," Hudson asserts. The TPQ-36 is an X-band system, while the TPQ-37 uses S band.

Scanning. Once the L-band beam detects an incoming projectile, the system's AN/UYK-20 computer determines the projectile's range, azimuth angle, and doppler velocity. This data is used to position the phased-array X-band pencil beam to track the target and to select a pulse-repetition frequency that prevents the lower X-band blind speeds from masking the round.

The X-band system develops a trajectory pattern after several scans, and the processor also computes the weapon's location from the trajectory data, all before the projectile's impact. The idea is to call in a counter-strike quickly—a goal that may be realized by linking through a modem the HWLS to the Army's Tacfire offensive-artillery system or to the Marine Tactical Data System.

The Univac UYK-20 is in volume production for the Air Force and Navy, Raytheon points out, and both the L- and X-band portions of their system are updated versions of proven hardware. While a production HWLS would cost more than the TPQ-36 countermortar radar's projected cost, Hudson and Bachman claim that it would be only half the cost of the artillery-locating TPQ-37. The HWLS, however, couldn't be operational as soon as the other two systems. □



Double up. With smaller L-band feed horn mounted on side of X-band horn, mobile hostile-weapons-location radar sports two reflectors, avoids blind-speed problems.

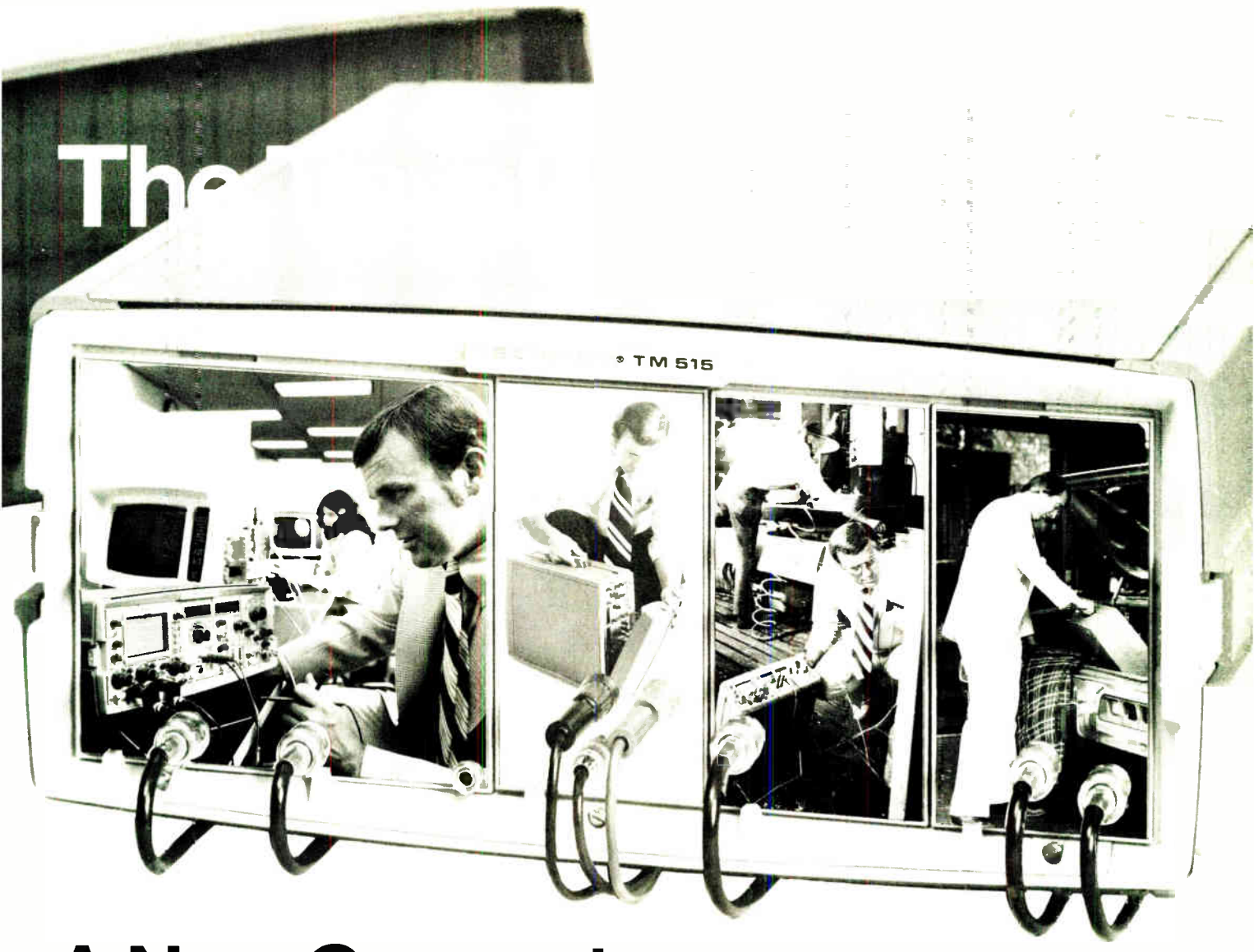
Speech analyzed by entry-control system

The military is becoming increasingly concerned about protecting secure areas—such as buildings that house computers with classified information in the data base. To control access, the Air Force has been given the task of developing systems for automatic speaker, handwriting, and fingerprint verification that can be used by all the services. The first to get a thorough field test is a speaker-verification system soon to be installed at Pease Air Force Base, near Portsmouth, N.H.

An advanced development model, developed by Texas Instruments and the Mitre Corp. for the Air Force Electronic Systems Division, Hanscom Air Force Base, Mass., works with four-word phrases spoken by a person seeking access to the secure area. It compares them with a digitized representation of that speaker's voice previously stored in computer memory. If the speaker passes the test, a door or gate opens.

Denial. In tests involving more than 200 persons at Mitre in Bedford, Mass., the system bettered established error rates, says Wolf Haberman, group leader in Mitre's Security Systems Group. It denied entry to authorized persons about 1% of the time and allowed entry by unauthorized users in less than 1% of the tests.

A potential user must first enroll in the system. To do this, he uses a keyboard to enter his four-digit identification number, which tells the TI980B computer that a new



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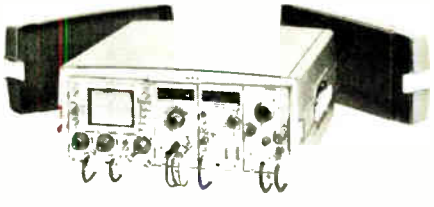

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reference file is being created. He is then directed by a recorded voice to speak at least 20 four-word phrases into a microphone, which are digitized and stored. Adolph Fejfar, Mitre's task leader for entry-control subsystems, explains that monosyllabic words with a single energy peak—usually centered on a vowel—are used to simplify the time registration in the computer.

Low-pass filters, an analog-to-digital converter, and a digital filter bank process speaker's stored phrases, using a technique that improves the signal-to-noise ratio and emphasizes variations between speakers. One part of the technique gives the high-frequency components more gain.

When the user wants to enter the secure area, he again keys in his identification number, calling up his reference file for comparison, and is directed by recorded voice to repeat one of the phrases. As he speaks, a time sample is taken every 10 milliseconds, with the reference pattern for each word totaling 100 milliseconds.

The new speech material is digitally processed to get a single numeric representation for a given time sample, which is compared with the representation for that word that's been previously stored. As the sampling continues, the computer tabulates the speaker's score for all four words, Fejfar says. This score becomes the speaker's standard error for that four-word phrase.

After the initial field tests are complete, the Air Force Electronic Systems Division will develop a system specification to be used for commercial procurement of more systems. The system, as well as the handwriting and fingerprint verification efforts, are administered by the division's base and installation security systems program office. □

Solid state

HP's 4-year gamble on SOS pays off in products, performance

A few years ago, it looked like silicon-on-sapphire would satisfy the quest for a process that would yield devices with the speeds of bipolar technology, the densities of n-channel metal-oxide-semiconductor devices and the low power of complementary-MOS.

After much investigation and a few casualties, such as Inselek, though, most semiconductor makers have pulled out of the search. The one exception is RCA Corp., which has the only commercially available SOS memories and is working on an SOS version of its 1802 microprocessor.

However, one non-semiconductor company—Hewlett-Packard Co.—felt that, for it, SOS was a viable process—one that would give it an almost overpowering competitive edge across its entire product line. As a result, it spent four years and several million dollars on developing a proprietary C-MOS-on-sapphire process.

Payoff. Now, it looks as if the gamble has paid off. HP computer-circuit developers have obtained two to five times better performance with SOS than with other methods. For instance, 16-bit minicomputer-type C-MOS-on-sapphire CPU chips, with densities in the range of 150 gates per mm^2, are operating with propagation delays of 1 to 4 nanoseconds at speed-power products of 0.25 picojoules. Noise margins are good and are in the comfortable 4-volt range.

According to Richard Anderson, general manager of HP's Cupertino, Calif., Data Systems Division, it has successfully manufactured thousands of circuits using SOS, and has at least eight large-scale integrated circuits on the way. The division's trump, though, is the 16-bit microprocessor chip that is equivalent to a minicomputer CPU and will run with cycle times in the 100–300-nanosecond range. HP will use a three-chip set of SOS processor circuits to build a machine with performance that will be equivalent to its present 3000 computer.

Why SOS. In the past, it was not so much developing the process that was the problem, as it was doing it in a cost-effective way. Admittedly, says Anderson, developing SOS has been an expensive proposition. Not only is the sapphire substrate, which acts as an insulator, much more expensive than the usual silicon wafer, it is harder to etch. However, HP executives are convinced that for high-performance circuits the SOS systems will ultimately yield lower-cost circuits than those built with bulk MOS and I^2L. So far HP's experience with SOS indicates that, once the SOS starting material is firmly in hand, wafer defect densities are much lower than those of comparable single-channel and bulk C-MOS designs.

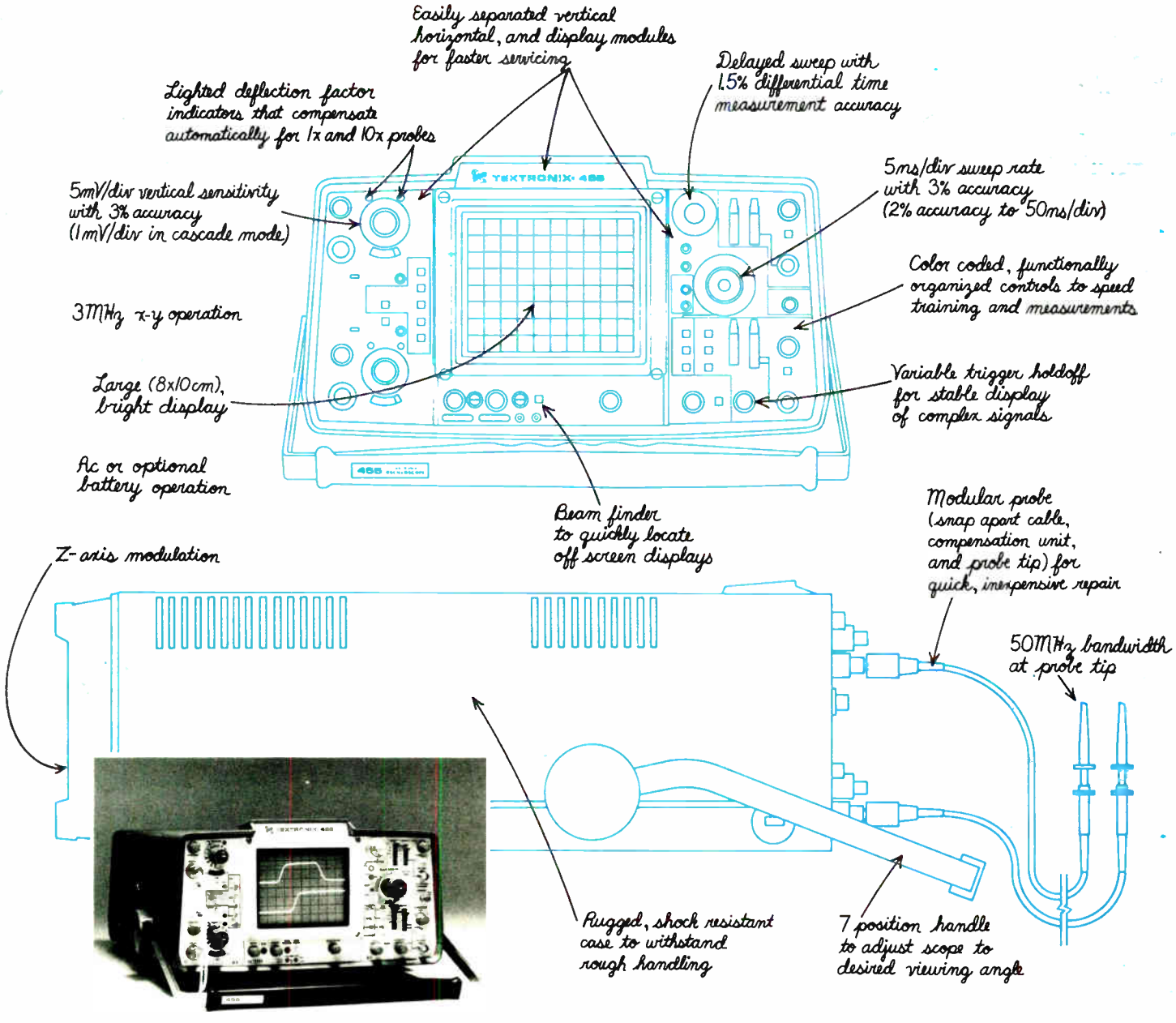
"Our economics are not the economics of a semiconductor company," he says. What HP was looking for, says Anderson, was something that would give its computer products a performance edge that was several orders of magnitude ahead of the competition—"Something the customer will be willing to pay handsomely for, and something hard for the competition to copy." □

Microprocessors

Emulation speeds 8080A at Signetics

Using Schottky-bipolar devices, Signetics Corp. is aiming to chip away at the high-performance end of the market for the Intel Corp. n-channel MOS 8080A microcomputer. The subsidiary of Philips in Sunnyvale, Calif., will soon begin volume production of a Schottky-bipolar emulation of the 8080A and several of its peripheral devices. To produce the chips, Signetics will use the ver-

Look what you get when Tektronix builds a 50 MHz portable



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sion of Intel's faster 3000 series that it second-sources.

What's more, Frank Brunot, bipolar-microprocessor marketing manager at Signetics, says the emulation—which the company calls the 80E—will achieve system speeds two to 12 times faster than the 8080A and will replace it in the high-speed end of the application spectrum. Although Signetics says this is only 5% of total 8080A applications, it represents a $1 million market that's growing at 5% to 10% a year.

Evolution. "When you look at what's happening in the microprocessor marketplace, the setup was a natural one," Brunot says. "What we saw was a large group of systems houses—such as NCR, TRW, and Sperry-Univac, to name a few—who use the 8080 in terminal-cluster controllers, for example. They've come up with new systems, and they want to do more things—do more diagnostics, use more terminals—and they find the MOS processors like the 8080 have run out of gas."

But most of these users have a minimum of 100 man-years of software written for the 8080, he continues. And they're faced with the choice of looking for a faster MOS processor or going to a minicomputer. "In either case it would involve rewriting all their software," he says, "throwing 90% of the development work on their systems into the trash can." A bipolar emulation like the 80E, he says, offers a third alternative that gives users the needed speed improvements and saves their software. Brunot figures enough customers will be willing to pay the 80E's price of $150 per kit or board in volume.

Emulation. Each 8-bit array has its own carry-look-ahead unit so that the two arrays may operate independently of one another, he says. During 16-bit operations of the sort handled by the 8080A, the two arrays are merged.

Functionally equivalent to a 10–20-chip microcomputer system consisting of the Intel 8080A central processing unit, together with Intel's 8228 system controller, 8224 clock generator and driver, and 8212 8-bit input/output port, the 80E emulation is configured around two independent arrays, each containing four 3002 CPUs. The two 8-bit buses for the processing units are tied together, and a single control bit from microprogram memory determines which data bus is to be enabled during a particular instruction.

In contrast to the 500-nanosecond clock-cycle time of the 8080A, Signetics' 80E emulation using the faster 3000-series devices has an equivalent microinstruction-cycle time of 110 ns. The performance advantages of the 2-bit-slice approach vary, Brunot says, depending on the kind of operation that is required and the number of microinstructions needed to implement it.

"In some cases, the 80E requires two to three times the number of microcycles to do an equivalent operation," he says. "But, at worst, the degradation is still a two-fold improvement over the 8080A system." In most applications, however, the same operations can be performed in fewer cycles, resulting in the increase in speed. □

Peripherals

TI adds to its TMS 9900 family

One of the strengths boasted by Texas Instruments for its 16-bit TMS 9900 microprocessor is the device's communications-register unit, an on-chip serial port and register that allows bits, bytes, or words to be addressed in the input/output interface. Now the firm is backing up that capability with a family of serial-structured peripherals.

"These circuits will allow the designer to better use the 9900's inexpensive serial I/O," says Alan Lofthus, TI's TMS 9900 project

News briefs

Hewlett-Packard upgrades its 3000 Series computer

A microprogramed processor and fast 4-kilobit RAMs are two of the major hardware features of Hewlett-Packard's new 3000 Series II computers. The systems are aimed at what Paul C. Ely Jr., general manager of HP's computer group, calls the "fastest growing segments of the computer market"—super minis, small-business computers, and general-purpose computers. The new models of the 3000 execute 50% more instructions per second than the earlier 3000 systems. The company announced three new models: Model 5, with 128 kilobytes of semiconductor main memory, 15-megabyte disk, 1,600-bit/inch tape, and an HP 2640 cathode-ray-tube system console; model 7, with 192 kilobytes of main memory, two 47-megabyte disks and similar tape and console; and the model 9, which differs primarily in its 320 kilobytes of main memory. Prices of the systems are, respectively, $110,000, $150,000, and $190,000.

Another industry peril: gold theft

Since public trading of gold became legal during 1975 in the U.S., electronic component firms using the precious metal as a plating material have become prime targets for thieves. While losses so far have not received wide attention, industry sources say they are on the climb.

The latest victim is Viking Industries Inc., Chatsworth, Calif. last month, it discovered it had been hit for about $250,000 in gold-plated contacts used in connectors for printed-circuit boards. The annual fiscal-yearend audit turned up the loss, an official said, which took place sometime since last October. Although Viking's security measures already were termed extra-heavy in the gold-plating area, their entire system is being reevaluated.

Further complicating the investigation by Los Angeles police detectives is the compact nature of the contacts. "They all could be packed in a 10-inch-square box," the company official says. "There's little question that the public gold market makes us more of a target than when it had to be sold through illegal channels."

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SCIENCE/SCOPE

Pictures from NASA's Landsat-1 satellite are helping Alaska's natives -- some 100,000 Indians, Eskimos, and Aleuts -- select the best lands from the 99 million acres set aside for them from the federal public domain. Doyon, Ltd., one of 12 regional native corporations, asked the University of Alaska to recommend the best land in a vast, roadless tract in central Alaska. Using the Landsat pictures and the limited ground and aerial data available, university scientists mapped seven million acres. The maps show potential farm land, marketable timber, and hard-rock mineral deposits. The Landsat pictures were taken by the Hughes-built multispectral scanner.

More than 20 countries have selected the U.S. Army's TOW (tube-launched, optically-tracked, wire-guided) missile as their infantry heavy assault anti-tank weapon. Hughes/Tucson has produced more than 120,000 TOWs to date. Test firings from 150 lots -- governed by the Army's rigid "fly before buy" program -- have resulted in 100 percent acceptance. Missile reliability in all firings, foreign and domestic, is 97.6 percent. TOWs fired from U.S. Army AH1Q Cobra helicopters have been equally reliable. TOW can also be installed in several other helicopters, foreign and domestic.

The Smithsonian Institution's new National Air and Space Museum in Washington, D.C., will have an automatic central control system manufactured and installed by Hughes' microelectronic products division. The high-speed, wide-bandwidth system will control exhibits, fire safety, security, environment, remote inquiry and display terminals, and two-way closed-circuit television. It also will transmit 464 channels of high-fidelity audio to locations throughout the museum for individual exhibit sound tracks and visitor information announcements.

Engineering opportunities at Theta-Com, a Hughes subsidiary which manufactures microwave and VHF-distribution equipment for the CATV industry, include: CCTV Applications Engineer experienced in security surveillance applications, to prepare proposals, design installations, supervise construction. Some travel....Microwave Relay Equipment Design Engineer, intermediate level.... Experienced Digital Communications Engineer. All positions require BS or higher degree. Send resume and salary history to: Director of Engineering, Theta-Com, P.O. Box 9728, Phoenix, AZ 85068. An equal opportunity employer.

A new type of high-voltage DC circuit breaker -- the first to be placed in commercial operation -- will be designed and built by Hughes Research Laboratories under contract to the Electric Power Research Institute. The breaker will be installed in the Pacific Intertie system. It will permit automatic transfer of current from an earth-return mode (which is used when station equipment of one pole of the normally bipolar system is rendered inoperative) to a metallic-return mode. The disconnect switch the Hughes breaker will replace requires about an hour to make this transition, during which the Intertie system is completely shut down.

manager in Houston. While the 9900 can handle faster parallel transfers, such as direct memory access and memory-mapped I/Os, "nobody else offers a microprocessor with a serial port," he explains, "so we're concentrating initially on peripherals for serial I/O transfer."

The 9900's communications register unit, adapted from TI's minicomputer family, will take 16 bits in or out of the microprocessor in 17 microseconds—about a third as fast as the simplest parallel-transfer scheme. But the serial transfer can be implemented for about a third the cost of a memory-mapped I/O, and about a tenth that of direct-memory-access transfers. And the register unit is fast enough for interfacing keyboards, displays, data converters, floppy disks, and some hard-wired logic, Lofthus says.

Coming soon. The new parts, all aimed at replacing multiple-package TTL designs, include:

- The 9901 programable interrupt and I/O chip, with samples available next November. The single 5-volt chip includes seven I/O ports and six individually maskable interrupt-request lines. The 40-pin dual in-line package contains an interval timer and nine programable lines that can be used for either function.
- The 9902 universal asynchronous and 9903 synchronous receiver/transmitters. The 18-pin UART, available late this year, will feature programable data rate (from 75 to 76,800 bits per second), character length (5 to 8 bits), stop bits, and parity. The 20-pin 9903 is similar, with programable sync register, and will support bi-sync and synchronous data-link-control communications protocols. Both contain on-chip interval timers (64 to 15,384 microseconds).
- The 9904 one-chip clock generator, a low-power Schottky part needed for the 9900's four-phase clock. Sampling starts this summer.

"These are all serial devices, not bus-oriented, and as such, their application will be limited to the 9900," Lofthus says. "There are any number of circuits that take advantage of a bus-type structure; they can be adapted to the 9900 for the faster parallel-transfer schemes." TI does plan, however, to develop its own bus interfaces for the 9900 where they are needed, he says. □

Mask combines metal, emulsion

Photomasks for integrated-circuit production are normally one of two types: a photo emulsion on a glass plate or a hard-surface chrome mask. Now, scientists at the Central Laboratory of Photoprocesses of the Bulgarian Academy of Sciences have developed a third type of photomask which combines the optical qualities of an emulsion mask with the long life of a chrome mask.

The new photomask starts out as a sandwich structure—photoresist, an isolating layer of Alvanol, and an evaporated silver bromide photosensitive layer built up on a chrome-clad plate. This light-sensitive layer is optically homogeneous, and its Rayleigh scattering is much less than in emulsion-type masks so that it can record micrometer- and submicrometer-sized details more sharply. Again because of negligible scattering, the silver bromide layer is less sensitive to overexposure, which with emulsions often coarsens details.

Processing of the mask, which is of the projection type, starts with exposure of the plate by a multichannel repeater with a standard light source. The silver bromide layer is developed, dipped in a stop bath and then rinsed in distilled water. The developed silver serves as a master mask for the photoresist. After drying, the material is exposed to ultraviolet light, and then the intermediate isolating layer along with the remaining silver bromide pattern is removed by dipping the plate in acetone or cyclohexane.

The resist-patterned chrome plate is then ready for conventional photolithographic processing. The final metal image, depending on the

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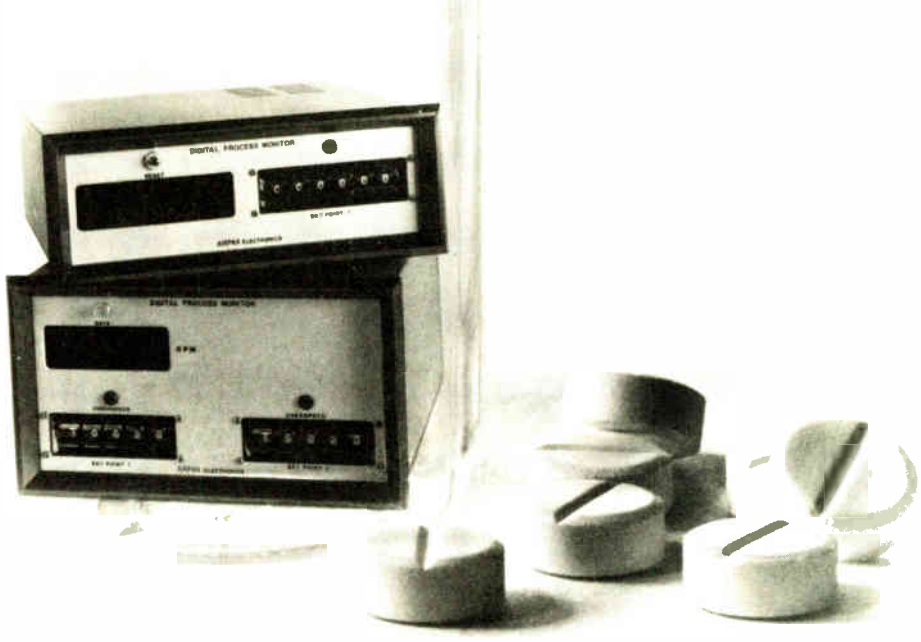

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combinations of positive or negative silver bromide and positive or negative photoresist used, may be either a positive or a negative copy of the original artwork. □

Solid state

CCDs go into digital processing

Although charge-coupled devices have primarily been used as digital shift registers or analog delay lines, a program at TRW Systems Group is using them to perform digital computations and logic. And when fabrication is completed sometime next year, a single CCD chip slated for military application will perform fast Fourier transforms for recursive filtering and even more complex signal processing.

According to Thomas A. Zimmerman, section head for development and applications at the Redondo Beach, Calif., Microelectronics Arrays department, testing the individual functions that will make up the chip has already been completed. He points out that the FFT configuration would satisfy applications in sonar, radar, communications, and voice processing.

Hardware on the chip includes three 16-bit adders and four 16-by-16 multipliers, and except for output buffers, everything on the chip is a charge-coupled device. The buffers could be built with bipolar or metal-oxide-semiconductor devices in order to achieve a high enough current-drive capability.

Present chip dimensions—350 by 300 mils overall—will be miniaturized as the program proceeds, Zimmerman says. The chip is based on 7.5-micrometer photolithography, two-level metal interconnections, and standard two-phase CCD design.

"We believe the chip's significance lies in the improvements that CCD technology permits in both packing density and speed-power-product ratios over n-channel MOS and bipolar integrated-injection logic," Zimmerman explains. The chip has five times the packing density of the n-channel MOS that performs an equivalent function and 10 times that of bipolar, he asserts. In speed-power-product terms, the CCD unit, operating in the 1–10-megahertz range, holds a 10:1 edge over n-MOS and as much as that over ECL at the higher speeds.

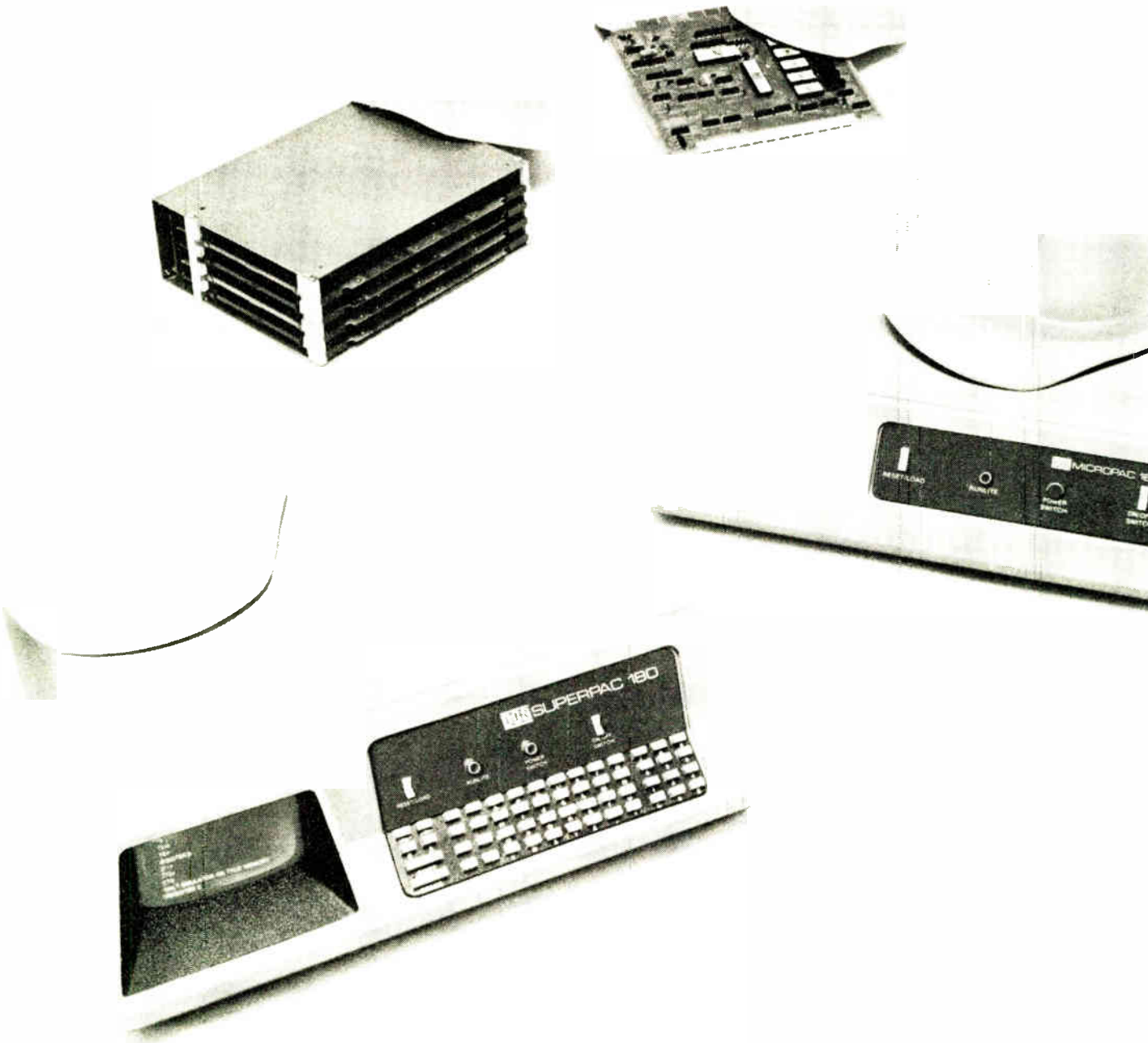
Serial correlator. A typical signal-processing function, where the chip would be used as a serial correlator, illustrates one of the simplest of its operations, since only two multipliers are needed, Zimmerman says. Here, the FFT provides two simultaneous serial correlations by accumulating the product of two input variables. This function would be useful in communications where in-phase and quadrature signals are to be obtained.

In addition, the chip's computational capability allows a number of other uses once control signals, gating, and timing sequences are provided. Thus, it could be applied as a two-pole, recursive digital filter; a single-pole, time-multiplexed, recursive digital filter, or a lattice, digital filter-analyzer and synthesizer for voice processing.

Despite the abilities of CCD technology in computational digital logic devices, their development lagged until TRW's program began several years ago, Zimmerman says. Soon after, the Navy started its funding. Development of CCDs by semiconductor firms was directed into memories and imaging devices that paid off commercially sooner. And the services themselves were focusing on analog applications.

To achieve acceptable speed with the technology, limited by the basic nature of the charge-transfer principle, TRW resorts to "pipelining." Zimmerman points out that this is a fairly common technique that moves data through the circuit in a serial fashion. New data is entered before previous results appear at the output. Thus, the output data rate is determined by a delay of only 1 bit rather than the 16 bits being processed. This allows operation at up to a 5 megahertz rate. □

The Hard Hats



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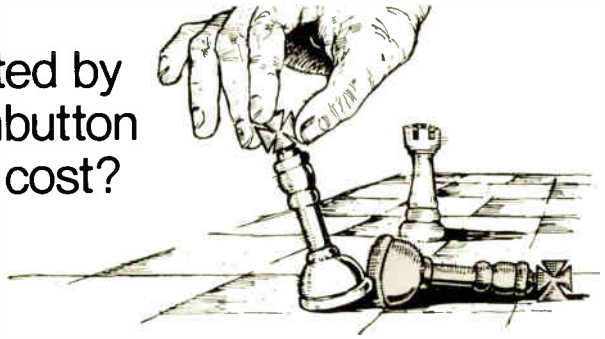

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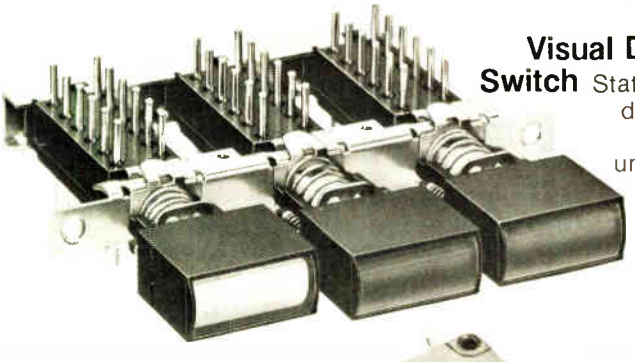

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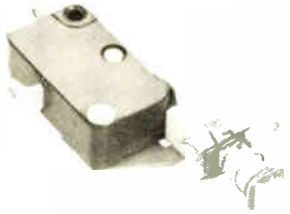

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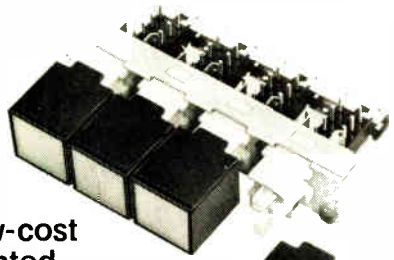

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Washington newsletter

NATO to start F-16 production before final approval

European production of the F-16 lightweight fighter for the North Atlantic Treaty Organization will begin later this year—**months before the Pentagon's scheduled approval next January of U.S. production tooling** and close to a year before full U.S. production by General Dynamics Corp. is authorized in September 1977. "There is really no risk involved," says program director Lyman Josephs of General Dynamics, "since the F-16 is essentially a tuned-up version of the prototype YF-16, which already has been thoroughly tested with over 750 hours of flying."

The longer lead times required to set up the Belgian and Dutch production lines—as much as a year longer than the U.S., says Josephs—make the early go-ahead necessary to meet the NATO delivery schedule of 348 planes. Current U.S. policies, Josephs says, "do not recognize these facts, and it is causing some anxiety among the more doctrinaire officials in the government." Josephs denied a published report that NATO is having problems lining up qualified European avionics suppliers for the plane and that General Dynamics plans to bring any of the NATO F-16 avionics business back to the U.S. as a result.

Navy's CMS-2 leads DOD competition for a common language . . .

The Defense Department is running economic trade-off studies on three candidate languages from as many services for selection as the single higher-order software of the future known as DOD-1 [*Electronics*, Dec. 25, 1975, p. 52].

Some insiders contend that the Navy's CMS-2, originally developed for use with Sperry Univac division's AN/UYK-7 system, **is leading the competition for selection within 12 to 18 months** as the Pentagon's answer to demands for a single tactical system language to hold down software-hardware cost ratios, which now run to 8:1. Competing with CMS-2 are the Air Force's Jovial and the Army's Tacpol.

. . . as Navy names four packages for tactical use

Until selection of DOD-1, which might very well be a derivation of all three competing systems, the Navy says it will standardize on four high-order languages for tactical use. To enforce its program throughout an estimated 60 combat-computer systems, the Navy plans establishment in the Naval Materiel Command in Washington of **"a single office for compiler-configuration management** to ensure that variations of basic language do not occur." So says the Navy's H. Tyler Marcy, assistant secretary for R&D, who says CMS-2 will be used for tactical ship and airborne applications.

The language for automated test equipment will be Atlas, originally developed for the avionics test system known as VAST, while the third standard language will be SPL/1, the Navy's newest and first adopted for acoustic-signal processing. To cut software support and transport costs, Marcy says, the Navy plans to standardize on Fortran as its single software-support language for all of its operating systems.

Washington commentary

Lyman Josephs' lesson in management

Federal frustration with the costs and performance of some of its major weapons systems and their contractors is well known. Hardly a week goes by that some member of the Congress doesn't charge the Pentagon or one of its contractors with failure to perform as promised. The charges are invariably picked up and disseminated by the press—sometimes incorporating the defendant's response, sometimes not.

The frustrations of contractors with their Federal customers, on the other hand, are less well known. Criticizing the customer is more than bad form. It is bad for business. Thus specific corporate criticisms of Federal failures in system management are rarely voiced publicly, no matter how valid.

Fort Worth's exception

One refreshing exception to the latter rule occurred in Dayton, Ohio, last month when General Dynamics Corp.'s Lyman C. Josephs addressed the closing luncheon of the National Aerospace and Electronics Conference. A corporate vice president of GD, Josephs functions as both deputy general manager for the company's Fort Worth division and as director of the company's F-16 lightweight fighter program for the Air Force and for NATO.

Josephs is a plain-spoken person who might easily be mistaken for a Marine Corps general. "When he says, 'jump'," says one of his Fort Worth subordinates, "the only question anyone asks is 'How high?'" But Josephs is also known and respected within his organization for supporting his managers. "The program manager," he argues, "must be the man whose decisions are upheld by higher authority, even when he is slightly wrong. It should be up to the functional specialist to justify his position against the program manager's decision, rather than the other way around."

Self-protection

The failure of the military to grant its project chiefs freedom to manage and then support their judgments is Josephs' biggest frustration. "There has been a lot of talk since Dave Packard's days" as deputy secretary of defense of the need "to loosen the reins on program managers and give them the authority they need to run their programs." But, he adds, "the subtle program difficulty is that they don't get the support they should."

Why the failure? "The trouble in the military," says Josephs, "is that there are too many people busy protecting their" careers by writing covering memos when critical choices must be made. "Too often a functional specialist will write a memo for the file in such a way that a program manager has no choice but to cave in or risk missing a promotion." The consequence, Josephs contends, "leads inexorably to cost growth, schedule problems, and unnecessary gold-plating. I spend more of my time fighting off people like this on the F-16 program than I do most anything else."

The performance of General Dynamics on the F-16 program thus far suggests Josephs is winning most of those fights. The two-plane prototype program, he says, was completed on schedule and within the $37.9 million ceiling price. "General Dynamics closed its books at the end of the program with earnings of approximately $2.1 million for all that activity," he revealed.

The winning management approach to the F-16 program is one Josephs calls "the matrix system" in which "the program director had all the authority and responsibility for execution of the prototype program which the chief executive of the corporation had." By using experienced personnel in building the matrix, the F-16 managers were permitted to make their own technical and business decisions without the necessity of checking with higher authority—a time-consuming process. "The principle we used was that decisions were audited by higher authority after the fact to avoid delays," Josephs explains. "We found that very few decisions required change." When the program moved to full-scale development, Josephs took "the same team that had done the prototype and expanded it, but the core people were still there."

Return to basics

There are some fundamental lessons worth learning again in the management principles adopted by Lyman Josephs for the F-16 program. They sound simple, of course, no more than common sense coupled with a willingness to delegate authority and responsibility throughout the program's management chain.

But the unfortunate fact of life is that these fundamentals have become the exception rather than the rule within the management structure of many military weapons programs. And until more contractors insist, like Lyman Josephs, on their restoration, congressional critics of military management will continue to find multiple targets of opportunity. —**Ray Connolly**

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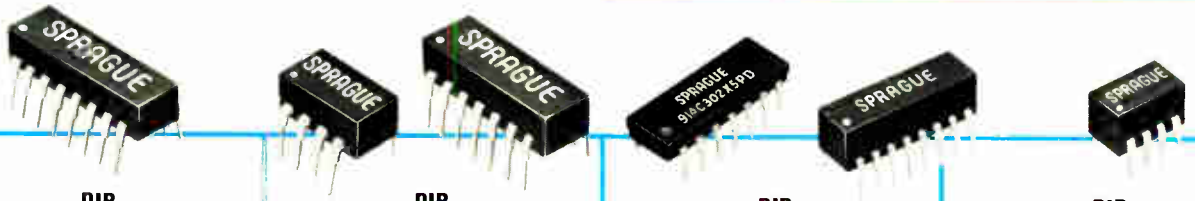

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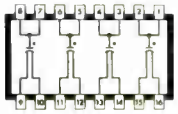

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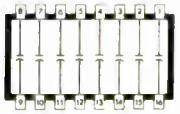

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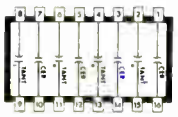
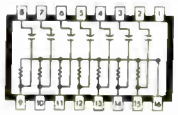
DIP TANTALUM/CERAMIC CAPACITOR ASSEMBLIES



Solid tantalum and Monolythic® ceramic alternating isolated sections. Choice of 4 or 8 sections per package. Standard tantalum ratings, 6.8 μF @ 35V, 15 μF @ 20V, 22 μF @ 15V, 33 μF @ 10V. Ceramic ratings .01, .047, .1 μF @ 100V. Cap. tol., ±20%. Write for Engineering Bulletin 6642 or circle 93 on reader service card.

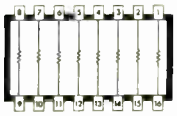
DIP RESISTOR/CAPACITOR NETWORKS



(1 of 3 designs)

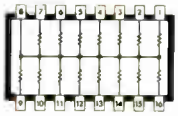
Metanet® metal-film resistors and Monolythic® ceramic capacitors in bypassed pull-up, R-C coupling, speed-up, and active terminator networks. Resistor ratings, 100 to 6800Ω with 125 mW power dissipation. Capacitor ratings, 100 pF to .01 μF @ 100V. Write for Engineering Bulletin 6612 or circle 94 on reader service card.

DIP MULTIPLE METAL-FILM RESISTORS



Noble metal film resistors encased in protective glass. Choice of 7 or 8 resistors per 14- or 16-pin package. Resistance values, 50Ω to 100,000Ω. Power dissipation, 125 mW. Standard resistance tolerance, ±5%. Operating temperature range, −55 C to +70 C. Write for Bulletin 7042 or circle 95 on reader service card.

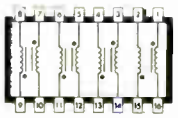
DIP PRECISION RESISTOR NETWORKS



(1 of 5 designs)

Noble metal film resistors in pull-up, pull-down, interfacing, and terminating configurations, for applications requiring repetitive resistance patterns. 14- or 16-pins. Up to 28 resistors per package. Individual resistors from 50 to 100,000Ω. Dissipation, 125 mW. Write for Bulletin 7042 or circle 96 on reader service card.

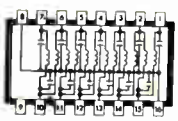
DIP MULTIPLE PULSE TRANSFORMERS



(1 of 2 designs)

Four transformers in 16-pin package. All cores have exclusive protective coating. Inductance values from 10 to 1000μH. ET product values of 5 volt-μsec. Choice of four turns ratios . . . 1:1, 2:1, 3:1, 4:1. Operating temperature range, 0 C to +70 C. Write for Engineering Bulletin 40400 or circle 97 on reader service card.

DIP TAPPED DELAY LINES



Lumped constant delay lines . . . ideal for timing and pulse synchronization circuits. 14- or 16-pin packages with delays of 50, 100, or 150 nanoseconds at a characteristic impedance of 100Ω. Working voltage, 50 VDC. Operating temp. range, 0 C to +70 C. Write for Bulletin 45004 or circle 98 on reader service card.

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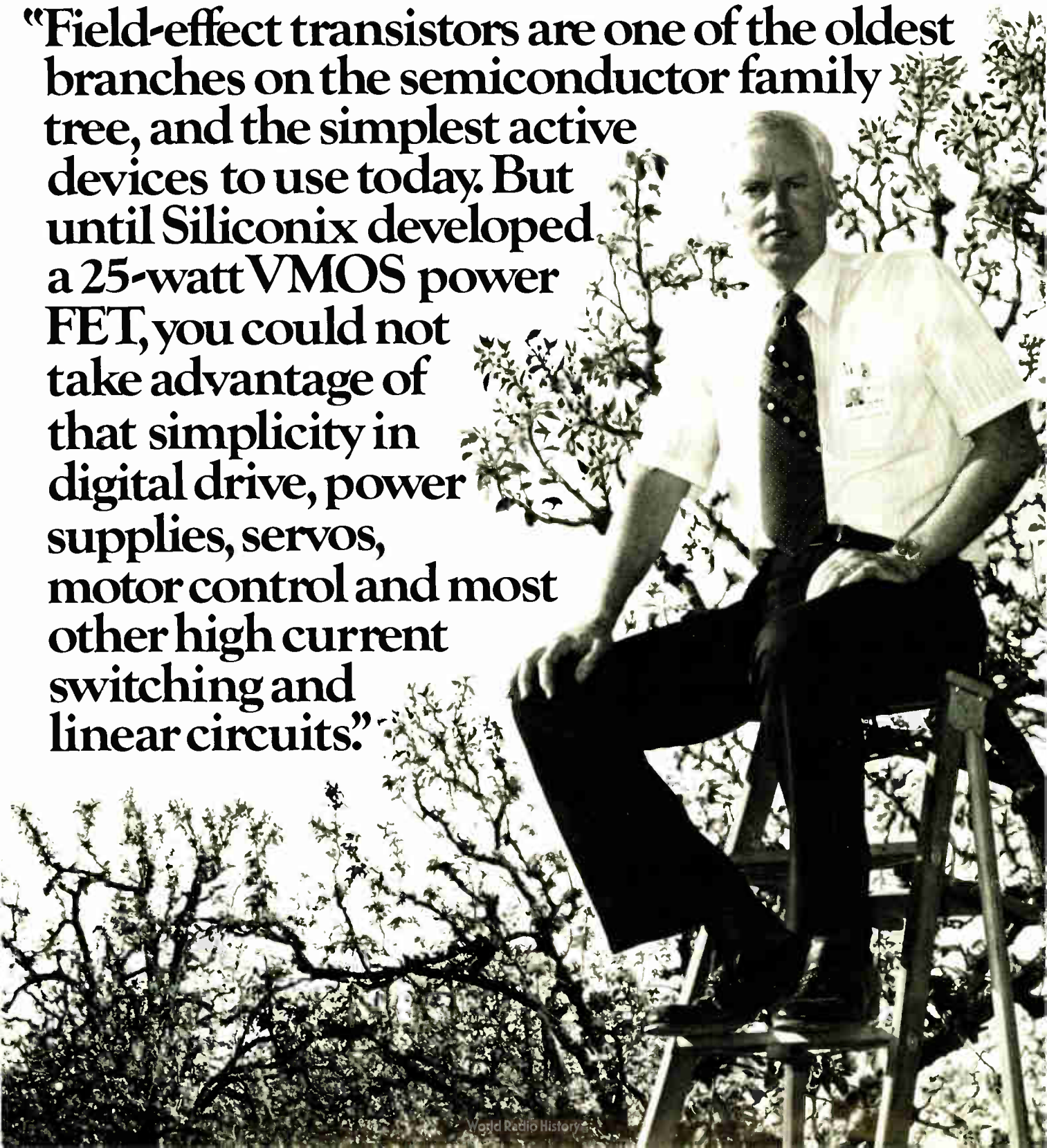
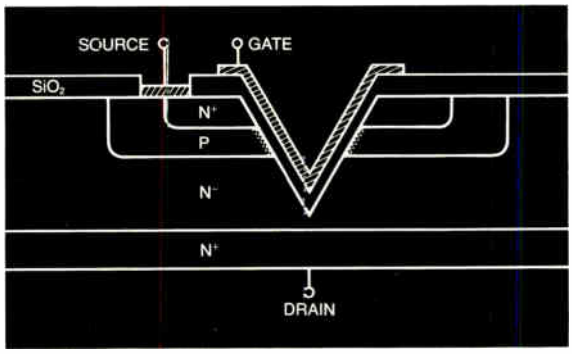
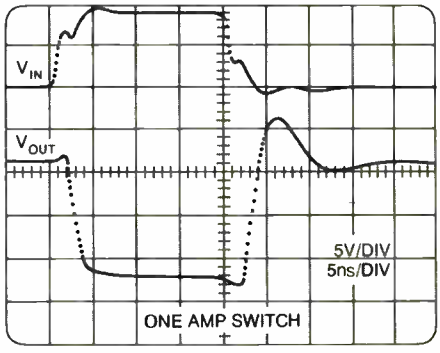


just may eliminate five years."





"Historically, designers have had to use Darlington bipolar devices to control high currents. But FETs have the advantage in other respects. They operate with near zero input current, are easier to bias, and are not susceptible to secondary breakdown, thermal runaway, or current hogging, and exhibit no minority carrier storage time.

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VMP 1	60	3 0
VMP 12	90	4 0
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VMP 21	35 Volts	2 0 Ohms
VMP 2	60	3 0
VMP 22	90	4 5

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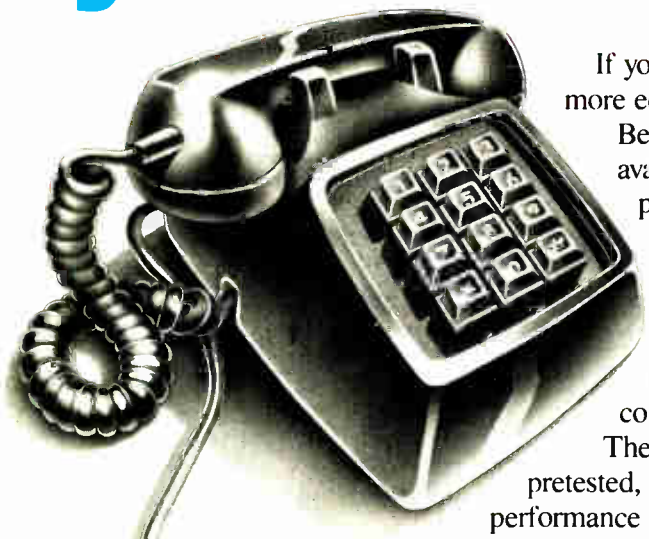
Siliconix incorporated

New: tone receiver hybrids from Beckman.



If you're into tone receiver applications, here's a smaller, more economical solution for your designs.

Beckman Series 883 Telephone Tone Receiver Hybrids, available off-the-shelf as individual modules or as preassembled systems.

First, they give you up to 75% space savings over conventional tone-receiver systems. They're so much smaller because we use hybrid technology. And each whole subsystem fits on one standard 4½" x 6" PC board. Picture it: your entire system cut to ¼ of the conventional size.

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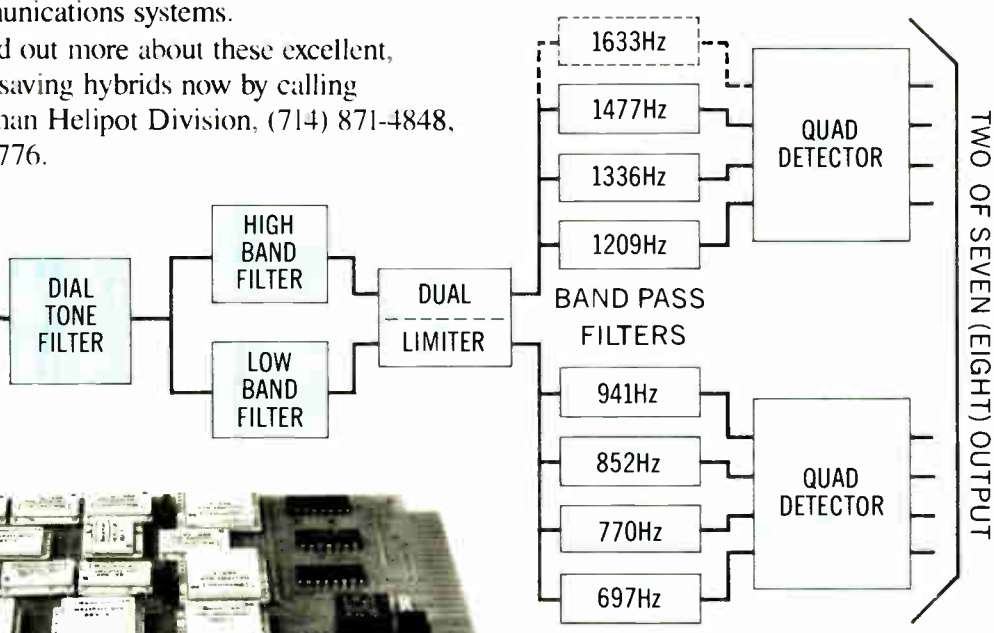
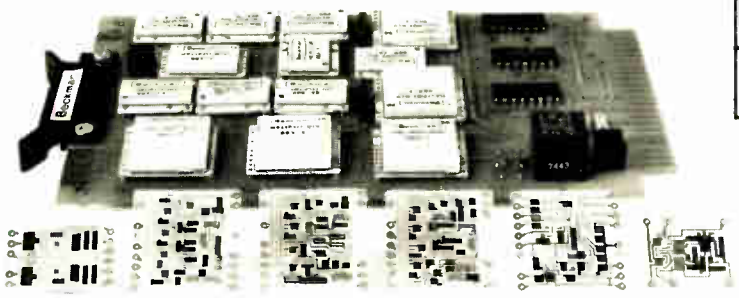
Find out more about these excellent, space-saving hybrids now by calling Beckman Helipot Division, (714) 871-4848, Ext. 1776.





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If you need hybrids, you should know about Beckman.

German post office broadcasts uniform field with wedge-shaped TV antenna

The West German post office has developed an antenna, somewhat like an inverted snowplow blade, that is said to broadcast television signals at microwave frequencies with much better radiation characteristics and signal coverage than standard antennas. An example is now atop a tower in West Berlin for use in a 12-gigahertz TV-transmission system.

To ensure uniformity of the signal and maximize transmitting power, more power must be radiated toward the far reaches of the antenna's coverage. This compensates for the fact that, with increasing distance from the antenna, the radiation density becomes smaller.

Angles. Assuming the antenna to be at the center of a circular, flat, obstacle-free area, a constant field-strength distribution is possible if the vertical-radiation pattern varies as the cosecant of the angle of depression below the horizontal and if there is a horizontal omnidirectional pattern. This antenna produces these radiation characteristics.

Developed by a team led by Herbert Thielen, the antenna has been successfully tested at the Darmstadt research institute of the post office. For omnidirectional signal radiation, the antenna would consist of six reflectors, arranged in the form of a hexagon. In the West Berlin application it covers only a 100° sector, so there are only two reflectors, each with its own horn feed.

Computer determination. The reflector shape, which approximates the ideal cosecant shape, was determined by a computer calculation and optimization process, Thielen says. Vertically, it has a curved surface, but horizontally, it has a straight surface. The top-to-bottom distance of the reflector is 1.25 meters, with top and bottom widths of 1.6 and 1.05 meters, respectively.

The light-weight antenna was built by Gruenzweig und Hartmann. The center is a honeycomb-structured aluminum layer, with glass fiber-reinforced plastic layers on either side. The reflecting surface is coated with copper foil less than 200 micrometers thick. The antenna gain is between 17 and 19 decibels—more than 7 dB higher than the gain of conventional TV signal-distribution antennas.

Great Britain

System keeps track of fleet vehicles

An automatic vehicle-location system based on a microprocessor can place a vehicle within 33 feet of its actual location, according to the developer, Marconi Research Laboratories. Known as Landfall, for Links and Nodes Data-base For Automatic Land-Vehicle Locations, the system is an extension of Marconi Labs' earlier work in automated vehicle location. Typical applications would be in police patrol cars and similar fleets, where a central dispatcher needs to know locations of individual vehicles.

The system has an Intel 8080 microprocessor that stores information on the road network in a random-access memory. The intersections are termed nodes, the exits are called ports, and the roads joining the nodes and ports are called links. The microprocessor has a dynamic random-access memory, complete with a coded map of the area. Each node and port is given an identifying number, and the lengths of connecting links are stored.

All this information is stored in

Around the world

German system indicates visibility on runway

Control-tower decisions on takeoffs and landings under limited visibility may become a lot easier with a microprocessor-controlled system that indicates precise visibility. Developed by AEG-Telefunken and its affiliate Eltro GmbH, the so-called RVR (for runway visual range) system is modularly constructed and thus can be adapted to the requirements of individual airports. A prototype was exhibited at the German aerospace show in Hanover last month.

The system consists of a number of sensors installed at strategic spots along the runway and a data-evaluation unit usually located in the airport's meteorological station. Three kinds of sensors are used: transmissometers for measuring the visibility of the atmosphere, background-luminance sensors for determining the environmental brightness, and devices to measure the intensity of the runway lights. A basic RVR system consists of up to five transmissometers and one sensor each for background luminance and runway-light intensity.

The parameters picked up and measured by the sensors are sent to the evaluator, where a 16-bit PACE microprocessor from National Semiconductor Corp. in the U.S. calculates the visual range on the runway. It uses the degree of transmission in percent, the background luminance in lux, and the runway-light intensity in candelas. It then references these values to a certain measuring distance and indicates the calculated result, the runway visual range, in meters on a gas-discharge display. Also indicated on similar displays are inputs from the sensors.

the 8080's RAM, which has a 12-kilobyte capacity. The vehicles have sensors. The driver activates the system by indicating his starting node, and the information is continually updated by the processor and displayed numerically.

The system has been tested in an area of 10–12 km in Chelmsford, and Marconi officials say it works even for 180° turns. Information about entire towns apparently will fit into a tiny memory storage—for example, all of Essex's 32,000 nodes fit into one 4-track cartridge.

Marconi's system—which cost about $5,000 per vehicle—differs from the Boeing Co.'s Flair system [*Electronics*, Feb. 21, 1974, p. 30], which relies on a compass to get dead-reckoning information. "We have a heading sensor to give us turn information," says one member of Marconi's systems-application group. "We have an ordinary distance transducer tied to the steering of the vehicle. We do know that magnetic compasses cause real problems." Also, accuracy of the Boeing system is to within 50 feet.

Later this year, Britain's Home Office will allow several companies, including Marconi, to test their systems on individual vehicles in the West Mercia area. □

France

Systems-building hardware has modules made of modules

When a manufacturer says his equipment is modular, that can mean almost anything. But a French systems-engineering company has made the word mean more than most. For the MAT 80 line of systems-building hardware introduced last week, Sodeteg-T.A.I. has come up with modules that are themselves modular.

For starters, the firm, part of the Thomson-Brandt group, has used MAT 80 (for Microsystème d'Automatisme Temps Réel) hardware to implement a letter-sorting system that can route up to 18,000 envelopes per hour into 20 different bins. A package sorter will follow, as will use as an interface in an electrical dispatching system.

In fact, the line could find a place in all sorts of industrial-control systems—its modules can be combined to make control equipment as

simple as a stand-alone fast scanner or as sophisticated as a microcomputer with multiple central processing units. "We think of the MAT 80 as an instrument that fits between the services of a minicomputer and a data-acquisition device," says Philippe Gutmann, deputy managing director.

To tailor the hardware to the application, there are some half a dozen kinds of modules—actually printed-circuit boards that plug into a cabinet designed to fit a standard 19-inch relay rack. The major modules are a microcomputer built around an Intel 8080, a programable controller of automated operations, memory cards with up to 32 kilobytes of random-access and read-only memory, direct bus address, multiplexers, and input/output interfaces.

A simple configuration—a small memory, a CPU, one or two I/O cards, the basic rack and cabinet, and a power supply—runs about $2,200. A top-of-the-line setup goes for about $17,000.

Combining. These basic modules add up to literally thousands of possible configurations. With the exception of the microprocessor and the programed controller, the boards are themselves modular. Each is split into five sections. The standard back section carries most of what is back-panel wiring in conventionally packaged hardware.

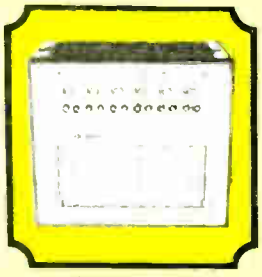
The other four sections—running at right angles to the fifth—carry submodules. And the firm has developed a library of 30 of them, including a "watchdog" for system surveillance, a block of 16 inputs, a data-transmission interface, and a group of 8 priority interrupts.

Sodeteg-T.A.I. stores the submodule layouts as Mylar masks. To produce a specific module for a system, it's mainly a matter of pulling the four masks needed out of the library and making a master for the whole board, which is photoengraved conventionally.

At first glance, it might seem it would be simpler to make each submodule a small, separate board. But Henri Carcassonne, the engineer who worked out the concept, can trot out a lot of solid arguments for putting quartets of modules on a big board.

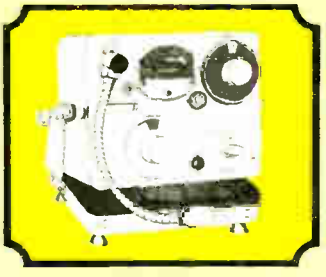
There's a significant saving in copper, he points out. Then too, the standard back section eliminates extensive back-panel wiring. What's more, the layout separates the logic from the output circuitry, a big plus in industrial environments. The connector at the rear edge of the board handles the bus connections. Four connectors on the front edge take care of the I/O connections to the process under control. □

The Ten Most WANTED INSTRUMENTS



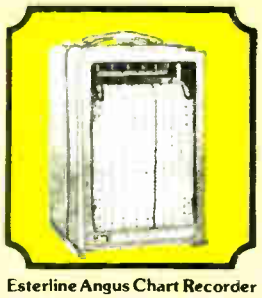
Brush Oscillograph 260

Associated Research
Fault Finder



General Radio
Sound Level Analyzer

Honeywell Tape Recorder

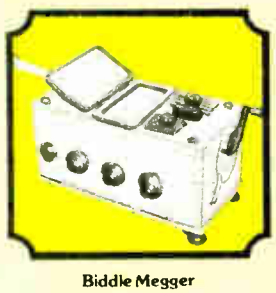


Esterline Angus Chart Recorder

Associated Research
Insulation Tester

Kaye Data Acquisition System

Tektronix Oscilloscope



Biddle Megger

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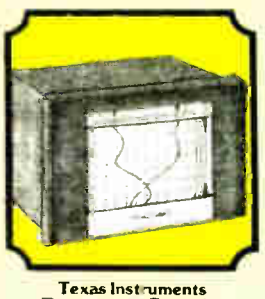

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International newsletter

Hitachi delivers 2-million-bit bubble memory

Hitachi Ltd. has completed a prototype 2-million-bit bubble random-access-memory module built of 32 64-kilobit chips that have an average access time of 5 milliseconds. **Aided by a subsidy from the Japanese government, the basic technology was developed during fiscal 1974 as part of the nation's pattern-information-processing project.** The prototype memory, delivered in December 1975, was fabricated to specifications of Musashino Electrical Communication Laboratory of the Nippon Telegraph and Telephone Public Corp. as part of its electronic-telephone-exchange development program. **Since the capacity of the chips has been growing about fourfold a year and the government subsidy is still being received, the company is obviously now making 256-kb chips.**

Despite their four times larger capacity, the 64-kb chips, which measure 6 by 6.4 millimeters, are only about 50% larger than Hitachi's earlier 16-kilobit chips. The new chips store each bit of information in a square measuring 20 μm on a side. The memory is organized as eight chips on a plane. To create a rotating magnetic field, the memory is structured into coils, with two planes per coil and two coils per module. The magnetic components of the memory module measures 23 by 48 by 120 μm, excluding peripheral electronic circuits, which are larger than the magnetic portion. This 2-million-bit memory has a larger capacity than some commercially available drums, which have an average access time of 10 ms.

Japanese develop ultra-low-loss fiber-optic cable

An ultra-low-loss fiber-optic cable has been developed by the Fujikura Cable Works Ltd., one of the three companies developing fiber-optic cables for Nippon Telegraph & Telephone Public Corp. The new cable has a loss of only 0.47 decibel per kilometer at 1.2 micrometers, and a loss below 1 dB per km between 0.95 and 1.37 μm. **This clad cable, which is produced by a chemical-vapor deposition method, has a core 58 μm in diameter and cladding 152 μm in diameter.** The loss was minimized by nearly complete elimination of water, the OH radical, from the glass. The remaining OH radical is said to be only 50 parts per billion.

The new cable will greatly extend the span between repeaters over which signals can be sent down fiber-optic cable. On the other hand, since clad, as opposed to graded, cable has poor group-delay characteristics it is not suitable for transmission of very wideband signals—signals with unusually high pulse-repetition rates.

Siemens seeks top spot in European LED products

Now that it has considerably expanded and mechanized its facilities for manufacturing discrete light-emitting diodes, Siemens AG this year is gunning to quadruple last year's LED production. This output, the German company says, will make it Europe's largest LED producer. **Another three-fold increase in production is planned for 1977.**

With gains like that, the firm's LED output will be growing faster than the market generally, comments a spokesman for the Munich-based company. The world discrete, LED market this year is estimated to be some 250 million units, and the company predicts it will expand to 350 million units next year. About 60% of Siemens' LED production is exported. The best-selling units are still red-emitting types, but sales of green and yellow versions are accelerating, Siemens says.

International newsletter

Data transmitter from Philips is integrated on chip

Researchers at the Philips Central Labs in Eindhoven, the Netherlands, have developed a digital data transmitter that integrates the input filter and modulator on a single chip of 3.6 by 3.7 millimeters. **The data transmitter, which is programable by an external read-only memory, is based on integrated-injection logic.** It is suitable for various modulation techniques, carrier frequencies, and spectral distributions.

With two transmitter/ROM configurations, various types of phase modulation are possible—for example, eight-phase modulation at 4,800 bits per second on an 1,800-hertz carrier frequency. Vestigial-sideband transmitters for 2,400 b/s and 4,800 b/s can also be implemented with a single I^2L chip. **The transmitter can be integrated on a chip because a complex digital post-modulation filter is eliminated, and a simply constructed interpolating-type digital input filter is used.**

New French laws to protect people from EDP abuses

The French government is expected by the end of 1976 to establish laws governing the use of computers. A government-appointed commission has just published a two-volume "Rapport de la Commission Informatique et Liberté," which will be presented to the Minister of Justice at the end of June. Ministry sources say that "specific proposals will be made in the next session of parliament" regarding the use of computers and their infringement on personal liberty. **Laws will be proposed "to limit certain projects involving computers which violate individual freedom."**

Philips group leads phone-pact bidders in Saudia Arabia

A consortium headed by Philips Telecommunicatie Industrie apparently is at the head of the line for a massive telecommunications contract in Saudi Arabia. The Dutch-led group has been asked by the Saudi government to put together a proposal for expanding the country's telephone network from the current 190,000 lines to 660,000.

In addition to the hardware—including 10 group-switching centers, 10 stored-program-control subscriber exchanges, and line equipment—the project involves training personnel and running the net.

Two Japanese firms combine car radio and CB transceiver

Japan's leading manufacturer of citizens' band equipment, Cybernet Electronics Corp., will join one of the leading automobile-radio manufacturers to produce a combination car radio and CB transceiver. The a-m/fm multiplex stereo radio is being made by Fujitsu Ten Ltd., a subsidiary of Fujitsu Ltd. The first customer is Midland International's Communications division in Kansas City, Mo. **About 30,000 sets a month will be produced initially. The expected retail price in the U.S. is $300.**

Germany and India install 60-MHz telephone systems

The use of 60-megahertz telephone-transmission systems with a capacity of 10,800 channels per coaxial line is proliferating. **The West German post office last month put into operation the country's first 60-MHz system, the Siemens-developed V 10800, in three sections that are part of the 300-kilometer route between Frankfurt and Duesseldorf.** Work is continuing to complete the link between the two cities. Meanwhile, Indian postal authorities have ordered a 60-MHz, 10,800-channel system from the Philips Communications division in the Netherlands. The system, India's first, will be installed along a 35-km route from Bombay to a nearby town. A 60-MHz system is already operating in Sweden.

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The secret of *CERBON* superior performance? A totally new thick film resistor element, which combines both potentiometer and conventional thick film technologies, *plus* a heat stable ceramic substrate, *plus* a dual-tine contact spring, *plus* "Fluxgard" protection from dust and wave soldering contaminants. In short, a totally balanced electromechanical system.

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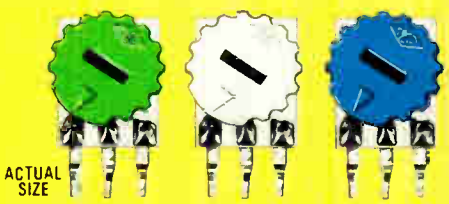
CERBON trimmers are offered in a resistance range of 1 K ohm to 1 megohm with a choice of standard PC terminal configurations. They fit universally accepted circuit board mounting patterns. And they're ready now for fast delivery in any quantity.

Write for complete technical data on Centralab's new *CERBON* trimmer resistors. Or call (915) 779-3961 for a free evaluation sample. Move up to *CERBON* and save!



Knob colors available in white, blue, red and green for ease in assembly operations.

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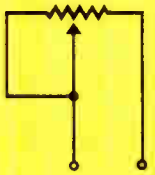
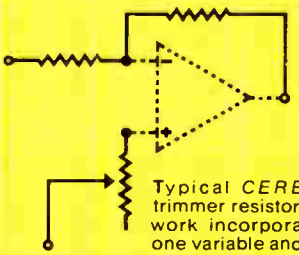
AVAILABLE CIRCUIT OPTIONS

Thanks to their ceramic substrate, Centralab *CERBON* trimmers permit a variety of screen printed circuit options. Here are three typical circuits:



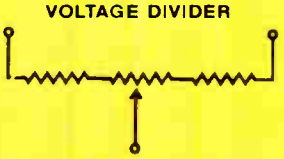
TERMINAL SHORTING
One of five electrical termination options available.

OPERATIONAL AMPLIFIER NETWORK



Typical *CERBON* trimmer resistor network incorporating one variable and two fixed resistors on dual substrate configuration.

VOLTAGE DIVIDER



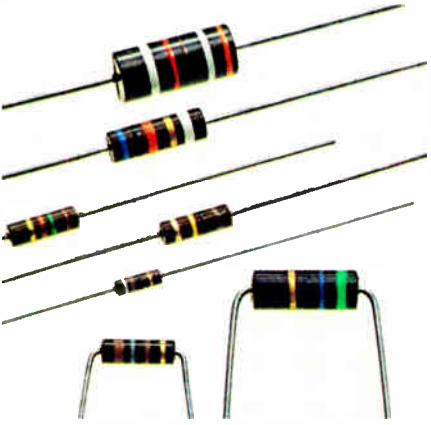
Fixed and variable resistors can be ratio matched for precise values and to insure temperature tracking. Eliminates need for costly discrete resistor selection.

Circle 57 on reader service card

Only TRW/IRC offers you complete resistor choice.

You get exactly the resistor you need for *your* application.

No compromises. No "favorites." Just quality.



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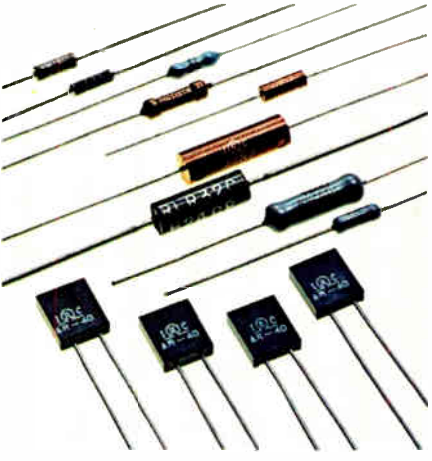
Billions used in consumer, industrial, military applications. TRW/IRC carbon comp. capability ranges from standard commercial types through established reliability RCR's, to ultra-high range (10^{11} ohms). Where you're using carbon comp.'s in automated assembly, TRW/IRC packaging options can help cut the cost of interfacing with your machines. Card packs, lead tape reels, cut and formed leads...we'll be glad to explore the potential economies with you.



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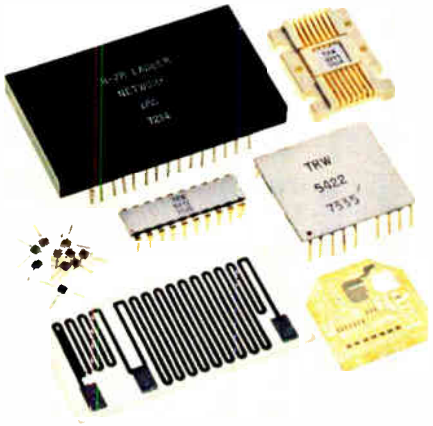

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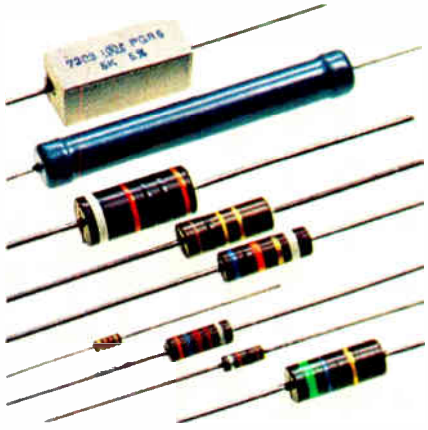

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TRW IRC RESISTORS

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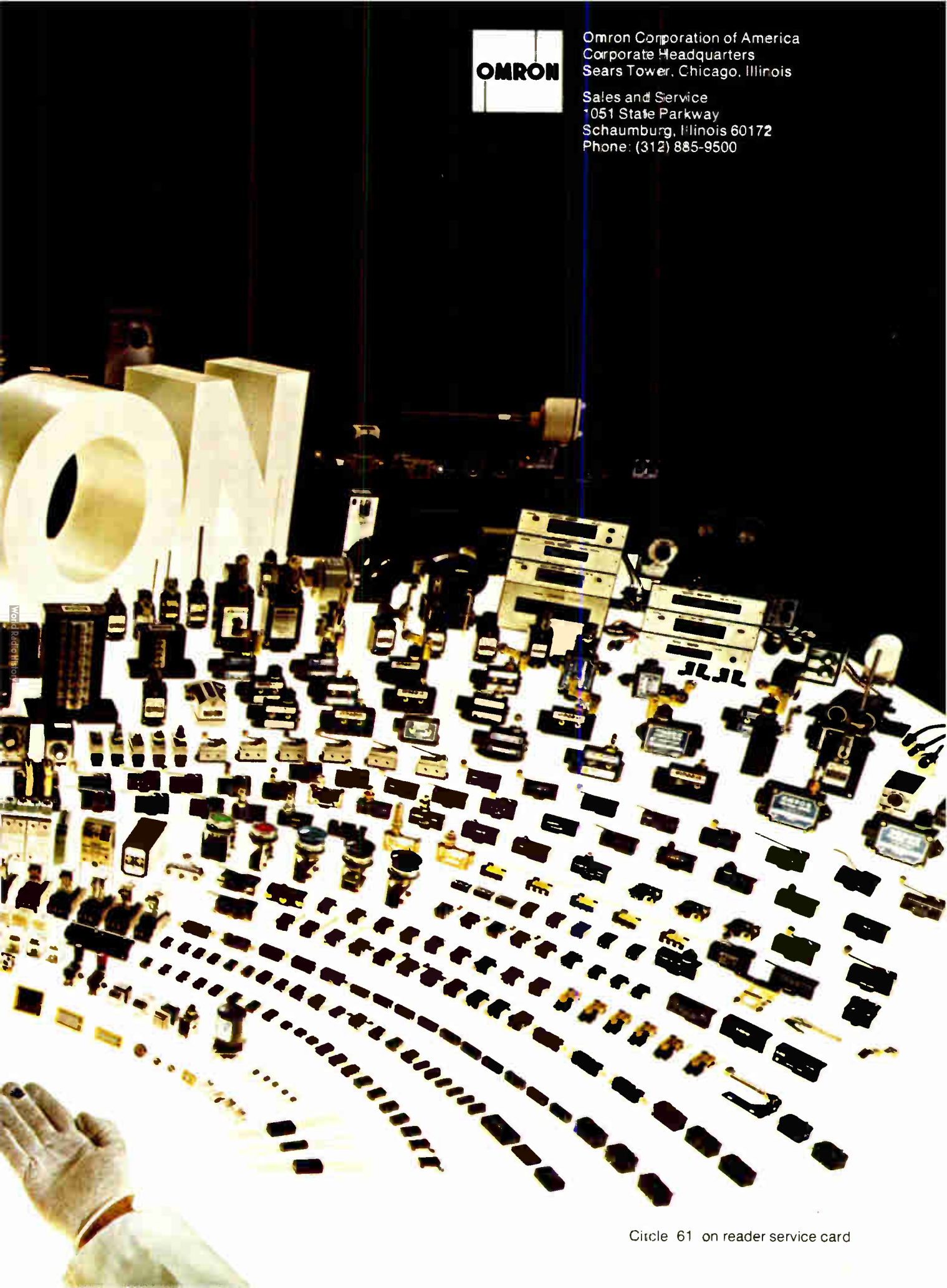
Welcome to the family, little fella



Circle 61 on reader service card

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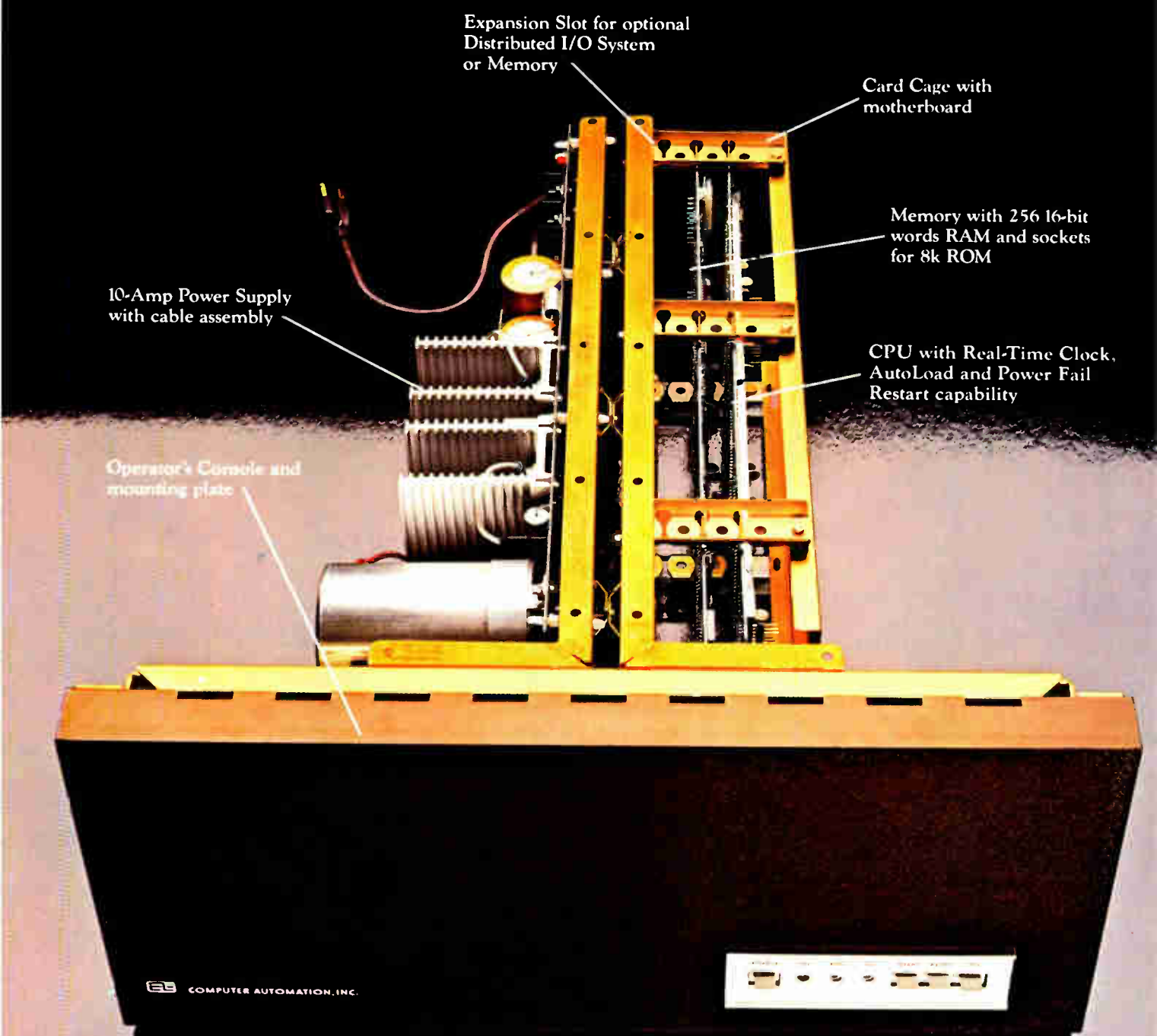

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The lowest priced, 16-bit, full-scale, packaged computer in the world.

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Especially when you consider everything we've got going for us.

Specialization, of course. OEM computers – *low-cost* OEM computers – are our only business. The NAKED MINI® people, remember? And when you do only one thing, you do it better.

Experience, too. Over 10,000 up-and-running, field-proven computers successfully integrated into all kinds of sophisticated OEM products.

Also, some things Henry Ford would have appreciated. Buying in volumes most OEM's can't manage. Building the same way.

Where all that gets you is on the down-hill side of the learning curve...where we get our pay-off and you get the lowest-priced, most reliable computers around.

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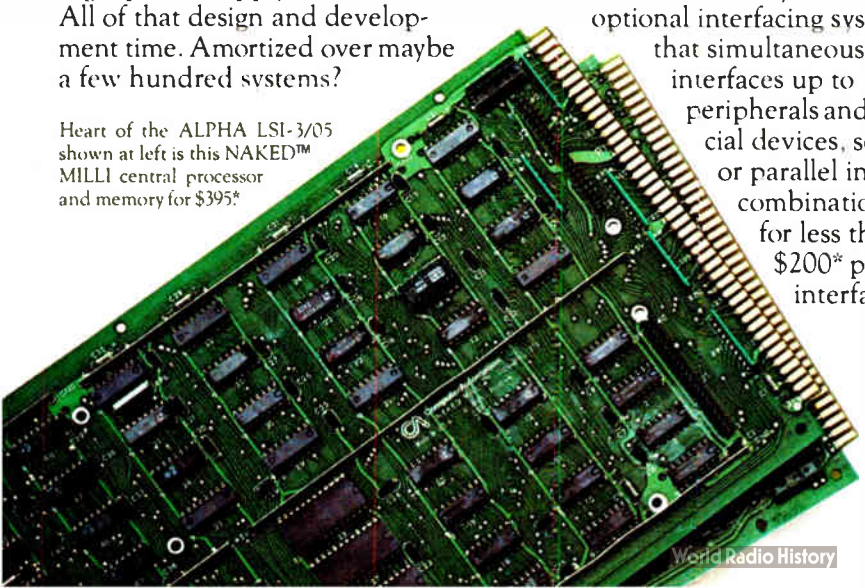

Heart of the ALPHA LSI-3/05 shown at left is this NAKED™ MILLI central processor and memory for $395*

ComputerAutomation will build thousands of ALPHA LSI-3/05 systems.

Then there's the packaging and fabrication. Cable assemblies, too.

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Getting our picture?

The ALPHA LSI-3/05 is offered in three series featuring a choice of card cages, consoles, memories and power supplies.

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Which is why we invented the Distributed I/O System. An optional interfacing system that simultaneously interfaces up to 32 peripherals and special devices, serial or parallel in any combination, for less than $200* per interface.

What you see is not exactly what you get

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- ☐ 95 powerful instructions
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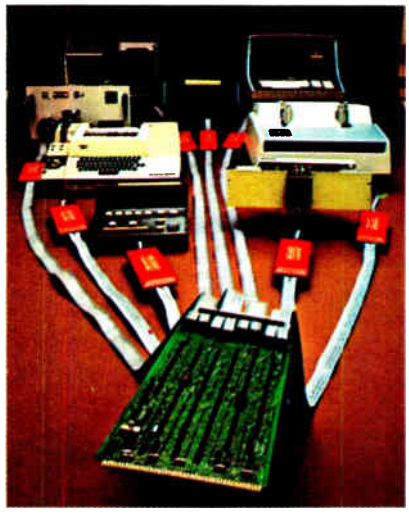
Plus full-fledged minicomputer software.

From the people who brought you the NAKED MINI

The people with the largest line of compatible computers in the world.



Maxi-Bus compatible ALPHA LSI-3/05 achieves unprecedented cost-effectiveness with ComputerAutomation's new Distributed I/O System.

The people with the lowest-priced computers in the world.

The people with the first and only Distributed I/O System in the world.

The people who've been simplifying OEM build versus buy decisions for years.

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IBM giveth and taketh away

Giant's reduction in prices will hit independent add-on-memory makers, but new operating system will give them new sales target

by Stephen E. Scrupski, Computers Editor

By reducing purchase prices by as much as 35%, IBM Corp. has at last reacted to growing incursions by independent manufacturers of semiconductor memories into the System/370 add-on-memory business. However, a parallel IBM move may aid the independents.

Although the independent manufacturers are exhibiting little concern over the cuts, the move was definitely a reaction by IBM, says Ted Withington, staff member of market analyst Arthur D. Little Inc. and veteran IBM watcher. "The market for the independents has been growing only by degrees," he says, "not by large leaps forward. The independents have been prosperous as their penetration into the IBM base has grown. Now IBM has counterattacked, and it's going to be a good deal tougher."

The bright spot in the price-cutting announcement, as far as the independents are concerned, was that it was followed a few days later by an announcement of a new operating system that requires more memory than previous ones. Thus, the two announcements seemed to go hand-in-hand: the need for more memory will benefit the independents as much as IBM. "I look for IBM's software over the next two to three years to be 'memory-eating,'" says Richard Andreini, vice president for systems marketing at Advanced Memory Systems in Sunnyvale, Calif., who thus feels little discomfort from the announcement.

As shallow as their penetration has been—the independents have been able to nibble off only 10% to 15% of the cumulative memory installations so far—in 1976, they could double that and install nearly 30% of the add-on memories, speculates Richard Egan, assistant general manager of Intel Corp.'s Memory Systems division in Sunnyvale, Calif.

Competitor. This is Intel's in-7168, an add-on for IBM's System/370 model 168. The Intel memory stores 1 to 8 megabytes.

Egan estimates that, of the 18 billion bits of additional memory expected to be installed on models 135, 145, 158, and 168 of the System/370 series in 1976, the independents will take about 5 billion bits. In 1977, Egan says, the additions will rise to a total of 21 billion bits with the independents taking about 6.3 billion.

The independents have been wielding a major selling point—prices have been less than half the IBM level in many instances. Datapro Research Corp., Delran, N.J., says that before the price cut, IBM prices for the model 158, to take one example, had been about $263,000 for 1 megabyte of additional memory. The independents, however, were quoting prices down around $120,000 per megabyte, or even lower. However, even at this price differential, Datapro says, the cumulative penetration by the independents hit only about 12% by the end of 1975 in the worldwide total of 1,000 installed 158s.

Now, with the price cuts, independent prices will be about two-thirds as high as IBM's—"about where they should be," claims AMS' Andreini. He and others point out that, traditionally, marketers of plug-compatible equipment for IBM systems have offered prices that were about 70% as high as IBM's and have been able to build a good business for themselves. Thus, the price cuts, they feel, will have little effect on their business. "It probably will inhibit some users who need a large differ-

ential in prices in order to justify going to the independents, but things will soon get back to normal," says Intel's Egan.

Census. Basically, here's the way Datapro Research Corp. sizes up the worldwide System/370 census:

- For the top of the line, the model 168, there are about 250 installations, and the independents have penetrated this add-on memory market only by about 1% (the percentage primarily reflects the infancy of the business).
- There are about 1,000 model 158s, and penetration is about 12%.
- There are about 2,700 145s, and penetration is about 16%.
- There are about 4,000 135s, and penetration is about 8%.

The independents can be classified in two groups: those that make the memory systems and those that market them. Makers include Advanced Memory Systems; Cambridge Memories Inc. of Bedford, Mass.; Intel Memory Systems division; National Semiconductor Memory Systems division of Santa Clara, Calif., and Electronic Memories and Magnetics of Hawthorne, Calif.

Marketers include: Intel; Cambridge Memories; EM&M (the only three makers that also sell directly to the end users); Control Data Corp. of Minneapolis; Storage Technology Corp. of Louisville, Colo.; Itel Corp. of San Francisco; Memorex Corp. of Santa Clara, and Computer Investors Group of Stamford, Conn. These marketers essentially buy the memory systems from the makers. National, for example, markets through Intel, Memorex, and STC, while AMS markets through Memorex, Control Data, Itel, and Computer Investors.

Shift. The leaders in this field are a brand new batch of semiconductor makers taking advantage of the latest in 4-kilobit random-access-memory chips. There's been a geographical shift to the West, says Intel's Egan, leaving only Cambridge Memories in the East—its semiconductor plant is in Poughkeepsie, N.Y. Egan, who himself emigrated westward from Cambridge, points out there were once about 15 suppliers of add-on core memories for the System/360, but with the 370, the number has shrunk to just the few that have the semiconductor technology well in hand. "The independents' prices are now generally in line with the costs of the chips, based on current yields," says Joseph Kruy, president of Cambridge Memories, but Cambridge and, presumably, all the other producers are looking at the 16-kb chips to see when they might be used to reduce costs and prices further. However, he says, there does not seem to be great pressure to get the 16-kb chips into production of add-ons.

However, even the independents' prices have been dropping. Datapro points out, for example, that during the first quarter of 1976, add-on memory for the model 145 dropped from about $140,000 for 384 kilobytes to about $83,000.

The independently produced memories, although fully plug-compatible with IBM mainframes, offer users some extra features not available from IBM. For example, Intel's new add-on for the model 168 uses an 8080 microprocessor in the maintenance panel to log errors and thereby warn of potential failures.

Extras. The independents' memories also allow users to go beyond limits established by IBM. The model 158, for example, has a limit of 4 megabytes (some observers say that the limits are set by IBM because users who will eventually need more memory will be encouraged to move up to a completely larger system, rather than just expand the memory), while the independents offer compatible memories that expand the 158's capacity up to 8 megabytes.

Finally, there seems to be little concern among the independents that IBM will soon announce its new series.

Instead of a new series, the independents are watching for announcements of the models 138 and 148—enhancements of the 135 and 145, just as the 158 and 168 represented enhancements of earlier models 155 and 165, which had core memories. The models 155 and 165 also represent a market for add-on memories, since the semiconductor memories can be made compatible and speed up the system at the same time. □

Consumer electronics

Quadraphonic sound poised again

Work on getting bugs out of matrix technique is spearheaded by IC decoding system developed by National and British firm

by Bernard Cole, San Francisco bureau manager

After five years of ups and downs in the marketplace with audiophiles being alternately charmed and disillusioned with its performance, quadraphonic sound appears ready for technical advances again.

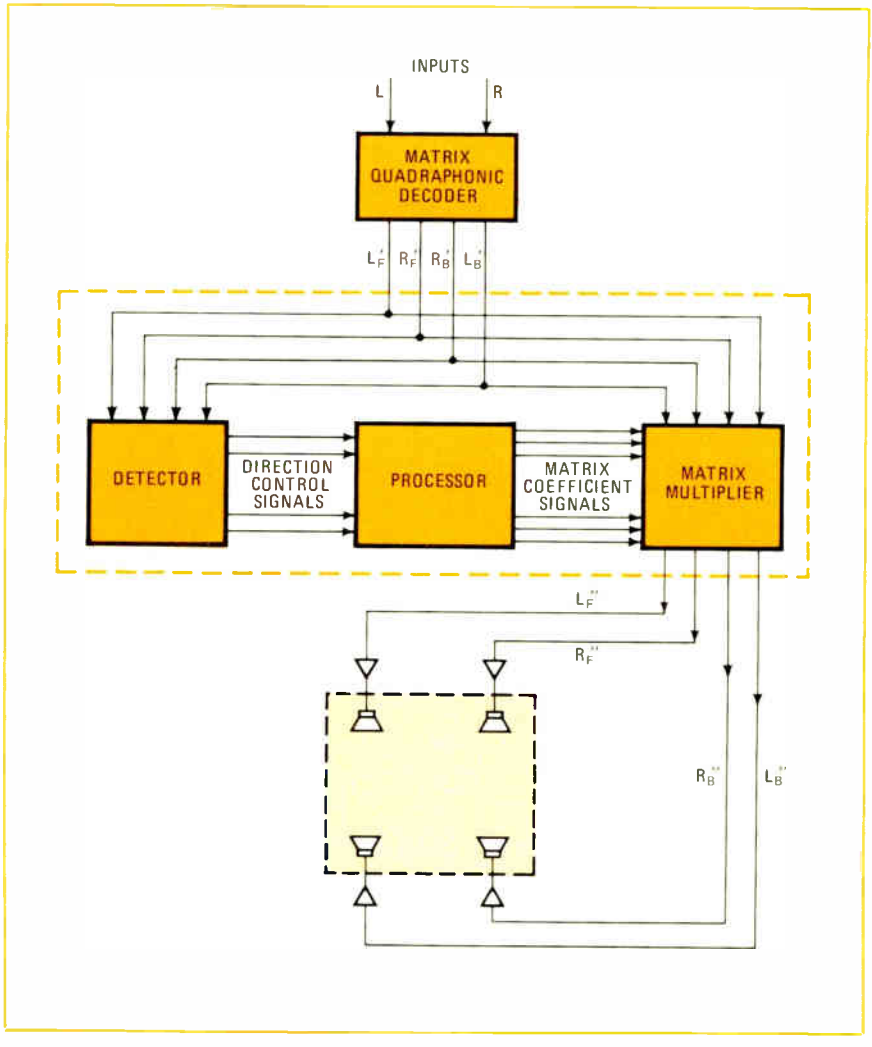
Indeed, if the development activity in one of the two main techniques of implementing four-channel sound on disks—the matrix system—is any indication, this time it's for real. Among other things, CBS Inc., which pioneered the matrix approach with its SQ system in 1971, has developed a so-called Paramatrix system that goes a long way toward solving the directionality and operation problems that turned off the public to its original system. And Sansui of Japan, developer of the competing QS quadraphonic approach, is reported also to be developing a similar advanced system.

But both are holding their work in abeyance until they see what happens as a result of a new agreement between Tate Ltd., a British audio electronics firm, and National Semiconductor Corp. to develop an integrated-circuit matrix decoding and enhancement system. Its promise is that, retrofitted to existing systems, it could improve the four-channel sound separation and directionality of any matrix decoder by 50% to 100%.

Present systems typically have channel separations that vary from 15 decibels to 40 dB, depending on direction, total harmonic distortion of 0.1% to 0.5%, and signal-to-noise ratios of about 40 to 50 dB. The Tate system in its breadboard version, says company managing director Wesley Ruggles, allows any matrix system to achieve a constant 30 to 40 dB of separation in any direction, as well as 0.05% distortion and 70 dB s/n. According to Thomas Recine, director of linear marketing at National, the Santa Clara, Calif., semiconductor company is at work on three bipolar linear ICs that could achieve comparable performance.

"From what we've seen and heard so far, the Tate system is far ahead of anything in the marketplace or in development," says CBS'

Sounding off. The three key elements to be reduced to ICs by National are the detector, a processor, and a matrix multiplier. Chips should be ready for testing by this fall.



Joseph Dash, director of new product marketing. "If it can be successfully produced in integrated-circuit form, it will bring quadraphonic sound back to life."

What the Tate system appears to do is eliminate many of the internal inconsistencies that have plagued the matrix approach since its introduction in the early 1970s by CBS, Sansui, and several other companies. In this approach, through various mathematical encoding techniques, a matrix algebraically combines four original signals—right and left, front and back—into two for recording in normal stereo fashion. In playback, a decoder converts the two signals back to four, delivering an approximation of the originals to four speakers in the receiver system.

"What excited many of us in the audio equipment and recording industries was that the matrix approach allowed us to dovetail quadraphonic very easily with stereo and quadraphonic receiver systems," says Herbert Lipold, chief engineer at Fisher Radio Corp., the Long Island City, N.Y., producer of audio equipment. "In addition, matrix quadraphonics could be broadcast over the same fm channels as stereo, which meant we had a built-in tool to boost sales of equipment."

"Unfortunately, in these early systems, each of a matrix disk's decoded channels—because of poor separation (about 3 dB)—contains not only the signal intended for it but also spillover, or crosstalk from other channels' signals." This poor performance, Lipold says, is one reason many audio manufacturers switched to the other approach to quadraphonic disk systems—the discrete channel, CD-4, system developed by Victor Corp. of Japan, built by Hitachi and Signetics, and promoted heavily in the United States by RCA Inc. [*Electronics*, March 1, 1971, p. 73].

In the years since 1971, companies such as Motorola Semiconductor—which built the first SQ matrix IC—have developed second, third, and fourth generation systems that add various kinds of front-to-back, left-to-right, corner-to-corner, and wave-matching circuitry to improve the separation. But while separation has improved five-to-tenfold, to about 15 to 40 dB, directionality is still a major problem, Lipold says. "Where separation in any one direction, say left or right, may be as high as 40 dB, the separation in other directions can be as low as 15 to 20 dB."

New matrix. What Tate engineers have come up with, Ruggles says, is a modifying matrix that extends the mathematical solution on which existing matrix decoders are based. "The difference between our solution and everyone else's, is that, where everyone else has tried to fix the matrix by adding compensating logic, we've gone back and fixed the mathematics."

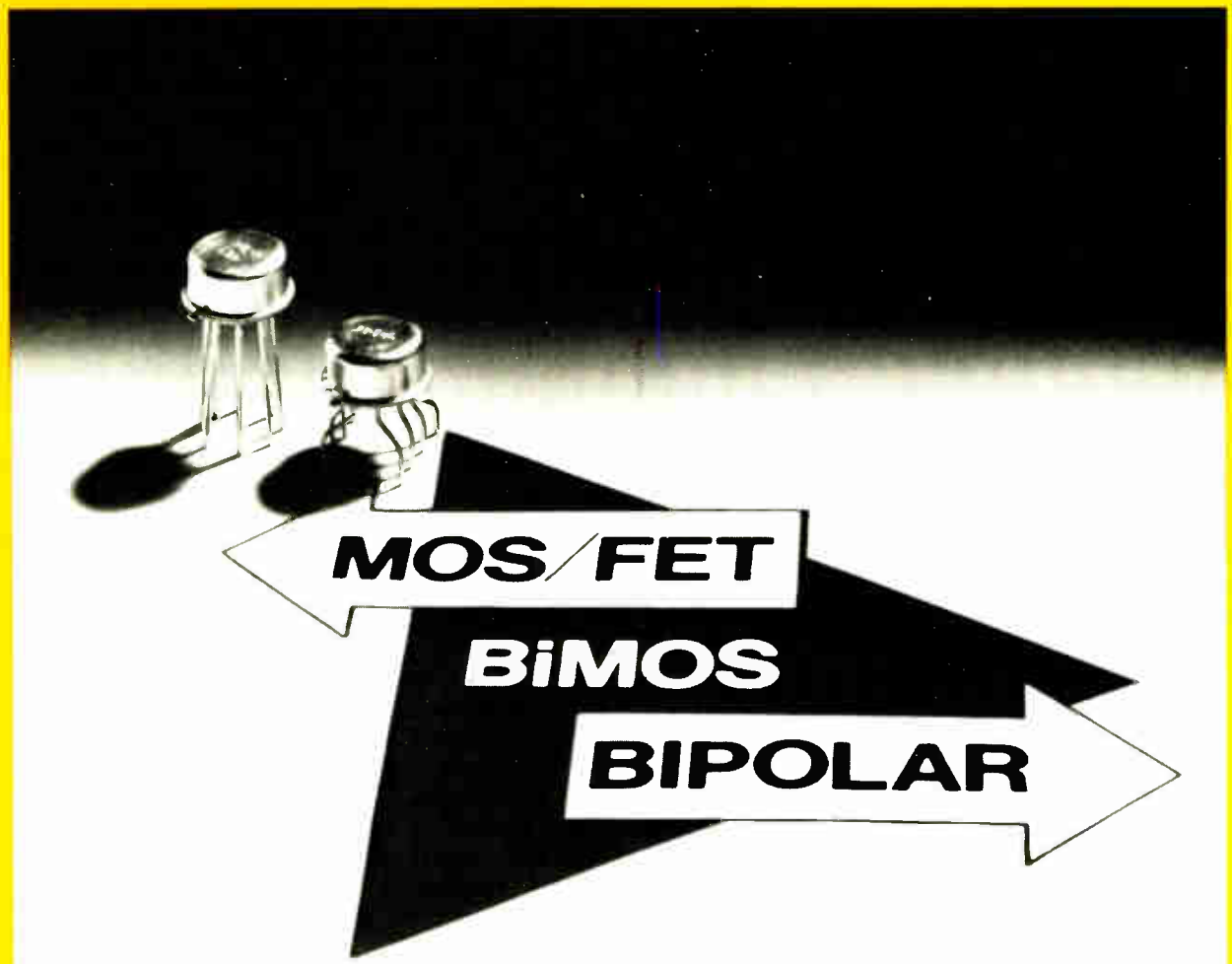
Functionally, this new matrix will be implemented by means of three specially designed circuits in the Tate/National IC set: a detector that continuously recognizes the direction of the predominant sound source from any matrix decoder, such as SQ, and produces corresponding control signals; a processor that imposes the suitable level-limiting and time-constant characteristics on those signals and generates from them a number of voltages representing the coefficients of the modifying matrix, and a matrix multiplier that multiplies the incoming four signals by the modifying matrix to obtain four output signals in which the directionality of the predominant sound source is enhanced.

The system, says National's Recine, is now in mask layout and prototype chips should be available for testing by this fall. He says National is committed to having a system up and running in time for the Consumer Electronics Show next spring and shipping parts in quantity soon thereafter.

And if the Tate/National system doesn't solve the problems, someone else will eventually come up with a system that does, Dash says. "The market potential is just too large to ignore." Recine agrees, and estimates that, if the IC set being developed jointly with the British firm works, it could bring "several tens of millions of dollars in sales to National over the next four to five years." □

Announcing a BiMOS breakthrough...

The RCA 3140: most useful op amp since the 741.



For the price of a 741 you get a lot more op amp. MOS/FET input makes the difference.

Every so often a new advance greatly expands op amp versatility. In 1965 there was the general-purpose 702. Followed in 1966 by the 709, with higher voltage, gain and input impedance. Along came the 101 with still higher voltage and gain. Then in 1968 the remarkable 741 gave you the added benefits of on-chip compensation and low cost.

Now, RCA announces a new giant step toward the ideal op amp. The CA3140 Series of BiMOS op amps.

It gives you the big advantages of MOS/FET input...*plus* bipolar speed and high supply voltage operating capability: 4 to 44 V, dual or single supply. That means very high input impedance: 1.5 TΩ typ. Very low input current: 10 pA typ. at ±15 V. Low input offset voltage: as low as 2 mV max. Wide common-mode input voltage range—can be swung 0.5 V below negative rail. In addition, output swing complements input common-mode range, permitting full utilization of low supply voltages (down to 4 V). And PMOS input devices are protected by rugged bipolar diodes.

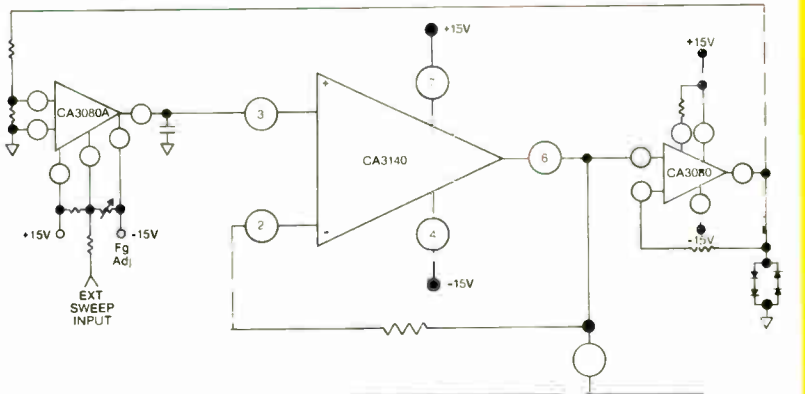
BiMOS vs. 741

You get all of those features for the price of a 741. 69 cents at the 100 unit level for the CA3140T, S. Plus big circuit savings. BiMOS minimizes bias circuitry. Allows single supplies in portable, automotive and instrumentation equipment.

BiMOS vs. BI-FET

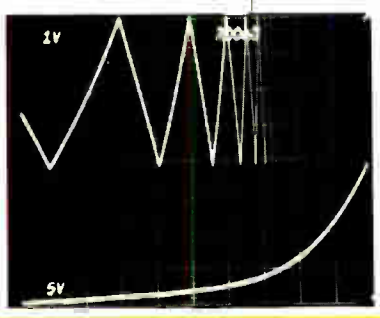
Compared to recently announced higher-priced BI-FET types, the CA3140 offers lower input currents, higher input resistance, improved offset current and comparable offset voltage—all with high slew rate and bandwidth. So chances are, you don't have to pay the higher prices.

In fact, in most existing circuits using premium op amps, the CA3140 permits cost reductions and/or improved performance with minimum circuit redesign. And if you have an application where you ruled out op amps altogether because of cost...reconsider. The CA3140 is cost effective in many places where other op amps are not.



Basic Function Generator

The CA3140 gives 1,000,000:1 range, single control when used as a buffer readout for the integrating capacitor in this basic function generator. The RCA data sheet (File No. 957) tells you how to build this circuit.



Low circuit cost

The CA3140 needs no external compensating circuitry. It is characterized for low-cost TTL systems requiring operation at 5 V and maintains operation down to 4 V. Its wide bandwidth—4.5 MHz unity gain—makes possible low-cost video and audio circuits. For low-cost sample and hold and other data acquisition systems, it offers fast settling time: 1.4 μs typ. to 10 mV. When it's driving power transistors, the output swings to within 0.2 V of the negative supply, eliminating the need for level-shifting circuitry.

CA3140 vs. 741 at a glance

Characteristics at Supply Volts: V = 15, V = 15 @ 25 C	Limits						Units
	CA 3140T, S			CA741CT,S			
	MIN	TYP	MAX	MIN	TYP	MAX	
Input Resistance, R_I	300,000	1,500,000	—	0.3	2	—	MΩ
Input Current, I_I	—	10	50	—	80,000	500,000	pA
Input Offset Current, I_{IO}	—	0.5	30	—	20,000	200,000	pA
Input Offset Voltage V_{IO}	—	5	15	—	2	6	mV
Slew Rate, SR (Closed Loop)	—	9	—	—	0.5	—	V/μs
Gain-Bandwidth Product f_T	—	4.5	—	—	1.0	—	MHz
Common-Mode Input Range, V_{ICR}	±5	-15 to +12.5	+11	-12	+13	+12	V
Output Swing R_L = 2KΩ	±4	-14 to +13.0	+12	-13	+13	+10	V
Large Signal Voltage Gain A_{OL} R_L = 2KΩ	—	20,000	—	—	20,000	—	

Versatile building block

Beyond standard op amp uses, the CA3140 can perform in many other applications. Such as ground-referenced single-supply amplifiers. Sample and hold amplifiers. Long-duration timers/multivibrators. Photocurrent instrumentation. Peak detectors. Active filters. Comparators. Tone control circuits. Function generators. Power supplies. Portable instruments. Intrusion alarm systems.

Six commercial versions are available: in the TO-5, the standard CA3140T and the premium types CA3140AT and CA3140BT; the CA3140S, CA3140AS and CA3140BS are the DIL-CAN versions of the TO-5. Also available is the chip version—CA3140H. The CA3140 series is available processed to all levels of MIL-M-38510/883.

Send for 13 useful circuits.

To show you how useful the CA3140 is, we've designed it into 13 typical circuits. To get these circuits plus other information, contact your RCA Solid State distributor. Or RCA.

Write: RCA Solid State, Box 3200, Somerville, N.J. 08876; Ste Anne de Bellevue H9X 3L3, Canada; Sunbury-on-Thames, U.K.; Fuji Bldg., Tokyo, Japan.

RCA

RCA. Full house in Linear ICs.

Circle 71 on reader service card

Communications

Canadians think digital

Plan to start with smaller switching in less centralized offices, while AT&T concentrates on big cities

by Richard Gundlach, Communications & Microwave Editor

The telecommunications industry is going digital: that's no longer in doubt. The only question remaining is how best to handle the transition. The answer, judging from the way it's being done in the U.S. and Canada, depends on competition and need.

South of the border, AT&T is faced with growing competition from specialized common carriers cutting into its lucrative toll routes, particularly in high-use metropolitan areas. So it has decided to beef up its large toll-switching systems to provide increased service at reduced costs per circuit mile. To this end, AT&T has already cut over its first all-electronic digital toll switch, No. 4 ESS, in Chicago, and plans to continue to add these large capacity switches in high-use areas. By 1978, 20 should be in operation.

But Bell Canada is taking a different tack. With a need to serve smaller, less centralized groups of subscribers, the Canadians see distributed digital switching as the key. The numbers tell the story: 1,300 to 1,400 central offices of all shapes and sizes with over 1.25 million lines serving less than 100 subscribers each.

Money saver. Bell Canada's commitment to speedy digital conversion is a strong one. "Although we have the option of waiting, delay could be costly," points out Robert C. Scrivener, chairman and chief executive officer of Northern Telecom Ltd., the manufacturing arm of the Canadian phone company. Three quarters of Bell Canada's intertoll network will be digital in the early 1990's and will be all-digital by the turn of the century.

The digital route is dictated by the simple need to reduce costs. With digital switching techniques, large switches can be replaced with small solid-state components to reduce costs of equipment and maintenance. And digital technology is particularly suitable for remote peripheral operation: with both control and voice signal in digital format, chunks of the switch can be moved to new locations close to clusters of subscribers and linked to the main switch by digital carrier lines. This means a tremendous savings in copper and outside plant as well as a savings in maintenance costs and space.

"Crowded cable ducts in cities are rapidly filling up, and the costs of replacing new cable is skyrocketing," says W. C. Benger, group vice president for transmission at Northern Telecom. And according to Scrivener, a way must be found to move digital equipment into central offices economically alongside analog gear, so that even the relatively few customers who want the benefits of digital services can be accommodated while those others still satisfied with only step-by-step switching can be served economically until the whole office has to be changed.

As Gordon E. Inns, vice president of Bell Canada's Ontario region, tells it: "We recently finished a study that showed we could save as much as $40 million per year in new capital if we went digital that otherwise would have to be spent on new trunks, loops, buildings, and wire centers needed to serve Bell Canada territory. And that's just capital. We haven't even begun to estimate the benefits that will accrue from increased flexibility, shorter provisioning intervals and easier maintenance."

Looking at the numbers, the Canadians figure that digital implementation of all the existing copper and mechanical switches could reduce the work force by a third. And today's large-scale integrated technology, coupled with increasing use of software, will make the switchover feasible, adds Scrivener.

Lloyd Webster, vice president and product-line manager at Northern Telecom, points out that digitizing and distributing switching equipment is already saving money and claims that Northern's new family of digital multiplexed switching systems, called DMS, will not only reduce maintenance costs, but will also eliminate equipment needed for digital-to-analog interfacing. The distributed-switching aspects of the new digital equipment family, which is LSI-implemented, stored-program controlled, and all-electronic, serves to place parts of

the central office closer to the subscriber loop.

Natural evolution. The DMS family carries the proven technology of Northern's digital private automatic branch exchange, the SL-1, into the local office or community dial office system. These systems need only a fraction of the space now occupied by the older mechanical switches. For example, 3,500 lines of DMS-10, Northern's digital multiplex switching system for local offices, fit into the same space now occupied by 500 lines of step-by-step switching equipment. To replace crossbar switching, the digital switch uses less than 25% of the space. It uses half the space of some of today's stored-program-controlled analog systems. Moreover, a DMS remote-switching system can easily handle the more demanding and growing needs of a new building over the same few pairs of wires that served the old building. And one central maintenance center can provide a teletypewriter printout in straightforward language as the system continuously monitors itself. The printout can pinpoint trouble areas as close as a specific circuit card.

The first in the digital-multiplexed family is the DMS-1 switch. It can handle up to 256 lines and will be introduced in the fall. To be used initially as an analog subscriber subcarrier system, it will later serve as a remote network when connected to a particular digital switch. Other systems will follow.

Included will be a fully digital central office for 1977. Called the DMS-10, it will handle from a few to 6,000 lines. By 1980 there will be a large digital system, similar to AT&T's No. 4 ESS switch, for local central office switching. It will be able to handle toll calls and control up to 100,000 lines.

"We at Bell Canada have decided that DMS is the way to go and we are planning for it right now," Inns says. "By the mid-1980s we expect to have DMS in most of our major cities and in many of our smaller central offices. That should account for about 15% of our exchanges, but will provide service to only about 8% of our customers." □

Companies

Israel's Tadiran finds the formula

$200 million company's steadfast faith in electronics has led to worldwide business in military radios

by Hesi Carmel, McGraw-Hill World News

In the short history of Israel's industrial development, one company has enjoyed unprecedented success. And one of the main reasons has been its unswerving belief that the future is electronics.

The company is Tadiran, Israel Electronics Industries Ltd. Turning out two thirds of Israel's total electronics product, Tadiran has also gained an eminent position on the world market in the field of military tactical-communications systems. In fact, with $100 million of its projected 1976 sales total of $200 million derived from exports, Tadiran will be the country's largest single exporter. And, at the AFCEA (Armed Forces Communications and Electronics Association) show in Washington June 8 to 10, Tadiran was scheduled to be the second largest single exhibitor and probably the only foreign one.

The company began in 1961 as a small maker ($750,000 in sales) of batteries and quartz-crystal devices. Its growth from then till now has been shepherded by a dynamic and enthusiastic director-general, Elkana Caspi, one of the new Israeli generation of American-style managers. It was Caspi who gave to Tadiran its esprit de corps and modern management methods, and it was Caspi who convinced government officials during the economic crisis of 1965–66 that electronics was the path to growth.

Long line. In 1969 it became an international corporation, with half its shares owned by the Israeli labor-union controlled Koor Industries Ltd. and the other half in the hands of Americans. Today, the company makes, in addition to military products, a line of consumer goods (air-conditioners, refrigerators, washing machines, and television sets), computer terminals, and telephone exchanges, as well as nickel-cadmium batteries and quartz crystals.

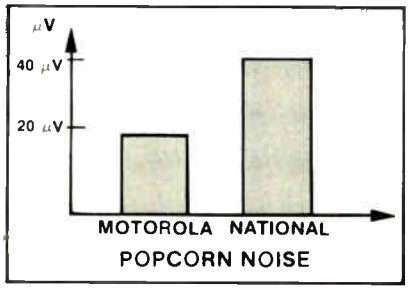
But the backbone of Tadiran is its military radios. Many have proved their worth in Israel's wars. And the war-won experience has led to the improvement of American radios made by Tadiran under know-how agreements. For example, the AN/VRC-12, a vhf/fm mobile set with 920 channels between 30 and 76 megahertz, has gone through many changes. The LSA-100T has gained a loudspeaker, and the AN/GRC-106A, an hf single-sideband model with 280,000 channels between 2 and 30 MHz, has an added automatic tuning system.

Besides foreign-licensed products, Tadiran has developed a variety of its own models. One, the PRC-660, has evolved into a family of multiservice radio sets. The most popular radio in the Israeli army, it is one of Tadiran's best export items and may become the standard radio in several European armies.

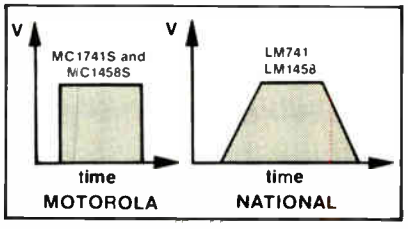
Currently the pride of Tadiran is the recently developed TRC-645T, a radio-telephone system housed in a shelter that can be mounted on vehicles or carried by helicopter. It is crowded with a variety of communications gear for use by senior officers during combat and can maintain long-range communications via teleprinter, telegraph, radio, or line. Foreign armies have already ordered $10 million worth as military

On the move. The TRC-645T is a shelter-contained radio-telephone system that can be truck-mounted or carried on a copter.

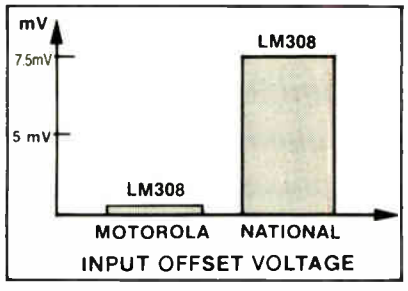
Motorola Modestly Publishes Op Amp Specs National Can't



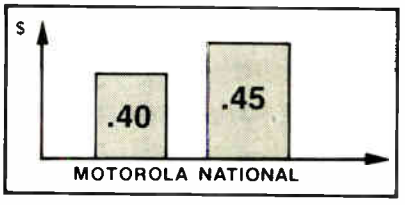
Motorola N series '1741 and '1458 are guaranteed less than 20 μV noise while others are typically above 20 μV.



Motorola S series '1741 and '1458 are guaranteed 20 times faster in slew rate and power bandwidth than other typical specs.



Motorola '308 series is laser trimmed to guarantee less than 0.3 mV input offset, ensuring far less adjustment at your door.



Motorola '1741 and '301 mini-dips are lowest priced in the industry (latest 100—up).

STANDARD PRODUCT RELIABILITY AUDIT PROGRAMS

MOTOROLA	NATIONAL
(1) EPIIC — Environmental Package Indicators for Integrated Circuits	?
(2) LAPP — Linear Accelerated Punishment Program	
(3) CRP — Consumer Reliability Program	

Motorola's first concern is op amp reliability and you can take that to the bank.

Op Amp Flip Chips

MCCF1709	Uncompensated
MCCF1741	Compensated
MCCF1458	Dual
MCCF3403	Quad
MLMCF324	Quad

Motorola offers the only Flip Chip op amps in the industry for the do-it-yourselfer.

1 Opmanship . . .

MC3403 Quad Op Amp—Right Now
MC3458 Dual Single Supply—Right Now
MC3471 Quad FET Input Op Amp—July '76
MC4558, a '1458 with guaranteed 2.5 MHz Bandwidth—Pretty Quick
MC4741, Four '1741 in Single DIP—Right Now
LF155/156/157 FET Input Op Amps—July '76
LM324 Quad Op Amp—Right Now

And you thought we were just a production house

MOTOROLA Semiconductors

P.O. Box 20912, Phoenix, Arizona 85036

Circle 75 on reader service card 75

Probing the news

planners look for more mobility in communications.

The third factor in Tadiran's success—in addition to devotion to electronics and modern management—is its R&D. That effort occupies 300 engineers and technicians (out of a total of 6,000 employees) and 4% to 5% of the company's gross. "We are already working on the products of the eighties and nineties," says Akiva Meyer, vice president for planning and development. The two-pronged objective is to increase the proportion of home-developed products from 20% today to 60% in 1980 and that of civil and consumer goods. By 1980, Meyer says, 20% of the projected $200 million in exports will be nonmilitary.

Other jobs. Among major development projects are:

- A rural telephone system that can handle up to 400 subscribers. It has its own power supplies and can be delivered by helicopter.
- SEDA—for solar energy for domestic applications—which has spawned an experimental solar-powered refrigeration unit. "In four years," says project director Heyuda Lando, "we expect to have a fully developed, mass-producible product." This project is expected to lead to a basic solar power supply for the home.
- Lithium batteries for medical and other special use. Tadiran is going into a joint venture with a German company to market the batteries in Europe.
- An advanced high-speed data terminal that prints 120 characters per second with its asynchronous serial impact printer. More than 200 units were sold last year in Europe; exports this year are expected to reach 1,000.

Tadiran says that, despite Arab boycott pressure, it continues to gain new customers and markets. In fact, it is said that Saudi Arabian companies have approached Tadiran, through its London agent, for details about the rural telephone system. It is such happenings that lead Caspi to say: "For a company from a small country like Israel, we have made some impact." □

HOW THE LEADER IN DIGITAL VOLTMETERS PLANS TO STAY THERE.

A while back, we got a head start on everybody else in DVM's. People bought more of our instruments than they did the competition's.

Nothing has changed.

We still have the lead because we discovered a few things about the test and measurement field. We learned some things about developing new DVM's for the changing electronics industry.

Above all, we learned, don't offer a DVM unless it truly has value for the guy on the bench.

That means value across the board.

Five-range AC/DC volts to 1200V	only Fluke
Six-month calibration cycle	only Fluke
10,000-Hour demonstrated MTBF	only Fluke
Environmental capability specified and defined	only Fluke
Full line of accessories offering HI volts to 40 KV, RF to 500 MHz, current to 600A	only Fluke

There's not much competition.

Not just one feature that's unique or one lock-out spec, but an entire package that makes complete sense and offers you total value all the way around. Take specs, for example. We publish very conservative specifications. No one else does, but we think it's important that the instrument gives all the specs we've guaranteed. And then a little more. We feel that you ought to get better performance than you expected when you buy a Fluke instrument.

So what should you expect in a DVM?

First, an initial low cost. But also a low cost of ownership.

The Fluke 8600A sells for $549.*

But, even more important, the 8600A has a demonstrated 10,000 hours MTBF. We've fully defined and specified environmental capabilities. And the calibration cycle is 6 months.

That's going to save you a bundle in cost of operation.

Without any sacrifice in specs. Guaranteed six-month accuracy specs at 15°C to 35°C with an extremely low

A running start helps.

temperature coefficient. Five ranges each of ac and dc volts to 1200V with 0.02% dc and 0.2% ac accuracy. Five ranges each of ac and dc current to 2A with 0.1% dc and 0.3% ac accuracy. Six ranges of resistance to 20 megohms with 0.1% accuracy. AC bandwidth to 100 kHz.

Autoranging through all ranges plus individual range selection. Continuous overload specified for all ranges/functions with overload indication.

Features for flexible operation. Environmental capability specified and defined. Automatic zeroing. Low 7-watt power consumption for reliability. And a full line of accessories including 40 KV high voltage probe, 500 MHz RF probe and 600 A ac current probe. A self-contained rechargeable battery option.

And remember, those are conservative specs for the 8600A. At $549.

A genuine value from Fluke.

Which suggests we plan on being the leader in DVM's for a long time coming.

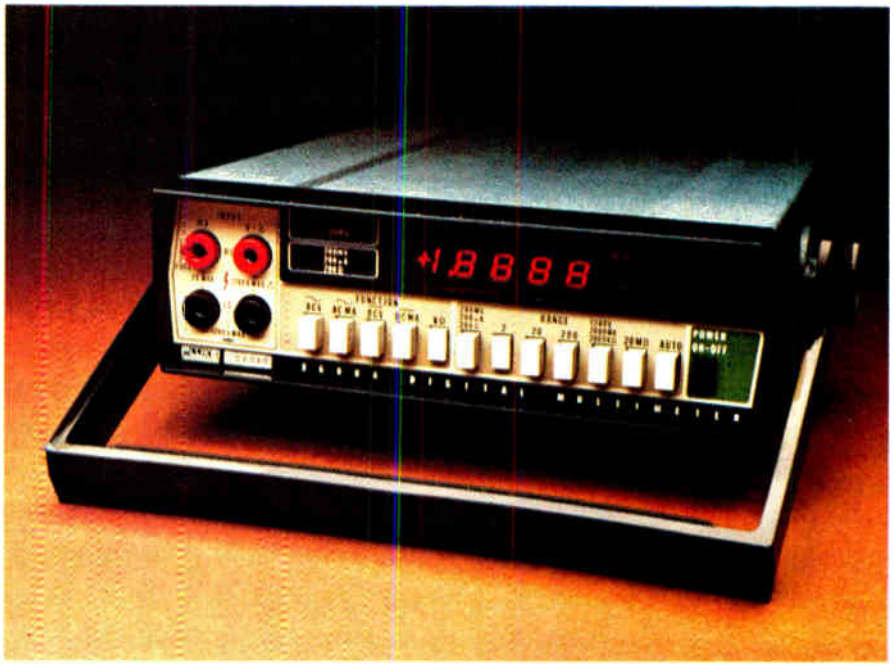
No matter how much it upsets our competitors.

For data out today, dial our toll-free hotline, 800-426-0361.

John Fluke Mfg. Co., Inc., P.O. Box 43210, Mountlake Terrace, WA 98043

Fluke (Nederland) B.V., P.O. Box 5053, Zevenheuvelenweg 53, Tilburg, Netherlands.
Phone: (013) 673-973 Telex: 52237

**Domestic price only.*



THE INDUSTRY STANDARD. 8600A DVM. FLUKE

POS outlook cheers TRW's Webb

Executive points to customer base acquired from Singer in a market he expects will grow at least 20% a year

Guided by J. Sidney Webb, a corporate executive vice president, TRW Inc.'s Electronics Group moved quietly into the data-communications market in 1971. First concentrating on equipment and services necessary to supply business credit data, then offering point-of-sale hardware, TRW's data-communications operations became profitable in late 1974. This was noteworthy at a time when losses forced many firms with wide experience and big investments out of the field.

Last month, TRW signed an agreement to take over service for all Singer Corp.'s POS equipment, some 65,000 installations with a value of about $500 million, the industry's largest customer base. Also, the firm introduced its microprocessor-controlled 2001 POS system, which features a video terminal and can be reprogramed on-site. Clearly, TRW Electronics is gaining momentum in an extremely competitive field. To update the firm's strategy and timetable, *Electronics* questioned Webb. Here are excerpts.

Q. Just how, why, and when did TRW get into data communications?

A. Briefly, six years ago the board asked me to look into whether we could get fallout from our high-technology-components and military-aerospace-satellite businesses. After a long study, we chose this area. One of the first things we ran into was Datapoint Corp. [a troubled terminal maker], where we took a minority interest, helped them, and in 1971 made an agreement to be their international distributor. At the same time we entered the related telephone-equipment business when we bought Digital Products. From over in the Systems Group, we transferred a company called Credifier, now Data Systems, and began to implement our strategy.

Q. What is your strategy, and how is it different from your competitors'?

A. One way is we decided against getting into the POS business right away with a "me, too" product. We didn't want to take huge losses, and mostly since we believe the coming thing is the microprocessor, we felt we had to have a new generation. So we began to design what became the 2001. At about that time we agreed to build and maintain May Co.'s own POS but not sell it to anyone else, because it was not right for the entire marketplace. And when Credit Data Systems was also transferred to me in 1973, we decided to concentrate on business credit. We are not a hardware company in the sense of selling individual parts, such as terminals, to anybody. We are an electronic systems company that can tell a customer we understand his business well enough to help solve his problems.

Q. How did TRW make money early in the game, while most others didn't?

A. One basic reason is we would rather sacrifice growth than profits. Our feeling is against pie-in-the-sky and huge losses for a long time, weighed versus possible payoff.

Q. How does the Singer deal fit into your plans?

A. Foremost, I believe it's going to be very profitable right from the start. Second, it will help our POS grow nationwide, adding maybe 2,400 people to our 400, and also help both retail and financial.

Q. How does TRW see the growth potential of data communications?

A. At least 20% a year; some parts like transactional data communications, 30% to 35% a year.

Q. Whom do you rank as the main competition?

A. That's a hard one, because it depends on their position in different segments. For example, I guess NCR is the biggest in POS, but small in financial. Burroughs is the opposite, and IBM is in everything, so it's hard to say. If you're talking about POS in supermarkets—and we're not in that—National Semiconductor is doing pretty well.

Q. What do you need to round out your plans?

A. A couple of years to demonstrate that large investments in POS and business credit are sound, especially to handle the huge task of Singer maintenance. And a bigger telephone-equipment business because we feel the communications and computer fields are so crossing and co-mingling, it's hard to tell one from the other. It's obvious the telephone industry has to go digital, with voice as well as data, and the software and equipment are similar. Finally, I don't see any big holes where, to complete our data-communications business, we need this or that. The areas we're in today in the next two years are going to show tremendous growth. □

IT WAS BOUND TO CAUSE DOUBT, CONFUSION, WORRY AND A LITTLE PANIC.

Before the 6011A came along, a lot of people thought they knew who made the best signal generator.

Now, there's doubt and confusion.

We started with the best everyone else had. Then, we began our serious design work on the 6011A—a new, microprocessor-based signal generator. And along the way, we also solved the problems of setting frequencies and amplitudes. There had to be less dialing, and no time standardizing. We decided to get rid of all the unnecessary adjusting. And let the microprocessor do the work for you.

People are finding they can't just buy that comfortable old name, with the same old features. Fluke has a signal generator that does a whole lot of things that no one else can do.

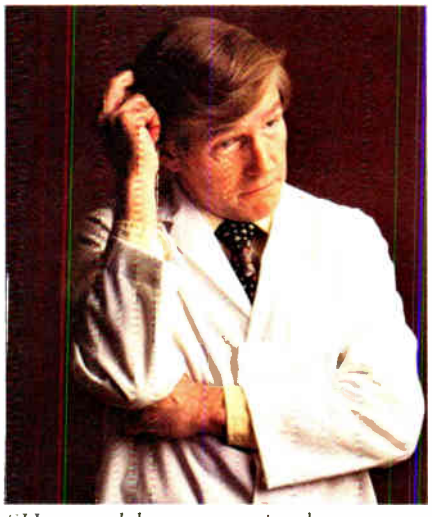
Read on. You'll see why the competition is a little panicky.

The 6011A performs the functions of an oscillator, counter and level meter setup over a range of 10 Hz to 11 MHz, within amplitudes ranging from 0.4 millivolts to 5 volts rms and −55 dBm to +27 dBm. And does it fast.

The microprocessor stores up to nine combinations of output settings in memory. That's frequency and amplitude combinations, with modulation and range settings. Particularly important for repetitive tests at several frequencies and amplitudes. Less time. No operator error. A push of the button recalls the setting.

We had a few people test the 6011A. Using the 6011A recall capability, they could call up nine different frequency and amplitude combinations within four seconds.

Once the setting is called up, edit control lets you modify your frequency or amplitude with a simple turn of a dial. Any decade, as indicated by the brighter digit on the readout, can be changed. Increment or decrement with complete carry and borrow capability. And a recalled frequency or level can be modified without changing the original stored entry.



"How much better can a signal generator be?"

The reference mode lets you add or subtract frequencies or levels relative to previously entered references.

Level limit eliminates damage to sensitive devices. The operator can't use an output greater than a pre-programmed safe limit.

The 6011A is designed for free form entry of volts, millivolts, dBm, Hz, kHz, and MHz. For example, output levels entered in volts can be modified in decibels to a resolution of 0.01 dB. The user can select volts peak-to-peak or rms volts terminated in 50 ohms or open circuit. Maximum open circuit voltage is 28.28 volts peak-to-peak. At 11 MHz!

Accuracy is so good there's no need for output verification. An rms sensor controls the output accuracy to better than ±0.05 dB. Frequency response is flat to within ±0.025 dB from 100 Hz to 5 MHz. Output frequency accuracy is within 3 ppm over a one-year period and a wide temperature range.

Finally, we kept the price way down. At $3995*, the 6011A is 40% less than anything remotely comparable.

About now, are you beginning to feel you're going to expect a lot more from your next signal generator? Well, ask for a 6011A demonstration first.

And find out how much you can expect from a signal generator.

For data out today, dial our toll-free hotline, 800-426-0361.

John Fluke Mfg. Co., Inc., P.O. Box 43210, Mountlake Terrace, WA 98043

Fluke (Nederland) B.V., P.O. Box 5053, Tilburg, The Netherlands.
Phone: (013) 673-973 Telex: 52237

**U.S. price only.*

INNOVATIVE 6011A SIGNAL GENERATOR

FLUKE®

Circle 78 for demonstration, circle 79 for literature

21 YEARS OF REASONS TO LOOK HERE FOR PRECISION MEASUREMENT.

For over 21 years, we have not altered the integrity of our precision measurement line.

Our general instrument line is built to the same standards of quality.

Before you buy a DMM, counter, signal generator or any other general instrument, always take a look at a company's precision measurement line. There is a connection.

Ask about their experience in precision technology. Inquire into the extent of their precision measurement product line. Find out about their standards and traceability.

Then compare to what you see here.

"I wouldn't expect anything less than a long and distinguished history."

1955: Fluke introduces the world's first DC differential voltmeter.

Over 21 years ago, we began building differential voltmeters—in many instances, setting the standards for the industry. Here are three.

The 893A is an AC/DC differential voltmeter with DC accuracy of ±0.01% of input and AC accuracy of ±0.05% of input. There is infinite input impedance from 0 to ±1100 VDC. Resolution is 1 ppm of range.

The 895A DC differential voltmeter achieves an absolute accuracy of ±(25 parts per million of input + 1 ppm of range + 5 uv) from 0 to ±1100 VDC. Over the entire range from 0 to ±1100 VDC, the 895A offers infinite input impedance at null. A unique Fluke solid state, photo-chopper-stabilized 1100 VDC reference supply is calibrated against a zener EMF with state-of-the-art stability and temperature coefficient parameters. Due to the excellent stability of the zener supply, the overall stability of the 1100 VDC reference is better than 5 ppm peak-to-peak per hour, and 8 ppm peak-to-peak per day.

The 931B is a true RMS voltmeter designed for rapid measurements of AC waveforms regardless of their shape. Accuracies to ±0.05% of reading are obtained in a simple-to-operate portable instrument with a five-digit readout. As with all Fluke differential voltmeters, the 931B incorporates a "TVM" or conventional direct-reading mode for rapid indication of the RMS value of input. Frequency response in TVM mode is 2 Hz to 2 MHz. Response in the null or differential mode is 2 Hz to 1 MHz.

The 893A is $1445*, the 895A is $1745*, and the 931B is $1545*.

1957: Fluke introduces ultra-stable DC calibrator.

Two years after introducing differential voltmeters, we expanded our precision measurement line to include DC calibrators. Now, Fluke provides a full range of instruments for all DC calibration needs. Here are three.

The 343A is a seven-dial DC calibrator that provides parameters of stability, temperature, and response required by a wide range of applications. Its accuracy is ± 0.002% of setting with 0.1 ppm resolution.

The 382A operates as a combination ±0.01% voltage calibrator and ±0.02% current calibrator. It offers voltage outputs to 50 V and current capabilities to 2 A. Maximum power available is 100 W. The stability of the 382A is 25 ppm per 24 hours.

The Model 335D provides ±0.001% accuracy as both a DC voltage standard and a differential voltmeter. Accuracy and stability across the operating range is unmatched by any other commercial instrument available.

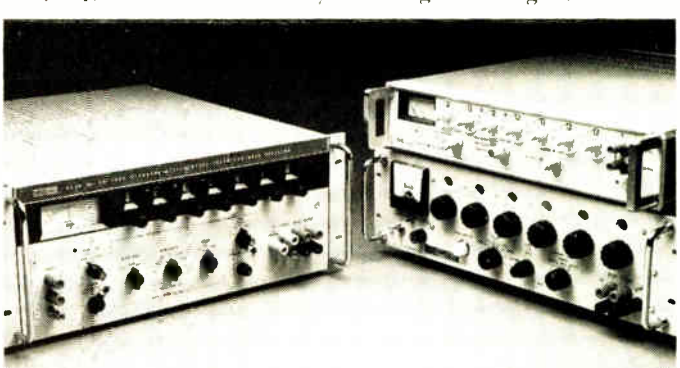
The 343A is $2195*, the 382A is $2245*, and the 335D is $3995*.

1963: Fluke introduces thermal transfer standard.

For 13 years now, we've been in the business of building high technology standards. Here are three standards representative of the Fluke line: 510A, an AC reference standard; 540B, a transfer standard; and 731B, a DC reference standard.

The 540B stands by itself in the industry. Nothing else this good is

893A, 931B, and 895A differential voltmeters.



335D, 343A, and 382A DC calibrators.

For information on the 343A circle 340
For demonstration on the 343A circle 341
For information on the 335D circle 342
For demonstration on the 335D circle 343
For information on the 382A circle 344
For demonstration on the 382A circle 345
For information on the 5200A circle 346
For demonstration on the 5200A circle 347
For information on the 5205A circle 348
For demonstration on the 5205A circle 349
For information on the 7105A circle 350
For demonstration on the 7105A circle 351
For information on the 515A circle 352
For demonstration on the 515A circle 353
For information on the 760A circle 354

commercially available. The 540B is a thermal transfer unit for NBS traceable measurement and calibration of AC voltage and current. Measurement capability is 0.25 V to 1000 V rms AC over 14 ranges, with a frequency range from 5 Hz to 1 MHz. Basic AC to DC transfer accuracy is ±0.01% without the use of calibration curves or correction tables.

The 510A is a precision-fixed frequency AC voltage source suited to calibration or test applications. Outputs of 10 V rms and 10 mA with available frequencies from 50 Hz to 100 kHz at an accuracy of ±0.01%. Total harmonic distortion is less than 0.005% to 50 kHz. Short-term stability is 20 ppm pk-pk.

The 731B DC Transfer Standard is designed to give the calibration facility and standards lab a working standard for production testing. Standard cells are extremely sensitive, especially to shock, vibration and temperature change. Instead, the 731B can be hand-carried and subjected to severe environmental conditions, yet still provide transfer accuracies to a few ppm traceable to the delicate saturated cells. Transfer accuracy is 2 ppm. One year absolute accuracy is 30 ppm.

The 510A is $645*, the 540B is $1795*, and the 731B is $595*.

1964: Fluke introduces total function meter calibrator.

Today, in the field or in the lab, Fluke meter calibrators give you accuracy, flexibility and safety in a total function meter calibrator.

Take the 515A portable calibrator. This lightweight precision calibration source is ideal for on-site calibration of measuring instruments. With four DC voltage ranges, 3 AC ranges, resistance capability from 10Ω to 10 MΩ and a rechargeable battery pack, you can perform eight hours of field operations on battery power. And that's with 0.003% DC accuracy from 1 V to 100 V.

For lab use, look at Fluke's 760A meter calibrator. With its all-solid-state construction, the 760A offers direct percent-error readout (without computation tables), on a single range for AC and DC volts, amps and ohms functions. DC voltage accuracy for the 760A is a respectable ±0.05% + 25 microvolts from 1 mV to 1000 V.

Calibrate with Fluke. In the field (model 515A) for $2145*, or at the bench (model 760A) for $3745*.

1966: Fluke introduces DC calibration systems.

Eleven years after we introduced our first precision measurement instrument, we offered the Fluke-designed system.

Accuracy to 5 ppm is standard in this DC voltage and ratio calibration system, with resolution and ratio accuracy to 0.1 ppm.

In a functional, self-contained enclosure, the 7105A offers voltmeter and power supply calibration capability, a differential voltmeter, ratio calibrator and a null detector.

The system is self-calibrating, and is supplied with certificates of traceability to the NBS. The 7105A sells for $8995*.

1972: Fluke introduces AC calibration system.

We entered the market with a fully programmable AC calibration setup.

Together, the 5200A precision AC calibrator and the 5205A precision power amplifier can calibrate AC devices up to 1200 rms. Frequency range is DC to 1.2 MHz. DC output of 1600 volts is available (using 5205A as a stand-alone amplifier). Maximum output current is 200 mA and will drive a 1500 pF capacitance load. Long-term stability is 200 ppm/6 months, midband accuracy is 0.02% overall, and response is a fast 0.5 sec.

Both instruments are short-circuit proof, fully guarded and interlocked. Phase lock input and quadrature output are standard features.

The calibrators interface easily with almost any system. Field installable serial and parallel isolated programming options are available. The system sells for $8990*.

**U.S. price only.*

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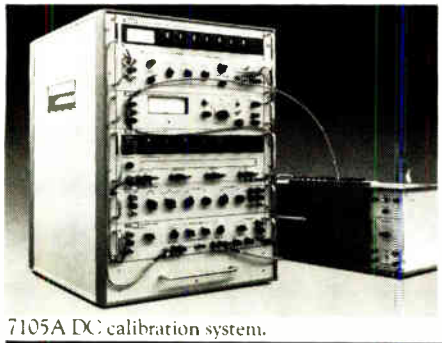
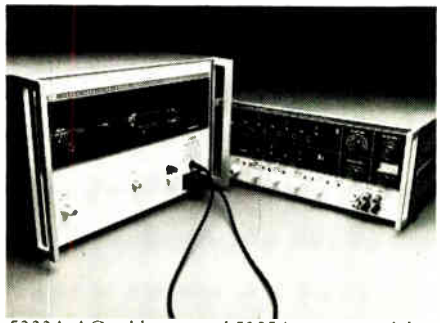


7105A DC calibration system.



5200A AC calibrator and 5205A power amplifier.

731B, 510A, 540B standards.

515A and 760A meter calibrators.

TEST AND MEASUREMENT INSTRUMENTATION. FLUKE®

For demonstration on the 760A circle 355
For information on the 893A circle 356
For demonstration on the 893A circle 357
For information on the 931B circle 358
For demonstration on the 931B circle 359
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For information on the 540B circle 372
For demonstration on the 540B circle 373
For information on the 731B circle 374
For demonstration on the 731B circle 375
For information on the 510A circle 376
For demonstration on the 510A circle 377

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Lower-cost coaxial ribbon cable assemblies. In any length.

New AMP coaxial ribbon cable is just that—true coax in ribbon form. With no compromises.
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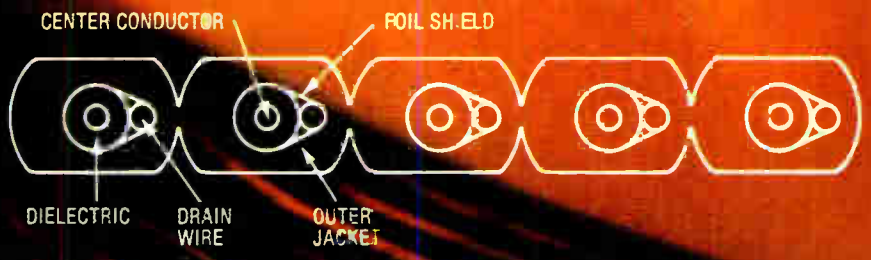

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TEKTRONIX logic analyzers

for the digital domain

Timing and binary information together with intensified trigger marker and cursor displayed by the 7D01 Logic Analyzer. The number of sample intervals from the trigger point to the cursor appears at the top of the display; cursor position—displayed in binary—appears across the bottom of the crt.

New Plug-ins with Expanded Capabilities

For digital design and testing applications, you'll find that Tektronix Logic Analyzers and Oscilloscopes are literally made for each other. To expand your digital analysis capabilities, choose either the 7D01 Logic Analyzer (a new plug-in for our 7000-Series laboratory oscilloscope family) or the LA 501 Logic Analyzer and its new companion plug-in, the WR501 Word Recognizer (these two are packaged as modular TM 500-Series instruments to work with almost any oscilloscope).

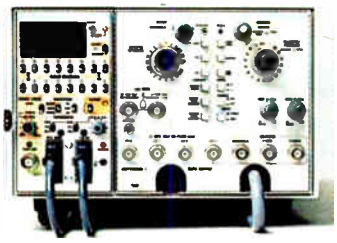
Features these analyzers have in common include:

- **16 Channel Operation**
- **15-ns Asynchronous Timing Resolution**
- **4k Memory to Store Pretrigger Data**
- **Word Recognition**
- **High Z Probes**

For versatile data acquisition, these logic analyzers let you select the number of channels and the resolution best suited to specific applications:

16 Channels, 20 MHz, 256 Memory Bits
8 Channels, 50 MHz, 512 Memory Bits
4 Channels, 100 MHz, 1024 Memory Bits

You'll like what we've done to **reduce circuit loading problems** associated with testing high-speed and high-impedance logic families. With our new P6451 active probes, which have an input impedance of **1 MΩ paralleled by 5 pF at the probe head,** you'll be able to test virtually any logic family.



LA501/WR501, Members of the TM 500 Series

Take your logic analyzer right to the problem with the LA 501 Logic Analyzer and its new companion word recognizer, the WR 501. Packaged as modular AM 500 test instruments, this pair works with any oscilloscope or X-Y monitor. Now you've got versatile logic analysis capabilities to complement the oscilloscope you probably already own.

Word recognition with digital delay gives you fast access to almost any location in the data stream.

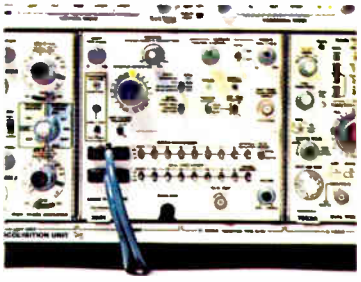
For **channel-to-channel timing comparisons,** you can select any trace and position it next to any other. And **timing tic marks** on each channel enhance visual analysis.

No matter what your application—design, production testing, or service—we've got a TM 500 logic analysis configuration for you.

On the bench, power the LA 501 and WR 501 with the TM 503 mainframe or the TM 504 mainframe (now you've got room for another TM 500 module like the DM 502 Digital Multimeter).

In a rack, use the RTM 506—there's room enough for the LA 501, the WR 501, the SC 502 Oscilloscope, and one more module. Or you can mount the LA 501 and WR 501 in a TM 503 side by side with a 604 Monitor. The 6½-in. display is easy to read.

For **field portability,** try the TM 515 Traveler Mainframe. It's rugged and durable, yet as attractive as carry-on luggage. You can pack the LA 501, the WR 501, and the SC 502 and have a complete logic analysis system in a suitcase.



7D01, A Member of the 7000 Series

Turn any 7000-Series laboratory oscilloscope into a versatile 16-channel logic analyzer with the new 7D01 dual-wide plug-in. Now, gaining logic analysis capability is as simple as adding a plug-in.

With a four-compartment 7000-Series mainframe and plug-ins, you get a truly powerful logic design tool: **a logic analyzer and a real-time oscilloscope in one unit.** Use the 7D01 Logic Analyzer to locate a digital domain problem, then zero in for detailed analysis by using the 7D01's word recognizer to trigger the analog portion of your oscilloscope. Now you can do it with one instrument and display your digital and analog information on the same crt.

With the 7D01 you also get **timing and binary information displayed simultaneously** on the crt. You do it with a cursor. And because the cursor can be moved in single clock intervals, **timing comparisons are faster, easier and more error-free than visual estimates.** When the cursor is moved to a given clock position, the binary word at that point is read out across the bottom of the display.

For more information, ask for our Logic Analyzer brochure A 3341. To get your copy, contact our local Tektronix Field Engineer, or write to Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077. Telephone: (503) 644-0161. TWX: 910-467-8708

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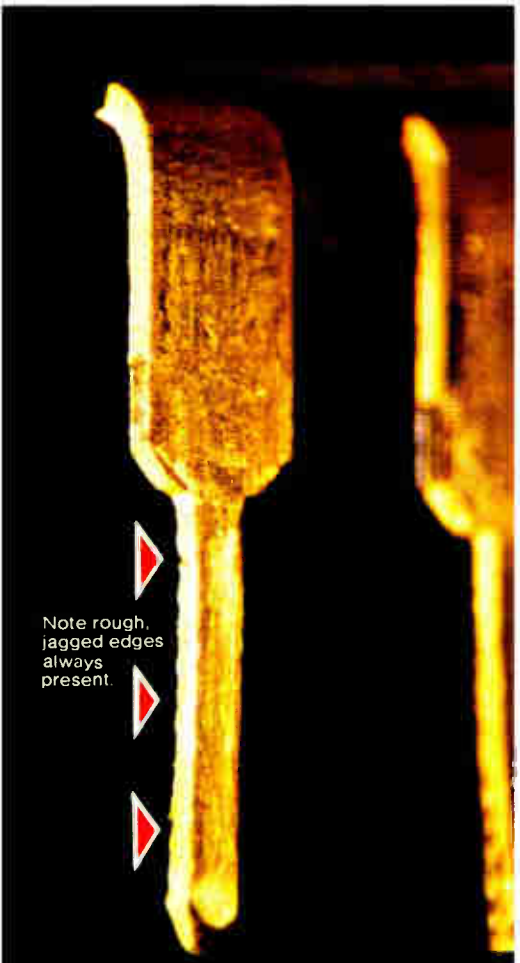
MICROPHOTOS



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

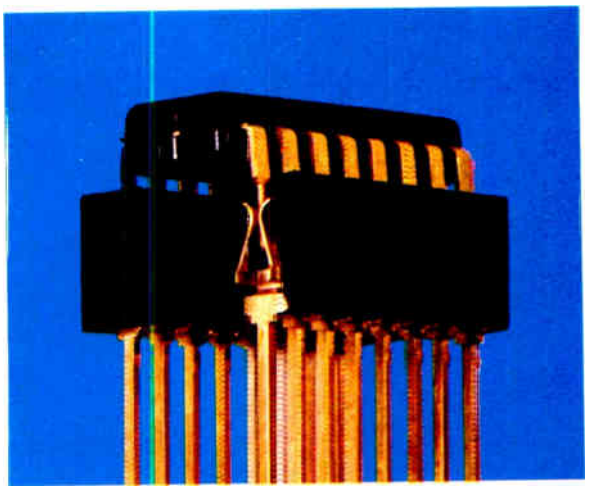
ROBINSON-NUGENT "side-wipe" socket contact after 5 insertions of DIP lead frame. Contact has been spread apart to show insice faces of contact. See how the RN contact—because it mates with tne *smooth, flat side of the IC lead frame*—retains its surface integrity. This 100% greater lead frame contact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

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

xpose 'junk' socket problems

Secret of RN high reliability 'side-wipe' DIP sockets revealed by microphotos

Here's microscopic proof that high reliability Robinson-Nugent "side-wipe" DIP sockets make 100% greater contact than any edge-bearing socket on the market. This advance design provides constant low contact resistance, long term dependability—trouble-free IC interconnects. Yet RN high reliability DIP sockets cost no more than ordinary sockets!



Get the high reliability that eliminates trouble. RN "side-wipe" DIP sockets make contact with the wide, flat sides of your IC leads. You get 100% greater surface contact for positive, trouble-free electrical connection.

WRITE TODAY

for catalog and informative book "What to Look for in IC Interconnects." Free from Robinson-Nugent—the people who make more kinds of high reliability IC sockets than anyone.

They're even packaged for high reliability. "Protecto-pak"® packaging delivers consistently perfect RN sockets to your production line—for automated or manual assembly.

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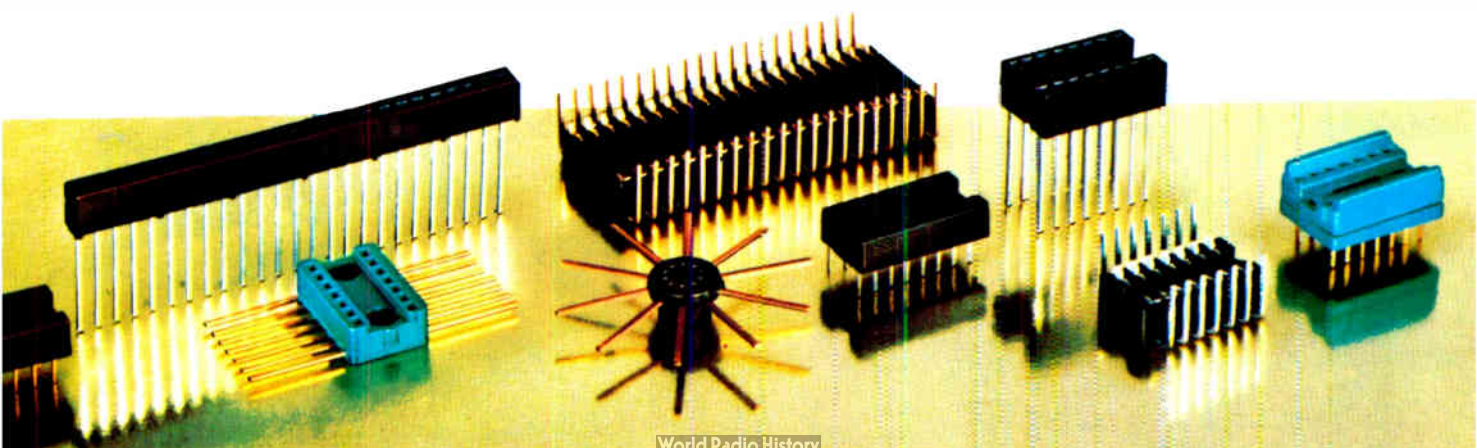

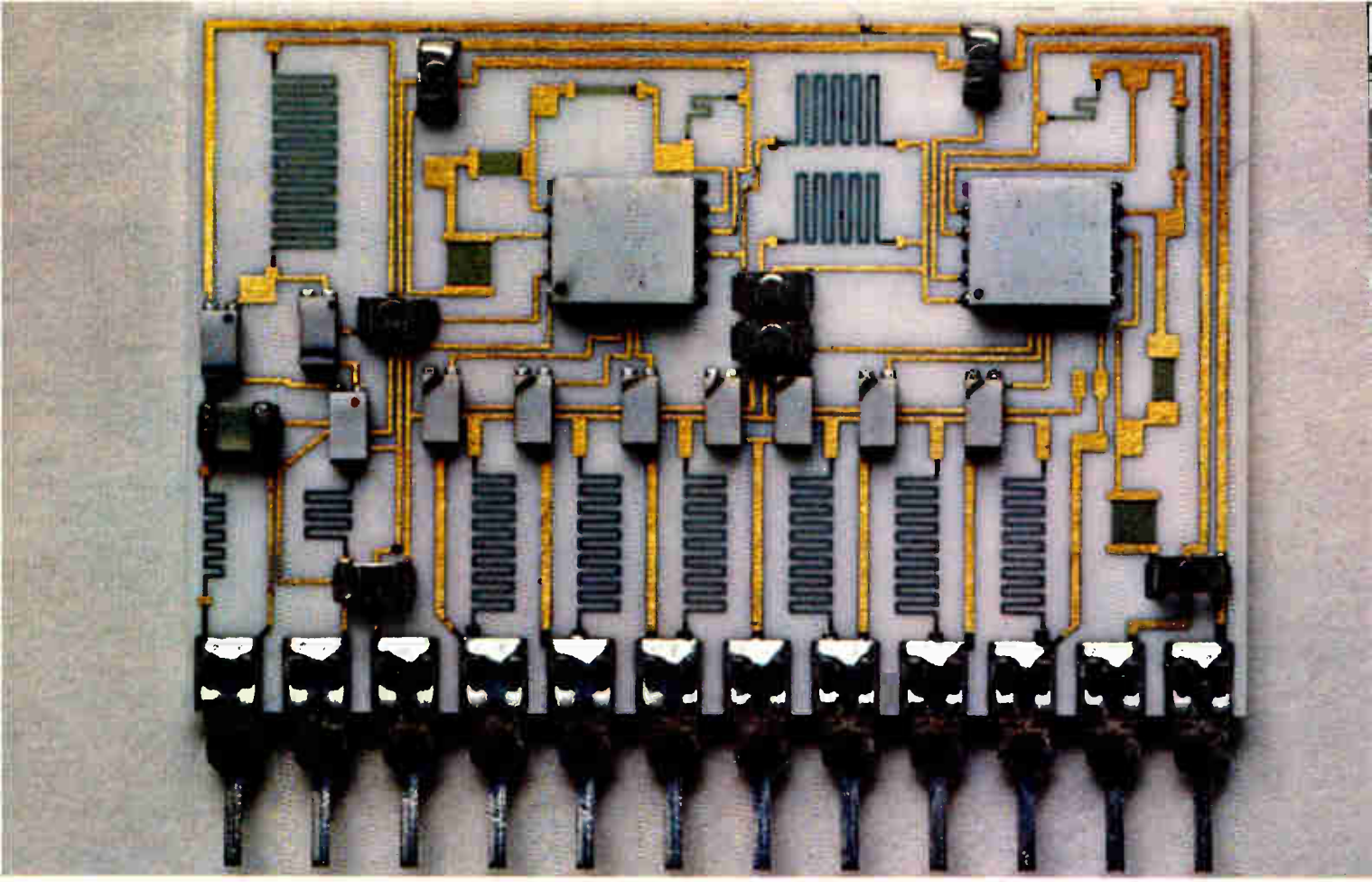

In this complicated world, you can't afford to be without us.

Introducing the GR 2230. The first computer-controlled network and module tester for under $20,000.

These days, multi-leaded networks and modules have become so complex, you simply can't get away with sample testing.

Yet in-house or calculator-based test systems are just too slow. And the computer-controlled ones cost an arm and a leg.

But now there's the GR 2230.

At the heart of this compact bench-top system is a small but powerful micro-computer. To give you computer-controlled speed, accuracy and flexibility. All starting at just $15,000.

The 2230 will test networks, modules, and low-frequency passive circuits at speeds up to 80 tests per second, measuring to specified limits the performance of each circuit component.

It can be programmed by just about anyone, thanks to its unique English-language macro-instruction keyboard. Programs are then automatically stored on magnetic cards for easy retrieval.

In addition, the system will continuously print out all test data and can be easily interfaced to virtually any device handler.

The new GR 2230. A computer-controlled tester you can afford. Now that you can't afford to be without a computer-controlled tester.

GenRad, Inc. (formerly General Radio), Test Systems Division, 300 Baker Avenue, Concord, Mass. 01742. 617-369-8770.

GenRad

The difference in software is the difference in testers.

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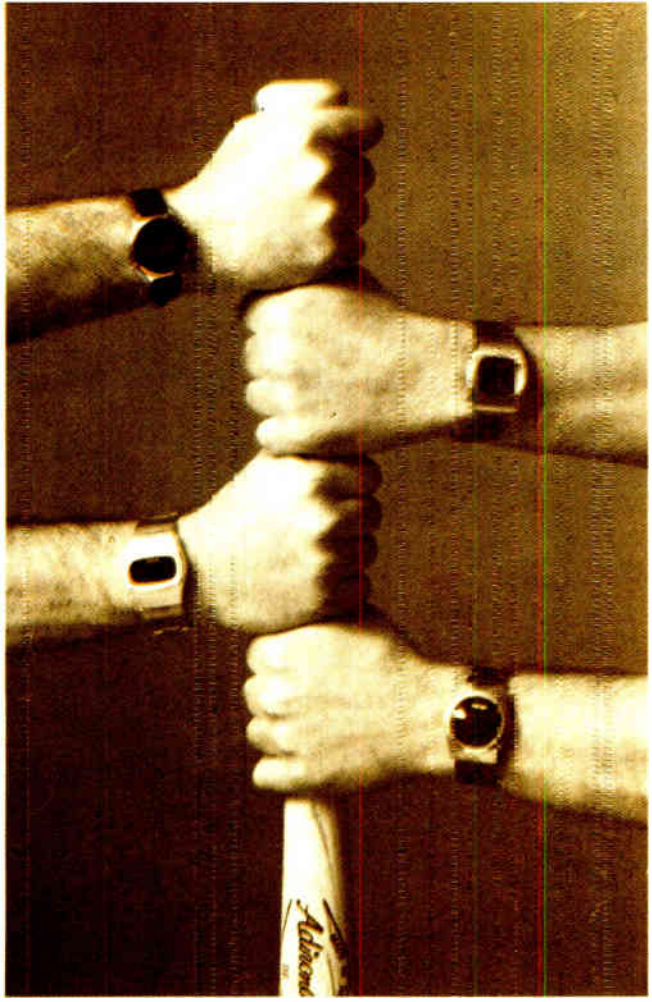


Choosing sides in digital watch technology

It's I^2L or C-MOS and LED or LCD as electronics firms perfect the approach to reliability and lower costs

by Gerald M. Walker, *Consumer Editor*

As solid-state digital watches have become an accepted part of the consumer market, new developments by the electronics companies fighting for a piece of the action have been tied to perfecting the technology to increase reliability and lower costs. In the 1976 models, exploitation of large-scale integrated semiconductor technology has made possible the new low-priced digitals, just as it already has provided affordable flexibility for the expensive, multifunction models.

While the watch industry has been forced to adjust to the dynamics of the technology, the semiconductor industry has been painfully adjusting to the cycles of the watch market. Although electronics companies around the world have dug in for the sales battle, which peaks at Christmas time, the technology driving product development has not settled down.

It isn't clear whether watches with complementary-metal-oxide semiconductor watch chips or those with integrated-injection-logic chips will be the preferred technology. Basically, semiconductor companies with MOS experience have tended to stay with this technology for their watch chips, although a couple have developed I^2L capability as well. And those manufacturers grounded in bipolar, transistor-transistor logic technology have tended to exploit their expertise in developing the closely related I^2L watch chips. As a result, there will be both kinds of chips in the watches sold this year.

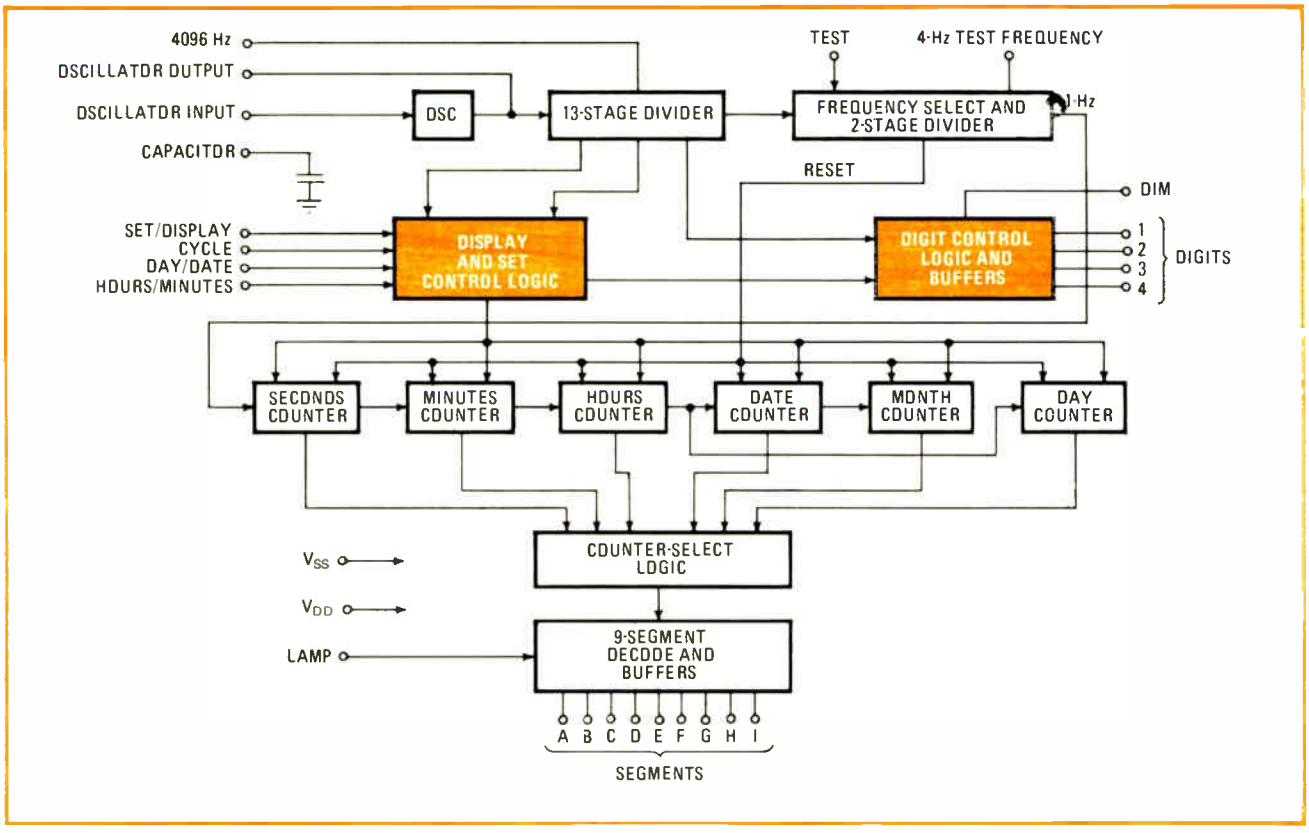
Both approaches offer advantages for watches. On the one hand, I^2L offers small geometries and the one-chip watch with segment drivers and digit drivers mounted on-board. By virtue of its current output, it is well suited to the light-emitting-diode display.

On the other hand, C-MOS supporters have recently been able to announce single-chip watches, thanks to the packing density possible with silicon-gate processing techniques. Putting the drivers on board also should reduce production steps for the watch module. Thus, the two technologies are running neck and neck at the watch-chip level.

Two display types

Watch displays have not been sorted out, either. Liquid-crystal displays are staging a comeback in the field-effect mode, after a disastrous debut in which the quality, appearance, and reliability of the dynamic-scattered mode turned off consumers. Field-effect LCDs have proved to be superior to dynamic-scattered types for the watch application in three ways—they require lower voltage to operate, they have faster response and erase time, and they eliminate troublesome ghosts.

The continuous display has been the preferred approach in Japan and in Europe. But, in the United States, the LED display continues to dominate for a number of reasons. First of all, cost and reliability were favorable before the digital-watch demand materialized, thanks to the impact of the handheld calculator on LED development. Indeed, some argue that, because of the design demands imposed by its volume production, the calculator explosion set the stage for the rapid



1. C-MOS consolidation. National's new light-emitting-diode display watch chip is an ion-implanted, metal-gate device with, typically, 15 microwatts of power dissipation and on-chip direct-drive outputs for alphanumeric display. It measures 157 by 155 mils.

development of the low-cost, high volume digital watch.

Actually, neither display has been ideal for a digital watch. The LED's power drain requires a battery-conserving switch to turn on the display. It's also almost impossible to see in direct sunlight. The LCD cannot be seen in the dark without an auxiliary light, is difficult to read at an angle, and, because of its sandwich construction, it suffers from double images under certain conditions.

Some of these problems have been overcome. There are inertial switches that turn on the LED at the flick of the wrist. Also, some models now have light-sensing capability to increase the intensity of the display in bright ambient light, while reducing it in dim light.

Virtually all LCD watches made this year will have some type of backlight for viewing in the dark. And ever-thinner glass sandwiches are making it possible to bring the display closer to the face of the watch, thus increasing the viewing angle and reducing double images.

Designing for mass production

Despite the publicity on solid-state watches last year, actual shipments in 1975 were probably not more than 3.5 million units, with an average retail price of $100 each. By contrast, worldwide sales for analog watches were 220 million last year. A report by securities analyst William D. Witter Inc. says the largest supplier of digital-watch modules in the world, Hughes Aircraft Co., shipped only 1.08 million units in 1975, and the largest producer of finished watches, financially troubled Litronix, shipped just 600,000 units. The largest producer of both modules and finished watches, National Semiconductor, only shipped 875,000 units.

But all of this is going to change rather quickly. This year total electronic watch sales should zoom to 15–17 million units with another 3–5 million in the supply pipeline. Average retail selling price will be around $50, since the $20 digital arrived this spring. Total worldwide digital-watch sales by 1980 are expected to pass the 90 million mark, with an average selling price of about $25.

These figures are having an important impact on watch design. The profits to be reaped from the digital-watch boom will go to the companies that can adapt to efficient mass production and keep prices coming down, yet cater to demands for styling and added features. Just how best to accomplish this tall order is still not clear—for that matter, there may not be a single right answer. While some companies have entered or dropped out, the basic structure of the digital watch industry remains essentially the same as it was last year.

MOS or I^2L depends on past know-how

Design of the present generation of watch chips reflects the rapid emergence of digital watches from novelty to mass production. Generally most of the effort has gone toward three goals: first, design to mesh with cost-effective production; second, design to accommodate new functions economically, and third, design to overcome deficiencies in previous models or else make the watch easier to use. The higher-priced models feature at least five functions—hours, minutes and sec-

The Swiss and the Japanese begin to move

American firms have moved so far and so fast into digital watches that industry observers are wondering if Switzerland and Japan, the major world producers of mechanical watches, will manage to close the gap. Switzerland's watch industry is just beginning major commitments to the new technology. The Japanese industry has the digital technology, but has delayed applying it in mass production because of its investment in the manufacture of quartz-crystal analog watches.

At the Basel Watch and Jewelry Fair in late April, Swiss exhibitors were hailing 1976 as the kickoff year for Swiss-made solid-state watches. Output of digital watches made with Swiss modules should jump from something like 70,000 units last year to over a million this year.

Ebauches SA, which produces 85% of the Swiss jewelled movements, is shooting for between 50% and 60% of the solid-state modules as its market share. The other major contenders are Société Suisse pour l'Industrie Horlogere, Modules Electroniques SA, and Mondaine Watch Ltd. SSIH is best known for its high-priced Omega and Tissot brands, MSA is a subsidiary of Nepro Watch, and Mondaine is a small, Zurich-based firm.

Ebauches has by far the most ambitious plans. "Our investment in microelectronics plants from 1975 to 1980 will run about 60 million Swiss francs" (about $25 million), says company executive Paul Tschudin. The firm decided in September 1974 that it had to get into watch-chip production. To save development time, it bought the necessary know-how on complementary-metal-oxide semiconductors from Hughes Aircraft Co. for $1.3 million. Late last year, the first circuits came off the line, which is running with adequate yield, Tschudin says.

The Ebauches line consists of two light-emitting-diode watches and two liquid-crystal-display models, all using 32,768-hertz crystals and C-MOS chips. One LCD model has solar cells flanking the readout to keep the batteries charged. The five-function models will probably sell for around $40.

Running second to Ebauches in module production is MSA, which should turn out close to 350,000 LCD modules this year, according to Nepro president Paolo Spadini. He expects to double or triple output next year.

Unlike Ebauches, MSA buys all of its chips from a U.S. C-MOS supplier and from Eurosil in West Germany. Its mainstay is an extra-flat (4.5 mm thick), six-digit LCD unit that lists for around $38.50 in large quantities.

At Mondaine the target is 10,000 LCD modules a month, all with 32-kilohertz crystals paired with C-MOS chips developed jointly with Eurosil. At the top of the line is a 6-digit display that lists for just over $75.

Another Swiss source for chips is Faselec, held by Philips Gloeilampenfabrieken of the Netherlands in association with watch-industry interests. It has a standard watch chip fabricated in silicon-gate C-MOS technology that's compatible with the 1424 chip of American Microsystems Inc. It makes custom devices as well. According to Faselec, about half the chips for digital watches made in Switzerland will come from Swiss sources.

Liquid crystal appears to be becoming the preferred display mode. Brown Boveri Co., whose main business is electrical equipment, went into mass production of twisted nematic LCD modules last year and is now turning out some 200,000 a month, mostly for export. The firm is pushing hard on prices, with a 3½-digit display selling for under $4.

Top-of-the-line brands such as Piaget and Omega are still banking on analog quartz-crystal watches. For instance, Piaget came to the Basel Fair with a watch using a new circuit developed at the Centre Electronique Horloger, the industry's research-and-development center. Instead of the usual 32-kHz quartz crystal adjusted with a trimmer capacitor, the scheme uses a "loose" 500-kHz crystal and achieves high accuracy by means of an adjustable frequency divider. It's adjusted to match the precise frequency of the crystal through a correction count stored in an on-chip memory. Faselec produces the chip for Piaget.

The Japanese watch makers, who rank second in worldwide production, have maintained a low digital profile, but more for business than technological reasons. Satisfied with concentrating on their domestic market for digitals, Seiko, Orient, Casio, Ricoh, and other Japanese companies will probably ease into foreign markets cautiously. Their major advantage is innovative use of LCDs for calendar and seconds readouts.

Seiko, the largest watch company in Japan, is set up to manufacture almost all of digital-watch parts—integrated circuit, quartz crystal, LCD display, and probably the power cell. It also buys C-MOS watch chips from outside.

So far the firm has been content to introduce a high-priced six-function chronograph watch that uses two chips. The company is cool toward fancier models such as calculator watches. It has developed an experimental inductive pager that uses mechanical filters. Because the pager draws high current, putting one in a watch would probably require the addition of a battery charger.

onds timing, an a.m. and p.m. indicator, and the date. A sixth function usually is the month. In low-priced watch lines, yield and economy in production looms much larger than adding any functions. To serve both ends of the market, C-MOS companies have concentrated on developing the single-chip watch with maximum density at minimum size for both LED and LCD displays.

The new six-function National Semiconductor C-MOS chip, for instance, is a device of 157 by 155 mils that is capable of directly driving an alphanumeric LED display. With single- or two-button control of the display, this unit draws 15 microwatts in power dissipation. Except for the quartz crystal and a trimmer capacitor, all the components required for the six functions are on this chip, including the resistor-capacitor oscillator used for the antiresonant type of quartz crystals (Fig. 1). This chip, like other recent C-MOS LED types with direct-drive characteristics, is actually smaller than previous chips that had separate digit drivers.

National's liquid-crystal-display chip, which will serve as Novus' entry into the LCD watch competition, is designed for high-volume production for basic five-function products. Measuring 176 by 177 mils, this C-MOS device has an on-chip voltage multiplier—either a doubler to provide 2.5 volts minimum at 1 microampere current or a tripler to provide 4 v minimum at 1

μA load current, depending on the model (Fig. 2). The chip can provide output pulses of 256 or 1,024 hertz to drive a dc-dc converter off the chip for the higher voltage needed for the display. This design provides enough display-drive capacity on one chip to add another function, a six-digit stopwatch.

With such new devices from various semiconductor houses coming on-stream this year, C-MOS proponents among watch and watch-module makers argue that I²L does not buy them any significant advantages. For example, current for C-MOS is 1 to 3 μA, compared to 7 to 8 μA for I²L. In addition, processing steps have become almost as simplified as those in I²L.

Touting what it calls high-density C-MOS (HD/C-MOS), Micro Power Systems Inc., Santa Clara, Calif., employs an improved silicon-gate interconnect system for creating very-large-scale integrated circuits, which it supplies as custom chips to watch makers. The key to HD/C-MOS is the use of low-resistivity materials that make multilevel interconnects practical.

According to the firm, silicon-gate conductors used for interconnections cannot provide resistivities any lower than 80 ohms per square, even when boron doped. The new process uses a proprietary material that can provide a resistivity of less than 1 Ω/sq.

For the new generation of the watches, the company has developed HD/C-MOS II, a refinement of the original process that features a smaller cell design in order to achieve circuit densities five to six times greater than conventional C-MOS. Compared to metal-gate C-MOS, it's 30% greater in density. When interconnect patterns for HD/C-MOS II and I²L are taken into account (not just cell size), the new process provides 190 gates per square millimeter compared to 120 to 200 gates/mm² quoted for I²L. Power dissipation is 3 nanowatts to 150 microwatts for the former; 6 nw to 70 μW for the latter.

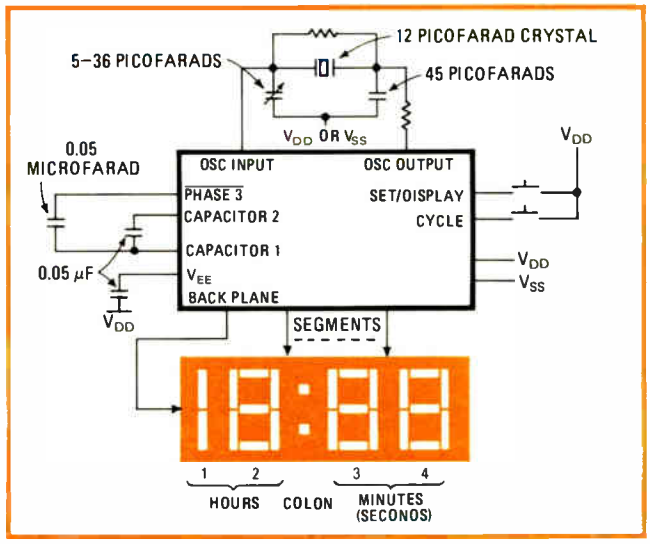
Agreeing that the performance and processing technology of MOS can now match the economies of I²L, Greg Reyes, group vice president and general manager of consumer products for Fairchild Camera and Instrument Corp., Palo Alto, Calif., points out that its new C-MOS watch-chip process benefits from the firm's ability to manufacture from a 4-inch wafer. The chip used in Fairchild's latest LED watches is about 140 square mils.

"No doubt the I²L process looks to be simpler than C-MOS initially," he says. "But in a watch design, it appears that more processing steps are required than were originally anticipated.

"The votes are not in on the advantage of one or the other, so we'll have to wait and see. However, based on our capability, we chose C-MOS." Fairchild has I²L capability too, but appears to be aiming it toward computer applications rather than watches.

"If we had never made C-MOS devices," says William Weakland, division manager of the solid-state products division of Hughes Aircraft Co. in Newport Beach, Calif., "we would have tried I²L as the quickest, least expensive way of getting into the watch module business. But we have more experience in C-MOS now and I²L does not represent an advantage."

Another reason Hughes is committed to C-MOS is that



2. Double or triple advantage. National's latest LCD watch chip permits an on-chip tripler, which provides 4 volts of minimum power at 1 microampere of load current. On-chip voltage doublers may be substituted for the tripler if only 2.5 V minimum is required.

it has chosen to use 786-kilohertz crystals rather than the 32-kHz ones generally designed into a watch. (Hughes makes 90% of its own quartz crystals.) While they are said to be more accurate and make possible a simpler module design, they draw more current than the 32-kHz version, so a combination with the I²L would reduce battery life.

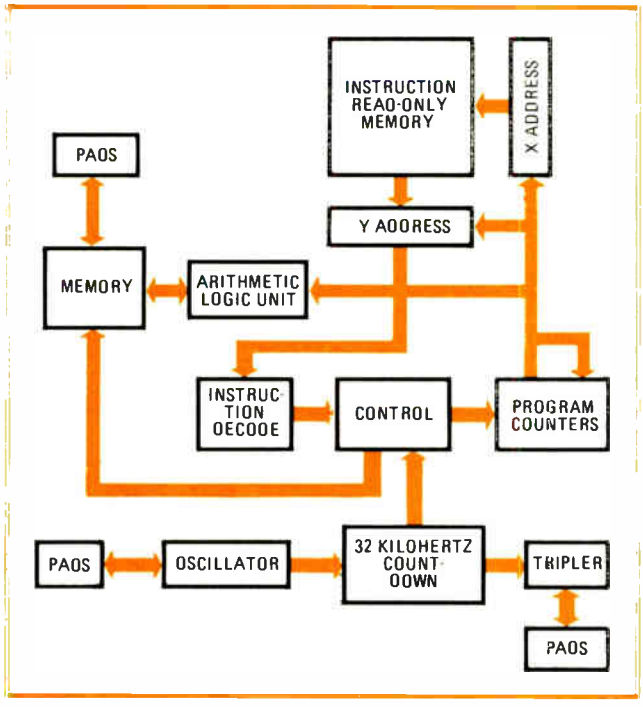
I²L doesn't waste time

While efforts by the C-MOS supporters have been directed toward maximizing chip density, I²L devices have this advantage intrinsically. High packing density and small LED driver circuits are particularly beneficial for digital watches. Earlier this year, Texas Instruments rocked the watch industry by announcing a new line of digitals, but the fact that they were to be I²L was almost incidental to the $19.95 price and the plastic case.

First significant numbers were shipped in March, well ahead of the promised date—confounding those who said it couldn't be done. National and Fairchild have since announced C-MOS watches in the same price range, also in plastic cases.

TI examined both I²L and MOS technologies before it entered the watch competition and chose the former route because of its high level of integration—making possible the single-chip watch module—and its promise of high yield. The company had a strong capability in the bipolar TTL process and felt that it could produce the bipolar I²L in equally large quantities. Moreover, C-MOS yields were not economical, the company decided. Finally, the elimination in the I²L module of the display driver that would be necessary in the C-MOS module tipped the balance to the former. Subsequent high-quantity yields for the $20 watches proved this decision to be correct for the TI.

Other semiconductor companies are entering the I²L sweepstakes. Signetics Corp., Sunnyvale, Calif., has developed a chip for a six-function LED watch. As a trial effort the company came up with a three-function de-



3. Processor-based. The new programable C-MOS watch chips like this unit from American Microsystems Inc., are more like micro processors in architecture and design implementation than they are like typical large-scale integrated circuits.

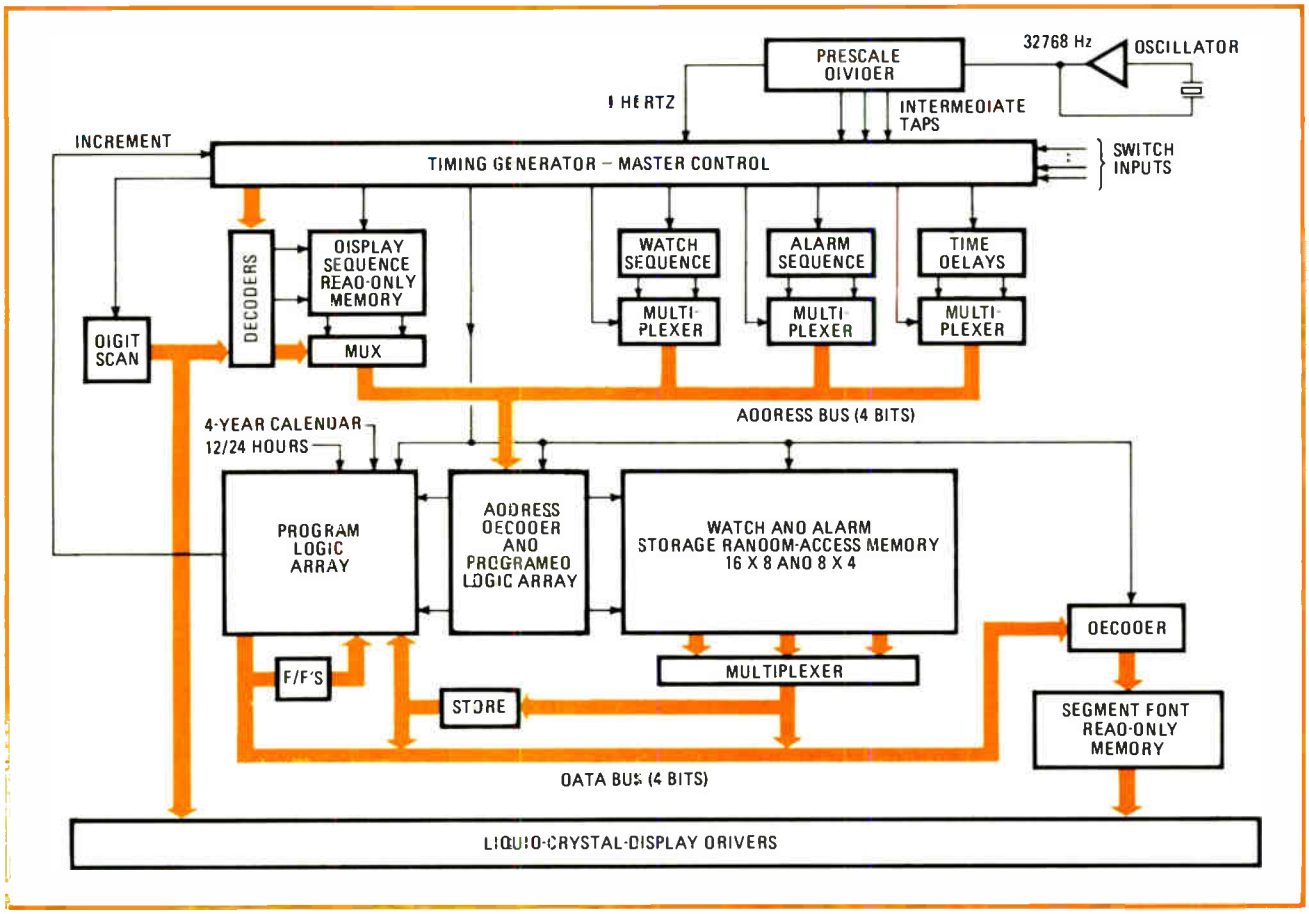
vice that measures 86 by 96 mils. The six-function version will be about 25% smaller. The chip size was achieved, not as a result of high packing density alone, but also by the use of divide-by-two circuits requiring only four base regions (Fig. 5). The average gate-packing density on this chip is 120 gates/mm². The highest density of 320 gates/mm² occurs in the 32-kHz-to-8 Hz countdown chain.

The divide-by-two circuit is the building block for the time counters and the divide chain on the three-function unit. The reduction from six to four bases in the divider gave a one-third savings in area, important because more than 35 of the circuits are used in the design, so that the four-base circuit is 12 mil².

ITT's Semiconductor division in West Palm Beach, Fla., has larger I²L chips, 240 mils square, custom designed for watches at both ends of the market. The high-end device is for a five-function watch plus stopwatch, which will be a first for I²L. The stopwatch will time in full seconds rather than hundredths, and the simple start-stop timer will have no lap-time call-up.

The design uses pnp segment drivers, rather than Darlington npn versions found in other digital watches. This feature helps extend battery life. The npn drivers draw 60 to 100 mA compared to 5 to 10 mA for the pnp version.

TI's espousal of I²L is not surprising considering the company's experience in bipolar transistor-transistor-



4. More programable. In order to provide flexibility in adding to watches new features such as stopwatches or two time zones, this Intel chip uses processor architecture, including programable logic-array portions. It may be programed for 4-, 6-, and 8-digit displays.

logic technology. Applying the economies of automated production to the injection technology played an important role in the firm's entry into the watch market. Because of the close relation between the bipolar technologies, the company has been able to move rapidly.

It has chosen a special approach to module-production. The watch chip is bonded to a lead frame and encapsulated in plastic, and the other parts—display, trimmer capacitor, crystal oscillator, and batteries—are mounted around the lead frame to form the completed module (Fig. 6). Other than the shape, the process is no different than that which the firm uses for standard plastic-packaged integrated circuits. Leads are bent around the module to make contact with the batteries, and the display switch is a simple single-pole contact to a lead brought through the side of the capsule.

Highly mechanized production

The finished module for TI's $19.95 watch is mounted in a plastic case also manufactured by the company. This entire manufacturing process is highly mechanized from lead bonding to final testing, at labor-saving costs that obviate the need for off-shore operation.

To lower costs, mechanizing module production while reducing materials costs and parts count represent the next big push in watch manufacture. To accomplish this, modules have been redesigned.

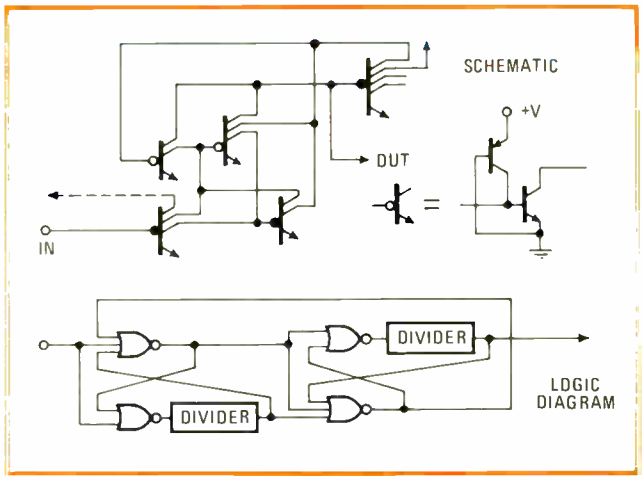
For example, Microma's new LCD module consists of 20 to 30 parts, compared to 90 or more in previous models. Three printed-circuit boards with attendant screws, nuts, wire interconnects, and other hardware have been reduced to one thick-film printed network on a ceramic substrate with the chip bonded in place. The substrate is soldered or connected by epoxy to the module frame. The incandescent backlight for the LCD and the display itself are held in place with one mechanical clamp. Finally the batteries have been positioned so that they cannot be improperly inserted. They are held in place by a new battery port cover.

Even though AMI has abandoned the module and end-product market, it is trying to set up a joint venture with another company to have its new module design put into production. Thus, there's a very good chance that its redesigned LCD module will eventually make it to the marketplace.

The module's configuration is keyed to large-scale, economical production. Basically, the firm's engineers changed the module's concept to include not only the chip, display, crystal, and batteries, but also the switching and waterproofing responsibilities normally assigned to the case. The command, set, and backlight buttons also are part of the module (Fig. 7). The only role for the case is styling and a means of attaching the watchband.

In the final format, the three switching buttons are on the face of the watch under the display. They are ultrasonically welded to the module in milliseconds to insure a watertight fit. The switch has been simplified as well. Y-shaped contacts ride on a rubberized base so neither spring nor button shaft is required to activate the backlight or seconds delay.

AMI estimates that this new arrangement could cost as little as 10¢ for all three switches, compared to 30¢ to 60¢ each for present spring-mounted units. The module material is a special, reactive-process plastic claimed to be stronger than previous materials.

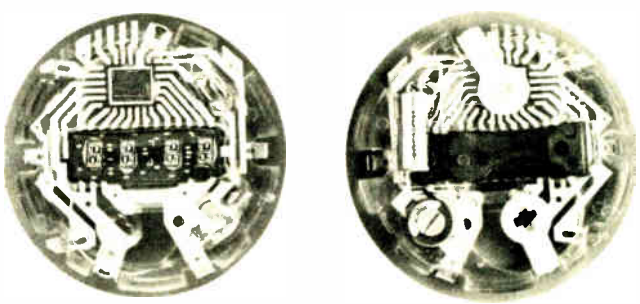


5. Space saver. Use of four-base-region, divide-by-two circuits in Signetics' I²L watch chip makes possible a reduction of almost a third in the divide-by-two area of the chip. The prototype is 86 by 96 mils. The production model will be smaller.

As watch technology settles down to more standardization in chips and displays, the next step in mass-production efficiency could be application of film-carrier technology [*Electronics*, Dec. 25, 1975, p. 61]. With sprocketed 16- or 35-millimeter film, the chip would be bonded to one frame of the film, and the other components to a second frame. These would be folded one on top of the other with the top frame containing the timekeeping die attached directly to the LCD display. This technique, which is in large-volume production of other semiconductor products, could be assembled in a high-speed automated line, eliminating boards, connectors, and wiring almost entirely.

Programing watch functions

The most significant development for the multifunction higher-priced watches has been this year's introduction of microprocessor-like architecture—the so-called programable chips—using C-MOS technology. While the single chips are meant to be very-high-volume devices produced economically, the programable chips are designed to accommodate various perform-



6. Plastic pack. This TI module is a chip and lead frame encapsulated in plastic (clear only in this model) similar to its other IC packages. Two of the leads bend around (right) to make contact with the batteries on the reverse side.

ance levels economically by providing the manufacturer flexibility to alter them at the mask level.

The economy comes not from minimizing the chip size, but from maximizing the number of optional functions available from the same basic architecture. Savings in turn-around time to meet changing market demands is the key here. Basically the difference between the programable chip and the standard watch chip is that the former's functions are established by a ROM that is mask-programed by the manufacturer, and the latter uses hardwired logic. The programable is in effect a small, serial-type computer.

American Micro Systems Inc., Intel Corp., and Harris Semiconductor have announced processor-like chips. The AMI device, which was originally 172 mils on a side, now measures 120 mils square. About half of the silicon-gate chip is a 6,000-bit ROM (Fig. 3). The company can set up a hardware simulator with a programable ROM and manipulate various functions during design, then set the ROM pattern for the production unit.

A 4-bit-by-28-word shift register provides static read/write memory capability needed by stopwatch or alarm functions for tracking time. A 4-bit, binary-coded-decimal adder performs the arithmetic/logic function. Also on the ROM is a program counter with a 12-bit address.

To save on chip space for the memory, the core circuitry is n-channel MOS and the decode is p-channel MOS. One p-type pull-up element controls each row or column of 32 n-type pull-down transistors. The chip would probably be two or three times larger without this arrangement. The first samples are due next month.

Programed logic arrays

Intel's processor-type watch chip, which has been customized for use by the company's watch subsidiary, Microma Inc., measures 164 by 197 mils. It differs from the AMI design by using programed logic arrays (Fig. 4) for timesetting control, along with a ROM and a random-access memory for time counting and related functions. It will be possible to program this chip at the mask level for 4-, 6-, and 8-digit displays, as many as eight timing functions, and choice of several styles of characters in an alphanumeric format.

This watch chip is almost as complex as the Intel 8080 microprocessor. It's actually two watches in one—a stopwatch and a standard time counter—with controls for both stored in a RAM. The area devoted to the stopwatch could be used for an alarm, storage of special dates set by the user, or else for a second time zone, if any of these functions were desired instead. It's a multiprocessor in that it decodes and processes independent information simultaneously—display, stopwatch, different time functions, and time-and-date setting, which is controlled by 424 bits of programed logic array.

Designed for a liquid-crystal display, the chip features internal multiplexing with signals fed out through the ROM decoder into the LCD drivers where information is latched and updated continuously.

Harris Semiconductor plans to have available soon its version of the mask-programable single chip with passive components and digit drivers for LED display. Here, too, it will be possible to call out such options as dual time, stopwatch, or alarm functions after layout and design of the basic chip. Included is a popular new feature—a register that automatically takes the watch out of the time-and-date setting mode after a number of seconds. This may prolong battery life.

Digital watch displays and overall styling are perhaps the most important features influencing purchase. Electronics companies have directed considerable effort toward improving displays, especially.

Right now LEDs and LCDs are the only viable display choices. It may be five years before any alternative such as electrochromic displays will come along to unseat them. There are about 70 companies around the world with some level of research in ECD, so it's reasonable to expect the technology may make it into watches in the future. A major difference between the two present technologies is the impact of the calculator explosion on the development of the light-emitting diode.

For some time, LED suppliers have been able to use more efficient materials for brighter displays, to apply magnification techniques for smaller, less power-hungry digits, and to select LED chips for better matching digit to digit. They acquired these techniques when upgrading calculator displays. For watches, though, there are new filtering combinations to improve LED visibility in bright light.

There's not much more that can be done with the LEDs, except expanding the number of character fonts available and introducing new colors. Hewlett-Packard's Optoelectronics division has just begun supplying a monolithic LED chip for use in a new Pulsar alphanumeric watch. The format is unusual because the two letters indicating the day of the week are vertical. The chip is strobed by a one-in-seven counter. Its most noticeable feature, the payoff of a monolithic chip, is the lack of segmentation in the characters. They are continuous, clean in appearance, and easy to read (Fig. 8). This will be especially important for watches intended for non-U.S. markets because some foreign names for days, particularly German and French, do not look well when displayed on a segmented LED watch.

Diodes with colors other than red are available, but it will require volume demand to help cross the yield barrier. Yellow will probably be the first to make it since the materials and wavelength are close to those used in red. Green displays are a more difficult problem, however, and may not be feasible for a watch for some time. Combinations of colors are possible, if not probable.

LCDs: comeback of the year

The improvement needed in liquid-crystal displays—visibility in the dark, color, increased angle of visibility, and more attractive character fonts—can all be achieved. And, after something like five years of promises, LCDs are beginning to deliver on these. What's more, new, more chemically stable materials that can operate up to 125°C and better packages have helped bring back the technique as a strong contender in reliability and cost for watch displays. The impetus in watches, of course, is that liquid crystal requires very low power and as a result can be a continuous display,

Waiting for Timex

Next month at the Retail Jewelers Show, the electronics industry expects to find out for certain what the giant of the American watch business, Timex, is going to do about digital watches. Unquestionably, it will jump in far more aggressively than it has so far.

Though highly secretive about specific plans, Timex has publicly cast its vote toward the liquid-crystal display. It has acquired RCA's LCD facilities while purchasing large quantities of the displays from outside vendors. The firm is buying chips and has cranked up its extensive production facilities to prepare for a counterattack on the upstart semiconductor-based watch companies.

After a couple of false starts and the introduction of a relatively high-priced (for Timex) LCD that didn't sell well, the mass-market tornado is almost ready to hit its electronics-company competitors where they are weakest—distribution. Through the sheer weight of its 180,000 to 190,000 retail outlets around the world, Timex will try to overpower the other digital watch makers.

Timex has the cash, the marketing know-how, and the muscle in pricing to be a factor in the low end of the digital watch market, despite the head start others have enjoyed. As one nervous semiconductor executive marvelled, "If Timex sells two watches in each of its outlets, it's got a big market."

7. **Simplicity.** This AMI module has command and set buttons on the face and simplified switches to mechanize production, save costs.

which the light-emitting diode cannot match.

At Beckman Instruments' Helipot division, Fullerton, Calif., the largest U.S. supplier of LCDs, efforts are toward perfecting faster-reacting materials. For now, volume is the main concern, so Beckman has concentrated on its screen-printing process to increase production and its glass-fret sealing process to insure reliability. Probably the most common field failure in the early LCDs was in faulty sealing of the frets that complete the glass sandwich forming the display.

Also, the LCD producers have slowly been able to influence the quality of the polarizers used to make the characters visible in the crystal field. The polarizer suppliers are mainly involved in the sunglasses market, which imposes totally different demands than those of the watch display. Minor imperfections, color variations, and other process faults hardly noticeable in mass-produced sunglasses are major flaws on a watch face. Polarizers do have a major unavoidable drawback: they cut down the amount of light striking the liquid crystals, dimming the display.

Virtually all new LCD watches will have some form of backlighting to make the display visible in the dark. While the majority will have incandescent lights turned on by a command button, a more interesting solution is the use of a beta-radiation light with two or three tiny phosphor-coated tubes filled with tritium gas.

Because the gas is a radiation source, a license from the Atomic Energy Commission is required to put watches on the market. Micro Display Systems, the Dallas-based maker of the Sensor watch, is the only firm to reach the market with the tritium backlight, but other watch makers have applied for government approval.

The firm puts phosphor-coated tubes of tritium gas providing a maximum radiation level of 160 millicuries into a metal pan and seals the unit to the back of the liquid-crystal display. The glow from the phosphor excited by the radiation is noticeable only in the dark. It solves the problem of seeing the LCD in the dark without a lightbulb and switch and without putting any wear on the batteries.

Safety, however, is a big factor in handling of the tubes. Tom M. Hyltin, company president, says, "The government is being super-careful and we have no argument with its motives. In two or three years when we have proved how safe the tritium source is, the restrictions will probably be relaxed. It's an absolutely safe product."

The firm's liquid-crystal process is somewhat different from others. It starts with a very thin glass, ¼ to ⅓ mm thick, which can be handled only in individual display-sized pieces. Therefore the patterns are etched one at a time, and the glass sandwich is made using a proprietary procedure. The result is a very thin display that does not produce multiple images at sharp viewing angles. The digits also appear to be very close to the surface.

Colored polarizers

About a year ago, MDS introduced a line using different polarizers for various colors, but they did not sell very well. The blues were accepted because they looked crisp, but the reds and oranges got nowhere. The firm's standard colors continue: a silver/blue combination for stainless steel cases and two brown shades for gold cases, both in eight different fonts.

There is ample opportunity for electronics companies

8. Easy reader. Hewlett-Packard's monolithic light-emitting-diode chip makes it possible for Pulsar to feature a vertical day display in readable script rather than in segments, useful in non-U. S. markets.

to exploit the flexibility and capacity of the digital watch in order to tap as many different buyers' tastes as possible. At the same time there have been some changes simply to make the standard five- and six-function watches easier to use or cheaper to produce.

One of the more controversial possibilities has been replacement of the quartz-crystal oscillator with a resistor-capacitor oscillator. Just about every company in the business has studied the possibility, especially when the quartz crystals were in short supply last year as digital watches went into mass production.

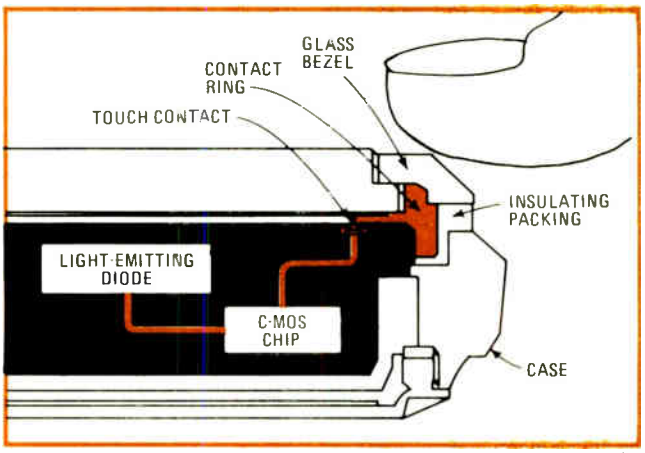
But there has been no discernible movement in this direction. The RC approach is not likely to attain accuracy equal to the quartz crystal. An oscillator of that type is extremely susceptible to drift from temperature coefficients. And converting to such a watch would introduce a problem of matching resistors and capacitors to perform efficiently together. Cost differences between the quartz crystal and RC oscillator are not as great anymore either. Nevertheless, a oscillator watch of this type will no doubt be designed to test market acceptance.

Eliminating the command buttons of an LED watch in favor of an inertial switch that turns on the display at the flick of the wrist is a potent innovation. Pulsar introduced a mercury-type version last year and Gruen has just brought out a watch with a simpler magnetic type of inertial switch.

The Pulsar switch is monitored by internal logic that provides a set of conditions during which the display will actually be energized. Even with this control, the firm's engineers estimate that 20 to 25% more activations than normal occur from arm movements. The Gruen switch is designed around a permanent magnet and a metal ball. When the wearer flicks his wrist, the ball slides away from the magnet and completes a contact that turns on the display. However, the ball does not leave the magnetic field, so that it immediately returns to its initial position, breaking the contact. Here, too, activating the display inadvertently through movement of the wearer's arm will be unavoidable.

Sharp Corp., Osaka, Japan, which makes digital watches for the Orient Watch Co., has a unique switch for its LED watch. The bezel around the watch face is insulated from the body of the watch (Fig. 9). A mere touch anywhere on the bezel completes a circuit through the body that turns on the display for 1.5 seconds. While the time display is still on, a second touch will show the date. A button is provided for calling out the seconds.

Some digital-watch wearers so dislike resetting them that they will ignore time changes while travelling and dread daylight-savings time. To make resetting easier, Pulsar has introduced a new procedure that eliminates



9. Easy-on LED. While some watches have inertial switches to make it easier to turn on the display, Sharp has a contact ring on the face that acts as the button. The user completes the circuit through his body by touching the ring.

the magnet required to set the watch. Now the wearer need only press the command buttons three times rapidly to call up the setting mode. One button turns on the month and hour display, and the other, day and minute. To advance the left-hand digits (month or hour), wearers push the top button, and, to advance the right-hand digits (day or minutes), they push the bottom button. The display goes out of the set mode automatically after five seconds.

More in sight

Until now the watch companies have been mainly interested in duplicating functions of a standard mechanical watch, yet there's much more in sight, made possible by LSI technology. Functions such as stopwatches, dual time zones, alarms, and date reminders are natural offshoots of the basic timekeeping operation. There are a couple of calculator watches on the market which have opened new marketing possibilities.

Two new areas, often discussed but difficult to realize, are biological monitoring and personal paging. The monitors for pulse or temperature will require good sensors to be mounted on the back of the case and a means of converting the readings to digital format. Monitor watches are feasible technically, but may be difficult to market, because they are quasi-medical instruments and might require some sort of medical clearance.

The paging watch, leading to a digital-communications instrument for the wrist, also involves innovations unrelated to digital-watch technology. Power drain would be quite high, although for an internal building-only pager the central transmitter could provide the chief energy source. Compact antennas would also be a problem, but not one impossible to solve.

Says Fairchild's Reyes, "In the 1980-to-1985 timeframe we'll have the Dick Tracy wrist radio. The first ones will be pagers using digital-signal processing, because they'll be easiest to do. But it's reasonable to expect voice communications too." By the end of this year, the possibility is quite strong that more innovative products will be announced, despite the problems of providing a marketable product. □

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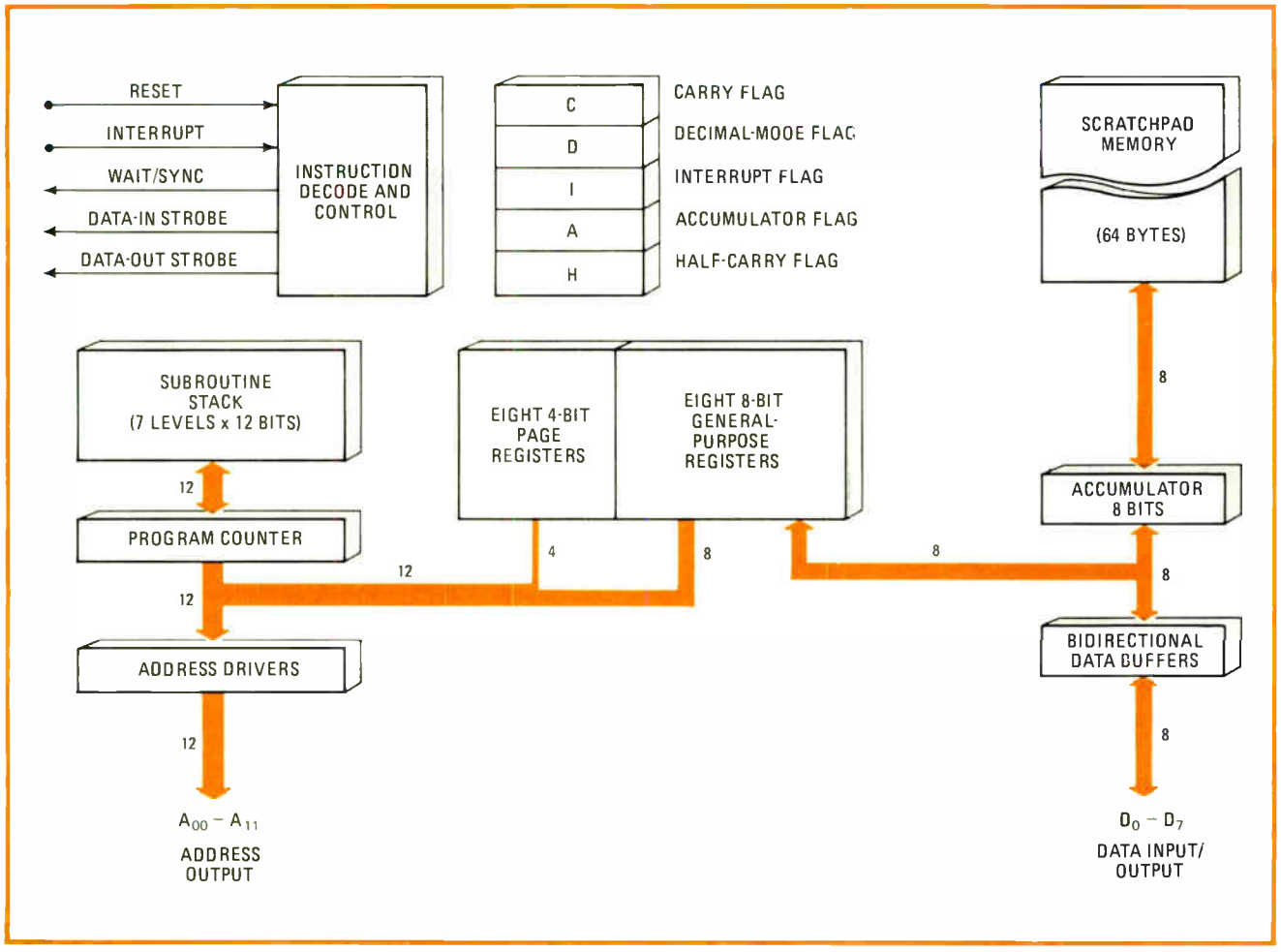
8-bit microprocessor aims at control applications

LSI chip uses single power supply, interfaces with any 8-bit bus-oriented TTL-compatible peripherals

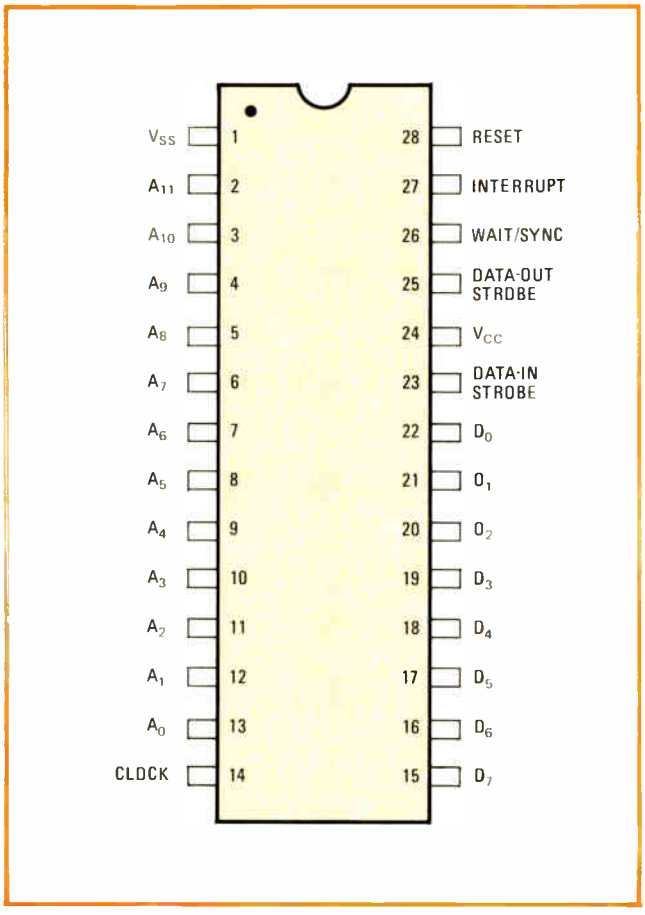
by W. E. Wickes, *Electronic Arrays Inc., Mountain View, Calif.*

☐ Although the microprocessor is rapidly taking over many tasks formerly performed by minicomputers, standard processors are too sophisticated for many controller applications. Popular 8-bit microprocessors such as the Intel 8080 and Motorola MC6800 are an overkill for controller jobs that don't require extensive processing or large memories.

Mindful of the difficulties and wasted power involved in designing a standard microprocessor into a simple controller system, Electronic Arrays started to design a large-scale integrated chip specifically for that purpose. Design goals were minimum device count, simple control capability, and operation from a single power supply. Not only were these objectives met in the EA9002, but the device can interface with any 8-bit bus-oriented peripheral that is compatible with transistor-transistor logic. Typical applications might be an electronic scale, a bulk-weighing system for proportioning ingredients



1. Stand-alone controller. Eight-bit LSI microprocessor chip interfaces with any manufacturer's bus-oriented TTL-compatible peripheral, offers a simplified instruction set, and contains 512 bits of on-board RAM, which is sufficient for many small control problems. The 28-pin package operates from a single + 5-V power supply and has a single-phase clock input that controls all internal clock phases and data flow.



2. EA9002. The one-chip, 8-bit parallel microprocessor is fabricated with n-channel silicon-gate MOS process.

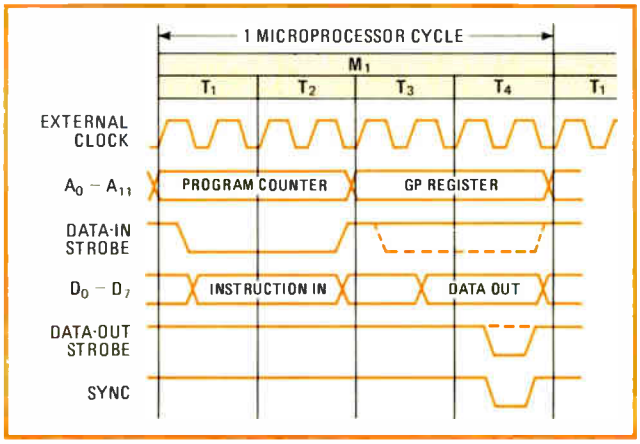
into a concrete mixer, and a point-of-sale terminal activated by either an electronic wand or keyboard inputs.

Because of the 8-bit TTL-compatible data bus, the user may select his favorite random-access and read-only memories, as well as the peripheral input/output devices that best suit his needs. He may mix or match the components to suit his application.

Typically, the EA9002 requires 20% less code than the MC6800 and 25% less than the 8080, but it does not provide the direct-memory access that the other two chips do. Its 12-bit address bus can directly access 4,096 words of memory, while the 8080 and 6800 both have 16-bit address buses that can directly access 65,536 words. This access to large memory capacity makes these chips more suitable for data processing or number-crunching applications. However, the EA9002 can access large memories through memory-bank-select techniques, such as those used for years with Digital Equipment Corp.'s PDP-8 minicomputer. Typically, though, the EA9002 fits the category of controllers requiring 2,048 words of ROM, 1,024 words of RAM, and associated I/O devices.

Internal arrangements

The LSI device (Fig. 1) has the standard microprocessor features: bidirectional bus drivers, control register, flags, accumulator, data registers, program counter and control-signal inputs. In addition, there are



3. Repetitive timing. Each time the MPU reads in instructions or data, a data-input strobe is generated. A data-output strobe is generated each time data is delivered. The end of each internal-instruction operation triggers a sync pulse.

a seven-level subroutine stack, eight 12-bit general-purpose data registers, and an on-board 64-byte scratchpad memory that is independent of external memory. For many small instrumentation-control problems, an external RAM is unnecessary, since the scratchpad provides enough memory by itself.

An internal flag D (for decimal) allows the user to perform 8-bit binary arithmetic or packed binary-coded-decimal (dual 4-bit operands) with automatic decimal correction. This is accomplished by simply setting the flag in one state or the other.

The accumulator (A) flag indicates whether or not the accumulator is zero, a convenient test indicator for many binary or arithmetic operations. When this flag is combined with a COMPARE instruction, the user can implement conditional-jump (GO-TO) routines as a function of the accumulator being equal to, less than, or greater than a designated general-purpose register. Also, an external interrupt input automatically vectors the microprocessor to a user-defined interrupt service routine.

A data-out strobe (DOS) is generated each time the microprocessor transfers data to an external peripheral. A data-in strobe (DIS) is generated each time it receives data or instructions from an external device.

Additionally, a wait/sync (WIS) pin serves a dual purpose. A negative-going pulse is sent from this pin at the end of each instruction-execution cycle. If this WIS pin is pulled low by external control at the beginning of an address cycle, the microprocessor will enter a WAIT mode and remain there until the signal is released. This maneuver allows the chip to wait for slow external devices or to be single-stepped through instructions.

Timing

The EA9002 has a single input pin to receive the single-phase clock that controls all internal-clock phases and data flow. This single-phase clock input was selected because of pin limitations: the EA9002 is a 28-pin package (Fig. 2), and an internal clock oscillator would have needed two pins. It was decided that control was a more effective job for the extra pin.

Timing is simple and straightforward (Fig. 3). One-byte, one-cycle instructions take one microprocessor cycle time, while one-byte, two-cycle instructions take two. Two-byte, two-cycle instructions also take two of these cycles.

The processor always addresses an instruction from the program counter and addresses the data field from a designated general-purpose register. During an instruction-fetch period, a DIS is generated, and another DIS is generated when data is moved into the processor. If the device is transferring data, a DOS is generated.

If the instruction calls for an internal operation such as ADD, no strobe is generated during the second half of a cycle. At the end of each instruction execution, however, a sync pulse will appear on the WAS pin. To operate the processor at a maximum external clock frequency of 4 megahertz, the maximum access time for external devices is 450 ns.

The instruction set provides for data-handling, address-formatting, jump, control, and input/output instructions. The state of the decimal-mode flag automatically designates either binary or binary-coded-decimal (BCD) arithmetic for add and subtract operations. The user may add or subtract from a designated general-purpose register or from any location in scratchpad memory. Logical operations are performed between a designated register and the accumulator. Also, four rotate instructions dictate the direction in which the accumulator will rotate and whether it will rotate with or without carry.

Internally, data may be moved to or from the accumulator and a general-purpose register or a location in scratchpad memory. Externally, data may be entered or retrieved either from the accumulator or a designated general-purpose register. In that way, a byte of data can be brought in or moved out from the processor without affecting the accumulator contents.

Since the EA9002 generates all instruction addresses from the 12-bit general-purpose register, the user need not worry about complicated addressing modes. There is no ambiguity or confusion in addresses. The internal seven-level, 12-bit subroutine stack automatically stores the next sequential address following a jump to subroutine (JSR); thus, a return from subroutine (RET) automatically enters the correct address pointer into the program counter.

Because no jumps are relative, programs can be easily created and edited. Many routines require a jump on all Os or all ls status after decrementing or incrementing a data pointer or index register. Two instructions, DRJ (decrement and jump) and IRJ (increment and jump), combine these actions to further minimize code and simplify program generation.

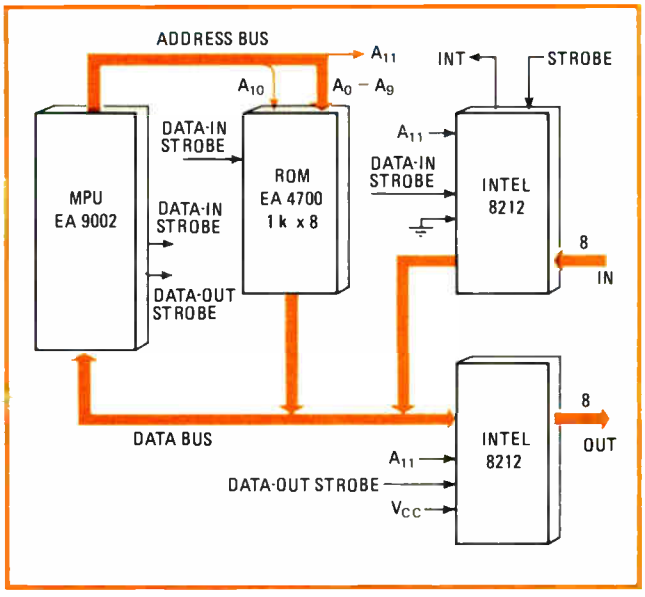
Special instructions are CSA, DLY and NOP. The CSA (copy to accumulator) examines all internal flags, as well as the 3-bit internal pointer to the subroutine stack. This check can be useful in program debugging, monitoring, or testing. The two nonoperating instructions DLY (delay) and NOP (no operation) provide internal timing delays at the user's option, or can fill a ROM coding with all 1s or 0s.

Comparing microprocessors

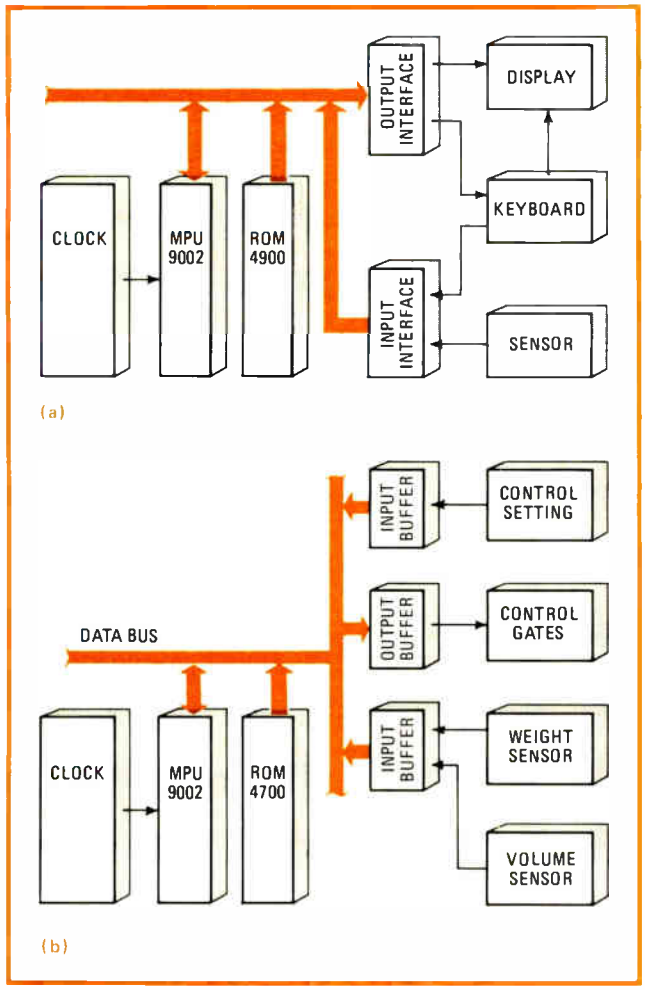
Figure 4 compares the EA9002, Intel's 8080, and Motorola's 6800 for an often-used routine—entering a data string from a peripheral to memory. The 9002 op-

	µs	BYTES	CODE			COMMENT
INTEL 8080	5	2	FETCH	IN	SOURCE	Input to accumulator from I/O
	3.5	1		MOV	M, A	Move A to memory
	2.5	1		INX	H, L	Memory pointer
	2.5	1		DCR	B	String length
	5	3		JNC	FETCH	Fetch next data
	18.5	8				
MOTOROLA 6800	4	3	FETCH	LDA	A	Input to accumulator from I/O
	6	2		STA	A, X	Store A to memory indexed
	4	1		DEX		Pointer and string length
	4	2		BGT	FETCH	Fetch next data
	18	8				
EA 9002	2	1	FETCH	INP	4	Input to accumulator from I/O
	2	1		WRS	5	Store in scratchpad memory
	4	2		DRJ	5, FETCH	String length and pointer
	8	4				

4. Comparing MPUs. When the minimum system in Fig. 5 transfers a 63-byte string of data from a peripheral to internal scratchpad memory or external RAM, it takes half the time and half the code of the same system built around the Intel 8080 or Motorola 6800.



5. Minimum system. A minimum system may consist of a MPU chip and associated ROM, which, in turn, interface with peripherals through devices such as the Intel 8212 input/output ports.



6. Weighing in. Two similar applications for the microprocessor are (a) the electronic scale, which weighs the product and calculates the bill, based on a price per pound, and (b) a batching system for weighing and dispensing a predetermined mix of ingredients.

erates twice as fast while requiring half as many bytes of instruction code. This example assumes a minimum system such as Fig. 5, but the microprocessor could just as easily be transferring the data string to external RAM instead of to the internal scratchpad memory. The data string can be any length (it is 63 bytes in this example).

In either situation, an initialization sequence identifies the source of data, destination of the data, and the length of the data string. It remains to the subroutine to send a byte from an I/O to the accumulator.

The next event is to move the byte from the accumulator to the designated memory location. The destination pointer must now be indexed so that the next byte will go to the next location in memory, and a string-length counter must be decremented. If all the data has not been received, the MPU must jump back to fetch the next byte. A test, therefore, must be performed on the string-length counter to determine whether or not it is zero.

In the 8080, the data-destination pointer must be indexed, the string-length counter must be decremented, and then a test on the string-length counter determines if the loop is completed.

The 6800, with its indexing capability, can utilize the X register for a memory pointer, as well as a string-length counter. However, it must still do an independent test on the X register to determine if the loop is completed.

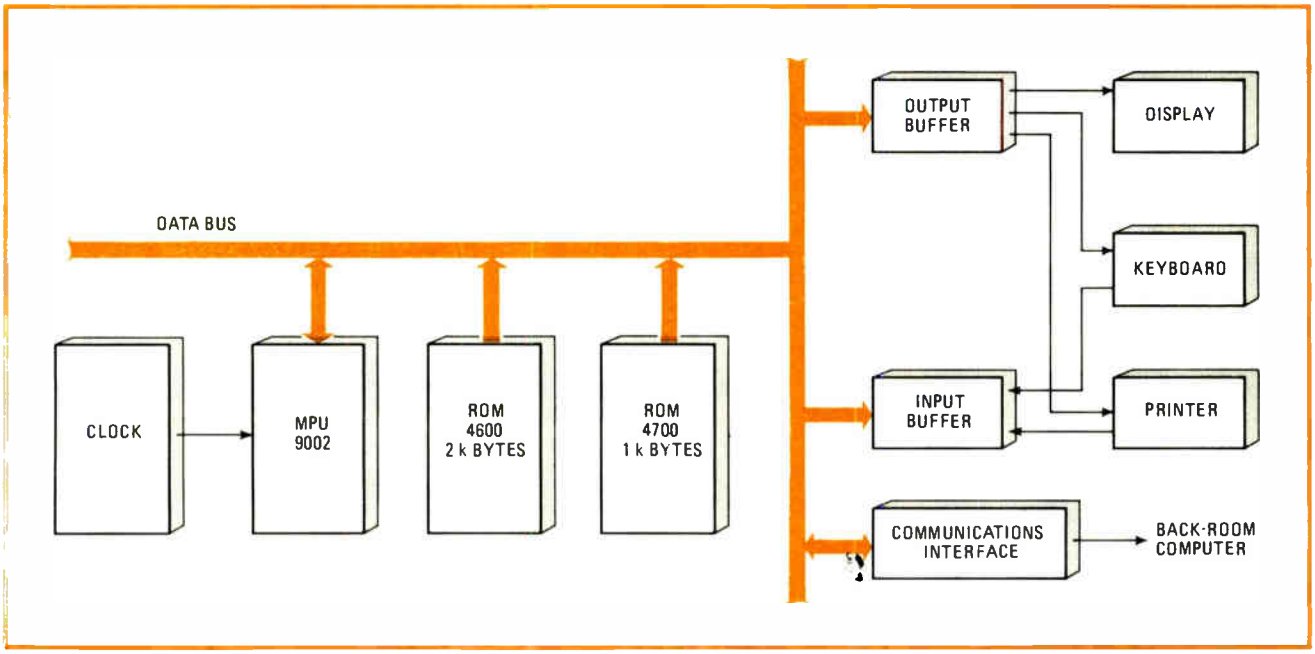
The EA9002 uses a general-purpose register as a combined memory pointer and string-length counter. In addition, the decrement-and-jump instruction not only decrements this counter, but also performs the "test for 0," which eliminates the need for separate test and jump instructions.

Tackling control

An electronic scale (Fig. 6a) commonly found in supermarkets is a typical application for the EA9002. For such a scale, whenever the weight sensor exceeds the null position, an interrupt is sent to the processor, which, in turn, responds by sending the weight to the display. Next, the operator keys in a price per pound, and the EA9002 computes the total price and displays it. In large-scale systems, a tare value may also be entered, and a record of the transaction may be printed.

The software can easily implement the interrupt routine, keyboard scanning, display formatting, and updating, as well as timing and formatting for the digital printer interfacing. In this application, the 9002 normally operates in a keyboard-scanning and/or display-refresh mode. And because the only mathematical subroutines are fixed-point add, subtract, and multiply in decimal arithmetic, the binary/decimal flag should be initially set to the decimal mode, and all arithmetic is automatically performed in packed binary-coded digits.

In this application, low-cost TTL devices can interface with all inputs and outputs because the EA9002 is fast enough to keep a display refreshed, scan the keyboard, and wait for a new key entry or an interrupt from the sensor. Since the on-board RAM is sufficient, no external RAM is required, and a 1,024-word ROM program is more than ample to contain all firmware.



7. Consumer sales. Another EA9002 application is this point-of-sale terminal in which the MPU responds to keyboard inputs, updates the display, and formats and sends data to the receipt printer. In addition, it may communicate with a back-room data-processing computer that transmits prices and a tax, when applicable, in response to product-code inputs at the keyboard.

Another typical application is loading a concrete mixer with the exact amount of sand, gravel, and cement by weight and water by volume (Fig. 6b). This system could rapidly pay for itself by eliminating human error in both the amounts and ratios of materials used.

The software program in ROM contains an algorithm that computes the mix of ingredients according to the amount of concrete desired. The microprocessor, under software control, opens the hopper gate until a sensor signals that enough has been loaded. Then the device turns off the gate and advances to the next ingredient until the sequence had been completed. When the mixer is filled, the processor notifies the operator.

Basically, the system needs the on-board RAM of the EA9002, 1,024 words of ROM, and any number of TTL-buffer interface devices. Although smart peripherals could be used, normally they are not cost-effective in small systems and only complicate the software. Because events occur more slowly than microprocessor speeds, the 9002 would have no trouble sampling the control setting and turning on and off the appropriate gates while sampling inputs from the various sensors.

A point-of-sale terminal (Fig. 7) represents a slightly more complex problem. The microprocessor must scan a keyboard, react to specific key inputs, set up and refresh a display, format data, and transmit sales data to a receipt printer, as well as transmit and receive data to and from a back-room computer.

If the back-room computer is assumed to contain all prices, the operator must key in a product code. This code is transmitted to the computer, which then sends back a price and tax, when applicable. These figures are displayed as well as printed on the cash receipt.

Typically, the terminals are polled constantly by the back-room computer. After a terminal transmits data, the computer acknowledges its receipt and responds with the price. This sequence is so fast that the operator is unaware of any time lapse and recognizes that the cycle has ended only when the terminal prints the ticket and displays the price.

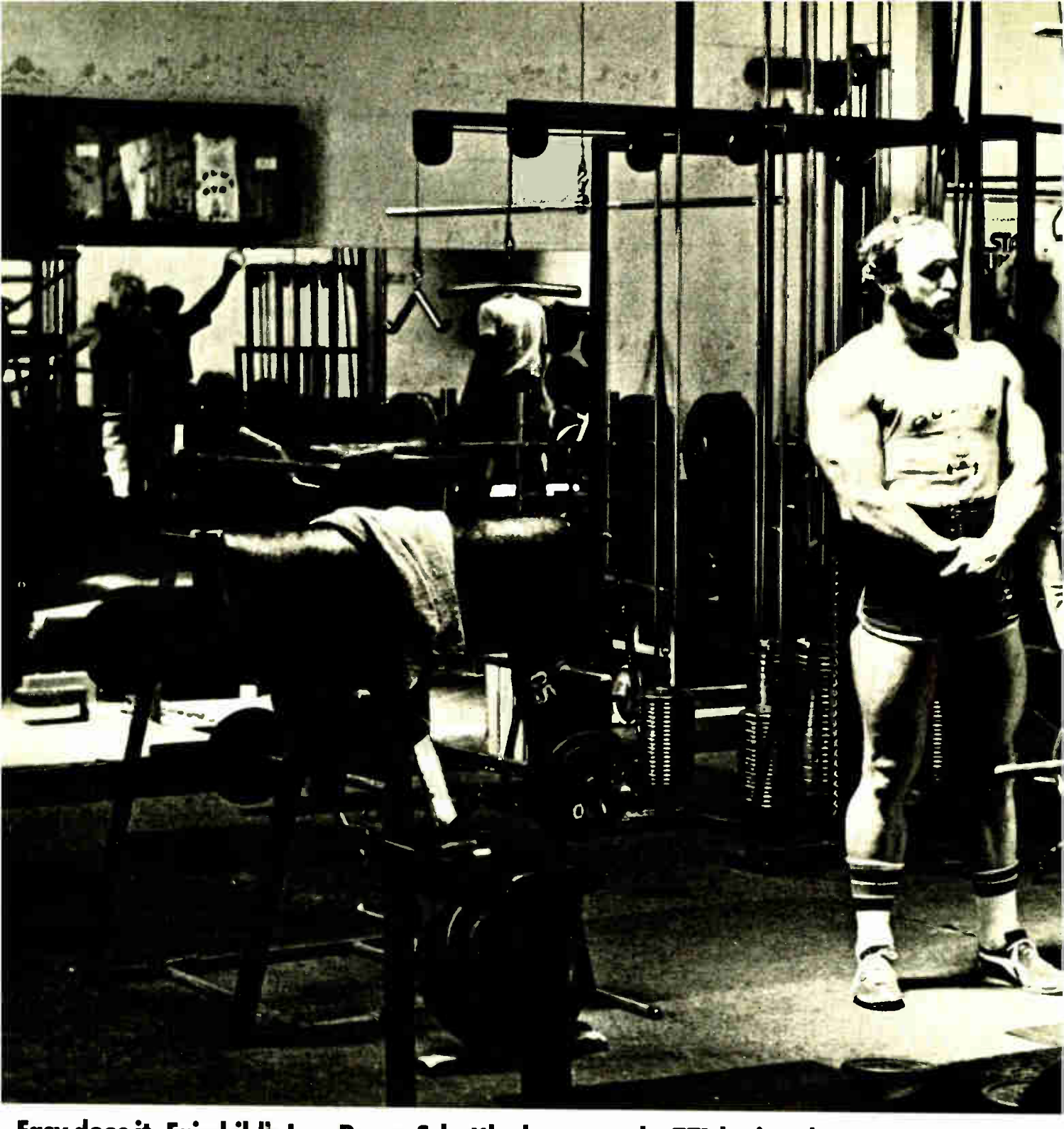
If an electronic wand reads the product code, the terminal treats the wand as a keyboard input. In this operation, the terminal normally does not require much working memory because the on-board RAM suffices. However, 2,048 or 3,072 words of ROM may be required to handle the more involved operating routines characteristic of this terminal, as well as the character-storage and timing requirements of the printer.

While all I/O interfacing can be handled by the microprocessor, a smart keyboard/display device is desirable. Such a device, now under development, will further minimize component count, enhance peripheral interfacing, and reduce ROM code.

Adding to the system

Electronic Arrays has already developed supporting memory components and a programable keyboard-encoder chip. Smart interface devices will become available the latter part of 1976. Assembler software programs are available for the NCSS timesharing network (an international network operated by National CSS Inc., Norwalk, Conn.), and a complete user's manual will be available soon.

Also, development boards, a low-cost, stand-alone system emulator, and a software development system will be available in the second quarter of this year. This emulator will contain a resident-assembler option, interface to teletypewriter or cassettes, have hex-pad input and hex displays so that the user can load programs, and execute in real time, as well as monitor and edit actual operations. □



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LS11	LS30	*LS75	LS109	LS139	*LS162	LS191	LS257	*LS295	*LS490
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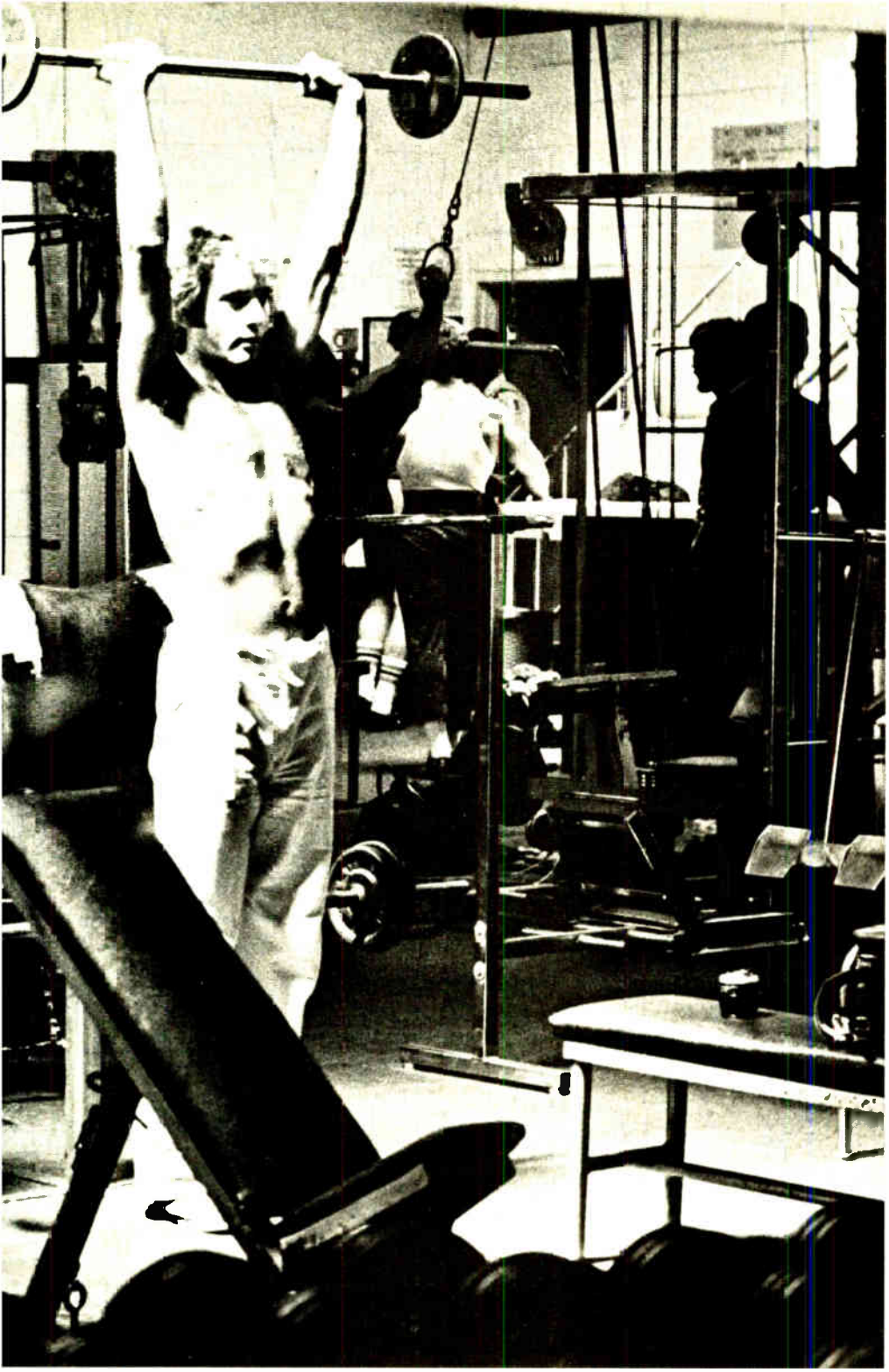
*Available 3rd Quarter 1976



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Current source and 555 timer make linear v-to-f converter

by Andrew McClellan
Case Western Reserve University, Cleveland, Ohio

In many situations it is desirable to linearly control the output frequency of a 555 timer circuit by adjusting a potentiometer or an input voltage. In the conventional astable configuration of the 555, the timing capacitor discharges and charges through one or two timing resistors. Thus the frequency is inversely related to changes in the timing components, and is also inversely related to changes in the control voltage.

However, inexpensive and accurate linear voltage-to-frequency conversion can be obtained from the 555 astable multivibrator circuit in Fig. 1. A voltage-dependent current I linearly charges the timing capacitor C so that output frequency increases linearly with the input control voltage V_{in}. During the charging phase of the cycle the capacitor voltage is given by:

$$V_C = V_{CC}/3 + It/C$$

Charging continues until V_C reaches $2V_{CC}/3$, making charging time t_c equal to $V_{CC}C/3I$.

At this point the capacitor rapidly discharges back to $V_{CC}/3$ through the ON resistance R_{CE} of the discharge transistor in the timer (pin 7). The discharge time, t_d, is approximately equal to $0.69R_{CE}C$.

The circuit is designed to make t_c much greater than t_d, so the period T of the multivibrator is very nearly equal to t_c and the frequency f becomes:

$$f = 3I/V_{CC}C$$

The 741 operational amplifier and transistor Q_3 form a voltage-dependent current source such that:

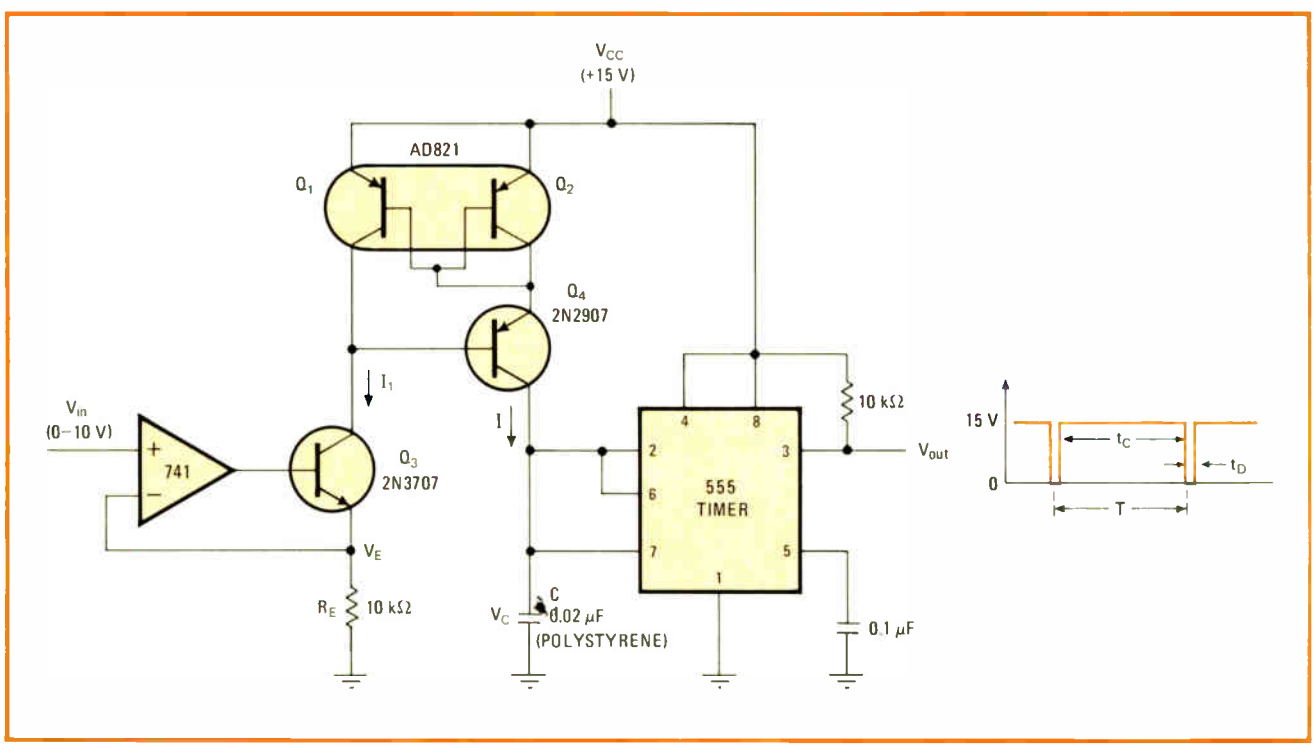
$$I_1 = (V_E/R_E)[\beta_3/(\beta_3+1)] = V_{in}/R_E \text{ (approx.)}$$

where β_3 is the forward current transfer ratio of Q_3. The op amp greatly reduces any drift due to change of V_{BE} in Q_3.

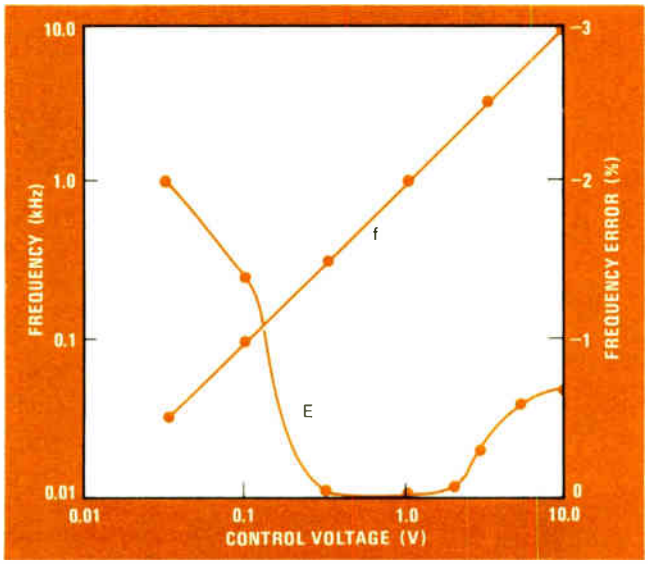
To allow the input voltage V_{in} to be referenced to ground, the capacitor is actually charged by current I from the current mirror formed by Q_1, Q_2, and Q_4 that makes I equal to I_1. The transistor Q_4 functions in a modified cascode configuration to increase the output impedance of the current source and increase the tracking of I_1 and I. Substituting V_{in}/R_E for I in the frequency equation gives:

$$f = 3V_{in}/R_ECV_{CC}$$

For a maximum input control voltage of 10 volts and the parameters used, the charging current can be easily varied over a range from 10 microamperes to 1 milliampere, and the output frequency in hertz is given by:



1. Linear voltage tuning. Inexpensive linear voltage-to-frequency converter uses an op-amp-driven transistor current source and a current mirror to charge the timing capacitor in a 555 astable multivabrator circuit from control voltage V_{in}.



2. Straight and accurate. Graphs show the experimental frequency-versus-voltage relationship, and the percentage departure from linearity, obtained with the circuit in Fig. 1.

$$f = 10^3 V_{in}$$

The experimentally obtained frequency and accuracy are shown in Fig. 2. At high frequencies (10 kilohertz) the non-zero discharge time (t_d) becomes significant and tends to make the frequency less than the predicted value. At low frequencies (100 hertz) the decreased transistor betas and the bias currents of the comparators (pins 2 and 6) decrease the voltage-to-current conversion factor and tend to also make the frequency less than the predicted value. This latter error may be compensated for to some degree by adjusting the offset of the 741 so that $V_E = V_{in} + 1.5$ mV. This has the effect of increasing the conversion factor at low input voltages without seriously affecting the accuracy at larger input voltages. Here this technique reduces the error in the 100-Hz region to less than ±0.4%.

For higher-frequency operation (1–100 kHz), it's better to reduce capacitor C to 0.002 microfarad, rather than decrease R_E; otherwise the ratio of t_d to t_c would become too large, and errors would result at the high end of the frequency range. □

Long/short-period pulses speed synthesizer setting

by Gregory W. M. Yuen
University of Technology, Loughborough, Leicestershire, England

An up/down counter is sometimes used to generate binary digits to tune a phase-locked-loop frequency synthesizer. However, the process is slow—each digital word at the counter's output is set to the desired value by push buttons that increment or decrement the count by one each time the button is pushed.

To speed up the tuning process, the buttons can be held down for a while. In this mode of operation the pulse generator rapidly steps the counter up or down through a succession of states.

The circuit shown below combines both tuning modes. Momentarily pressing a button generates a single pulse that increments or decrements the counter by one, as shown in cycle 1 of the timing diagram.

Keeping the button depressed for more than about half a second steps the counter to change the tuning at a 10-hertz rate; this condition is illustrated in the cycle diagram. Depressing the appropriate button causes the counter to step in the desired direction. As the desired frequency is approached, the button is momentarily pressed to manually step the counter repeatedly until the desired frequency is obtained. Since the method combines the speed of oscillator-derived stepping and the precise tuning of manual stepping, it provides both coarse and fine tuning.

In the circuit diagram, IC_1 is an ITT 74124 universal pulse generator. It consists of two cascaded monostables with feedback to make it operate as an oscillator. When the inhibit-oscillator input is high, this feedback path is active.

In the quiescent state, no button is pressed. Because IC_1's inhibit oscillator input is low, there is no oscillation. Because flip-flop FF_1's $\bar{Q}$ output is low, both transistors are off. When a button is pressed momentarily, it triggers the first monostable in IC_1 to send a pulse to output Q_1. Pulse width T_1 depends on the timing circuit connected to pins 1, 2, and 3. The second monostable is triggered from the trailing edge of Q_1. The Q_2 and $\bar{Q}_2$ outputs from the second monostable, at pins 10 and 9 respectively, have widths T'_2 that depend on the timing circuit connected to pins 11, 12 and 13 (C_2, R_1 and the internal resistance connected to the second monostable—the transistors stay off because FF_1's $\bar{Q}$ output does not change). When cycle 1 is completed, the output pulse from Q_2 has incremented or decremented the counter by one.

If either button is pressed for a considerably longer period, the initial sequence of events is essentially the same as before. However, FF_1's $\bar{Q}$ output goes high when its clock input is taken high by $\bar{Q}_2$ which goes high at the end of cycle 1. This turns on the transistors and R_1 is shorted out, resulting in a shorter pulse width, T_2, from the second monostable. T_2 is smaller than T'_2, and the period of oscillation is $T_1 + T_2$. Cycle 2 repeats for as long as the button is pressed.

For both monostables in IC_1, the output pulse width is given by 0.695CR seconds, where C is the capacitance in farads across pins 1 and 2 or 11 and 12, and R is the resistance in ohms across pins 2 and 14 or 12 and 14. (Pin 14 is the V_{CC} supply pin.) Internal timing resistors with a nominal value of 7.2 kilohms each are connected at pins 3 and 13 for monostables 1 and 2 respectively. To use the internal resistor, the appropriate pin is taken to V_{CC} either directly or via an additional series resistor. In the latter case, the timing resistance R is the sum of

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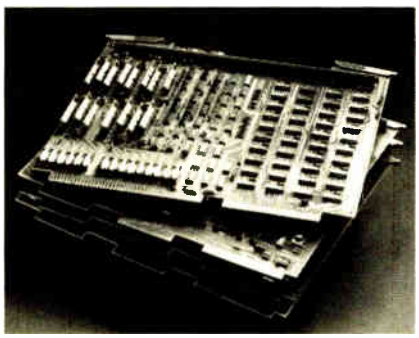

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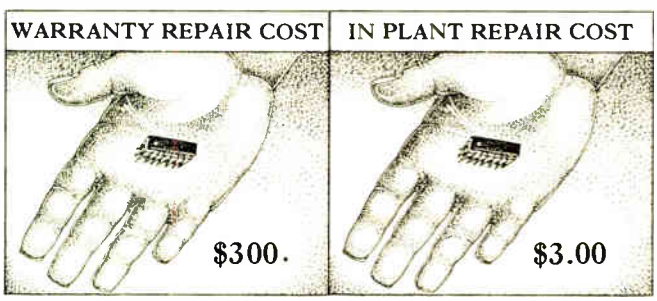

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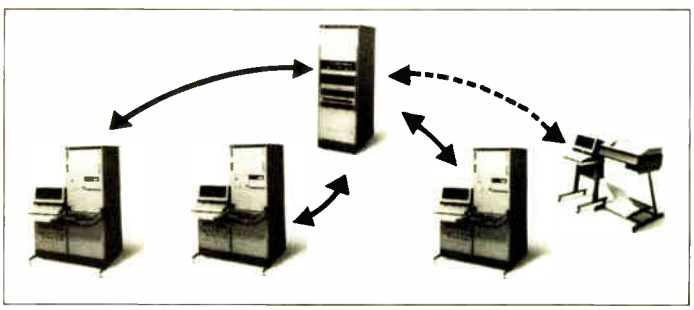

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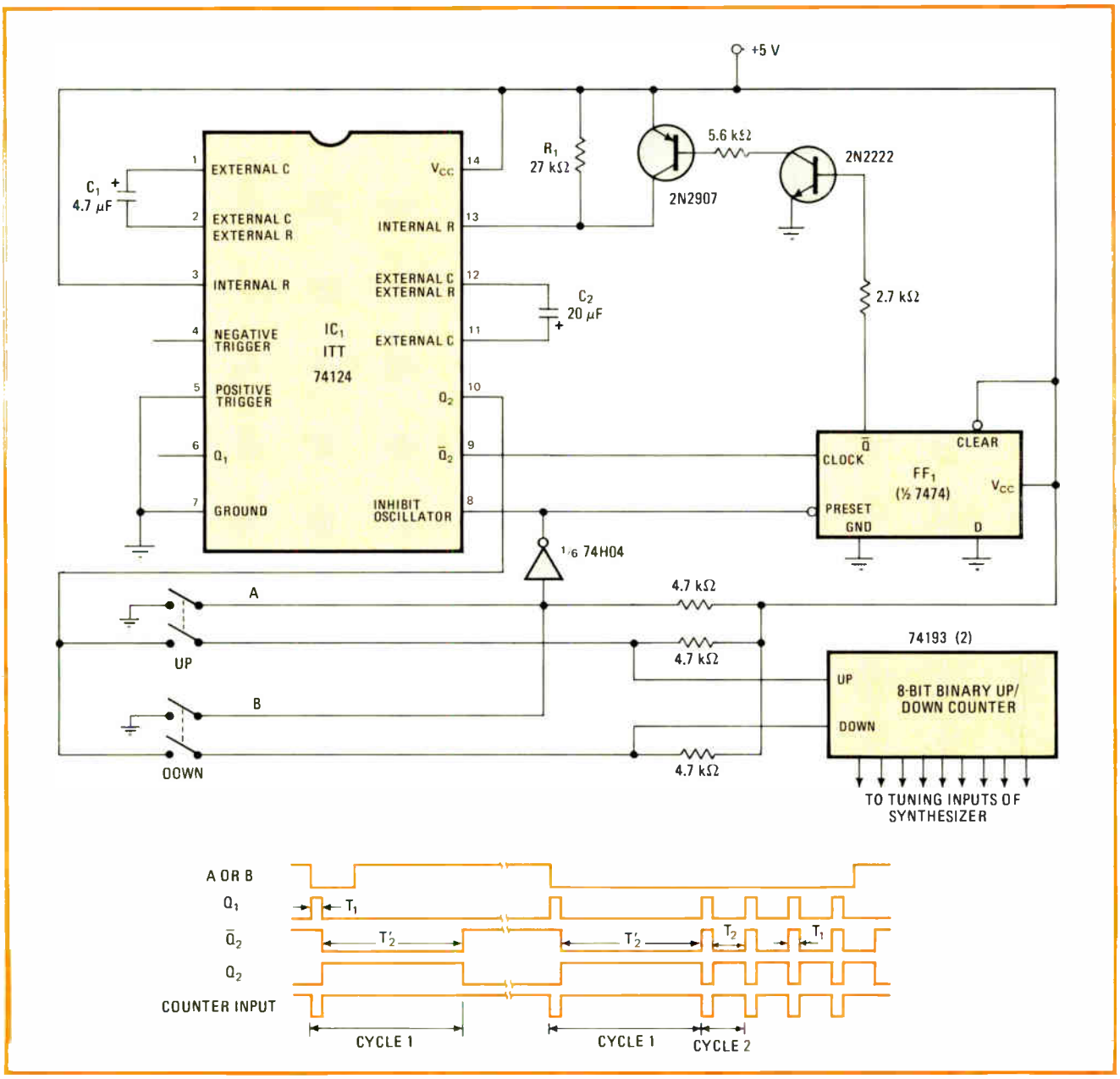

Two buttons set digital tuning word. Digital outputs from up/down counter constitute an 8-bit word that specifies the output frequency of a frequency synthesizer. Speedy access to any of 256 possible words is provided by incrementing or decrementing the counter with pulses. If a button is depressed momentarily, a single pulse is generated; if the button is held down, a fast stream of pulses is generated.

the internal and external resistances. Thus:

$$T_1 = 0.695(4.7\ \mu F)(7.2\ k\Omega) = 24\ ms$$
$$T_2' = 0.695(20\ \mu F)(7.2\ k\Omega + 27\ k\Omega) = 480\ ms$$
$$T_2 = 0.695(20\ \mu F)(7.2\ k\Omega) = 100\ ms$$

The measured pulse widths agreed well with these calculated values. Tantalum capacitors were used for C_1 and C_2.

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If the synthesizer's address word for tuning is in binary-coded decimal, 74192s or other up/down decade counters may be used. Larger tuning-address words can be accommodated by cascading more counters.

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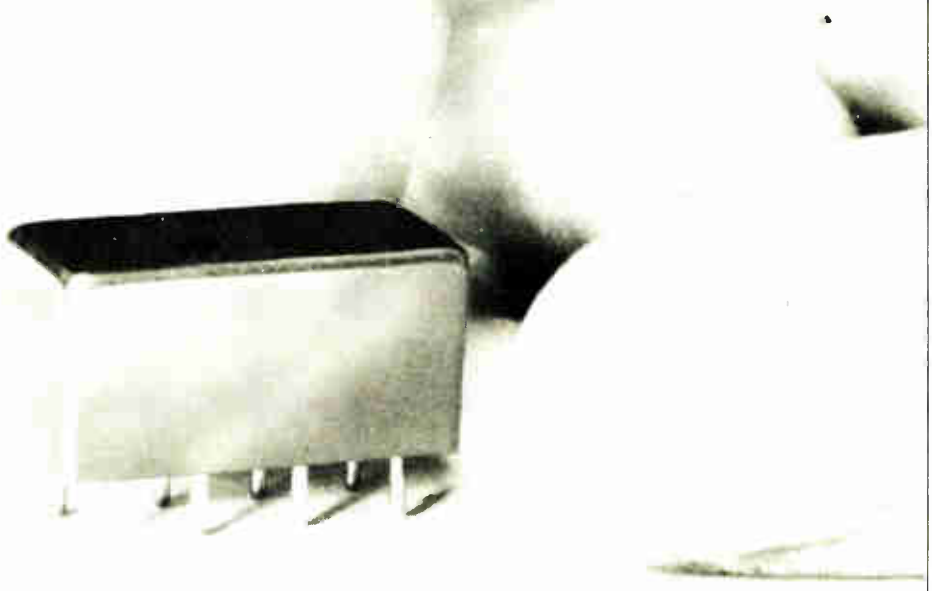

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Total range		6.5	8.5
Isolation (dB)		**Typ.**	**Min.**
Lower band edge to	LO-RF	50	35
one decade higher	LO-RF	45	30
Mid range	LO-RF	45	30
	LO-IF	40	25
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Advances in CRT design augur improved oscilloscopes

by A.G. Shephard, Thomson-CSF
Electron Tube Division, Paris, France

☐ The oscilloscope has become an indispensable measuring tool in all fields of science and technology, at least partly because of improvements in the oscilloscope's basic component—the cathode-ray tube. Although some CRTs being manufactured today are little different from those introduced in the first scopes in the 1930s, during the early days of television, the capabilities of some modern CRTs have outpaced the electronics used in scope design. And recent developments, chiefly charge-coupled devices, will probably bring about an oscilloscope generation that is more likely to be integrated into data-collection systems than to stand alone as isolated instruments.

In choosing a cathode-ray tube, the scope maker considers deflection factor, bandwidth, storage capability, reliability, and display quality, which includes screen dimensions, trace brightness, spatial resolution, and geometric distortion. With the variety of CRTs now available, the manufacturer can satisfy most requirements on these counts.

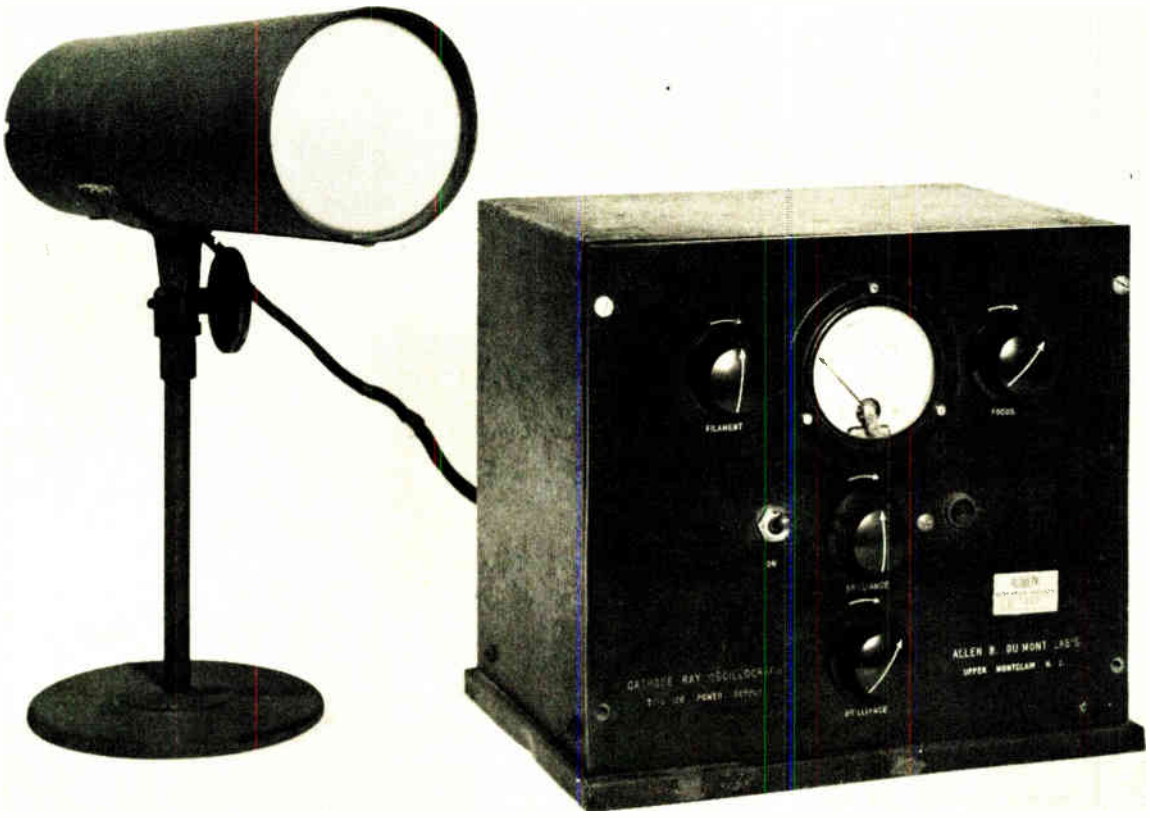
The remaining headaches mainly concern bandwidth. The upper limit is being raised constantly. Whereas a 30-megahertz laboratory oscilloscope was considered exceptional in 1955, 350-MHz models are now in common use, and a demand, admittedly limited, exists even for gigahertz capability. Working in close liaison with oscilloscope designers, CRT manufacturers have played, and are still playing, an important role in this evolution.

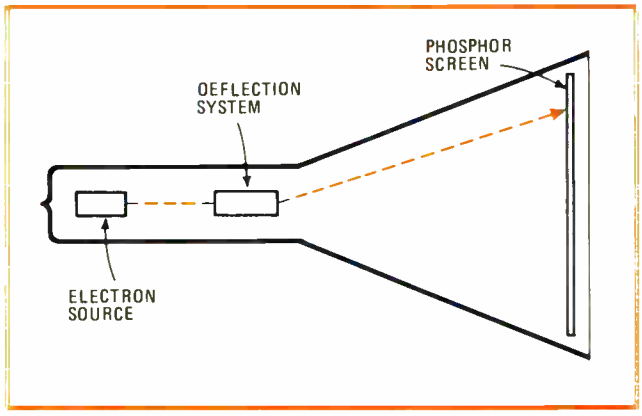
Simple beginnings

Many of the requirements of educational institutions and repair shops can be satisfied by 10-MHz oscilloscopes that use CRTs of relatively simple design (Fig. 1), differing little in principle from the first tubes ever to be manufactured. Electrons from a hot cathode are collimated into a fine beam and accelerated toward a phosphor screen that is several kilovolts positive with respect to the cathode.

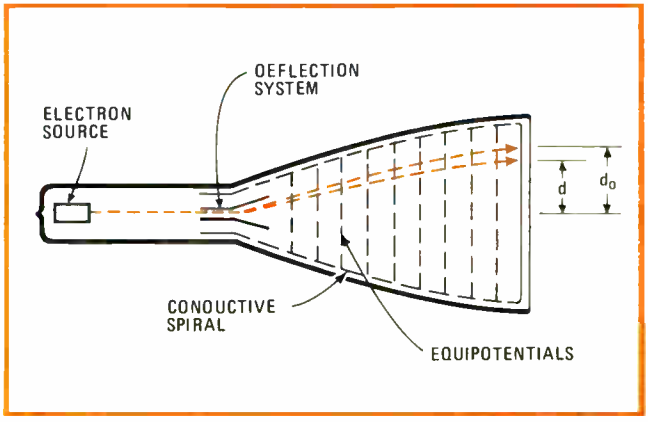
The electron beam is deflected so as to graphically display the incoming signal information (usually as a function of time) along horizontal and vertical axes. Electrostatic deflection is nearly always used. Although

1. On screen. The first commercial oscilloscope, of which an example is in the Smithsonian Institution, was introduced by Allen B. DuMont Labs in the 1930s. Deflection connections were made directly to the CRT, the box shown acting only as a high-voltage power supply.

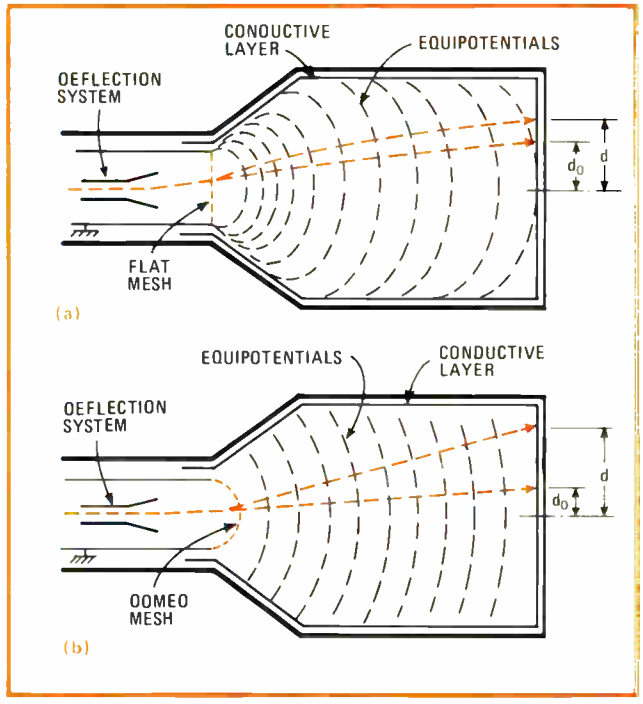




1. Simple CRT. The most common oscilloscope CRT, still widely used in low-frequency instruments, differs little from early units.



2. Spinning a field. The voltage across a conductive spiral on the inside surface of the CRT creates a field that accelerates the beam.



3. Magnifying through a mesh. Either a flat or curved mesh helps improve the deflection factor of a scope CRT. The radially traversed equipotentials of the domed-mesh tube increase this effect.

magnetic deflection gives a slightly smaller spot size, coil-design problems and excessive power consumption impose an upper limit on useful operating frequency of 2 to 3 MHz. Tubes using this principle are normally found only in oscilloscopes that have limited frequency response and large screens.

Because of their unsophisticated design, these simple tubes are relatively cheap to manufacture, but their low trace brightness makes them totally unsuitable for operation above 20 MHz. Since trace brightness depends on the energy imparted to the screen by the electron beam, and hence on accelerating voltage, the only way to improve trace brightness would be to increase the accelerating voltage. But to do so would automatically increase the already high value of the deflection factor (see "Measuring deflection," p. 116). Increasing the length of the deflection plate could reduce the deflection factor, but the increased interplate capacitance would hurt the CRT's high-frequency performance.

Post-deflection acceleration

In an attempt to increase trace brightness without unduly affecting the deflection factor, CRT manufacturers long ago introduced tubes in which the energy of relatively low-voltage electrons was increased after deflection. This technique is known as post-deflection acceleration, or PDA.

The first tubes of this kind had a resistive spiral electrode painted on the inner surface of the glass bulb (Fig. 2), and the potential difference across the two ends was about 10 kilovolts. The spiral creates equipotentials that act as a converging lens, progressively accelerating while bending the beam toward the tube axis. The deflection that would occur if there were no convergence, d_0, divided into the actual deflection, d, is known as the compression ratio; it is commonly 0.4 to 0.6. Since the beam is divergent, the compression ratio can be improved by lengthening the tube. Unfortunately, a CRT made that way tends to be rather cumbersome.

The next development was the introduction of a flat or domed field mesh into the spiral PDA tube. Placed just after the deflection plates, it modifies the shape of the equipotentials, thus avoiding the compression effect associated with pure spiral PDA tubes. These tubes are much shorter than spiral PDA CRTs that have the same deflection factor.

In modern tubes, the spiral has been eliminated altogether. It has been replaced by a continuous conductive coating (Fig. 3) that has a potential of 15 to 20 kV with respect to the field mesh. A strong field is created between the mesh and the bulb wall, which yields two results: it accelerates the electrons (PDA) and also increases the deflection (deflection magnification).

The earliest tubes had flat field meshes. They provided good trace brightness and deflection factor and were suitable for operation up to 100 MHz. Domed-mesh tubes have an even more pronounced deflection-amplification effect. Typical figures for d/d_0 are 2 to 3.5, compared to 1 to 1.5 for flat-mesh tubes. They are now being used in oscilloscopes designed for operation in the 50-to-300-MHz range.

Both types suffer from disadvantages that directly re-

sult from the use of field meshes. First, the beam is diffracted by the grid-like form of the mesh, increasing spot size and reducing contrast. Second, an appreciable part of the beam is intercepted by the mesh, which then emits secondary electrons that reduce control further and can also cause a halo effect on the screen. This halo, although always present, is not noticeable under most conditions. However, when the time base is unusually slow, the halo is clearly visible. The effect is more pronounced with domed-mesh than with flat-mesh tubes.

Quadripolar Lenses

An improvement in the tubes, the use of quadripolar and slot lenses, was developed in 1967 by Thomson-CSF. These tubes, which are extremely compact, have a very low deflection factor, wide frequency response, excellent trace brightness and geometry, and complete absence of the problems that characterize mesh-type tubes. The secret lies in their PDA/deflection-magnification system, consisting of a set of quadripolar lenses followed by a slot lens (Fig. 4).

This tube design greatly reduces the problems encountered in developing large-bandwith oscilloscopes. Yielding a bright trace because beam-attenuating meshes are eliminated, it allows signals with very fast rise times to be displayed. Because of the extremely low deflection factor, the deflection sections can be driven by amplifiers that have moderate gain. The low deflection factor also makes possible compact, large-screen tubes, which are ideal for the growing market in large-display portable oscilloscopes. Spatial resolution is excellent because there is neither beam diffraction nor secondary emissions. And because tubes of this design are lighter and more robust than field-mesh tubes, they are ideal for applications where weight and mechanical reliability are of utmost importance.

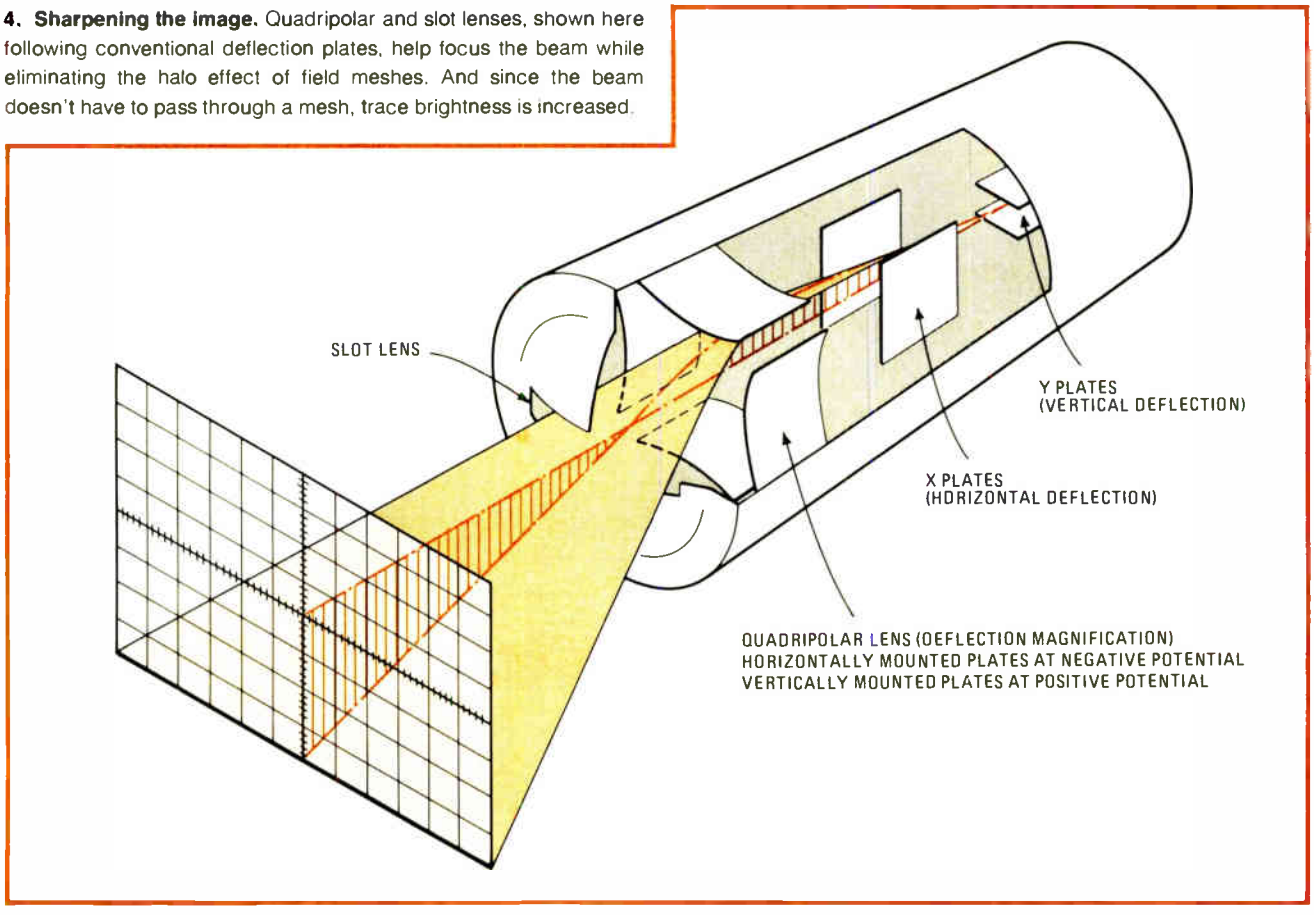
Deflecting the beam

So far, little has been said about the primary deflection system, and, for the sake of simplicity, all of the drawings have shown conventional deflection plates. The maximum frequency response of a set of conventional plates depends on the time taken by an electron to pass between them. If it takes more than an appreciable fraction of the signal cycle time, then the net deflection will be either reduced or zero.

Frequency response could be improved by reducing transit time by means of a reduction in plate length or an increase in electron velocity, but either technique would adversely effect the deflection factor. Because of the high degree of deflection amplification obtained in quadripolar lens tubes, the deflection factor may be sacrificed to a certain extent. For that reason, such tubes, even with conventional plates, have a larger bandwidth than their domed-mesh counterparts.

Another problem becomes apparent when the CRT is judged as part of an oscilloscope, instead of alone. Because the impedance of the plates is inversely proportional to the signal frequency, the amplifier that drives them must be capable of functioning correctively with a

4. Sharpening the image. Quadripolar and slot lenses, shown here following conventional deflection plates, help focus the beam while eliminating the halo effect of field meshes. And since the beam doesn't have to pass through a mesh, trace brightness is increased.



Measuring deflection

Two terms to describe the capability of a deflection system to alter electrons' trajectories are deflection factor and its inverse, deflection sensitivity. The meanings of the two terms are sometimes reversed. An electron of energy eV_a, passing through an electrostatic field V_s that is perpendicular to its original trajectory (V being the potential difference across the deflection plates), will be deflected. The deflection, d, is $(V/V_0)(Ll/2s)$.

The deflection factor of a CRT, V/d, is the number of volts required for a 1-centimeter (or graticule division) deflection:

$$V/d = (2sV_a)/(Ll)$$

This capability can also be expressed in terms of deflection sensitivity as the number of centimeters or graticule divisions of deflection obtained with a deflection voltage of 1 volt.

wide range of loads. The design of such amplifiers becomes difficult, if not impossible, for large-bandwidth oscilloscopes.

For these reasons, conventional plate systems are not to be recommended beyond 150 MHz for domed-mesh tubes and 250 to 300 MHz for quadripolar-lens tubes, which have shorter deflection plates and less plate-to-plate capacitance. For frequencies higher than these, transmission-line systems are used (Fig. 5).

Instead of one relatively long plate, a series of short plates is used. These are interconnected by inductive/capacitive delay elements to match the signal propagation time to the electron transit time so that the electron is constantly deflected during its passage between the plates. In addition, and of major importance to the oscilloscope designer, correctly adapted transmission-line systems have a frequency-independent impedance, which greatly simplifies design of the deflection amplifier.

In addition to the previously mentioned improvements, which are largely concerned with electron optics, the actual presentatation of the visible image has changed over the years. The P1 phosphor, in common use for a long time, has now been replaced to a great extent by P31, which exhibits superior characteristics for most oscilloscope applications. The color is more agreeable to the eye and better matched to the spectral sensitivity of films used in oscilloscope cameras. In addition, P31 has a more rapid rise time and higher luminosity, which makes it superior for display of fast transients.

Trace brightness has been nearly doubled by coating the back surface (electron-gun side) of the phosphor with a thin layer of aluminum. The metal acts as a mirror, reflecting outward the light that is emitted from the phosphor back in the tube.

Adding a grid

Until the late 1960s, most oscilloscope measurements were made by reading along a plastic graticule in front of the CRT. This graticule was easily damaged, and parallax resulting from the separation between the image

TABLE 1: OSCILLOSCOPE CRTs

CRT type	Advantages	Disadvantages	Frequency range
Simple	Low cost Fairly small spot (0.4 mm)	Low deflection factor (30 V/cm) Low trace brightness	Up to 10 MHz
Spiral PDA	Medium price Small spot (0.2 to 0.3 mm) Bright trace	Medium deflection factor (10 V/cm) Bulky	Up to 50 MHz
Flat-mesh lens	Medium price (higher than spiral PDA) Fairly small spot (0.4 mm) Good deflection factor (6 V/cm)	Medium trace brightness Halo caused by mesh	50 to 100 MHz
Domed-mesh lens	Medium-sized spot (0.45 mm) Compact Very good deflection factor (4 V/cm)	High price Medium trace brightness Halo caused by mesh	50 to 300 MHz 500 MHz possible
Quadripolar lens	Fairly small spot (0.4 mm) No halo Compact Excellent deflection factor (1.5 V/cm)	High price Medium trace brightness	50 to 500 MHz 800 MHz possible

on the phosphor and the graticule caused reading errors. In later CRTs, the graticule is being placed inside the tube in the same plane as the phosphor.

Although increasing accuracy, internal graticules caused unexpected problems for the CRT manufacturer. The slightest errors in trace geometry, not noticeable with an external graticule, became immediately obvious and reason for complaint. However, accuracy in mounting and the general precision of the electron optics have been improved, so that the accuracy of the modern oscilloscope CRT is becoming more and more accepted.

Many oscilloscopes can display two or more traces at the same time. The simplest technique with a standard CRT is to chop or alternate the incoming signals at a high frequency and apply them at different times to the vertical-deflection plates. The traces are separated by dc-level controls.

Another technique provides two continuous traces by means of a special CRT in which the electron beam is split in two after leaving the horizontal-deflection plates, but before reaching the vertical-deflection plates, of which two independent sets are used. A third technique permits all parameters to be varied by means of two completely independent sets of electron guns and horizontal- and vertical-deflection plates.

The most recent change has been made possible by the availability of large-screen CRTs. For many years, the standard display format has been 8 by 10 centimeters, but new CRT screens are 10 by 12.5 cm, and even larger sizes are becoming available. Although the absolute resolution remains the same, the readability has been greatly improved by 10-by-12.5-cm screens, so that this format may rapidly replace its predecessor as a standard.

All of the CRTs described so far have one thing in

common: when an electron strikes the phosphor screen, the resulting luminous spot is only visible for an instant. When looking at sufficiently fast, repetitive phenomena, the eye integrates the successive traces to give an impression of continuity. With very slowly evolving signals or fast nonrecurrent phenomena, some form of image-storage system is required. When required for use with a conventional oscilloscope, storage is usually provided by a camera.

Capturing the image . . .

However, another type of instrument is available for these applications. This is the storage oscilloscope in which a direct-view storage tube (DVST) replaces the conventional CRT. And even though a DVST can store incoming signals and display a continuous image, the stored data can be totally erased in a few milliseconds.

The main difference between the two basic classes of DVST is where the signal is stored. In one, the phosphor-target tube, the storage medium is the phosphor of the screen. This system is inexpensive because it is simple to construct and also simple to operate. Because of the way it works, the phosphor-target tube is commonly called a bistable tube. Since the operation of this class of tube has been extensively described elsewhere, it won't be dealt with here.

Capable of much better performance is a class of tube, in commercial production at Thomson-CSF since 1962, in which the storage medium is a special mesh that is placed near to the phosphor (see Table 2). Because of the principle of operation, this tube is known as the variable-persistence (or half-tone) storage tube.

The basic structure of a variable-persistence DVST resembles that of a conventional CRT with several components added (Fig. 6). The storage-and-display section consists of a phosphor viewing screen, a metal-mesh collector electrode, and a metal-mesh backing electrode that has a thin layer of dielectric (the storage surface) deposited on the side facing the writing gun.

Operation of the tube depends on the secondary-emission characteristics of this dielectric so that the storage surface can be charged either positively or negatively, according to the energy of the incident electrons.

The flood guns (normally two) continuously emit a wide-angled beam of low-velocity electrons that is shaped by the collimator so that the meshes and phosphor are evenly and orthogonally irradiated. Electrons approach positively charged areas of the storage mesh, then will pass through the holes in the backing electrode, be accelerated, and strike the phosphor.

Those approaching negatively charged areas will be repelled back toward the collector. The storage mesh acts like the control grid of a triode in that the transmitted beam of electrons will be modulated by varying levels of positive charge present on the storage surface. In this way, half-tone information can be displayed on the phosphor screen.

. . . storing it . . .

To write and store information, the storage surface is locally charged in a positive-going sense by the beam from the writing gun. The electrons are energetic enough to give a secondary-emission ratio that is greater than one.

The resulting trace of positive charges can be turned into an image by the flooding beam. Because the flooding-beam electrons don't remain on the storage surface (they are either repelled or transmitted through the holes), an infinite-duration display seems to be possible. But in practice, residual gas molecules inside the tube are ionized by the flooding beam, positive ions are deposited on the storage surface, and display contrast is reduced by the appearance of a luminous "stain" of increasing intensity until, eventually, the information is lost. This phenomenon is called "fading positive." Long-term retention can be accomplished by switching off the flood guns so that written information is stored indefinitely before being displayed.

. . . and letting go

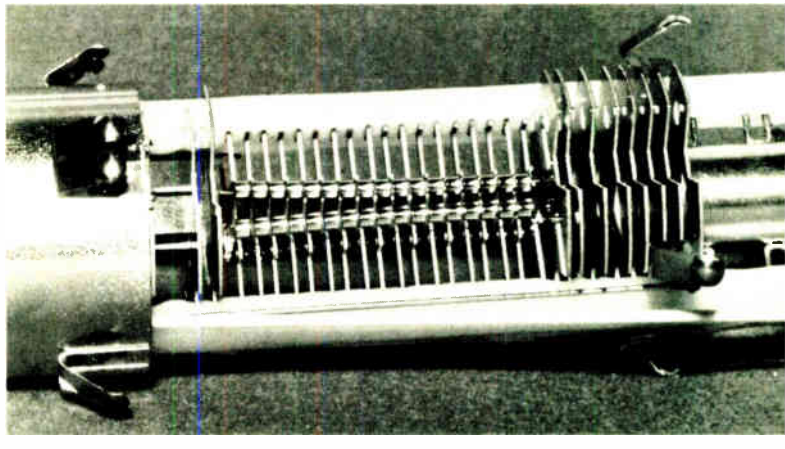
To erase stored information, a positive pulse is applied to the backing electrode. Low-energy flooding-beam electrons are then attracted toward the storage dielectric (the surface potential of which has also been raised because of capacitive coupling) and charge it uniformly to the negative flooding-gun cathode potential. On removal of the positive pulse, the backing-electrode potentials falls to its original value and, because of capacitive coupling, the storage-surface potential falls to the unwritten state. New information can then be written and stored.

If variable-persistence operation is required, the single positive erase pulse is replaced by a train of shorter pulses, each of which partially erases. Persistence may be varied by adjusting the pulse duty cycle.

The DVST can be used as a normal CRT by cutting off the flooding beam and dropping the collector potential (normally around +100 V) to 0 V. To prevent trace broadening, the backing electrode must also be biased negative enough to keep secondary electrons, which are generated by writing-beam electrons striking the storage surface, from reaching the phosphor viewing screen.

Stored writing speed and viewing time are inter-

5. Down the line. Large-bandwidth oscilloscopes demand deflection systems more complicated than simple plates. Electrons are accelerated all along the delay-transmission line shown here.



related. If information is written onto the storage surface by a very fast beam, the displayed trace will be faint, and it will soon be drowned in the increasing background glow of the fading-positive effect. Because of this, the effective writing speed in storage operation is limited to around 500 cm/μs in most tubes. This is equivalent to storing a single-shot 9-ns rise-time signal with 3.5-cm amplitude.

Although this is sufficient for the majority of applications, higher stored writing speeds are desirable in certain domains. In such cases, a fast-transfer storage CRT can be used.

The fast-transfer-storage CRT is similar in principle to a variable-persistence DVST, but it has two storage meshes instead of one. The first has been designed to capture high-speed signals at the expense of viewing time. The stored signal is then transferred to the second mesh, which is designed for long viewing times.

What's coming in scope CRTs

Future developments in CRTs will be aimed at separating the data-gathering from the display functions. In the past, CRT development has been stimulated by the demands for such improvements as increasing bandwidth, sensitivity, brightness, and resolution. Virtually all of those needs can be met by present-day tubes, except for some problems in the gigahertz region. Even there, highly specialized (and also rather expensive) tubes yield reasonable results. However, the total market for oscilloscopes with this level of performance is limited to a handful per country, since their main application is in advanced research into nuclear and laser phenomena. The vast majority of users are more than satisfied by the performance of scopes at 10 to 500 MHz.

For some time, the oscilloscope has been widely considered part of an integrated data-treatment network, rather than an isolated unit. Hence, the demand is increasing for models with digital outputs, compatible with standard data-processing equipment. Various ways have been tried to adapt relatively conventional oscilloscope technology to satisfy this demand. But is this the way to solve the problem, or should the whole function of the CRT and oscilloscope be reconsidered? This question was posed to a group of Thomson-CSF engineers responsible for CRT development, and they tried some crystal-ball gazing.

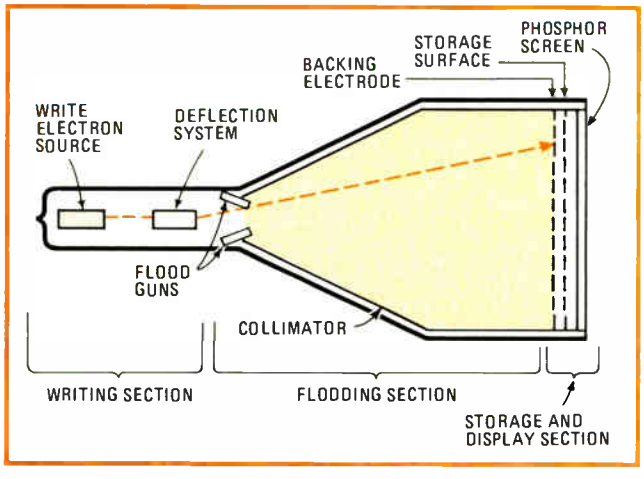
The opinion was unanimous that, although the conventional oscilloscope will continue to be used for the foreseeable future, it will soon be complemented, and for certain applications replaced, by a high-speed data-storage system with digital readout plus an auxiliary display monitor.

How could high-speed data storage with digital readout be obtained? Among the various ideas proposed, three give food for thought; all are based on CCD technology.

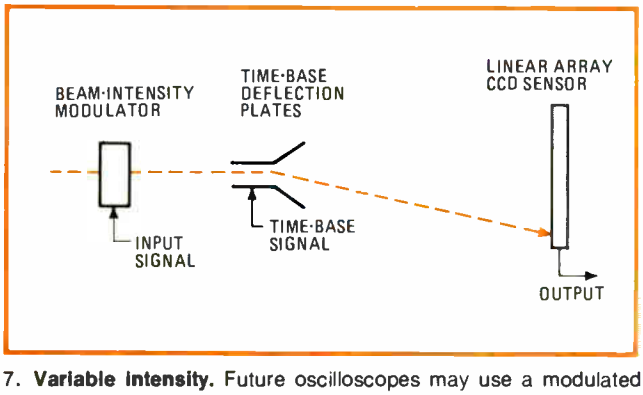
Applying CCDs

The first idea calls for a linear-array CCD to be enclosed in an evacuated glass bulb that also contains an electron gun and horizontal-deflection (time-base) plates (Fig. 7). No vertical-deflection plates would be required because the incoming signal information would modulate the electron-beam current by means of the electron gun's control grid, for example.

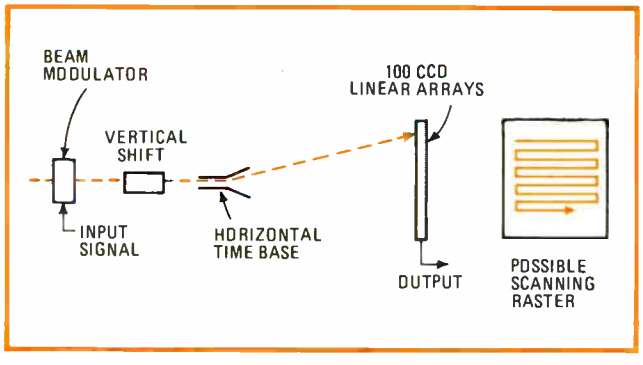
The information would be captured by the linear-array CCD, read out, and stored by a second CCD. It could then be displayed at will by means of a simple, low-cost CRT or digitized for further data treatment. This approach would provide a good digital-output oscilloscope at relatively low cost; the combined cost of the CCD unit and simple CRT monitor could be appreciably less than the cost of today's high-performance CRTs that not only have to display information, but also have to be able to



6. Holding on. The flood guns in a typical direct-view storage tube supply electrons that pass through the storage mesh, on which a trace has been written, before they illuminate the screen.



7. Variable intensity. Future oscilloscopes may use a modulated beam writing on a CCD target instead of on a CRT.



8. More data. Raster scan across a CCD array could extend the recording time of the modulated-beam system.

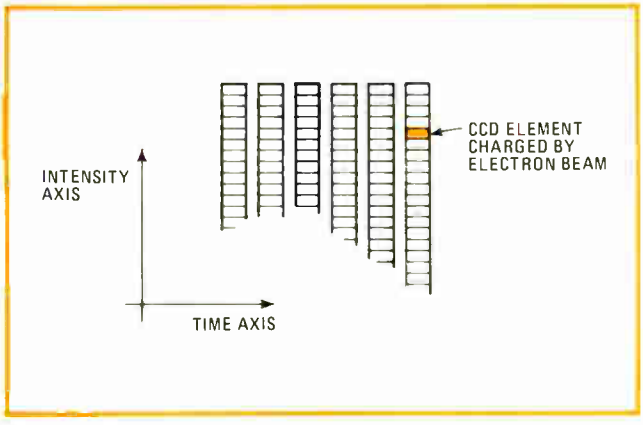
TABLE 2: MESH VS. PHOSPHOR STORAGE		
	TYPICAL MESH STORAGE TUBE	TYPICAL PHOSPHOR STORAGE TUBE
Phosphor	P31: High brightness	P1 or similar: less bright
Variable persistence	Yes	No
Half-tone storage (z-axis modulation)	Yes	No
Writing speed	Unaffected by aging	Decreases with aging
Stored brightness	Unaffected by aging	Decreases with aging
Brightness	Up to 100 times higher	
Split-screen capability	No	Yes
Structure	Relatively complex	Simple

capture it. With present CCD technology, models working at 20 to 100 MHz are envisioned.

The next idea is a variation of the first. The single linear array would be replaced by a set of up to 100 parallel linear arrays (Fig. 8). The principle of operation would be the same, but since the time base describes a raster, the possibilities are numerous. For example, the information could be treated as a continuous train of signals so that the capacity would be increased a hundredfold. Alternatively, the information in each linear array could be extracted separately for such signal processing as eliminating noise.

In these two concepts, a sampled analog output would have to be subsequently digitized. The third idea would give a direct digital output (Fig. 9). And, when suitably read out, the output signal could be treated directly by standard data-processing units.

A series of linear-array CCDs would be scanned in both X and Y directions by the electron beam as in a conventional oscilloscope, but the operation would be fundamentally different. Intensity would be indicated by position along the array, and time would be governed by which array the information is stored in. The two previous plans would furnish time information by position along the array and intensity information by the quantity of charge in the CCD elements.



9. CCD CRT. If scanned like a standard CRT, a CCD array can give the same information as the tube but in digital form.

Evaluating CCD potential

The advantages of the three proposed systems over standard CRTs would be:

- An output that would be either digital or sampled and therefore easy to digitize.
- High writing speeds, because an inherent gain of several thousand is possible with CCD targets.
- Readout that could be handled by a cheap standard CRT so that high performance would be possible at a relatively low overall cost.
- Compactness, and low manufacturing costs. By exploiting the technique of the single CCD strip with beam-intensity modulation, it should be possible to construct storage-oscilloscope systems that are cheaper than conventional models.

Such a new-generation oscilloscope would require some form of display unit to provide a visual check of the signal being fed into associated data-processing unit. This check could be made by a simple low-cost CRT for many applications, but an alternative immediately springs to mind—the plasma-discharge display panel.

The plasma panel, which has high writing speed and an inherent memory, is ideally suited for this type of oscilloscope because of its compatibility with digital and sampled signals. And since the typical panel is only about 12 millimeters thick, an instrument using it would be considerably less bulky than one using a CRT.

Research-and-development work now being carried out on these projects will doubtless open up new horizons in signal monitoring and measurement. However, the conventional oscilloscope, with its advantage of immediately showing what is happening, is likely to remain the primary research tool for many years, and the new instruments will be used in a backup role for more detailed or convenient analysis. □

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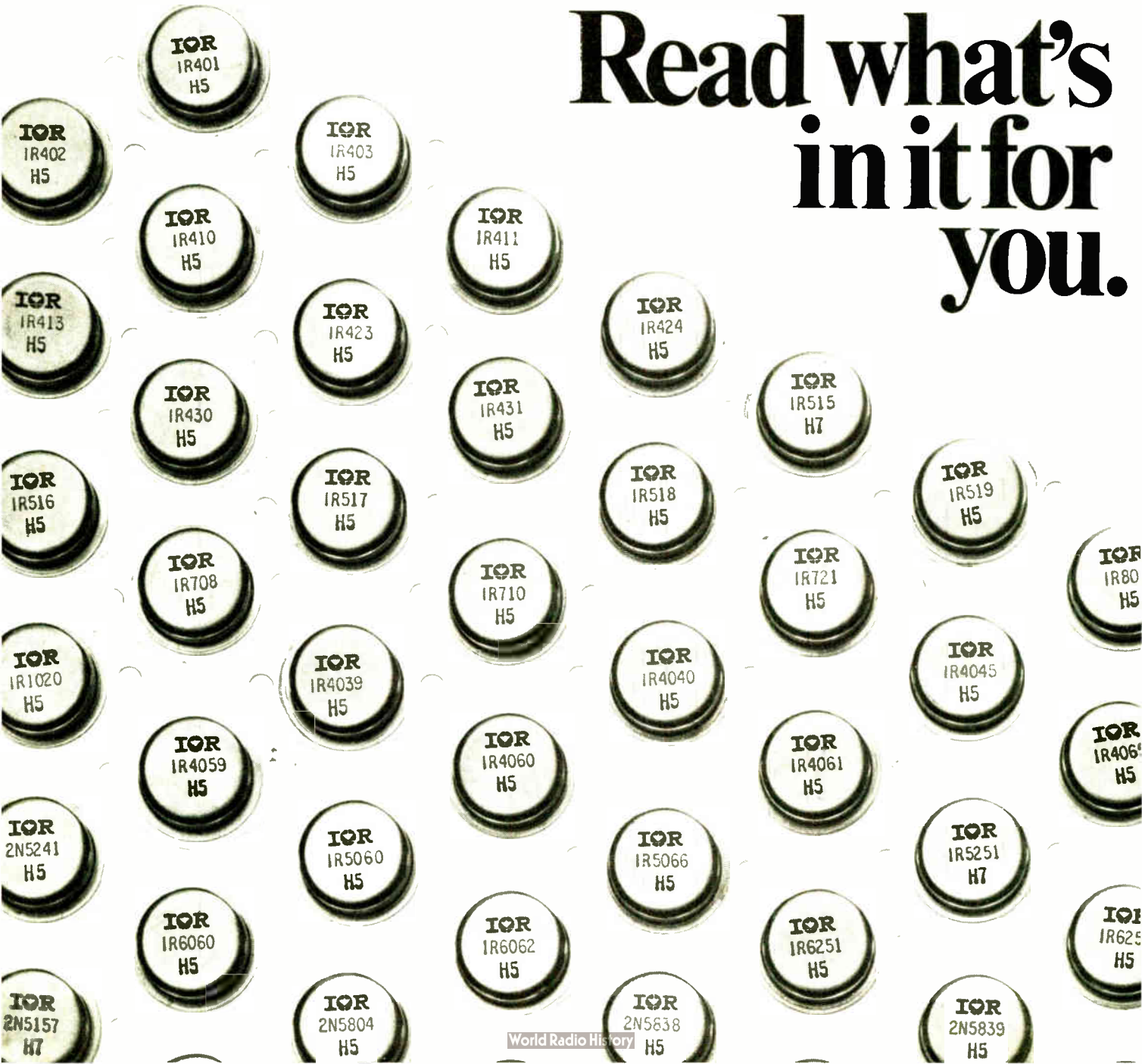

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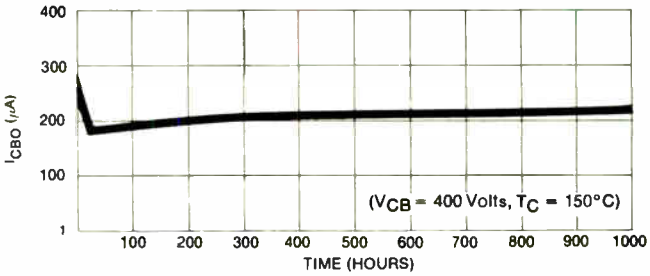

FIGURE 1 Typical High Temperature Reverse Bias Characteristics Vs. Time

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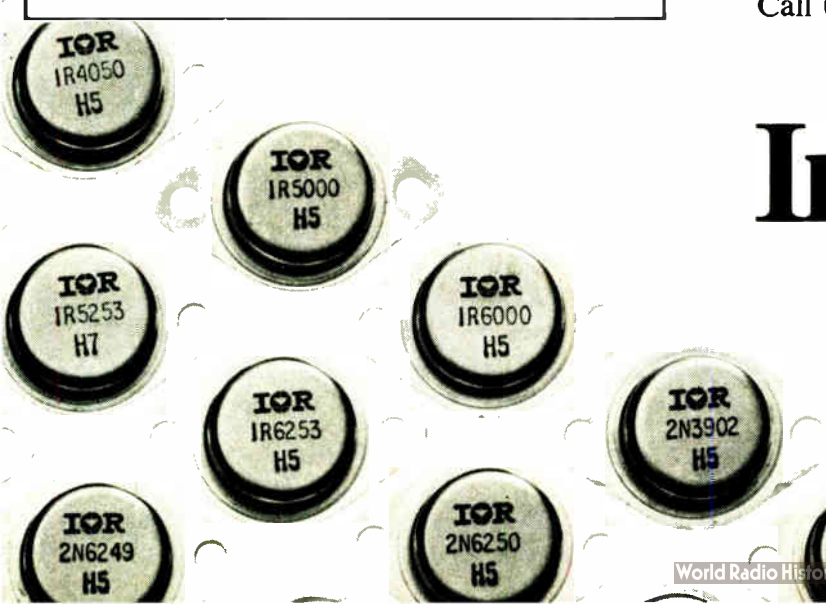

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FET power amplifier boosts transmitter efficiency

by Frederick H. Raab, Polhemus Navigation Sciences Inc Burlington, Vt

Most of the power needed to drive a radio transmitter is consumed in the power amplifier. For that reason, the efficiency of the power amplifier determines the battery and heat-sink requirements of portable communications equipment and rescue beacons. Increasing this efficiency can improve performance, increase operating life, or decrease the size and weight of a transmitter.

The high-frequency power amplifier described here operates in the class F mode for high output efficiency and exploits the negligible drive-power requirement of a field-effect transistor. The prototype produces a maximum of 330 milliwatts with 73% efficiency at 25 megahertz. This design won an award in the 1974 double-diffused-MOS contest sponsored by Signetics Corp. while the author was with Cincinnati Electronics Corp.

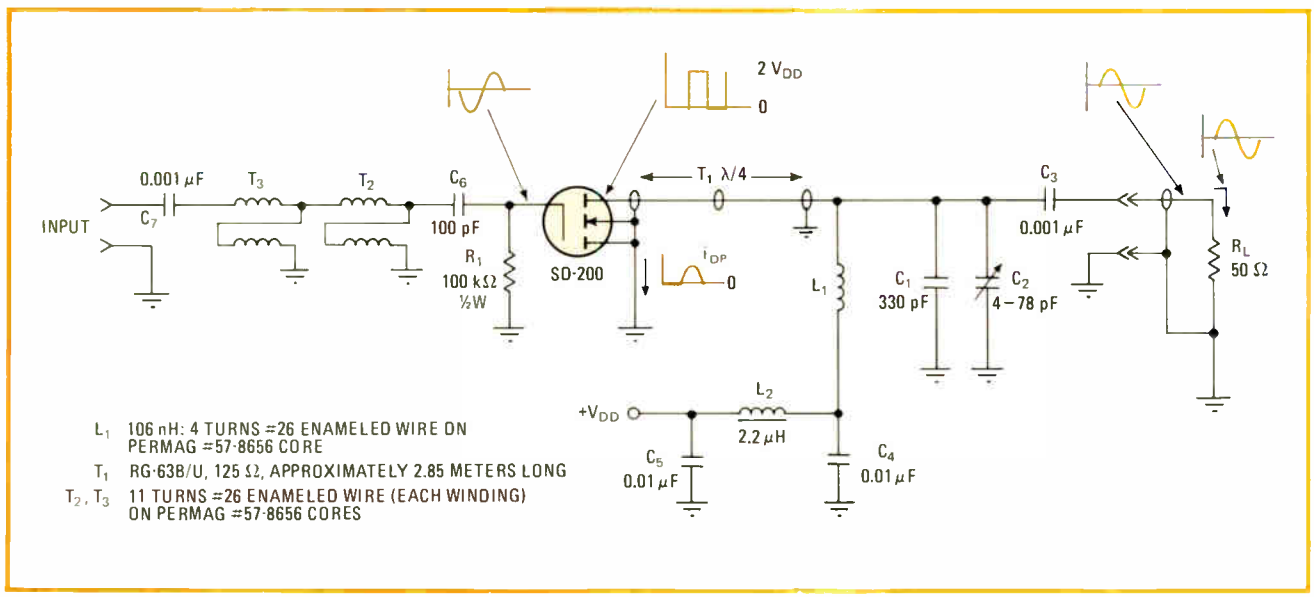
As shown in Fig. 1, the amplifier uses a single FET or a pair of FETs in parallel, driven to act as a switch. The parallel-tuned output circuit acts as a short circuit to all harmonics of the signal frequency, but the impedance transformation produced by the quarter-wavelength transmission line causes the drain to see a short circuit for the even harmonics and an open circuit for the odd harmonics.

This combination of impedances produces a square-wave drain voltage and a half-sine-wave drain current. Since the drain voltage is near zero while drain current is flowing, the FET dissipates very little power. This mode of operation, designated class F, could ideally be 100% efficient and thus provide 27% more output power and 27% greater efficiency than class B operation (see F. H. Raab, "High efficiency amplification techniques," IEEE Circuits and Systems Journal, 1975, vol. 7, no. 10, pp. 3–11).

The Signetics SD-200 is well suited to this application because it can operate as a switch at frequencies that reach into the very-high-frequency region. To operate the FET as a switch, more voltage is applied to the gate than is necessary to sustain the current flowing in the drain. Since the drain current is sinusoidal when it is not zero, a sinusoidal gate voltage of sufficient amplitude causes switching. What's more, because the gate voltage is sinusoidal and gate current is negligible, this amplifier can be driven directly by the radio-frequency oscillator or frequency multiplier. This capability eliminates components and reduces power consumption.

Transmission line boosts efficiency

Figure 2 depicts an equivalent circuit for the amplifier shown in Fig. 1; the FET is replaced by a switch and a series saturation resistance R_{on}. The switch opens and closes at the signal frequency. Load resistor R_L is shunted by a tank circuit that has infinite impedance at



1. High efficiency. A microwave field-effect transistor acts as a high-speed switch in a highly efficient rf power amplifier that operates in the hf region. A quarter-wave transmission line produces the desired impedances for multiresonator class F operation. Without the quarter-wave line, the amplifier would operate in the class B mode. This circuit operates at 25 MHz and delivers 330 mW into a 50-ohm load.

the signal frequency and zero impedance at all harmonics. The impedance presented to the drain by the transmission line therefore depends on the frequency. At the fundamental frequency, the transmission line is a quarter-wave transformer; its input impedance is:

$$R = R_o^2/R_L$$

where R_o is the characteristic impedance of the line. At the even harmonics, the line acts as if it were a half-wavelength long and reproduces the short-circuited output at the drain. At the odd harmonics, it acts as a quarter-wavelength line, converting the shorted output into an open circuit at the drain. This set of impedances is the key to high-efficiency operation.

The FET is driven so that it is turned on to act like a closed switch half of the time and turned off to operate as an open switch half of the time. When the FET is driven on, the drain voltage must be zero. The short circuits for the even harmonics require that only the fundamental and its odd harmonics be present in the drain-voltage waveform. These components combine to produce a square-wave drain voltage.

Since the average voltage on the drain must be V_{DD} so that there is no dc drop in the rf choke, the square wave has levels of 0 and $+2V_{DD}$. To simplify the discussion, the characteristic impedance of the line is assumed to be the same as the load resistance, so that R and R_o are equal to R_L, and R_{on} is assumed to be zero. The fundamental-frequency component of the square-wave drain voltage then appears across the load:

$$v_L(t) = (4V_{DD}/\pi)\sin\omega t$$

Incidentally, this voltage lags the drain voltage by 90° because of the phase shift in the quarter-wave transmission line.

The fundamental-frequency current that flows in the load is just the load voltage divided by R:

$$i_L(t) = (4V_{DD}/\pi R)\sin\omega t$$

The odd harmonics in the drain-voltage waveform convert the sine wave into a square wave, but since they do not cause current to flow, they consume no power. The output power is produced entirely by the fundamental-frequency current and voltage:

$$P_o = \tfrac{1}{2}v_{LP}i_{LP} = 8V_{DD}^2/\pi^2R$$

When the FET is off, the drain current must be zero. The rf choke passes only dc, so the fundamental-frequency current that flows through the load must also flow through the drain. Since the transmission line is an open circuit to odd harmonics, the drain current must be composed of a fundamental and even harmonics. Furthermore, because the transmission line acts as a short circuit to even harmonics, the drain can draw any amount of even-harmonic current necessary to meet other circuit requirements. This even-harmonic current results in a half-sinusoidal drain current whose peak amplitude is equal to the peak-to-peak amplitude of the output current:

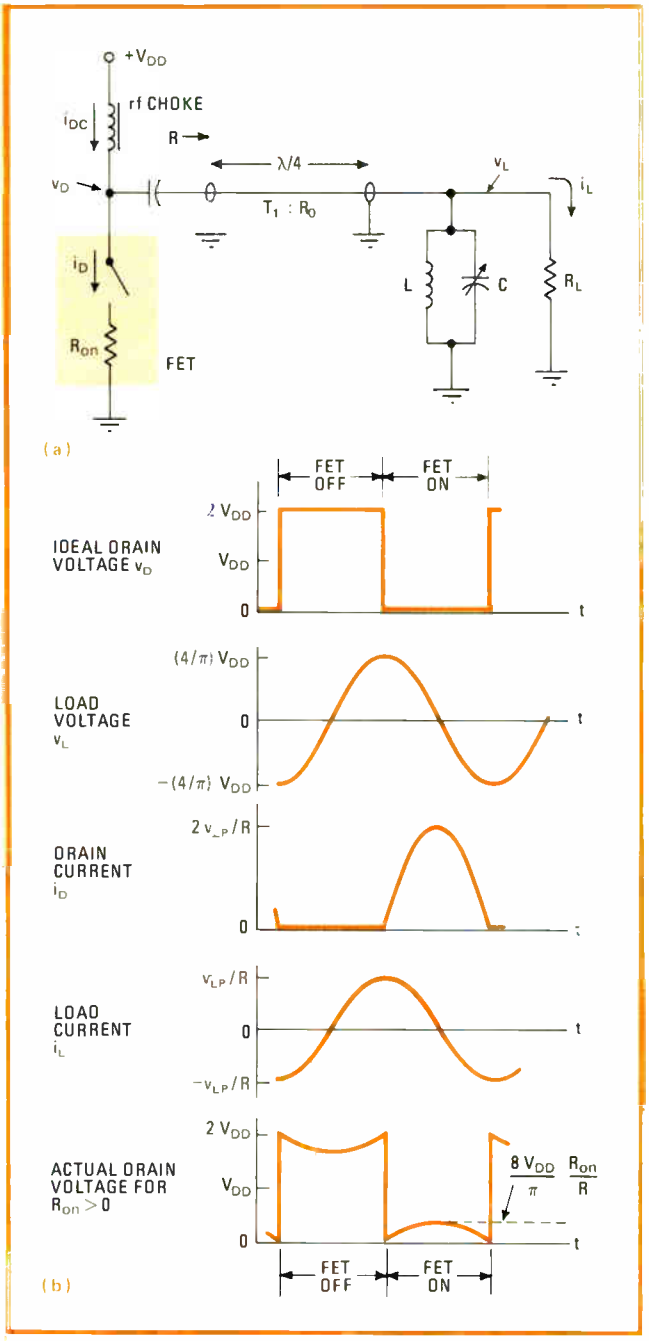
$$i_{DP} = 8V_{DD}/\pi R$$

The even-harmonic currents circulate through the drain, transmission line, and output network, but no power is consumed because they produce no voltages.

The dc input required is the average drain current, which is obtained by dividing i_{DP} by π:

$$i_{DC} = 8V_{DD}/\pi^2R$$

Multiplication of i_{DC} by V_{DD} gives the input power as $8V_{DD}^2/\pi^2R$; since this is the same as the expression for output power, the efficiency of the ideal class F amplifier is 100%. This result is also apparent from the drain



2. Here's how. Equivalent circuit (a) and waveforms for voltages and currents (b) show operation of class F amplifier. Switching action of FET produces square drain-voltage wave, but tuned circuit and transmission line remove harmonics to produce sinusoidal outputs. Values on curves are for case of $R_o = R_L = R$.

voltage and current waveforms in Fig. 2b. When drain current is not zero, drain voltage is zero, and when drain voltage is not zero, drain current is zero. Consequently, no power is consumed by the device.

Saturation resistance lowers efficiency

In a real FET, saturation resistance R_{on} is greater than zero and, therefore, the device consumes some power, reducing the efficiency of the amplifier below 100%. The output voltage and current must be sinusoidal, however, and the drain current must be half-sinusoidal. This drain current, flowing through the saturation resistance, causes the bottom of the drain voltage to differ from a square wave by a half-sinusoid with a peak value $i_{DP} R_{on}$, or $2v_{LP}R_{on}/R$, as shown in Fig. 2b.

Since there can be no even harmonics in the drain-voltage waveform, the half-sinusoidal droop also appears in the top part of the waveform. This droop reduces the output voltage because it acts in opposition to the fundamental component of the ideal square wave. The resulting output voltage across the load can be determined by equating the fundamental component of the drooping drain voltage and the output:

$$v_{LP} = (4V_{DD}/\pi)[R/(R+2R_{on})]$$

When this equation is used in the expressions for drain current, dc current, output power, and input power, the efficiency of the class F amplifier is found to be:

$$\eta_F = R/(R+2R_{on})$$

Maximizing the power

In a reliable amplifier circuit, the peak voltage and peak current should not exceed the ratings of the FET. For the SD-200, these are 25 V and 50 mA, respectively; therefore, V_{DD} must not exceed 12.5 V, and i_{DC} must not exceed 15.9 mA for a single device or 31.8 mA for two devices in parallel.

Maximum power output is obtained by choosing the load line R so that maximum drain current is reached when the maximum supply voltage is applied. This value of R is:

$$R_{MP} = (8V_{DD\,MAX}/\pi i_{DP\,MAX}) - 2R_{on}$$

If the saturation resistance R_{on} were zero, the optimum resistance would be 637 Ω, yielding an output of 198 milliwatts. Saturation resistance reduces not only efficiency, but also the maximum power. For the typical R_{on} of 40 ohms, R_{MP} becomes 637 − 80 or 557 ohms. The efficiency is therefore:

$$\eta_F = 557/637 = 87.5\%$$

A single device with typical saturation resistance can thus produce about 173 mW.

Assessing actual performance

A working model of the circuit in Fig. 1 is shown in Fig. 3a. Transformer T_1 used a 125-ohm transmission line simply because it was available; however, its load line produces nearly maximum power for a parallel pair of FETs. Although it may seem crude to use such a large coaxial cable with such a small device, the same load could have been produced with a pi-network matching 50 Ω to 30 Ω and a 95-Ω miniature transmission line, and at higher frequencies, the line could be printed on the circuit board. The carrier frequency of 25 MHz made it possible to build components easily and to measure impedances of the first three harmonics with a vector-impedance meter.

The input circuit is simple and noncritical. Transformers T_2 and T_3 multiply the input voltage by four. R_1 prevents charge buildup on the gate. The parallel-tuned output tank has a Q of 3. The rf choke delivers dc power through L_1 and T_1 so that it operates into a low impedance and it does not have to contend with harmonics.

The 125-ohm transmission line and 50-Ω load should produce a drain load line of $125^2/50$ or 312 Ω, but the measured load line was 280 Ω. The difference may have been caused by variations in the coaxial cable and impedance transformation by stray reactances. With the measured load-line resistance of 280 Ω and R_{on} of 45 Ω, the expected efficiency is 280/(280+90), or 75.5%. The power output of a single FET with this load line will be limited by the peak-current rating of 0.05 A. The maximum supply voltage and power output are consequently:

$$V_{DD\,MAX} = (0.05)(280)\pi/8(0.755) = 7.25\ V$$
$$P_o = 8(0.755)^2(7.25)^2/280\pi^2 = 86.5\ mW$$

This load line is much more suitable to a pair of FETs. If the saturation voltages are equal, the equivalent R_{on} is half that of a single FET. For an R_{on} of 22.5 Ω, the pre-

Evaluating class F operation

Class F operation of a power amplifier in a high-frequency transmitter provides 27% higher efficiency and 27% higher output power than class B. A quick comparison with class C is difficult because class C amplifiers are operated with many different conduction angles and varying degrees of saturation.

The efficiency of an amplifier in Class C operation can be increased by decreasing the conduction angle toward zero. But since the power output decreases when the conduction angle is decreased, class C operation provides high efficiency only when output power is low. Class F operation, however, provides the high efficiency at high output power.

The field-effect transistor in the circuit of Fig. 1 would operate as a conventional class B amplifier if the transmission line were removed. In that mode, the FET is driven to act as a current source instead of a switch. The parallel-tuned output causes the drain voltage to be sinusoidal. For maximum efficiency, the drive voltage is adjusted so that the drain voltage swings from 0 to +2 V_{DD}. By analysis similar to that for the class F operation, the efficiency for class B is found to be

$$\eta_B = (\pi/4)[R/(R+2R_{on})] = 0.785\eta_F$$

When R_{on} is zero, the class F circuit has an efficiency of 100%, and this equation yields the 78.5% maximum efficiency of class B operation.

dicted efficiency is 86%, and the power output is 332 mW. The FETs must have the same saturation resistances, or else the current must be divided equally by matching resistors or a current transformer.

If the same FET were operated in class B with the same load line, its efficiency would be only 59.3% and its power output 53.5 mW. A pair of FETs operated in class B would have an efficiency of 67.5% and an output of 205 mW.

The SD-200 performs well as a switch, as shown by the waveforms in Fig. 3b. The FET showed no tendency to oscillate during transition, and no neutralization circuitry was required. Any tendency to oscillate is reduced by operating as a switch because the FET has no gain when saturated or cut off.

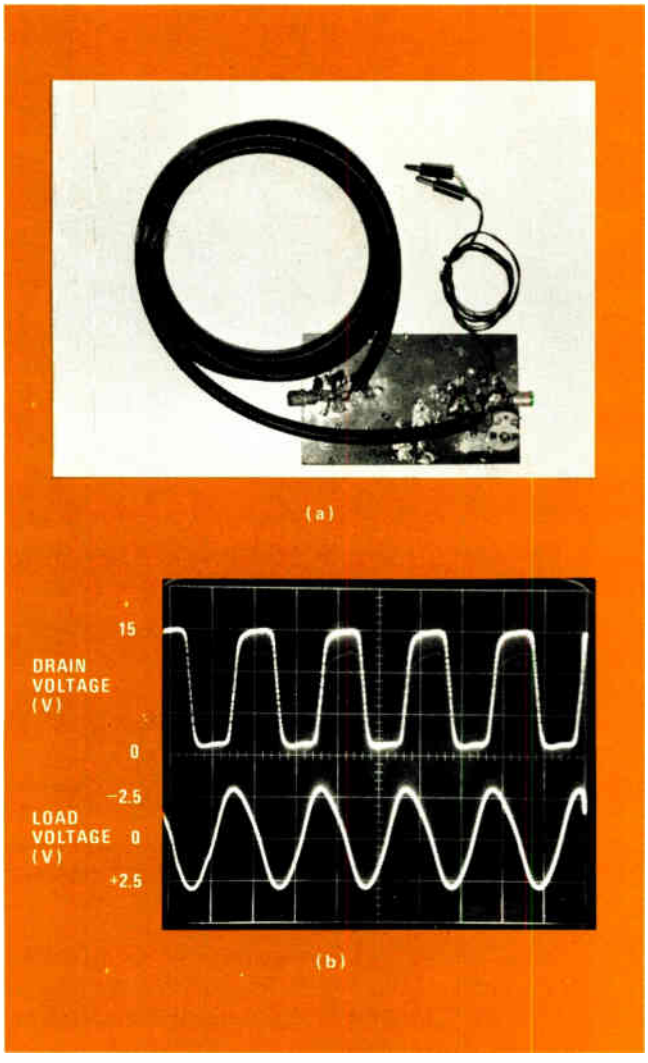
The measured performance of the amplifier is shown in the five graphs of Fig. 4. Graph 4a shows output power as a function of supply voltage. Agreement with theoretical calculations is very good. Graph 4b shows that efficiency is nearly constant for all supply voltages, except for a slight tendency toward higher efficiency at lower outputs. The single FET achieved an efficiency of about 71% at 86 mW output, which is nearly the predicted 75.5%.

By using two FETs, efficiency was improved to 73%. Why the efficiency did not improve as much as predicted is not known. Possibly, the current did not divide equally, which would have made equivalent R_{on} larger than expected. But when both one and two FETs were used, the class F amplifier exceeded the theoretical efficiency and power output for class B operation.

This type of amplifier has excellent amplitude-modulation characteristics, as shown in graph 4c. Output voltage v_{LP} varies linearly with supply voltage V_{DD}, except when the single FET exceeds its ratings (above V_{DD} of 7 V). The drive voltage was the same for all values of V_{DD}. This useful property of class F amplifiers results from using the drive to operate the device as a switch. In a class B or C amplifier, the FET acts as a current (or voltage) source, and both the drive and supply voltages must be modulated.

Feedthrough from the gate was negligible, even at the lower output levels. Since efficiency at reduced outputs is at least as high as it is at maximum power output, the efficiency of a modulated amplifier is at least as high as that of a continuous-wave amplifier. This is not true of a transistorized amplifier, where the saturation voltage becomes more significant at low outputs.

Graphs 4d and 4e demonstrate that this type of amplifier does not require critical adjustment. Although it is certainly not a broadband amplifier, it can be operated over a 10% bandwidth with negligible loss in efficiency. The peak drive voltage was held constant at 17 V at the gate, and 17/4 V at the input, for all of the previous data, but it could have been decreased by 6 dB without significant loss in efficiency.



3. Model operation. Actual circuit (a) has input circuits and FETs on the left, output tuning and dc feed on the right. Transmission line T_1 is obvious. Voltage waveforms (b) correspond to those in Fig. 2. To miniaturize, a transmission line could be printed on the circuit board or approximated by discrete elements.

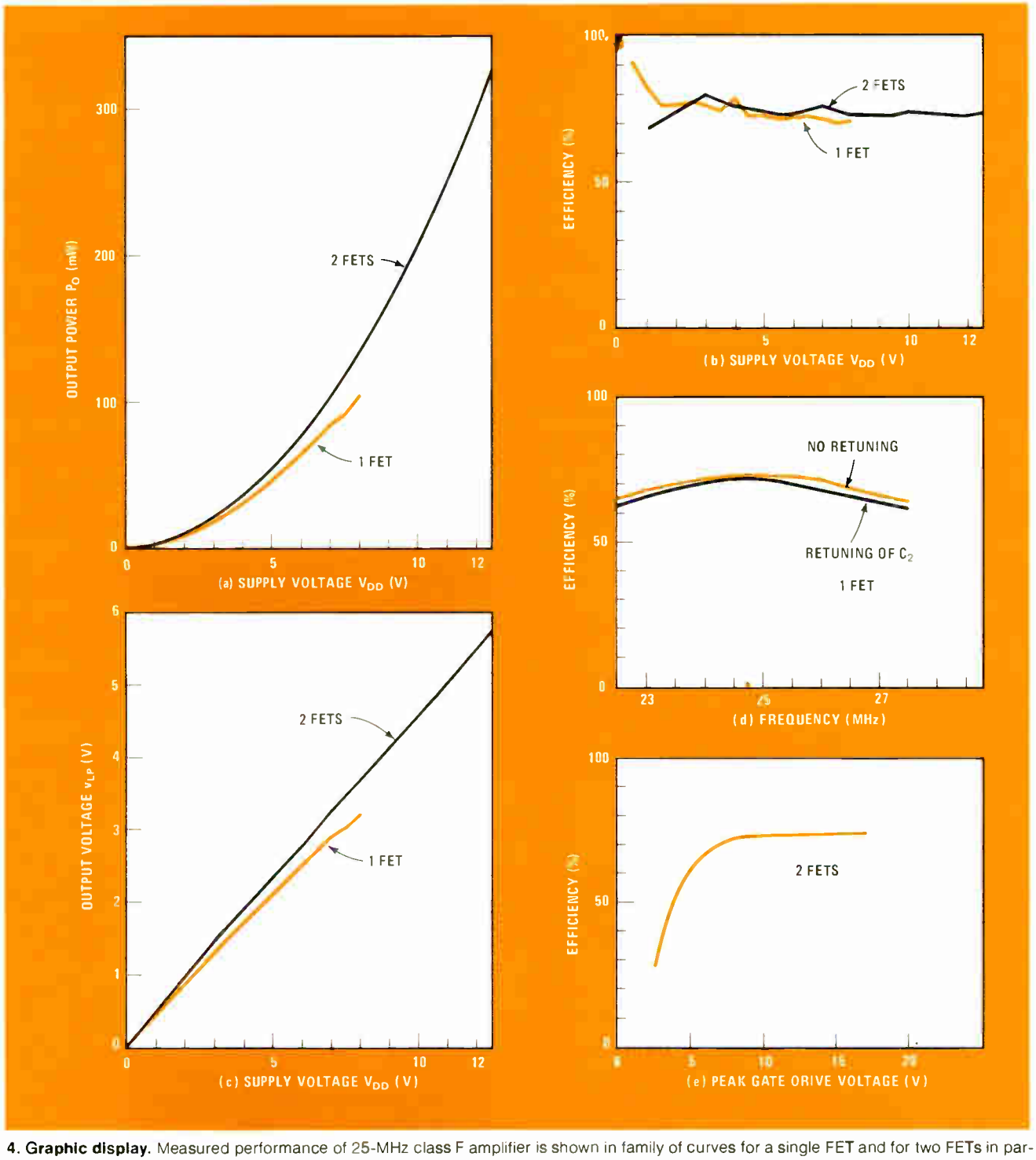
Refining the design

Higher efficiencies may be obtained by using a value of R larger than R_{MP}, but then the output is less than maximum. The use of R less than R_{MP} lowers both the efficiency and the output power.

The desired drain-load line can be produced in a variety of ways. If the parallel-tuned output were replaced by a π-network, the input impedance of the π-network and the characteristic impedance of the transmission line would then determine R. As an alternative, broadband transformers might be used. The transmission line must have essentially the same propagation velocity for at least the fundamental through the fourth harmonic. Coaxial cable is satisfactory, but 300-Ω television-antenna lead-in is not.

The carrier frequency must be low enough that switching occurs in a small fraction of a cycle so that, generally, the carrier frequency should not exceed about one tenth of the unity-gain frequency of the device.

The SD-200 has a unity-gain frequency higher than 1 GHz, so operation is possible at frequencies above 100 MHz. The SD-202 could be used at even higher frequencies, but it has a lower output. Capacitance at the



4. Graphic display. Measured performance of 25-MHz class F amplifier is shown in family of curves for a single FET and for two FETs in parallel. The nearly constant efficiency with varying output is demonstrated in (b), while modulation linearity is apparent in (c). Performance over a 10% bandwidth is shown in (d), and insensitivity to drive variations in (e). New V-MOS FETs can provide greater rf output.

drain should be kept to a minimum because it impedes rapid switching.

Since the gate voltage required for saturation depends on the drain current at a particular instant, sinusoidal drive can be used. When the driving voltage is below about 1 V, the device is cut off. The characteristic curves suggest a peak voltage of at least 6 V. The SD-201 should not be used because the diode protection will interfere with the driving signal. The gate capacitance may be included as part of the tank circuit of the previous stage. It should be possible to drive this amplifier from an oscillator or frequency multiplier with sinusoidal output, since negligible power is required.

Advances in FET technology will make it possible to extract higher output power from this type of circuit. For example, the recently-announced Siliconix VMP-1 V-MOS FET with a 50-Ω transmission line and a 30-V supply should produce about 12 W of rf output. □

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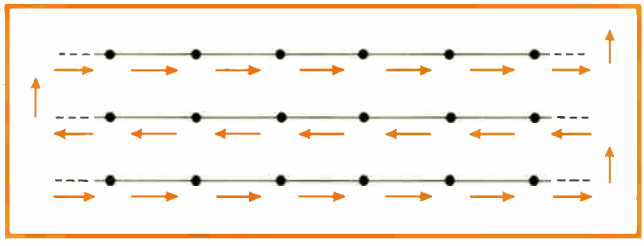
Back-and-forth scanner overcomes slewing-rate limits

by James A. Blackburn
Wilfrid Laurier University, Waterloo, Ont., Canada

An incremental plotter or line printer that can store entire lines in a buffer memory can be made to print the lines alternately forwards—from left to right—and backwards—from right to left. This refinement will significantly increase its speed because it will no longer need the carriage return function with its all-too-finite slewing rate. In fact, only the minimum character-to-character print rate will then be affected by the mechanical inertia of the print-head assembly (or, in the case of an all-electronic display system, by the finite settling time of the amplifiers).



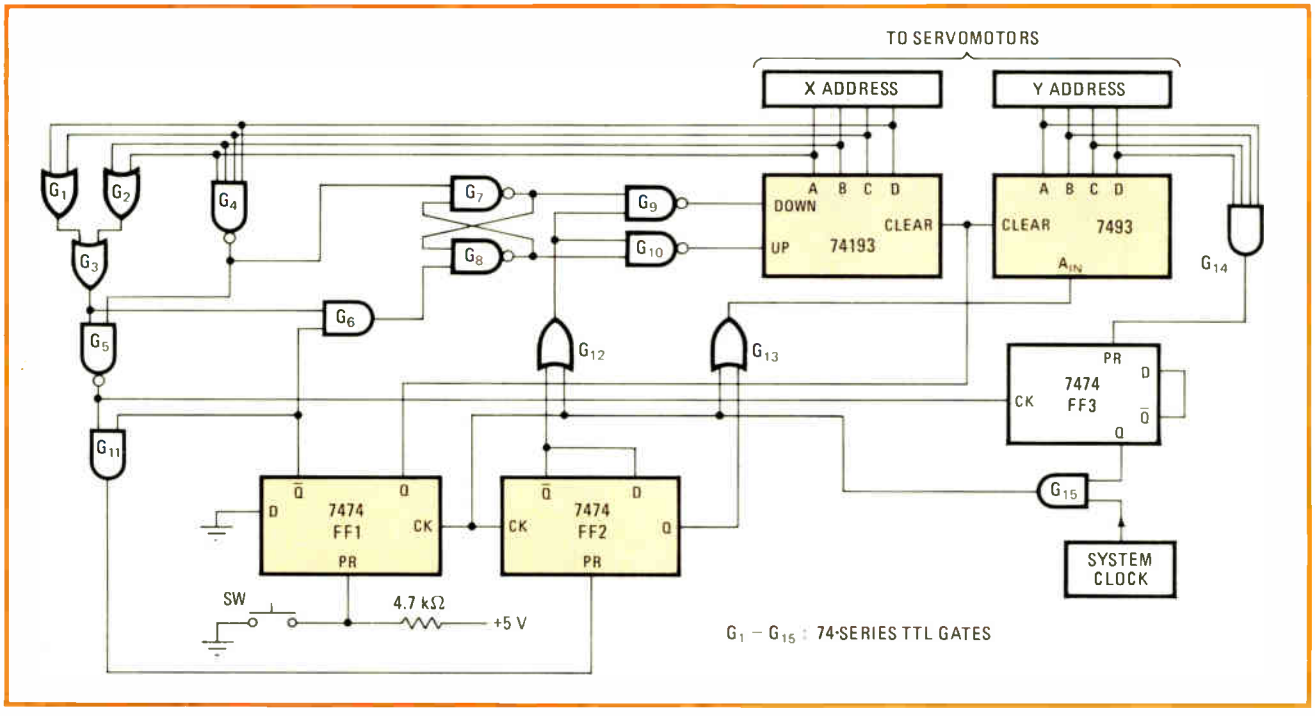
1. Zig-zag scan. Two-dimensional scan in minimum time is achieved by reversing scan direction on alternate rows, as indicated here. Initial address (0,0) is at lower left, and scan halts at (15,15).

The technique is applicable to all two-dimensional scanning that must be performed incrementally. However, it is particularly efficient when each horizontal line contains many points, because in such cases the dead time during carriage return is proportionately large.

The circuit described here generates the required address sequences. It was designed as part of a rapid-film-scanning densitometer. The X and Y addresses can be sent via digital-to-analog converters to a servo system for incrementally moving the film holder past a photodetector. Alternatively, the vertical and horizontal count pulses may be used directly to drive stepping motors. If an appropriate clock frequency is chosen, the film may be scanned in the minimum time compatible with motor torque, sample stage inertia, and step size. A digitized replica of the image on the film may then be obtained by logging the densitometer output at each selected address.

The circuit shown in Fig. 2 performs an alternating-direction scan with TTL integrated circuits exclusively and is thus capable of high-speed performance. The clock frequency would normally be selected so that it is optimum for incremental motion in the X direction. In the example presented here a 16-by-16-address grid is employed. Other choices would be relatively easy to implement by cascading counters and/or changing the max-min address testing.

Briefly, the circuit functions as follows. Switch SW is

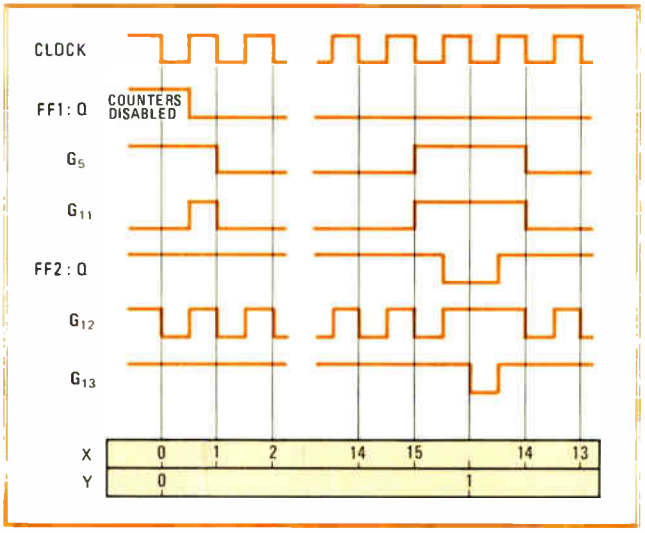


2. Scan-control logic. Logic circuit for alternating-direction incremental scanner uses 74-series TTL gates, flip-flops, and counters. Flip-flops are triggered by rising pulse edges, and counters by falling edges. Count pulses could drive stepping-motor controllers directly.

depressed. This sets all counters to zero, presets the three D-type positive-edge-triggered flip-flops (7474), and initializes the R-S flip-flop composed of gates G_7 and G_8. Note that the output of G_{14} is low; therefore clock pulses are passed freely through G_{15}. The first rising edge on the clock stream to occur after SW is released triggers flip-flop FF_1, thus enabling the X and Y counters and G_6. Gate G_{11} is now irreversibly enabled so that the end-of-line test performed by gates G_1–G_4 directly controls the PRESET function of FF_2.

As can be seen in the timing diagram (Fig. 3), the output of G_{11} rises for a half cycle because G_5 is initially high. However, the clock pulse has preceded this event by an interval equal to the propagation delay of FF_1. Therefore FF_2 does not toggle, and its Q output remains at logic 1.

Subsequent negative clock edges are passed through G_{12} and G_{10}, causing the X address to increment steadily. The timing diagram indicates the sequence of events as the end of the first line is reached. A final negative clock edge causes a count of 15 to be achieved. The output of G_4 immediately goes low, toggling G_7/G_8. As a result G_9 is enabled and G_{10} disabled, while the outputs of G_5 and G_{11} rise, enabling FF_2. A half cycle later, the rising clock-edge toggles FF_2, enabling G_{13} and disabling G_{12}. The next falling edge increments the Y address without affecting the X counter. Following this a positive edge again toggles FF_2, this time closing G_{13} but opening G_{12}. The X address now will decrement steadily until a zero count is reached, when a similar logical sequence will route a clock pulse to Y and prepare G_7/G_8 for upcounting. (Note that FF_2 can be toggled by the clock pulses only when the output of G_5 is high—that is, when either a minimum or maximum X address is obtained.)



3. Pulse sequences. Timing diagram shows output states of selected gates and flip-flops in circuit that produces back-and-forth scanning, and the X and Y addresses that control servomotors.

When the fifteenth Y increment occurs, G_{14} goes high and enables FF_3. From the timing diagram it can be seen that G_5 will already be high at this moment. FF_3 does not change state until the next rising edge is applied to its clock input, at the completion of the last horizontal scan. A final falling clock edge causes G_5 to go high, toggling FF_3 and disabling G_{15} so that no further clock pulses reach the rest of the circuit. The X and Y addresses are thus frozen at this terminal count.

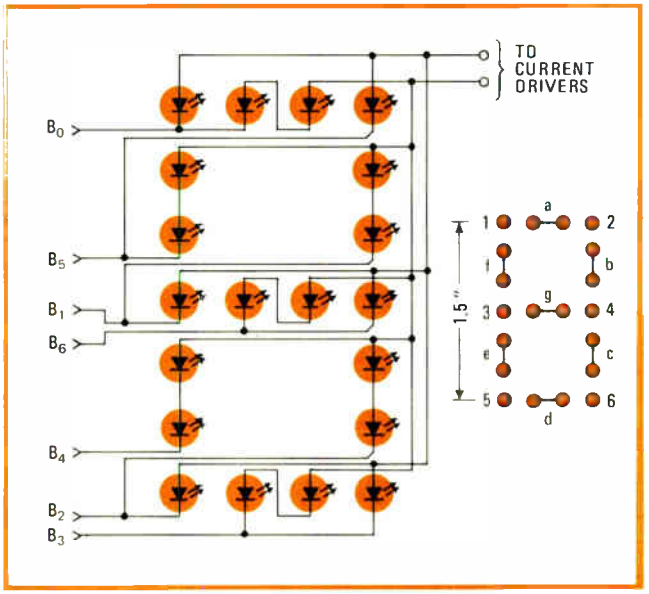
Once SW is released, the entire scan proceeds automatically and halts at the final address. Logging an entire image therefore requires no attention from the operator. □

Large hexadecimal display is legible from afar

by A. J. Bryant
Manelco Electronics Ltd., Winnipeg, Manitoba

Better visibility and a wider range of alphanumeric characters result when the seven segments standard in light-emitting-diode displays are made up of two LEDs each and multiplexed with six other LEDs. The arrangement of 20 discrete LEDs described here provides 1.5-inch numerals and letters that can be read from 30 feet away with clear distinction between such "twins" as 0 and D.

The display can be particularly useful in microprocessor applications in process and machine controllers, where hexadecimal numbers representing steps or parameters must be clearly visible from distances of 10 feet or more. Commercial displays do not meet this need. The numbers 0–9 plus the letters A–F represent



1. Really big show. Twenty light-emitting diodes arranged in a ⅞-by-1½-inch array display any symbol in the hexadecimal number system. This display can be read at distances as great as 30 feet.

the quantities 0–15 in hexadecimal notation.

Figure 1 shows the 20 LEDs in a 4-by-7 array. There are seven segments made up of two diodes in series and six individual diodes; the two-diode segments are labeled a, b, . . . g, as in any seven-segment display, and the six individual diodes are labeled 1, 2, . . . 6. The 13 different current paths that these segments and individual diodes provide are controlled by the outputs of a read-only memory and an on/off multiplexing voltage. So only two current drivers are required.

When a character is displayed, the multiplexing voltage causes the appropriate segments and then the appropriate individual diodes to light, but they go on and off so quickly that they appear to be on continuously.

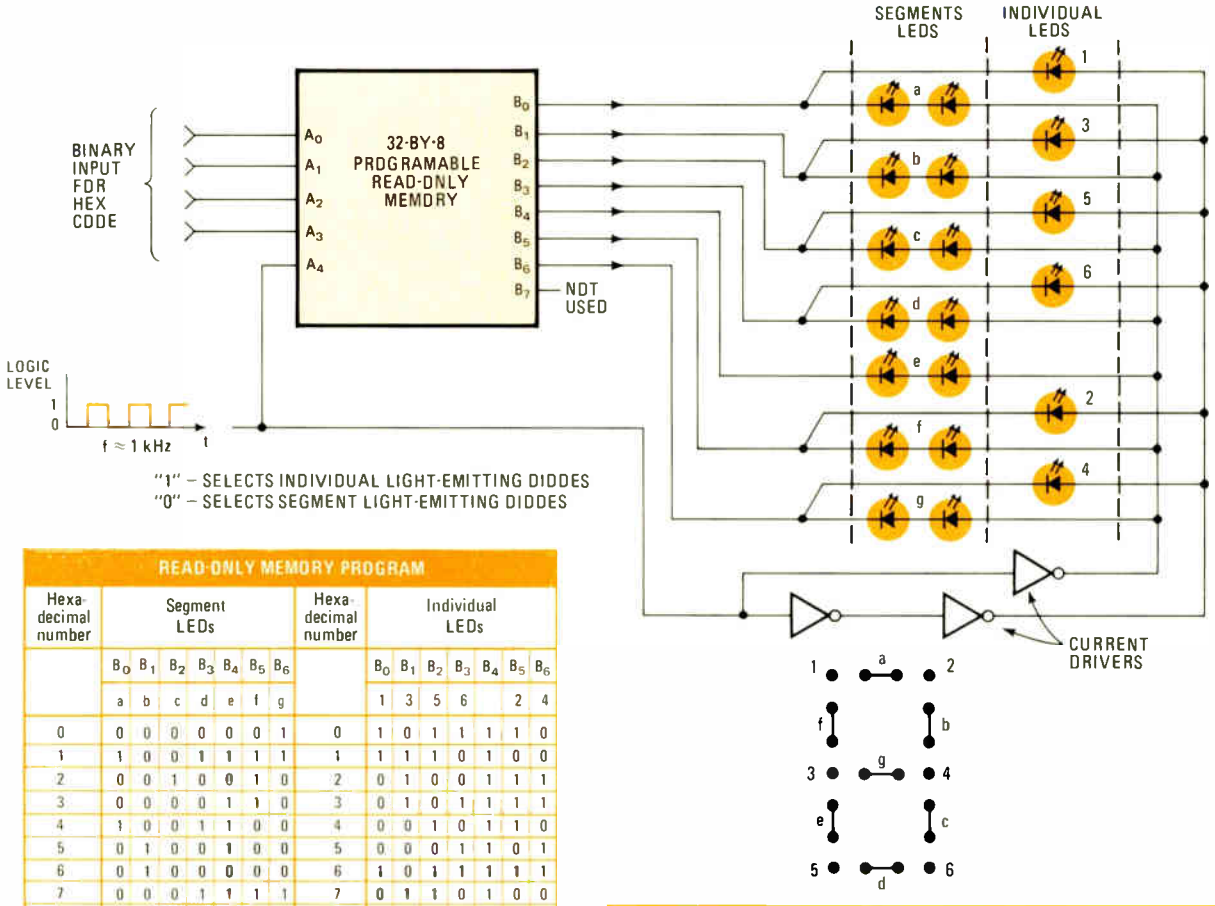
Figure 2 shows the display-circuit arrangement and the program of the ROM. If the symbol B is to be displayed, then all of the segment LEDs and individual diodes 1, 3, and 5 must light. The program shows that for the letter B, all of the segments are 0s (low voltage). When the on/off multiplexing signal is 0, the inverter puts high voltage on the segments and they all light.

When the multiplexing signal is a 1, high voltage is applied to all of the individual diodes. The cathodes of 1, 3, and 5 have been grounded by the ROM, so those diodes light up; but the cathodes of 2, 4, and 6 are held high, so they do not light.

For representation of the hex B, the binary ROM inputs to A_3, A_2, A_1, and A_0 are 1011, and A_4 is 0 for the segments and 1 for the individual diodes. Thus the memory chip is programed so that input 01011 produces outputs 0000000 on B_6 . . . B_0, and input 11011 produces 1111000. Note that output B_7 is not used.

To provide a more even distribution of light in the multiplex mode, different current drivers can be used for the segment line and for the line to the individual diodes, or the duty cycle of the on/off signal can be changed. Most available ROMs can sink the current required by the LEDs, but a buffer may be required, depending upon the specific combination. □

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.



READ-ONLY MEMORY PROGRAM

Hexadecimal number	Segment LEDs							Hexadecimal number	Individual LEDs						
	B_0	B_1	B_2	B_3	B_4	B_5	B_6		B_0	B_1	B_2	B_3	B_4	B_5	B_6
	a	b	c	d	e	f	g		1	3	5	6		2	4
0	0	0	0	0	0	0	1	0	1	0	1	1	1	1	0
1	1	0	0	1	1	1	1	1	1	1	1	0	1	0	0
2	0	0	1	0	0	1	0	2	0	1	0	0	1	1	1
3	0	0	0	0	1	1	0	3	0	1	0	1	1	1	1
4	1	0	0	1	1	0	0	4	0	0	1	0	1	1	0
5	0	1	0	0	1	0	0	5	0	0	0	1	1	0	1
6	0	1	0	0	0	0	0	6	1	0	1	1	1	1	1
7	0	0	0	1	1	1	1	7	0	1	1	0	1	0	0
8	0	0	0	0	0	0	0	8	1	1	1	1	1	1	1
9	0	0	0	0	1	0	0	9	1	1	1	1	1	1	0
A	0	0	0	1	0	0	0	A	1	0	0	0	1	1	0
B	0	0	0	0	0	0	0	B	0	0	0	1	1	1	1
C	0	1	1	0	0	1	1	C	1	0	1	1	1	0	1
D	0	0	0	0	0	0	1	D	0	0	0	1	1	1	0
E	0	1	1	0	0	1	0	E	0	0	0	0	1	0	1
F	0	1	1	1	0	1	0	F	0	0	0	1	1	0	1

2. Great program. ROM and multiplexing on/off voltage cause diodes to light up and display hexadecimal symbol corresponding to binary input. Each of the 16 hex symbols uses two input words—one with A_t high, and the other with A_t low; the two words are rapidly interchanged by the on/off (1 or 0) signal applied to A_t. This mode of operation uses the full capability of the 32-word ROM. Any compatible ROM, driver, and LED can be used; with TTL, for example, a Signetics 8223 PROM and 5-volt signals do the job.

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Engineer's newsletter

Thermal jacket aids some pc-board tests

There's an easy way to test circuit boards functionally at high or low temperatures, says Suzanne Jenniches, project engineer, Westinghouse Defense and Electronics Systems Center, Baltimore, Md. Speaking at the Westinghouse Machine Tool Forum, she suggested building a thermal jacket. You sandwich the board between the halves of a metal jacket that is filled with a nonconductive foam like polyurethane (but do make sure that the board's edge connector extends outside the jacket). Place the assembly inside the thermal chamber, and let it soak for an hour at the desired temperature. Then pull it out and plug it into the interface used for ambient testing. **The jacket will maintain the temperature with less than 1°C drift for 3 to 5 minutes**—more than ample time, she says, since most automatic functional tests are over in 20 seconds or less.

Flux estimates for magnetic shields need tripling

When designing magnetic shields, most engineers estimate the flux exposure to the shield and calculate shielding attenuation using the shield's B-H curve. But even though the calculations are correct, the shield may not produce the anticipated result, cautions Richard D. Vance, president for Ad-Vance Magnetics Inc. Tests in his firm's labs show that **attenuation resulting from the shield varies with the shield's orientation and often deviates from the calculated value by a factor of two or three.** He therefore suggests using triple the flux density in calculations to yield a more acceptable correlation.

More information on this anomaly is in the company's new catalog, more than half of which is devoted to engineering aids, calculation assists, typical solutions, and reference data. Write Ad-Vance Magnetics Inc., Rochester, Ind. 46975.

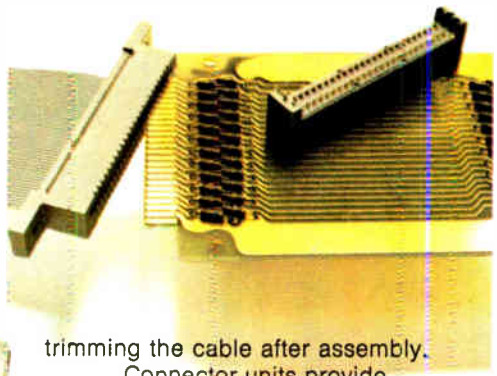
LEDs can survive in 120-V ac circuits

A light-emitting diode can be made to operate directly in a 120-volt ac circuit, says Alan R. Miller of New Mexico Institute of Mining and Technology. You must **place a 1N1461 rectifier across the LED (but with reverse polarity) to guard against destructive reverse voltage,** and you must also put a capacitor of about half a microfarad in series with the parallel diodes to limit the LED forward current to a safe 20 milliamperes without consuming appreciable power. The capacitor must be nonpolar and be rated for at least 200 volts.

How to keep that idle iron cool but not too cool

"I used the series rectifier arrangement to hold idling soldering irons cooler [*Electronics*, Dec. 11, 1975, p. 120], but I was not quite satisfied—the copper tip cooled too much with the rectified current," writes G. Lohrmann of Zurich, Switzerland. (Remember—the rectifier was connected in series with the soldering iron and a shorting switch was connected across the rectifier to bring the iron up to operating temperature when necessary.) But with a zener diode in place of the rectifier, he says, **current flows fully in one direction and partially in the other, keeping the iron warmer.** For 120-V lines, a zener with about 72 to 82 V breakdown is adequate, he adds. **—Stephen E. Scrupski**

Design with the complete flat cable/connector system.



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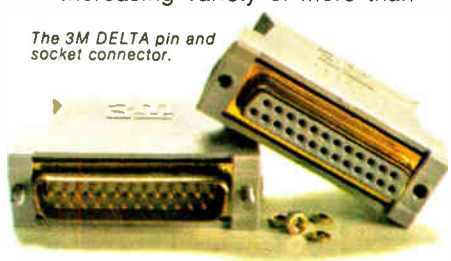

100 connectors to interface with standard DIP sockets, wrap posts on standard grid patterns, printed circuit boards, or headers for de-pluggable applications. 3M's DELTA "D" type pin and socket connectors are now also available. For full information, write Dept. EAH-1, 3M Center, St. Paul, MN 55101.

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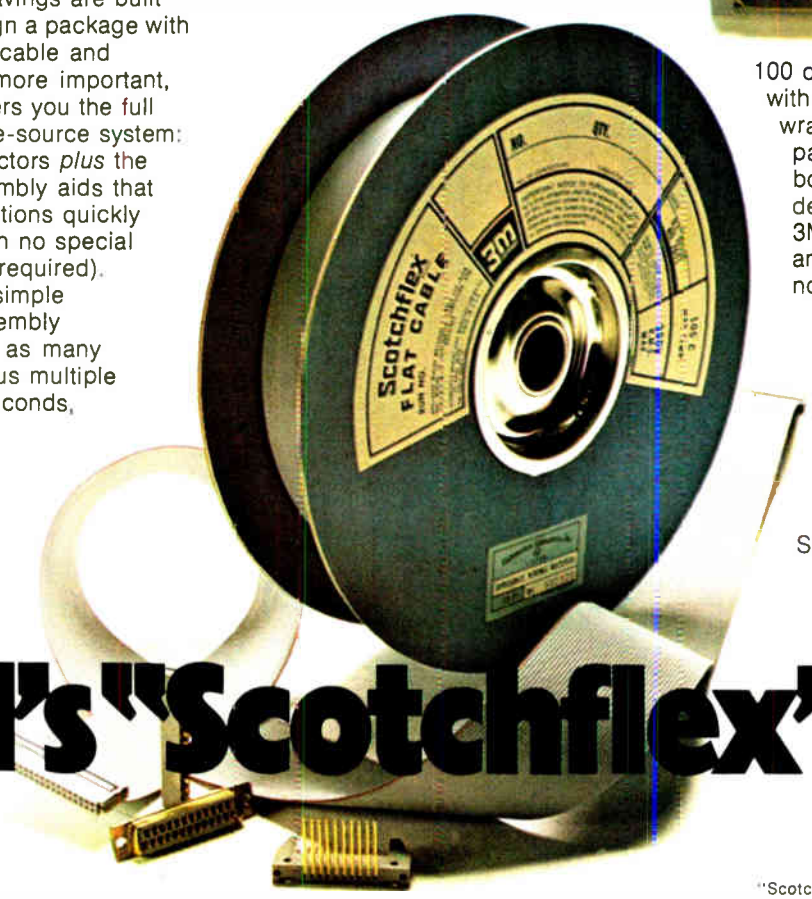

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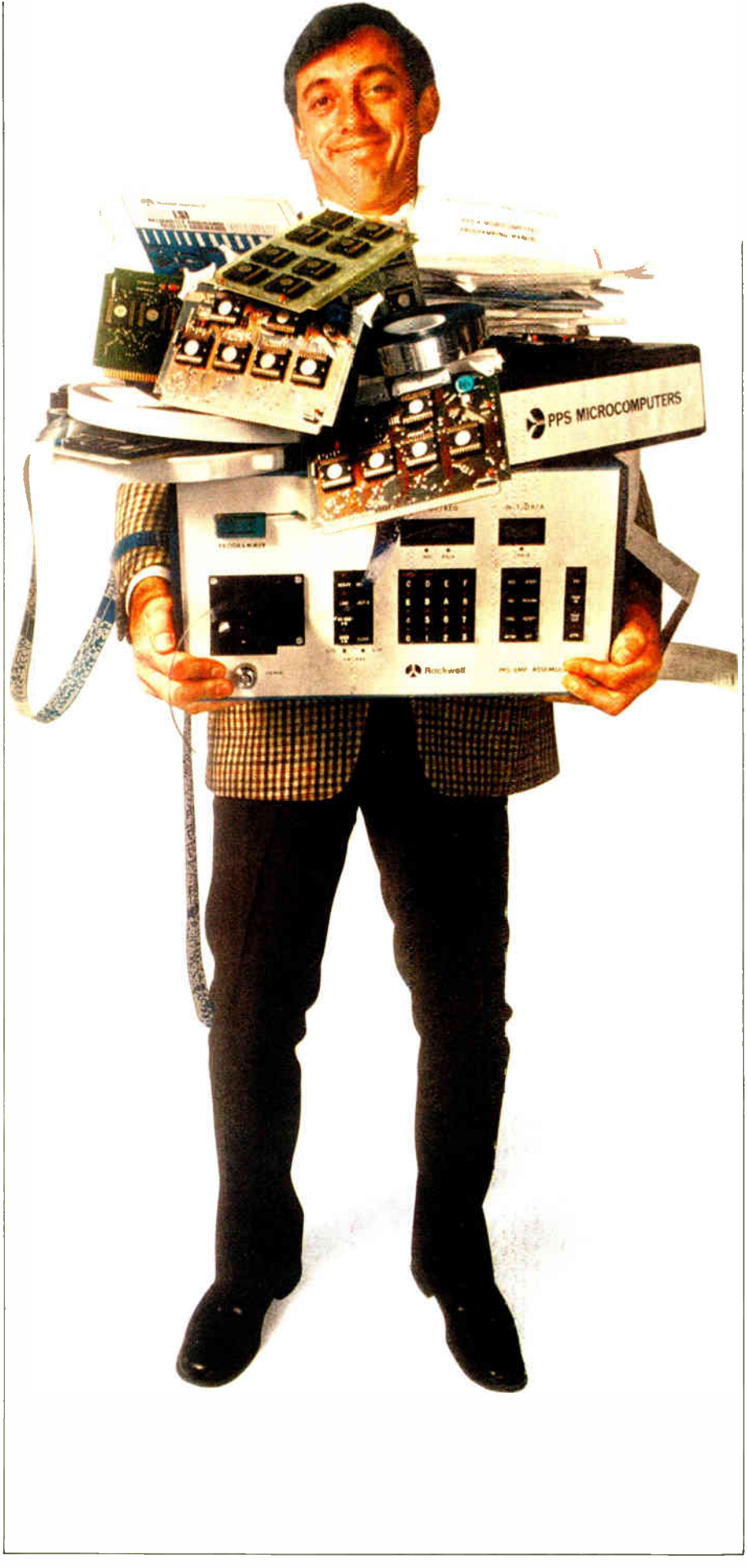

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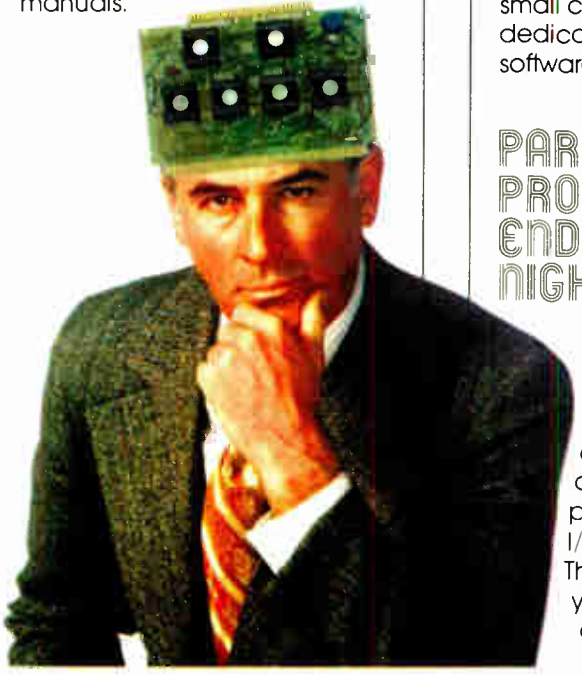

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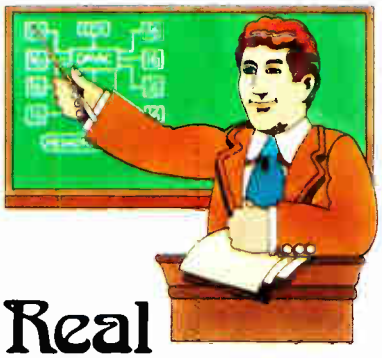

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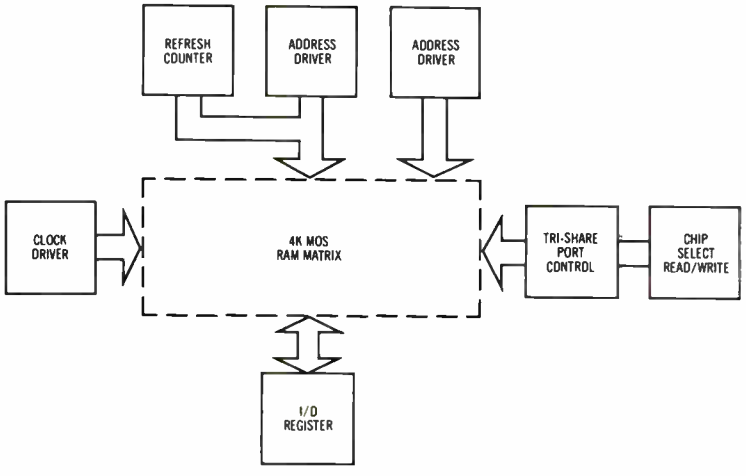

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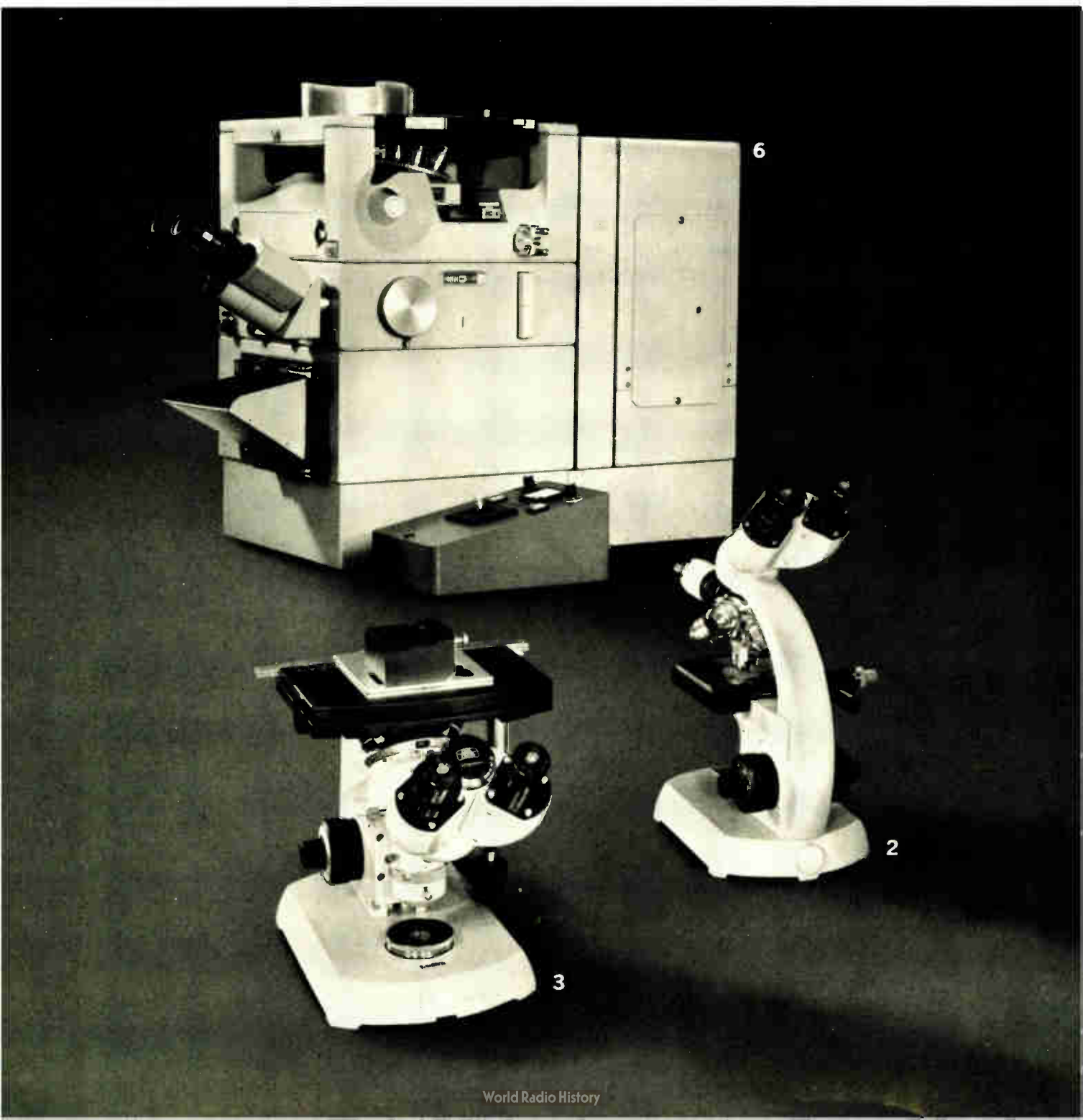
3. Invertoscope M. The smallest, most compact metallographic microscope. Ideal for fast, routine examinations. Yet has great optical features found in our larger microscopes. Excellent for brightfield and microscopy in polarized light and Nomarski interference contrast, even with Glarex projection screen. Great stability, low price. **Reader service number 158.**



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For details write Carl Zeiss Inc., 444 5th Avenue, New York, N. Y. 10018. Or phone (212) 736-6070.

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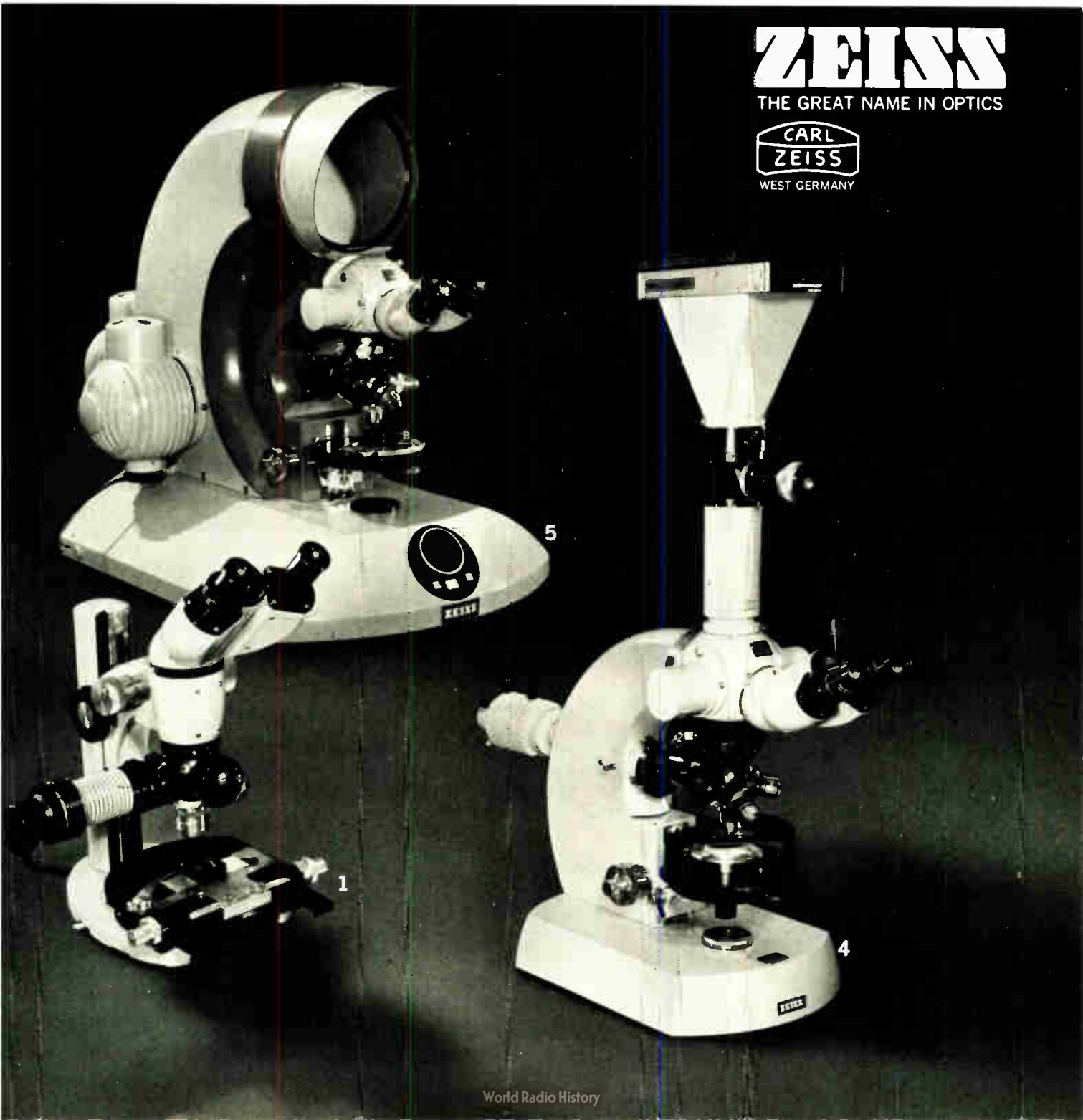
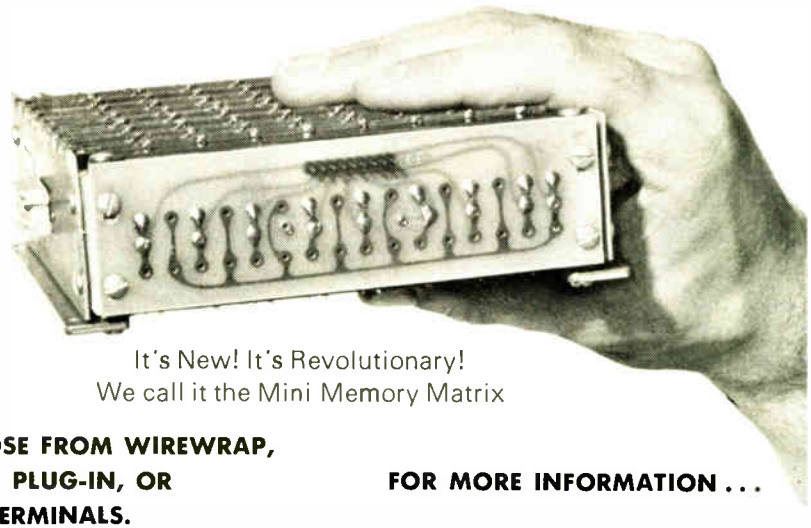


64 crosspoint Self-latching reed matrix



It's New! It's Revolutionary!
We call it the Mini Memory Matrix

CLARE'S NEW MINI MEMORY MATRIX OFFERS A PACKAGING SELECTION THAT STRETCHES THE IMAGINATION.

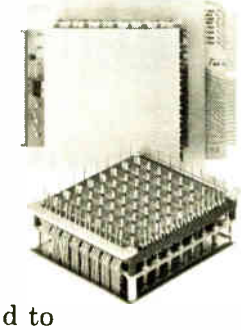
Four compact packaging formats offer engineers real flexibility in creating multi-pole switching arrays for telecommunications, process controls and automatic test equipment systems. The basic 64-cross point switching module is built around Clare's durable magnetic self-latching dry reed switch capsule. With Rhodium-plated contacts insuring several million operations.

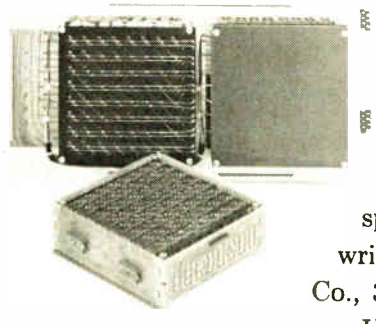
IT REMEMBERS. IT ERASES.

The multiple crosspoint coils are uniquely interconnected to provide coincident selection paths. Simultaneous current pulses on the X and Y axes address the crosspoints. A new selection automatically erases the previous selection. Dielectric spacing inhibits crosstalk while providing a stand-off rating at 600 Vdc on standard models, 800 Vdc as an option.

CHOOSE FROM WIREWRAP, CABLE PLUG-IN, OR PCB TERMINALS.

Both the wirewrap and cable plug-in units are available in 2 or 4-pole 8X8 arrays. The PCB unit comes in 2-pole 8X8 and 8X16 arrays.





The PCB unit is compatible with conventional pre-wired card cage assembly techniques. The cable plug-in units mate with standard 9-pin in-line socket and 16-pin DIP jack terminations.

FOR MORE INFORMATION . . .

The new 969 Series is certainly worth finding out about. A New Mini Memory Matrix catalog is now available. Also available are two "TAR" (Technical Application Reference) publications: TAR-Clare Mini Memory Matrix and TAR-Clare Self-Latching Dry Reed Relays. For more specific design information, write G. Neeno, C. P. Clare & Co., 3101 W. Pratt Ave., Chicago, Ill. 60645. Phone: (312) 262-7700.

QUALITY, SERVICE, RELIABILITY

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GENERAL INSTRUMENT CORPORATION

new from CLARE

Ion implantation opens another door

National's bipolar FET process used for op amps yields monolithic instrumentation amplifier with J-FET inputs

by Bernard Cole, San Francisco bureau manager

Using the ion-implanted bipolar process it has applied so successfully to operational amplifiers, National Semiconductor Corp. has gone into production on the industry's first monolithic instrumentation amplifier that incorporates junction-FET inputs.

The closest approaches until now to a one-chip op amp combining FETs and bipolar devices have been hybrid devices costing about $9 each in quantity, says David Whetstone, Bifet product marketing manager at National. What National has achieved with the LF152/252/352, he says, is a single monolithic device measuring 55 by 91 mils that will be priced at about $5.50 each in similar 100-piece quantities. Compared to existing monolithic instrumentation amplifiers, he says, the LF152 combines the high speed of all bipolar devices with the low power of all complementary-metal-oxide-semiconductor chips. "And of all the existing monolithic instrumentation amplifiers," says Whetstone, "the LF152 is among the lowest in gain nonlinearity error—typically 0.02% to 0.05%."

If standard diffusion techniques had been used to put the high-voltage p-channel junction FETs on the same chip as bipolar transistors, the device would have drifted more than bipolar amplifiers with temperature and voltage. "But because the J-FETs are made by means of ion implantation, there is uniform doping across the wafer," he says, "with the result that matching is very close, with offset voltages typically less than 3 millivolts and offset temperature drift about 5 microvolts per degree centigrade."

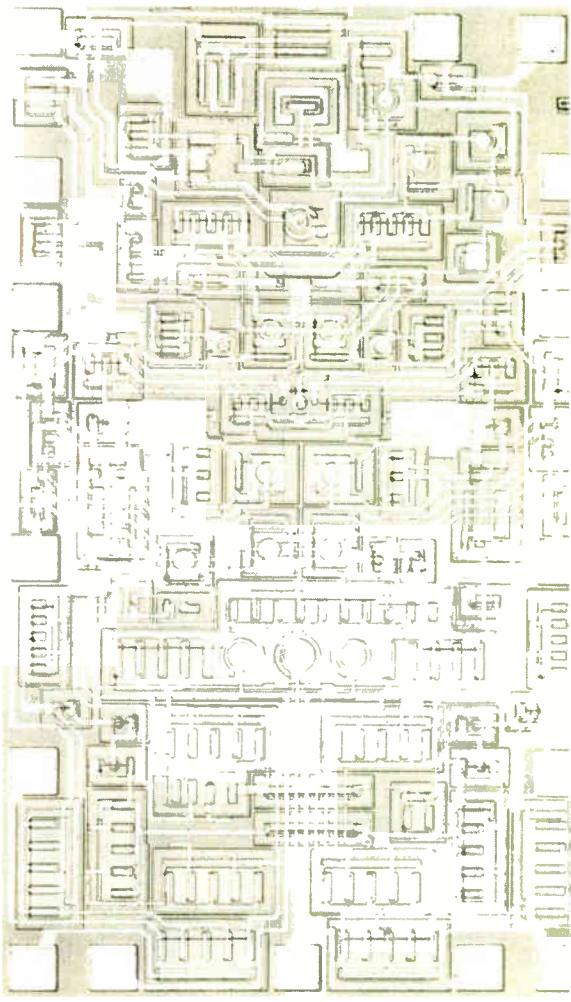
High impedance. As a result, the high-accuracy matching gives the J-FET input devices on the LF152 very high input impedances—about 2×10^{12} ohms—and extremely low bias currents—about 3 picoamperes. An internal differential feedback technique gives it a high common-mode rejection—about 100 decibels minimum when gain is set at 100—without going to the expense of color resistor matching, the company points out.

The amplifier gain can be easily adjusted from 1 to 1,000, says Whetstone, by changing the value of a single resistor. The bandwidth and slew rate are also controlled externally, and the sense input and device output are pinned out separately for added versatility and to allow a change of gain without rezeroing. The devices are aimed at microprocessor-based systems in industrial process control and instrumentation.

Bifet switches. Another Bifet family scheduled for release this month is a broad selection of quad analog switches, in which a unique circuit technique maintains a constant resistance over the analog voltage range of +10 volts. The inputs are designed to operate from minimum transistor-transistor-logic levels, says Whetstone, and switch operation also ensures a break-before-make action. Configurations of these single-pole single-throw devices include both two and four normally open and normally closed switches, with and without disable. Advantages over their chief competition—C-MOS units—are no latchup problems for the user and no worry about electrostatic charge.

Other features of the family include small-signal analog signals to 50 megahertz, −50-decibel open switch isolation at 1.0 MHz and about 1-nanoampere leakage current in the off state. Available now, the devices are priced at $2.85 each in quantities of 100.

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif., 95051 [338]



Multimeter packs logic on one chip

Data Precision's 3½-digit model 175 is priced at $189, features lower range and same 100-microvolt resolution as costlier model 245

by Lawrence Curran, Boston bureau manager

Pack a single C-MOS chip with all the logic required for a 3½-digit (2,000-count) multimeter—something that takes six integrated circuits in a 4½-digit instrument with the same resolution—and you can cut costs substantially. That's what Data Precision Corp. has done with its $189 model 175. For that price, the buyer also gets batteries, a recharger, test leads, and a carrying case [*Electronics*, May 27, p. 35].

Nor has the Wakefield, Mass., firm skimped on the unit's specifications. It handles five ranges of ac and dc voltage and current, plus six ranges of resistance measurements, with a basic accuracy within 0.1% ±1 least significant digit and a full year between calibrations. The 175 brings Data Precision a step down in price from its own 4½-digit model 245 but adds a lower range—100 millivolts full scale—that the 245 lacks, giving the 175 the same 100-microvolt resolution as the 245.

The ac and dc voltage ranges are 100 mV, 1, 10, 100, and 1,000 volts; resistance may be measured from 100 milliohms to 20 megohms in six full-scale ranges from 100 ohms to 10 megohms, and the ac and dc current ranges are from 100 microamperes to 1,000 milliamperes. The unit is 1¾ inches high, 5½ in. wide, and 3½ in. deep, and comes with an instruction manual and a one-year warranty on parts and labor.

"We're hoping to open a new market for people who don't want to spend more than $200 for an instrument," says Harold Goldberg, president. He says that among potential customers are manufacturing and field-service personnel who are not trained in sophisticated test techniques. Besides cutting the IC parts count by five from the company's model 245, Goldberg says costs have been cut also because a 0.443-in.-high light-emitting-diode display is used instead of a gas-discharge display, which eliminates the need for a dc-dc converter. Further, use of a ceramic resonator for a clock, instead of an RC feedback oscillator as in the 245, allows greater precision at no increase in cost, he points out.

The unit offers frequency response to 50 kilohertz, with accuracy to within 3% at that limit. In current measurements, both dc and ac sensitivity is 100 nanoamperes; in both cases a maximum current of 2 amperes may be read without using external shunts.

The 175 also provides common-mode voltage tolerance of 500 V dc (or peak ac) maximum when connected to an ac power line, or 1,000 V dc (or peak ac) maximum for battery operation. On the resistance ranges, the instrument will withstand 25 V dc or rms ac continuously without losing calibration.

The rechargeable nickel-cadmium batteries will operate for up to six hours without recharging. A low-battery condition is indicated by the decimal point on the display, which blinks continuously some 10 minutes before the battery level will invalidate the reading.

The model 175 will be available within 30 days from the stocks of representatives.

Data Precision Corp., Audubon Rd., Wakefield, Mass. 01880. Phone (617) 246-1600 [339]

The REMEX RFD 1000—Because It's Versatile. Double or single density with capacity up to 6.4 Mbits...IBM standard or 32 hole hard sectored media without drive modification...IBM compatible or expanded hard and soft sectored formats for application flexibility...Unit select daisy chain capability for maximum controller efficiency...Selectable DC negative voltage for system compatibility...Individual drive housing or two drives horizontally side by side in a 19 inch rack configuration.

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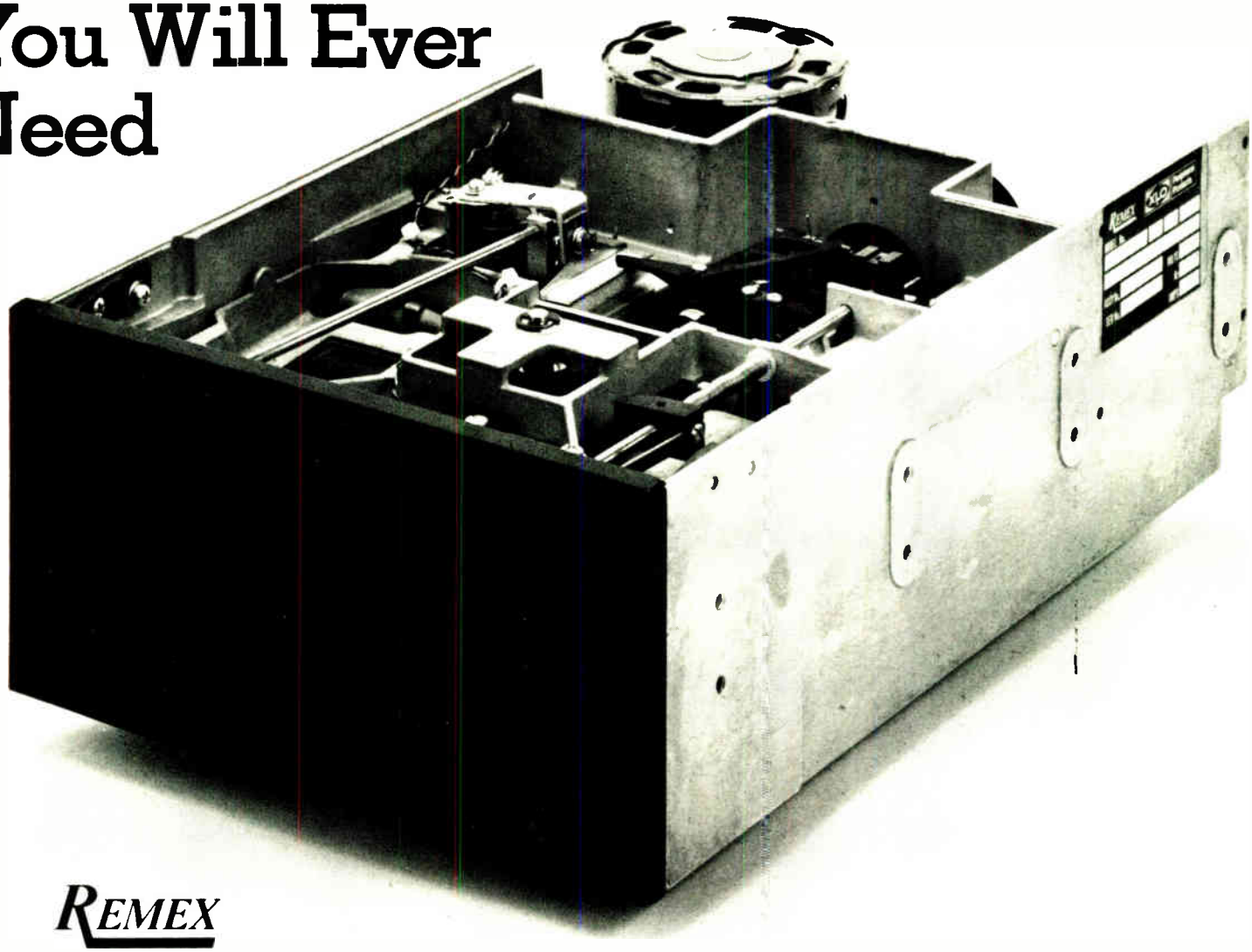

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If greater bit density, P. C. board savings and high reliability are essential in your PROM design, and you can't afford to sacrifice speed, and you need it now, at the lowest possible price, this is your part.

MMI PROMS

DEVICE	OUTPUT	ORGANIZATION	PINS	OPERATING RANGE	MAX ACCESS TIME*	100–999 PRICE
6352/53-1	OC/TS	1024 x 4	18	comm	60 ns	$15.95
5352/53-1	OC/TS	1024 x 4	18	mil	75 ns	33.50
6340/41-1	OC/TS	512 x 8	24	comm	90 ns	15.95
5340/41-1	OC/TS	512 x 8	24	mil	90 ns	33.50
6305/06-1	OC/TS	512 x 4	16	comm	60 ns	7.00
5305/06-1	OC/TS	512 x 4	16	mil	75 ns	15.95
6300/01-1	OC/TS	256 x 4	16	comm	55 ns	3.25
5300/01-1	OC/TS	256 x 4	16	mil	75 ns	7.90
6330/31-1	OC/TS	32 x 8	16	comm	50 ns	2.55
5330/31-1	OC/TS	32 x 8	16	mil	60 ns	5.00
10149 ECL	OE	256 x 4	16	comm	30 ns	17.50

*Access times guaranteed over the full temp range.

Selection.
MMI 1k x 4 PROMs are available in both commercial and military temperature ranges and with open collector or three state output options.

Compatibility.
MMI 1k x 4 PROMs are available in standard 18 pin cerdip and ceramic packages. The MMI 5352-1 series 1k x 4 PROMs are pin and function identical to the Harris HM-7642-5 series, yet the MMI parts are substantially faster.

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If only half the companies who have announced this part are able to deliver it, there will still be adequate second sources.

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MMI 1k x 4 PROMs were the industry first and have been in high volume production for over 9 months.

Speed.
At 60 nsec max over the full commercial temp and voltage variation the MMI 1k x 4 PROMs are the fastest available.

Support.
MMI applications engineers are available for consultation on your particular application. Programming is available at MMI facilities in Sunnyvale, California, Munich, Germany and Tokyo, Japan as well as at MMI distributors worldwide.

Price.
Our PROM prices are always the lowest, not only for 1k x 4 PROMs, but across the board. Check the table against what you're paying elsewhere and prove it to yourself.

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MMI started the PROM revolution with the first 1k, 2k and 4k PROMs and is now the world's largest bipolar memory supplier. The Schottky TTL process and nichrome fuse technology have been proven in a host of high volume production programs. Our reputation for high quality parts and on-time delivery is unmatched.

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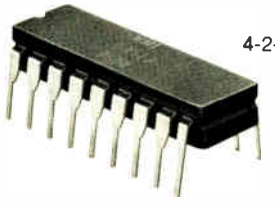


Monolithic Memories, Inc.

Packaging & production

Three gases aid passivation

Low-temperature silicon nitride technique permits higher wafer throughput

Using a three-gas approach, a low-temperature silicon nitride passivation system is ready for production by Applied Materials Inc. Its Plasma I reactor system is capable of depositing silicon nitride films on wafers at anywhere from room temperature to about 400°C. Inputs for two more gases allow etching, too. What's more, wafer throughput is higher than other machines known to be in development [*Electronics*, p. 40, Mar. 4, 1976].

In conventional, high-temperature silicon nitride passivation, temperatures higher than 750°C are used. However, high-temperature passivation of an entire wafer can destroy its electrical characteristics. So semiconductor manufacturers coat them with a final oxide layer of glass, which does not seal the wafer completely.

In applications where a hermetic seal is important, says Ted Rafalovich, marketing manager for chemical-vapor-deposition equipment at Applied Materials, it is necessary to use a ceramic package. Plasma I, he says, being a low-temperature nitride process that gives complete passivation, allows the use of considerably less expensive plastic packaging.

The basic system is packaged in an enclosure that measures 72 inches wide by 32 in. deep. The top of the enclosure functions as a counter-high work station that provides space for wafer loading and unloading. The reactor itself is a resistance-heated, parallel-plate system equipped with electrodes to generate a glow discharge.

Reactant gases, injected at the center of the reactor, are dissociated into a plasma and flow outward in a radial pattern over the substrates. Unlike some other low-temperature nitride-passivation machines using silane and nitrogen, the Applied Materials process uses a mix of silane, ammonia, and nitrogen. The company went that route, Rafalovich says, because the nitrogen-silane approach, while it permits a relatively low temperature, lacks flexibility. Plasma I, on the other hand, he says, can mix the three basic gases to obtain a number of different processing profiles, depending on the temperature constraints, wafer throughput, deposition thickness, and other user considerations. Temperature is automatically regulated by a closed-loop control system incorporating a fixed-thermocouple temperature sensor, with a stability of ±5°C.

At an operating temperature of 300°C, capacity of the system for a

New products

5,000-angstrom passivation layer is 60 2-inch-diameter wafers, or 14 4-inch wafers per half-hour run. Deposition thicknesses range from 1 to 10,000 angstroms, while deposition rates are typically 200 to 400 angstroms per minute. Thickness is guaranteed at ±10%, and the refractive index at 2.0 ±0.1.

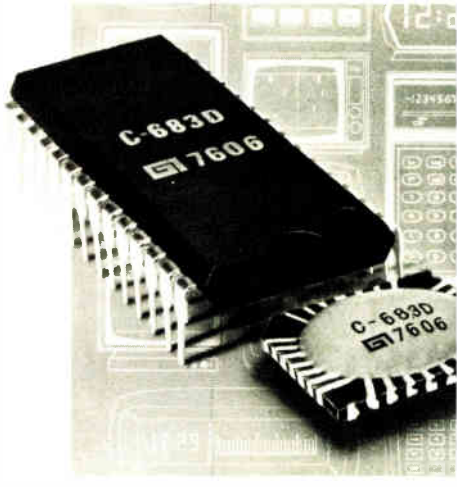
Basic system cost is $44,000 to $55,000, and delivery is 30 days.

Applied Materials Inc., 2999 San Ysidro Way, Santa Clara, Calif. 95051 [391]

Small solder-bump package competes with the DIP

Where board space is at a premium and assembly and manufacturing cost-cutting is vital, the dual in-line package may not be the best way to package integrated circuits. After about a year of development, General Instrument Corporation's Microelectronic division has developed a square chip-package called the Mini-Pak. It is about ½ inch on a side and ⅛ in. thick (about a third the size of a DIP). The Mini-Pak's connections are brought out on solder bumps 0.015 in. high on 0.050-in. centers on the bottom of the chip carrier, eliminating the rows of printed-circuit holes needed for assembly of DIPs.

In the manufacturing stage of the new package, the chip is mounted on top of a small square piece of G-10 glass epoxy and wire-bonded to plated conductors that link up to



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microscope

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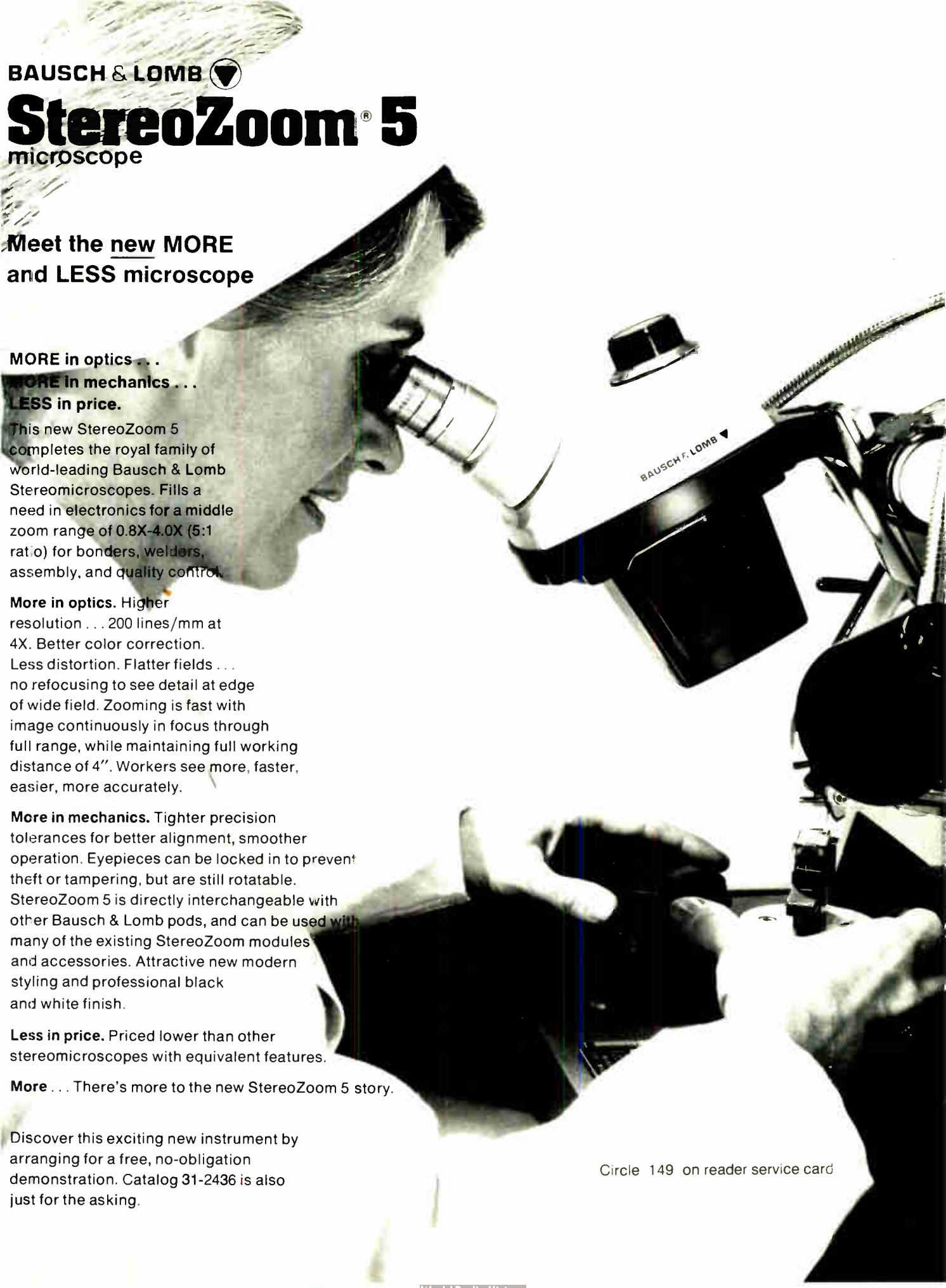


MORE in optics . . .
MORE in mechanics . . .
LESS in price.

This new StereoZoom 5 completes the royal family of world-leading Bausch & Lomb Stereomicroscopes. Fills a need in electronics for a middle zoom range of 0.8X-4.0X (5:1 ratio) for bonders, welders, assembly, and quality control.

More in optics. Higher resolution . . . 200 lines/mm at 4X. Better color correction. Less distortion. Flatter fields . . . no refocusing to see detail at edge of wide field. Zooming is fast with image continuously in focus through full range, while maintaining full working distance of 4″. Workers see more, faster, easier, more accurately.

More in mechanics. Tighter precision tolerances for better alignment, smoother operation. Eyepieces can be locked in to prevent theft or tampering, but are still rotatable. StereoZoom 5 is directly interchangeable with other Bausch & Lomb pods, and can be used with many of the existing StereoZoom modules and accessories. Attractive new modern styling and professional black and white finish.

Less in price. Priced lower than other stereomicroscopes with equivalent features.

More . . . There's more to the new StereoZoom 5 story.

Discover this exciting new instrument by arranging for a free, no-obligation demonstration. Catalog 31-2436 is also just for the asking.

Circle 149 on reader service card

Bausch & Lomb, Scientific Optical Products Division, 62306 North Goodman Street, Rochester, New York 14602

the array of solder bumps on the under side of the package. The chip is then protected by a gray plastic coating.

To attach this Mini-Pak to a circuit board, it's only necessary to heat its perimeter and allow the solder bumps to reflow onto the pc board's connections—a process that is self-aligning. GI has developed a simple soldering head (with a square adapter) that permits easy attachment and removal of Mini-Paks.

At present, 20 GI calculator chips, all with compatible pinouts allowing for a standardized calculator-board layout, are available in 28-pin packs. Chips housed in the new 28-pin package will be about 7 cents cheaper than the same units in DIPs.

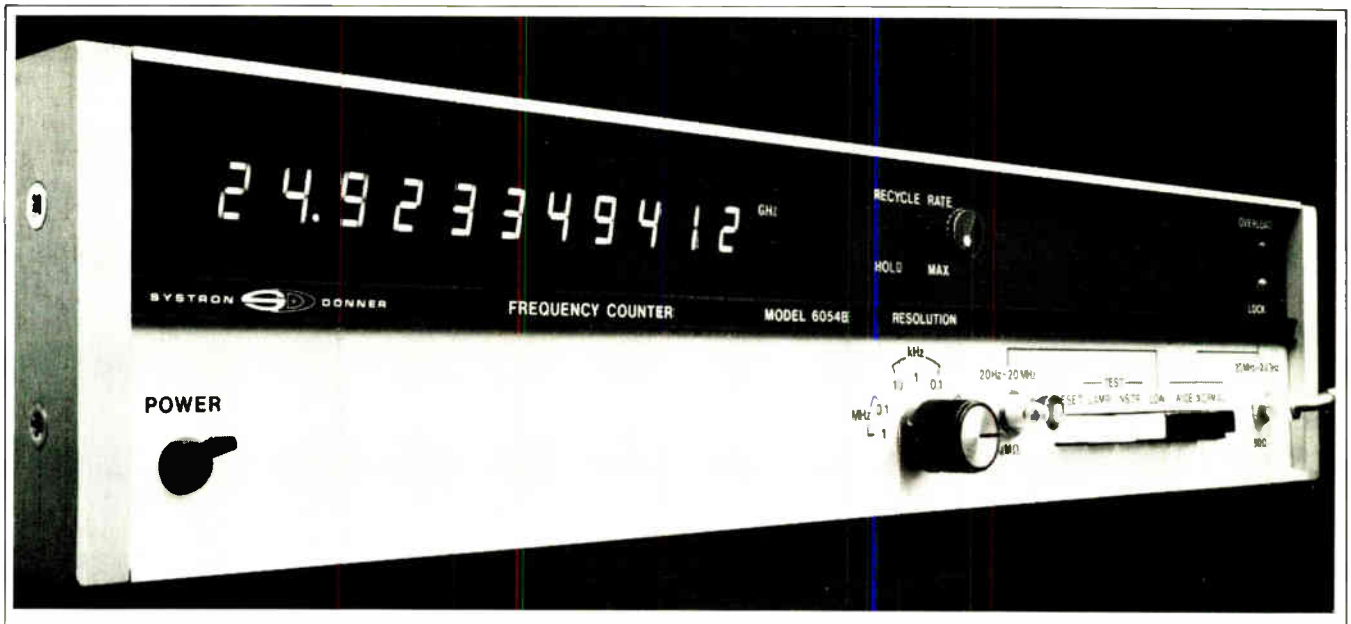
The next chip to go into the new package has been designed for a TV game. Eventually an entire line of standard chips will follow. To accommodate larger chips, a 40-pin version will be ready later this year.

The Mini-Pak is compact enough to compete in those applications where bare chips are wire-bonded directly to pc boards and hybrid substrates. Moreover, it is easier to handle and test than a chip, and it lends itself to batch assembly.

General Instrument Corp., Microelectronics, 600 West John St., Hicksville, N.Y. 11802. Phone (516) 733-3000 [392]

Magnetic-card programs digital-IC tester

Instead of changing a hard-wired performance board or rewiring the jumpers on a patch panel every time he wants to test a different type of circuit, the user of a model 5045A digital IC tester merely slips a single magnetic card into the tester's front-panel slot. The unit is then ready to test the device fully. For any given IC two cards are available: one for go/no-go testing, the other for diagnostic. The 5045A can handle a wide variety of logic types, such as RTL, DTL, HTL, TTL (including low-power and other sub families), ECL, and C-MOS. Universal pin electron-



24 GHz

−30 dBm sensitivity, FM tolerance standard

Just those three features alone put Systron-Donner's new Model 6054B Microwave Counter in a class by itself! But there's lots more:

Complete Coverage: From 0.02 to 24 GHz in one band with one connector input. **Eleven** digits give you fully displayed readings.

Sensitivity: −30 dBm to 10 GHz; −25 dBm to 18 GHz; −20 dBm to 24 GHz.

Dynamic range: No dead zone! Operative over the complete range up to +30 dBm (1 watt).

Protection: Unlike other counters offered to date, the Model 6054B provides early warning of pending overload conditions via flashing LED's.

FM tolerance: Full channel loading and heavily modulated signals with rates up to 10 MHz are measured easily with S-D's FLACTO™ technique.

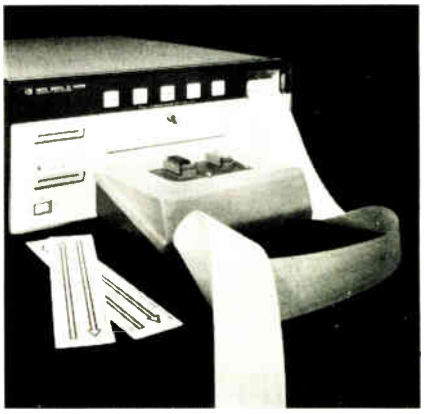
Speed: Fast acquisition and 1 Hz resolution in one second are provided over the entire frequency range.

Discriminator output: Gives the operator a visual picture of any modulation characteristics on the carrier.

Other Models: If you don't need 24 GHz coverage, S-D also offers 18 GHz and 3 GHz automatic counters.

To find out more about the new performance leaders in microwave counters, call Scientific Devices or contact S-D at 10 Systron Drive, Concord, CA 94518. Phone (415) 676-5000. Overseas, contact Systron-Donner in Munich; Leamington Spa, U.K.; Paris (Le Port Marly); Melbourne.

SYSTRON DONNER



ics let each pin act as a driver, receiver, clock, power supply, input, or output. Power-supply voltages to 15 V or both positive and negative voltages to 7.5 V are available.

A built-in thermal printer provides a permanent record of failure information. Included in the printout is the total number of devices that have passed or failed since the card was entered.

An important feature of the instrument is its ability to produce a program card for a read-only memory regardless of the ROM's program. All that is needed is a single card for the generic ROM type and a known good ROM. The 5045A sells for $9,000; magnetic cards sell for $30 each in small quantities, $25 each for 10 and up.

Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [393]

Unit tests solderability of plated-through holes

An instrument for testing the solderability of plated-through holes has the advantage of doing its testing in a nondestructive manner. The unit operates by measuring the time it takes for capillary action to draw a bead of molten solder up through the hole. After testing, if the board proves satisfactory, it may be put back into production by simply blowing the molten solder from the hole. This nondestructive feature is expected to save the price of the instrument—$4,800—in a very short

Lost any data lately?

Loss of power doesn't bother data stored in Nitron's MNOS non-volatile memories. The data is safe even if the power stays off for several years. Without backup batteries.

Nitron's NVMs can be erased and reprogrammed in or out of your circuit. Electrically. And because they're fully decoded and bus compatible, using them is just like using more conventional memories. No programming hardware or UV light sources to mess with. They're single word alterable and interface with either TTL or CMOS. What more can you ask for?

Nitron's new generation of NVMs: First the 64x4 NCM7040, and now the 256x4 NCM7050. Available off the shelf. So don't lose any more data. Or time.

Write or call

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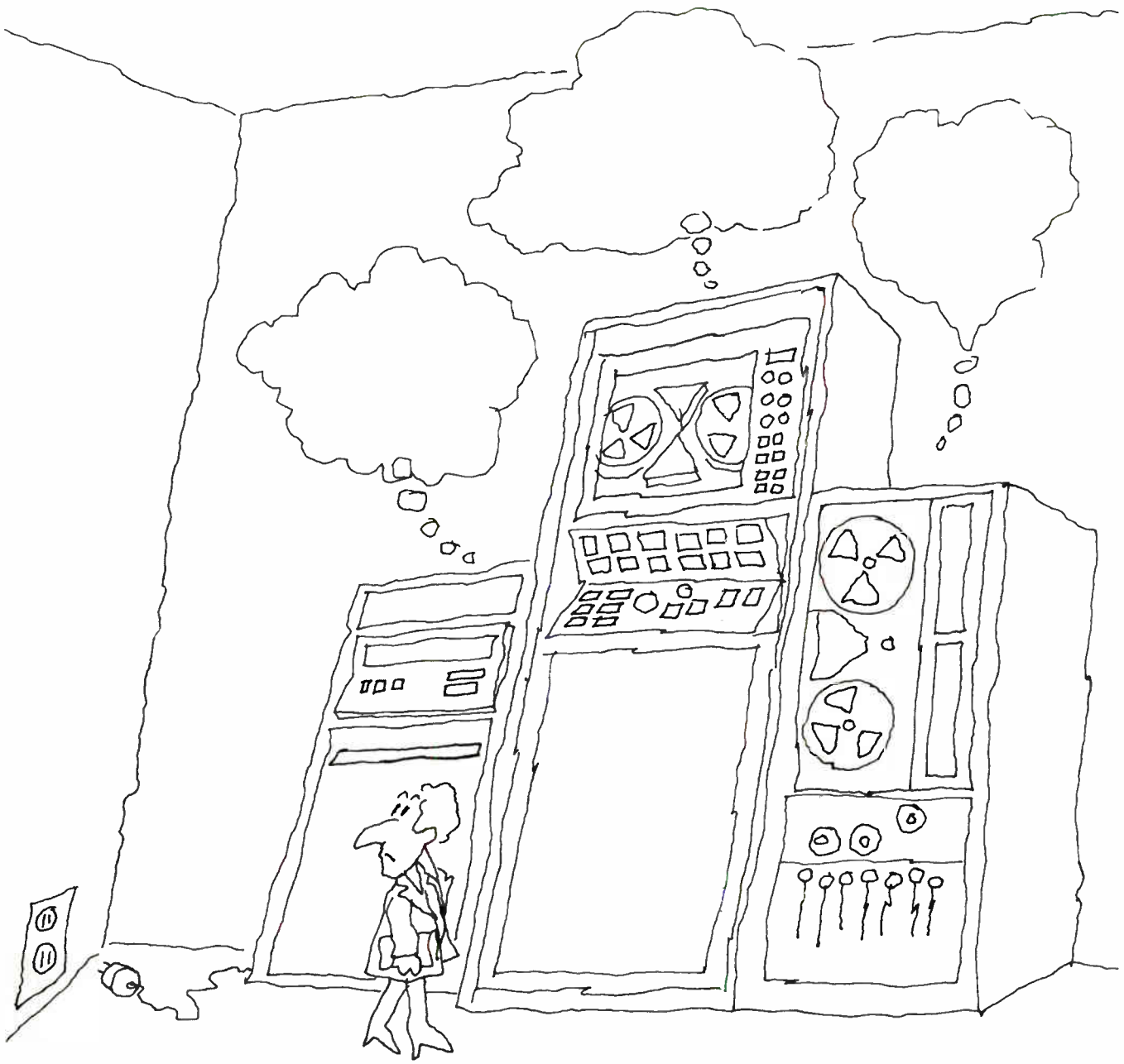


New products

time. The tester, which can handle multilayer boards up to 24 inches by 24 in., has a delivery time of two weeks.

Multicore Solders, Westbury, N. Y. 11590 [394]

Garry offers stitch-weld versions of its IC panels

Garry Manufacturing Co., a major producer of wrapped-wire boards of many types, is offering stitch-weld versions of its entire line of IC pluggable packaging panels. The new boards will use individual socket contacts made with a 303 stainless-steel shell, gold-plated over nickel, with a gold-plated beryllium-copper contact spring member. The socket contacts are designed to accept standard ICs with 14, 16, 18, and 22 pins. Larger patterns for LSI devices and universal patterns are also available, as are boards with ground- and voltage-committed terminations. The new panels sell for from $1 to $2 per IC position in small quantities. Delivery time is four to six weeks.

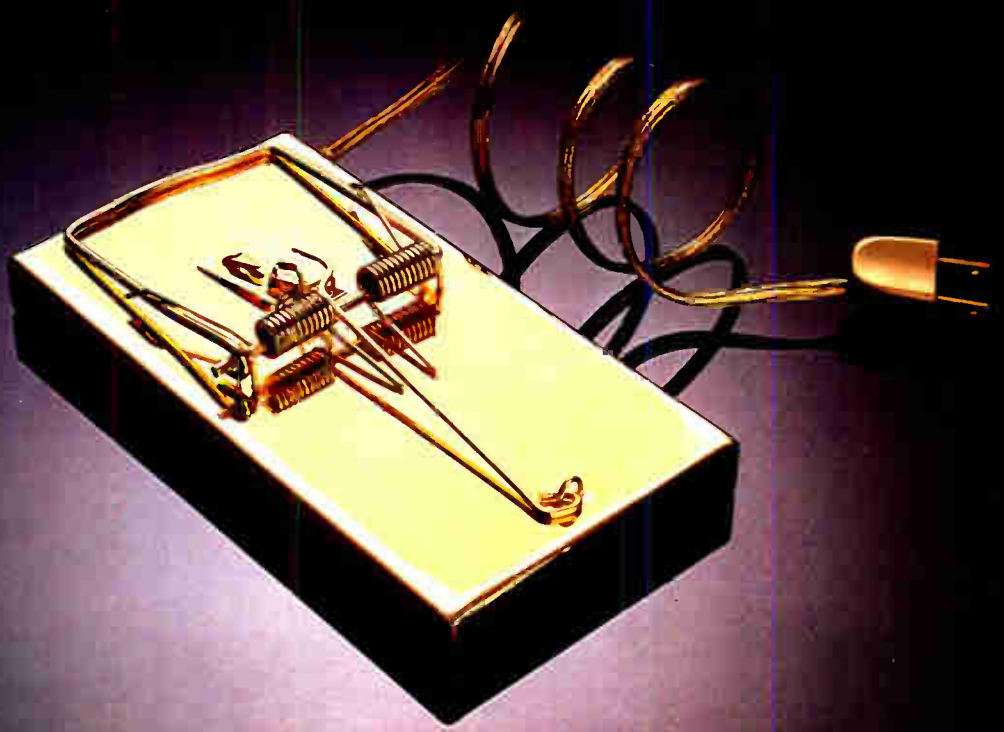
Garry Manufacturing Co., 1010 Jersey Ave., New Brunswick, N. J. 08902. Phone Harry A. Koppel at (201) 545-2424 [396]

TOPICS

Production

B&G Enterprises, Santa Clara, Calif., has introduced a can opener for semiconductor metal-can packages from size TO-3 to TO-46. The device, which is claimed to open the cans with a clean, burr-free cut, sells for $250. . . . **Rogers Corp., Chandler, Ariz.,** is marketing a flexible-circuit prototyping kit. Priced at $25, the kit includes three 8-by-10-inch sheets of copper circuit elements on 1-mil polyimide film. Instructions and a designer's guide are also included. . . . **The Du Pont Co., Wilmington, Del.,** has announced increases in the price of its Mylar polyester film. The increases typically range from 7% to 11%.

We did it.



We built a better

The AMI 6800.

The verdict is in from engineers, scientists, universities and magazine editors. The 6800 has become the most sought-after microprocessor family in the world.

With our new price breaks, it now makes sense to use the AMI 6800 for all applications—from simple, low-cost controllers to high-end microcomputers.

And with our system, you only need one 5-volt power supply. That brings the cost down even more. So for about the same price you'd pay for a 2-chip system, you can get the fast, flexible AMI 6800. The 8080 needs three power supplies. Not to mention at least four TTL devices. That puts it right out of the low-end ballpark.

Even when you move up to a more sophisticated microcomputer, you'll find the same kind of cost advantage in our favor. With the bus-oriented AMI 6800, you can hook up a total of ten memories and peripherals without adding any TTL.

This point underlines the basic reason for the AMI 6800's superiority. It was designed after a thorough study of the early microprocessors, and was patterned after the most successful minicomputers. Whereas the 8080 was designed to be compatible with the 8008. So it's stuck with many of the 8008's weaknesses.

You can learn a lot from other people's mistakes.

A comparison of the 6800 and the 8080 is a classic example of this truism. In virtually every important feature, the 6800 comes out ahead. Often way ahead.

We've already mentioned power supplies (our single +5V versus their three ±5V, +12V) and interface (no buffering needed for up to 10 devices our way versus 4 to 6 packages for the 8080). But now take a good look at some other key hardware differences.

We have a simple 5-volt non-overlapping clock which is easily generated from a dual one shot such as a 9602. Theirs is a 0 to 8.5 volt or 0-11 volt non-overlapping asymmetrical waveform with specified delays between phases.

Ours has two levels of external interrupt, one of which is non-maskable. Theirs has only one maskable interrupt.

We save program space with two accumulators instead of one. But even more important in terms of space and cost saving is our interrupt stacking. This automatically stores all registers when the program is interrupted. With the 8080, you need an external subroutine of 4 or 5 instructions every time you hit this condition.

Now look at addressing. They don't have an indexed mode. We do. That can be really important, especially in peripheral applications. We give you a very powerful tool in relative addressing, allowing self-relative code. The 8080 doesn't. And we also have direct addressing, which lets the 6800 use two bytes of code to three for the 8080—a saving of 33 percent.

Our instruction set tells you a lot.

Ours is very flexible and much easier to learn, tailored more like a minicomputer. Take the 6800's branching ability. Besides positive, negative and zero, ours can branch on equality and all inequality conditions. The 8080 can't test directly for inequalities. So it has to go through two or three additional steps to test for these conditions.

The 6800 can also isolate and test bits in a word much more easily than the 8080.

All this adds up to a 15 to 30 percent more efficient use of memory space. So the 6800 requires less hardware, less interface, less software. And being so much easier to use, the AMI 6800 microprocessor helps you beat the competition to market with a more reliable product.

The family plan makes growing easy.

The AMI 6800 is now a thriving family of nine, with more on the way.

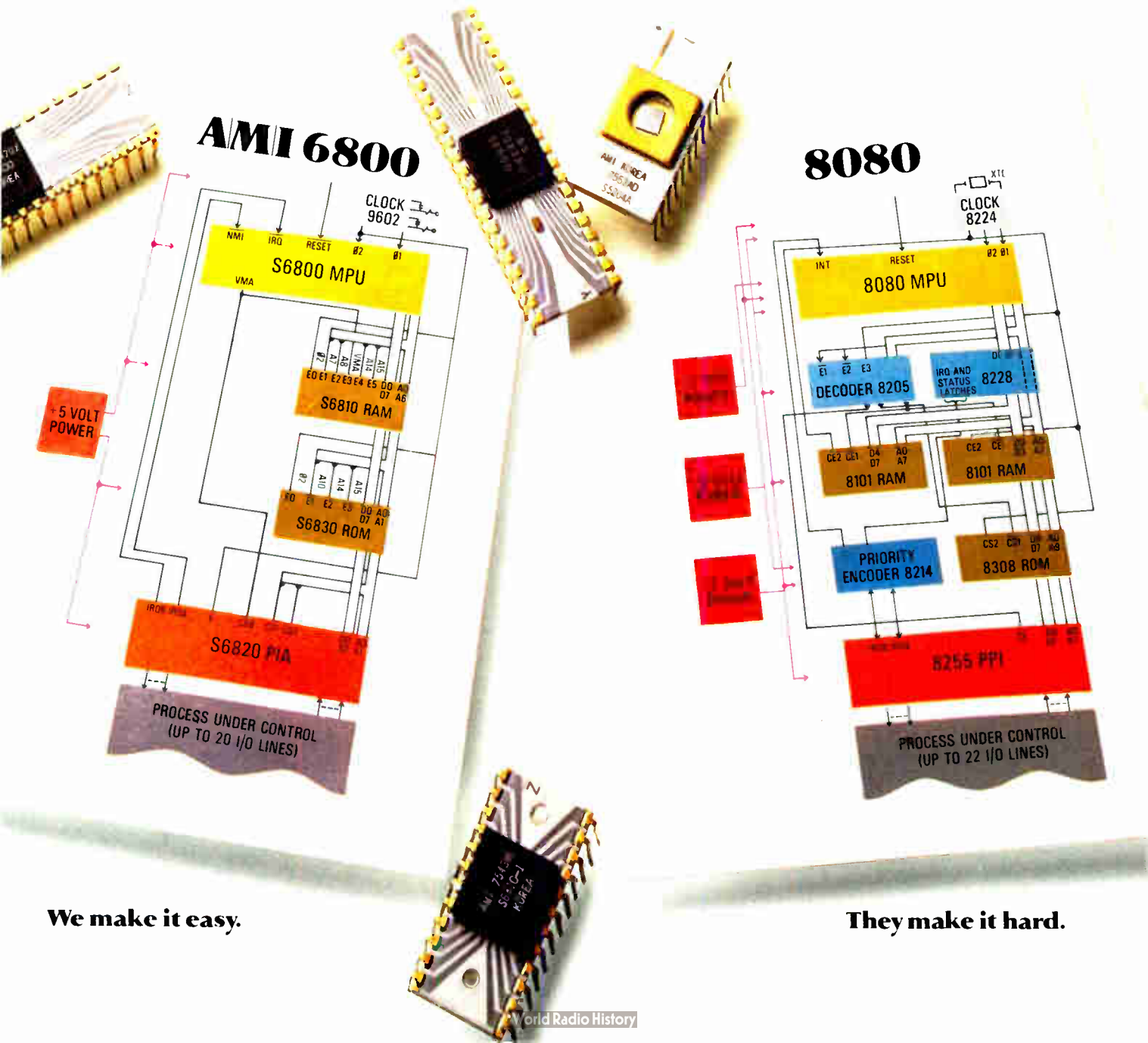
Besides the S6800 MPU, there are the S6810 128 x 8 static RAM; the S6820 Peripheral Interface Adapter; the S6830 8K static ROM; the S6831 16K static ROM; the S6834 512 x 8 EPROM; the S6850 Asynchronous Communications Interface Adapter; the S6860 MODEM; and the S2350 Universal Synchronous Receiver/Transmitter.

For low power or battery backed-up products, our new S5101 256 x 4 CMOS RAM fits right in.

Our S6800 is not only versatile. It can be very tough. It now comes in an industrial temperature range of −40°C to +85°C.

The AMI 6800 microprocessor family: you can't do better than that.

microprocessor.



We make it easy.

They make it hard.

We built a better

The AMI 6800 Development

It's so much better than the competition, they'll have to change their whole development philosophy to catch up.

The standard AMI 6800 Microcomputer Development Center consists of the 80 character x 25 line CRT, the dual floppy disk with disk operating system, an S6834 EPROM programmer, an RS232 interface, 16K words of RAM memory, a software debug package, editor and assembler.

You will also have options coming out of your ears. The most significant for most people probably are a character printer; EPROM and RAM memory modules; and soon an in-circuit emulator so you can use the CRT like a front panel.

Like everything else about the AMI 6800, our development system is a programmer's dream. We avoided the multiple box approach, with lights and switches, in favor of a very smart CRT with full debug software.

This bypasses all those hassles with paper tape, front panels, teletype or cassettes. In many cases, it cuts programming time from hours to minutes.

With your hands on the keyboard, and your eyes on the screen, you can modify programs instantaneously. You can interrupt after every instruction, and get a complete snapshot of the state of the machine. Or look at all the registers and change their values, simply by pressing a key. And you never have to translate addresses into binary to get information. In short, our smart CRT helps you make the right decision right away.

Why learn two processors when one will do?

Strange as it may seem, some development systems have different microprocessors inside than the one you're program-

support system.

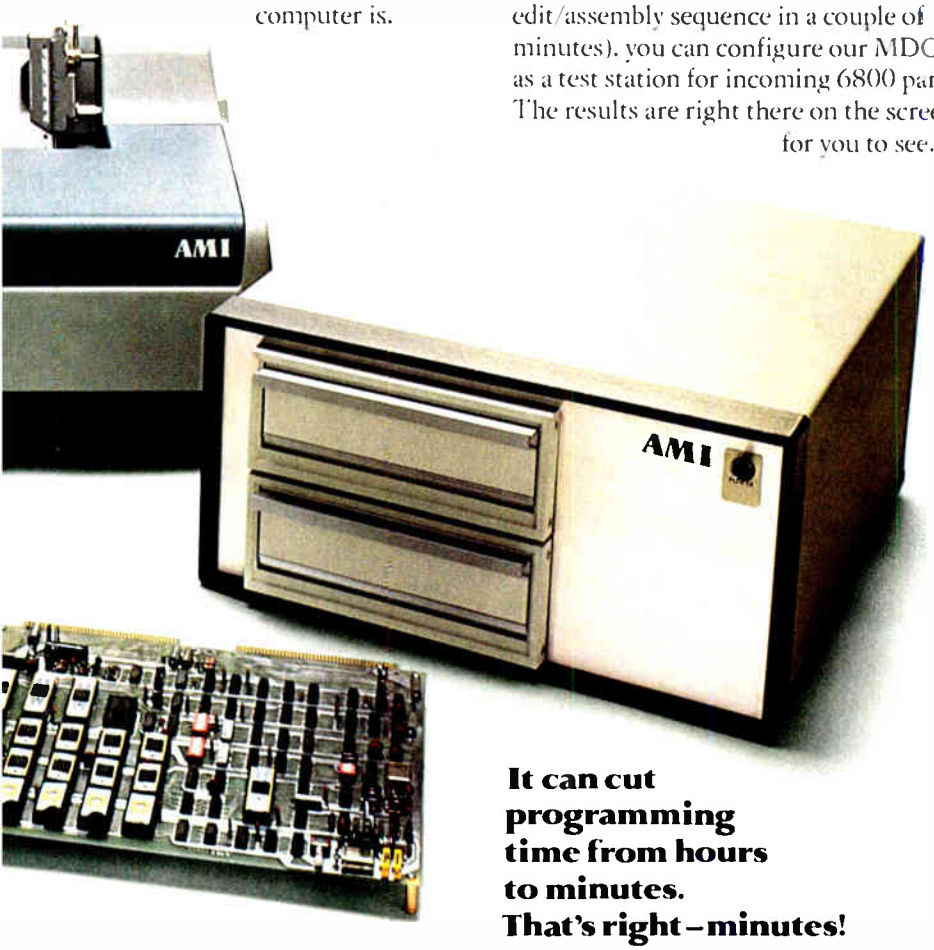
Microcomputer Center.

ming outside. So you have to learn two instruction sets instead of one.

Naturally, there's an AMI 6800 inside our terminal. And its performance there proves once again how powerful and versatile this microcomputer is.

Among many functions, it edits the screen, controls the communication's interface, and interacts with the disk and keyboard.

Besides high-speed program development (you can complete a typical edit/assembly sequence in a couple of minutes), you can configure our MDC as a test station for incoming 6800 parts. The results are right there on the screen for you to see.



It can cut programming time from hours to minutes. That's right—minutes!

There's no such thing as obsolescence.

With up to one megabyte of storage on-line in the dual floppy disk and a CRT controlled by our versatile 6800, you don't have to worry about this system ever gathering dust.

It converts very easily to a powerful, stand-alone microcomputer for a variety of uses, such as inventory control. Try that with any other development system, and you wind up with a pain in the peripheral. (Ask the competition for even a dumb CRT and they'll send you away to an independent supplier.)

We have another handy development tool, too, called the AMI 6800 Prototyping Board. This helps you debug programs, build 6800 hardware, evaluate parts, and even program our S6834 EPROM in about 40 seconds.

The Board has two 86-pin edge connectors, one for microprocessor bus extension and the other for input/output. Also on-board are 2K bytes ROM; 2K bytes EPROM; EPROM programming; 1K bytes RAM; totally buffered MPU; restart address selection; TTY operating system software; ROM subroutine program library; serial and parallel I/O ports.

In short, there's no better microcomputer than the AMI 6800. And there's no better way of developing it than with the AMI 6800 Microcomputer Development Center.

Don't take our Take theirs.

The facts about the AMI 6800 family speak pretty clearly for themselves. But the actions of some pretty big companies say even more.

Companies like Conrac, Hewlett-Packard, Memorex, Tektronix and TRW have selected the AMI 6800 for new products. And the varied uses they're

word for it.

making of our microcomputer speak volumes for its flexibility, power and organization.

The AMI 6800 turns the Conrac CRT into a highly intelligent terminal that adapts easily to perform a variety of stand-alone and peripheral computer functions. Hewlett-Packard's model 9815 programmable calculator achieves more speed and interface capability with the help of the AMI 6800.

Memorex selected the AMI 6800 for use in their new 1377 high-speed CRT.

In Tektronix' case, it allowed the 4662 Interactive Digital Plotter to include multiple interfaces, resident alphanumeric character generation and digitizing capability in a low-cost package.

TRW's new point-of-sale terminal, through the use of a 6800, offers multiple terminal personalities.

Although everyone recognizes the basic strengths of the AMI 6800, it seems everyone has a different reason for specifying it. Another tribute to its tremendous versatility.

The AMI 6800 has a great past, present and future.

We've been making MOS longer than any other company in the world. In our ten year history, we've never made a bigger commitment to any program, in terms of money and manpower, than we have to this one.

It marks a turning point for us. Although we're still the leading custom MOS manufacturer (and intend to remain so), the AMI 6800 is spear-heading our rapid advance in standard products.

Much of this effort is dedicated to keeping the AMI 6800 as the Number One microcomputer family. Soon 16K RAMs will be joining our 4K EPROM and other compatible memories. And new communications circuits will extend the 6800's capabilities in that field.

With plants in Santa Clara, California, Pocatello, Idaho and Korea, we're geared to handle any size orders. Very small to very big.

That's another important reason the big companies are coming to us. So why don't you get in touch with your nearest AMI sales office, distributor or representative listed on the next page. Or contact us at AMI, 3800 Homestead Road, Santa Clara, California 95051. Phone: (408) 246-0330. You couldn't make a better decision. Take their word for it.

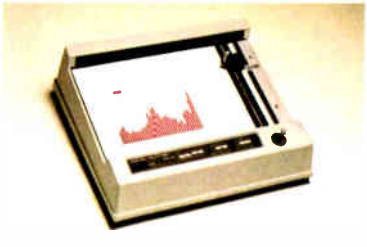
AMI®
AMERICAN MICROSYSTEMS, INC.

The Conrac 480-25 CRT Terminal

The TRW 2001 Point-of-Sale Terminal

The HP 9815 Programmable Calculator

The Memorex 1377 High-Speed CRT



The Tektronix 4662 Interactive Digital Plotter

How do you get the AMI 6800?

It's a snap.

Now it's as easy to get hold of the AMI 6800 as it is to use it.

We've built up our sales and distribution network to give you the products you need as soon as you need them. So snap up some AMI 6800s for your new products. And watch people beat a path to your door.

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AMERICAN MICROSYSTEMS, INC.

Communications

Optical links made simpler

Single-fiber cable has tough plastic sheath, takes inexpensive connectors

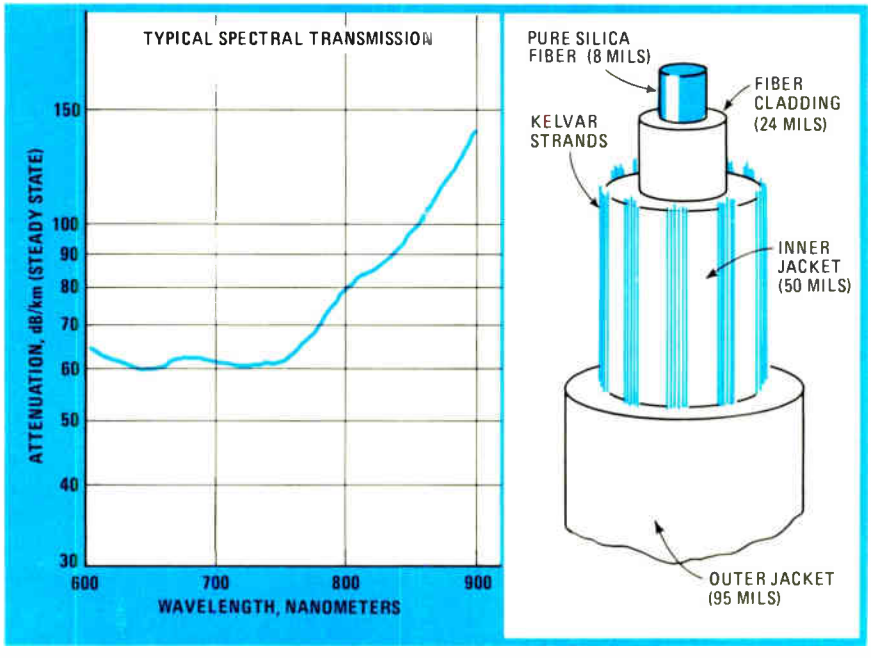
Because relatively inexpensive connectors latch with relative ease onto its tough plastic sheath, a new fiber-optic cable from Du Pont should make it simpler and economically feasible to set up optical communications links. Joining other improved cables that have recently been announced by Fiber Communications Inc., Galileo, ITT Electro-Optics and Valtec, Du Pont's new entry is a pure-silica single-fiber cable.

Labeled PFX-S108R02, it has an attenuation of less than 80 decibels per kilometer at wavelengths from 550 to 800 nanometers. That attenuation level gives a cable-run capability of 300 meters, a sizeable increase over Du Pont's earlier PFX-0715 seven-fiber cable. What's more, the cable's large, 8-mil-diameter core and numerical aperture of 0.4 allow efficient coupling without concern about fiber misalignment.

The cladding material is made with a special proprietary polymer to which a connector can fairly easily be directly attached without throwing the fiber off center. Misalignment losses are thus minimized even without the use of elaborate tooling. Moreover, the Lucite-like cladding is tough and thick so that crimping problems are lessened. A soft jacket of Hytrel is easily stripped off, leaving high-strength Kevlar strands to grab in the connector, which provides good strain relief. Furthermore, Du Pont engineers feel that even inexpensive injection-molded plastic connectors will provide good performance—a plus in fiber-optic links requiring many connectors.

Another feature of the cable is its extremely small bend radius—put at 0.125 in. on the data sheet—which helps when installation must be made in very tight quarters. (Indeed, Du Pont engineers say fibers didn't break even with the cable knotted tightly and pulled from either end.)

The pure silica core used in the new cable has much higher radiation resistance than glass or doped silica. This resistance, according to



New products

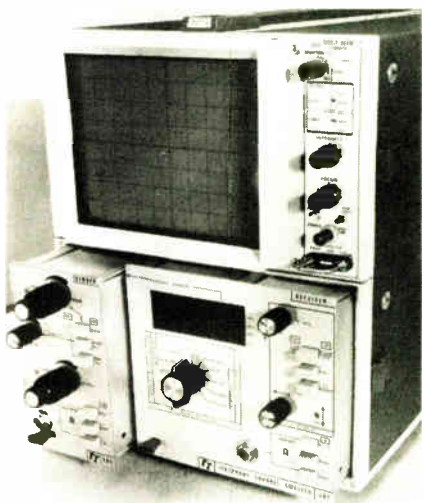
Du Pont engineers, is important in military and nuclear environments.

The cable is available for immediate delivery in 50–300-meter lengths at a cost of $5 per meter. Du Pont sees the price dropping to about $1 per meter for large-quantity orders.

E.I. Du Pont de Nemours & Co., Plastics Dept., Wilmington, Del. 19898 [401]

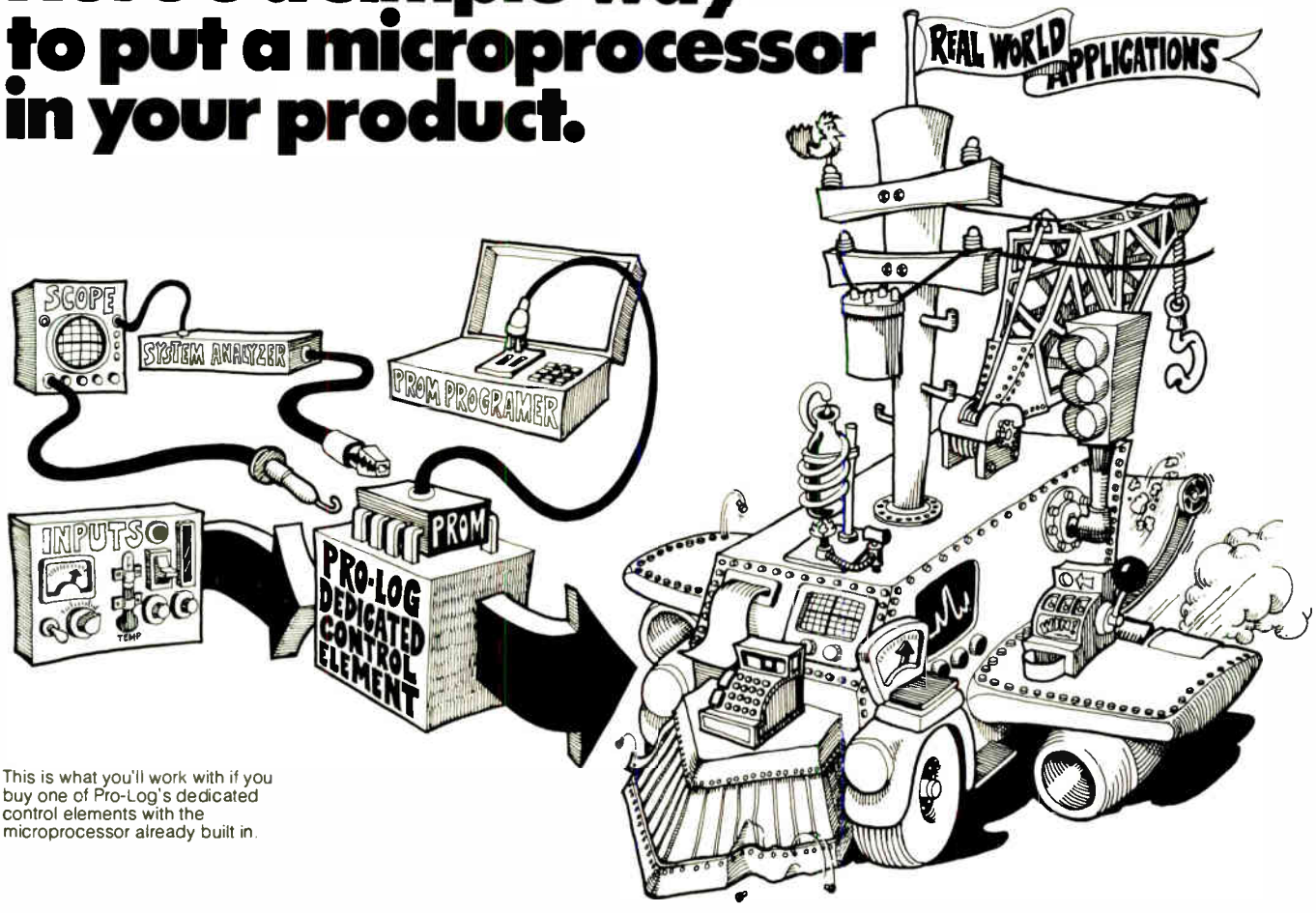
Audio analyzer makes multiple measurements

Unusually flexible and complete, an audio analyzer system for the telecommunications and broadcast fields offers a combination of measurement modes, including stereo phase and level differences. The model ROR300 saves time both in broadcast studios, in testing and



aligning radio channels, and in recording companies, in testing and equalizing consoles and tape-recording equipment. It may also serve as a standard for audio measurements on telephone program channels and for production tests for audio-equipment makers. Because there is a digital readout for each type of measurement in addition to the scope display, point-by-point as well as swept measurements are possible. The basic system (shown above) includes the scope mainframe plus the model 301 generator plug-in and the model 302 analyzer plug-in. Price of the basic

Here's a simple way to put a microprocessor in your product.



This is what you'll work with if you buy one of Pro-Log's dedicated control elements with the microprocessor already built in.

Buy a dedicated control element, for all practical purposes a black box, with a microprocessor already built in.

We've developed subsystems using microprocessors. They come in modular configurations readily expandable to meet your product requirements. You hardwire them directly to relay contacts, switches, push buttons, displays or other real-world devices. They give you all the capabilities of a microprocessor with none of the headaches. And we deliver them in a matter of weeks.

When you use our subsystems, we give you the kind of production and documentation assistance that results in a product your present manufacturing people can build and your present service force can support.

And system design stays with the design engineer.

Plus, we give you something more, a free set of plans and a second source.

Order 250 subsystems and we'll throw in free non-exclusive manufacturing rights and a complete set of manufacturing and assembly plans allowing you to build your own hardware, relying on us as an established and dependable second source.

We make everything you need to design with microprocessors.

Our starter sets include a microprocessor subsystem, a Series 90 PROM programer, a microprocessor system analyzer, plus all associated hardware. 4-bit sets cost around $3,000, 8-bit sets around $3,500, a substantial savings over what you'd pay if you purchased all these items separately.

We have education too.

Our half-day introductory seminar takes a hard look at the function of microprocessors in real-world applications.

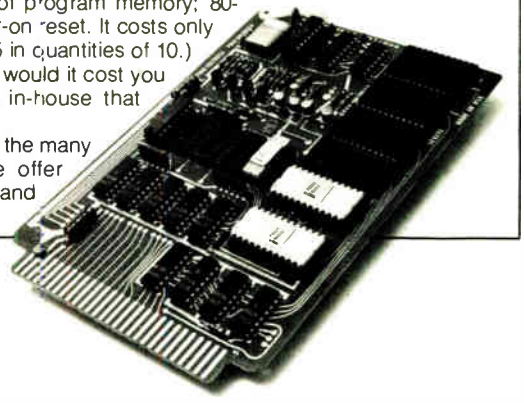
Our three-day hands-on design course teaches engineers how to formulate, program and use microprocessor modules.

Our free booklet, "The Microprocessor User's Guide" answers all your questions.

It explains what a microprocessor is, what it's capable of doing, what criteria you need to evaluate the ones on the market and how Pro-Log can help you put them to best use. Write for your copy.

To show how much Pro-Log can save you both in time and money, consider this. We've got a one-card 4004-based system called the PLS-401A. It includes a microprocessor; crystal controlled clock; 16 lines of TTL input; 16 lines of TTL output; sockets for 1024 words of program memory; 80-character RAM and built-in power-on reset. It costs only $99 in quantities above 500 ($175 in quantities of 10.) How long would it take, and what would it cost you to design and build something in-house that could do the same job?

And this is just one example of the many microprocessor subsystems we offer using 4004, 4040, 8008, 8080, and 6800 microprocessors.



PRO-LOG CORPORATION
2411 Garden Road
Monterey, CA 93940
Telephone (408) 372-4593
TWX 910-360-7082

Circle 165 on reader service card 165

New products

system is $4,720. Delivery time is less than 90 days.
W&G Instruments Inc., 119 Naylon Ave., Livingston, N.J. 07039 [403]

Digital phase shifters cover bands through uhf

Driven directly from transistor-transistor-logic circuits, a line of digitally controlled phase shifters is particularly useful for phasing antenna systems, scrambling data communications, and other signal-processing applications. The PSD series shifters which are designed for applications through the high- to ultra-high-frequency ranges, vary the phases of rf signals in binary increments up to 360°. Overall phase-shifting error is less than the least significant bit. Incremental accuracies within ±0.2° are described as typical.

A key unit of the new line, the PSD-84-53-1, covers the full 0-to-360° phase-shift range. It is an 8-bit device and uses p-i-n diodes to switch precise lengths of cable in and out. Frequency range is 30–76 megahertz; maximum input, +10 dBm; impedance, 50 ohms; VSWR, 1.25; insertion loss, 3 decibels, and switching time, 4 microseconds.

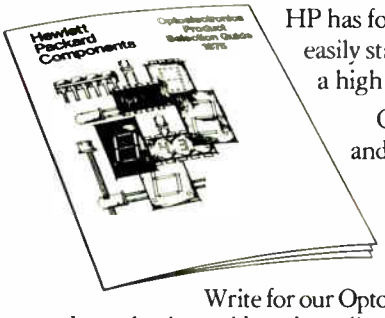
Although standard units operate from TTL devices driven by other logic types, including ECL and MOS, can be supplied.
Merrimac Industries Inc., 41 Fairfield Place, West Caldwell, N.J. 07006 [404]

Phone-line equalizer has wide dynamic range

For use with subscriber lines and automatic secure switches, as well as applications where equalization is required for voice and data signals being transmitted on the same line, a wideband line equalizer covers 10 hertz to 70 kilohertz. The model 133 incorporates a 25-dB gain-regulating amplifier to compensate for flat line loss. Also included is an adjustable RC equalizer to compensate for

SURPRISE!

HP's New Stackable Subminiature Lamps



HP has four new LED lamps in radial lead subminiature epoxy packages. And they can be easily stacked on 2.21mm (0.087″) centers for high density applications. These lamps offer a high on/off contrast ratio combined with a wide viewing angle.

Choose the HP 5082-4100 for the red, -4150 for the yellow, -4190 for the green and -4160 for our new high-efficiency red.

Contact Hall-Mark, Schweber, Wilshire or the Wyle Distribution Group (Liberty/Elmar) for immediate delivery.

Write for our Optoelectronics product selection guide and get all the details on HP's broad line of LED lamps.

01603

HEWLETT hp PACKARD

Sales and service from 172 offices in 65 countries.
1501 Page Mill Road, Palo Alto, California 94304

168 Circle 242 on reader service card

New products

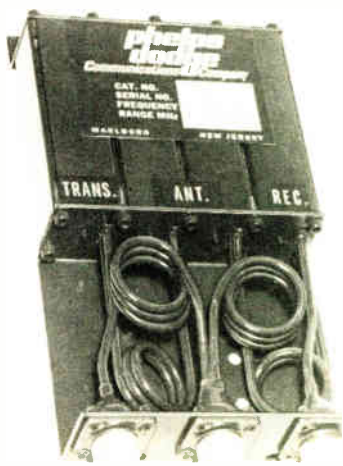
high-frequency rolloff of cable transmission systems. Basic frequency response is flat over the specified range, with equalization gain adjustable up to 25 dB at 70 kHz. Impedance is 135 ohms, balanced, and impulse noise is specified at 20 bits in a 10-minute period. The model 133 consists of one or two plug-in equalizer modules and one plug-in power supply module containing a power switch, fuse, and pilot lamp.

TM Systems Inc., 25 Allen St., Bridgeport, Conn. 06604. Phone S Feldman at (203) 366-4571 [405]

Mobile duplexers cover range from 144 to 174 MHz

Two additions to a line of duplexers include the model 636A mobile duplexer (shown below), which has four capacitively tuned temperature-compensated helical resonators, two in the receive channel and two in the transmit. The model 636-S6A, also a mobile unit, uses six resonators, the two extra cavities providing the added isolation required in some systems. Both devices have a frequency range of 144 MHz to 174 MHz with a minimum separation of 4.5 MHz. Maximum power input is 50 watts.

Phelps Dodge Communications Company, Route 79, Marlboro, N.J. 07746 [406]



Why Parylene works where other microelectronic protection fails:

Crevice penetration in hybrids

This beam lead has a 0.3 mil parylene coating all the way to the weld. Parylene penetrates deep within small crevices, maintaining clearance while putting a coherent coating under beam leaded chips and air bridges. No area is left unprotected, preventing shorts and allowing the designer great latitude in component spacing and sizing. And parylene secures loose debris while preventing breakoff of pigtails during shock and vibration loadings.

Controlled conformality

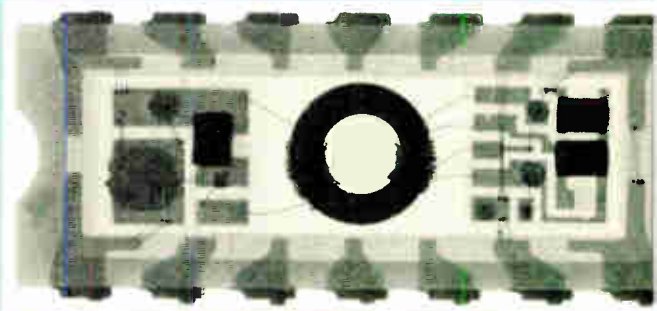
There's a uniform coating of parylene all the way around the half-mil tip of this phonograph needle. That's true conformality, and only parylene gives it, in precisely controlled thicknesses from .002 to 3 mils, in one step. Unlike spray or dip coatings, parylene won't bridge or puddle, or thin out at sharp edges, creating potential failure points. The parylene coating is completely uniform, no matter how dense or intricate the module. And because it's applied at room temperature, there's no component discomfort.

Lead Strengthening

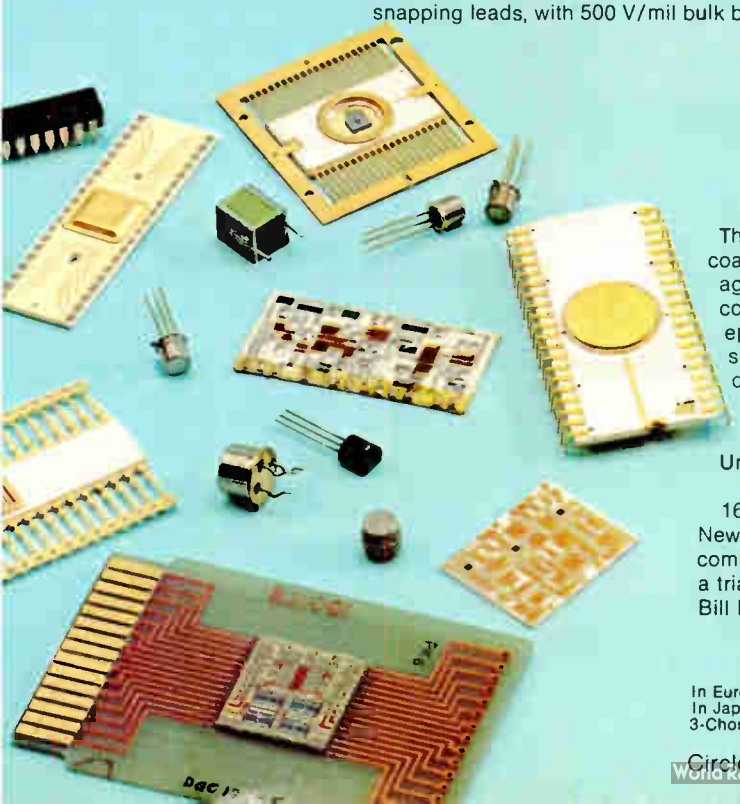
It took up to 75 grams pull to break these 1 mil wires. Bare 1 mil aluminum wires, for instance, exhibit bond strengths of 3-5.5 grams; coated with 1 mil of parylene, pull strength increases by 60-70 grams. So wire and bond are stronger, and sideward shorts and loop collapse during extreme g-loads are prevented. Parylene coatings will penetrate the less than 1 mil clearance between beam lead bonded chips and the substrate, giving such strong coating coverage that the chip cannot be lifted without destroying it.

△200 C thermal shock protection

This hybrid microelectronics relay has undergone 200 45-minute cycles from −120 to 80°C, simulating earth-orbiting conditions. This X-ray shows all leads remain intact. Parylene protection was at work, on the transformer core and then the whole assembly before packaging (TO-116). There was no appearance of corona up to 5000 V_{dc} ; leakage was reduced from 10μA to <.001μA at 1000V. RTV encapsulation suffered dimensional mismatch, straining and snapping leads, with 500 V/mil bulk breakdown.



X-ray courtesy NASA Lewis Research Center and Sterer Eng. & Mfg. Co.



Broad cost effectiveness

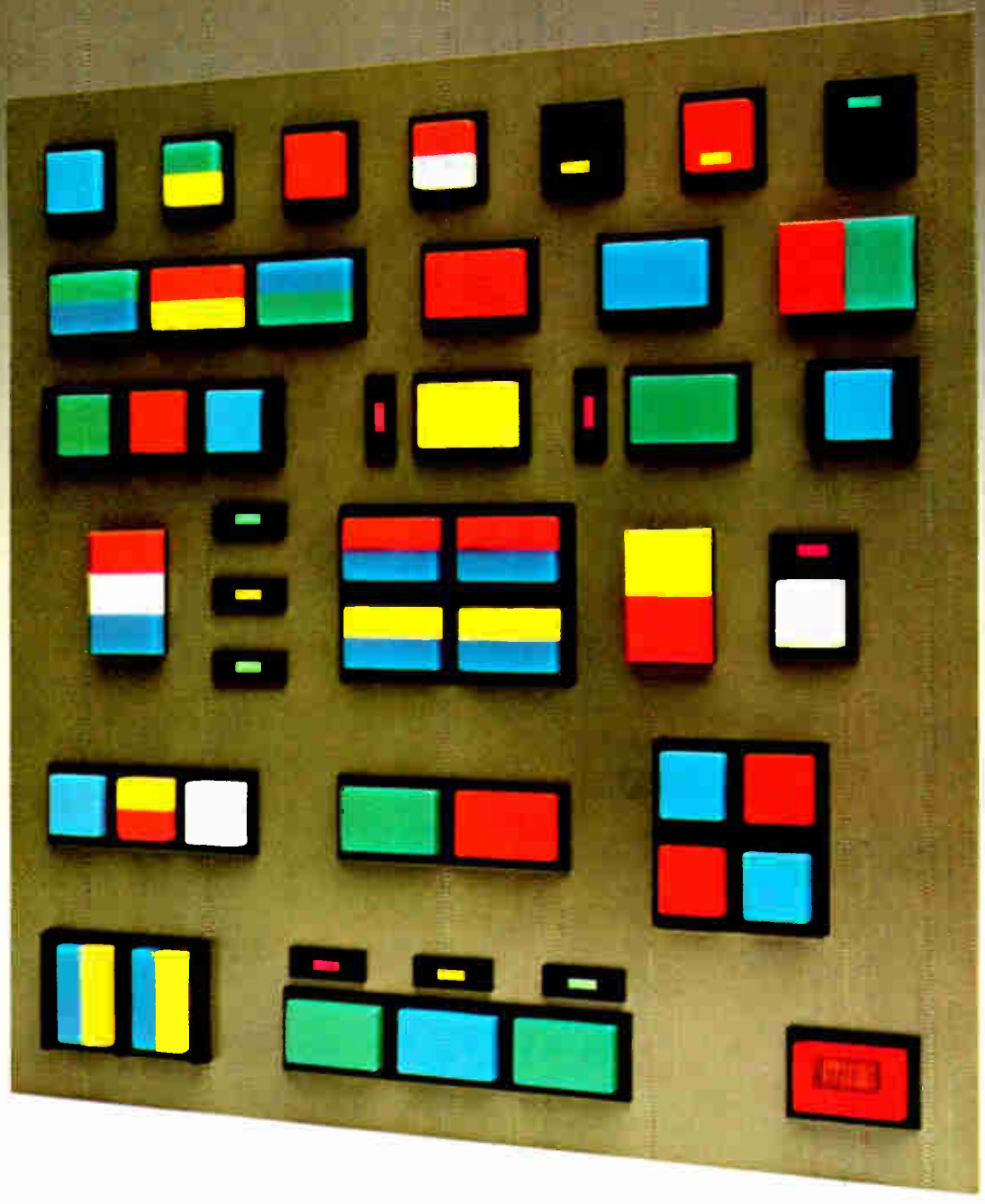
These are some of the circuit modules now being protected with a conformal coating of parylene. Because nothing else offers parylene's combined protection against thermal cycling, shock, vibration, humidity, solvents, radiation, ionic contamination. Better barrier protection than liquid coatings like silicones, epoxies, and urethanes. On hybrids you can combine parylene with a hermetic seal for optimum environmental protection . . . and parylene alone will often do the job, and at less cost than hermetic seals. Parylene is compatible with active devices, and meets the tough requirements of MIL-I-46058C. For long term reliability, parylene provides a cost-effective solution.

Union Carbide invented the parylene system. Various patents apply; commercial use of the patented technology is licensed. Write for our 16-page brochure: Union Carbide Corp., 270 Park Avenue, Dept. RFB-65, New York, N.Y. 10017. For instant communication, and information about a trial run at reasonable cost, call Bill Loeb at (212) 551-6071.

UNION CARBIDE **PARYLENE**

In Europe: Mr. Peter Crook, Bakelite Xylonite Limited, Redfern Road, Tyseley, Birmingham, England. In Japan: Mr. N. Fusada, Tomoe Engineering Co. Ltd., Shin Shin Kai Bldg., 14-1 Nihonbashi 3-Chome, Chuo-Ku, Tokyo.

Circle 169 on reader service card



The first good-looking pushbutton that looks

Until recently, if a pushbutton looked good, its electrical flexibility usually didn't. And if it offered electrical flexibility, it usually didn't offer much in the way of looks.

Then MICRO SWITCH introduced the AML (Advanced Manual Line) pushbuttons and indicators. The most comprehensive line ever designed.

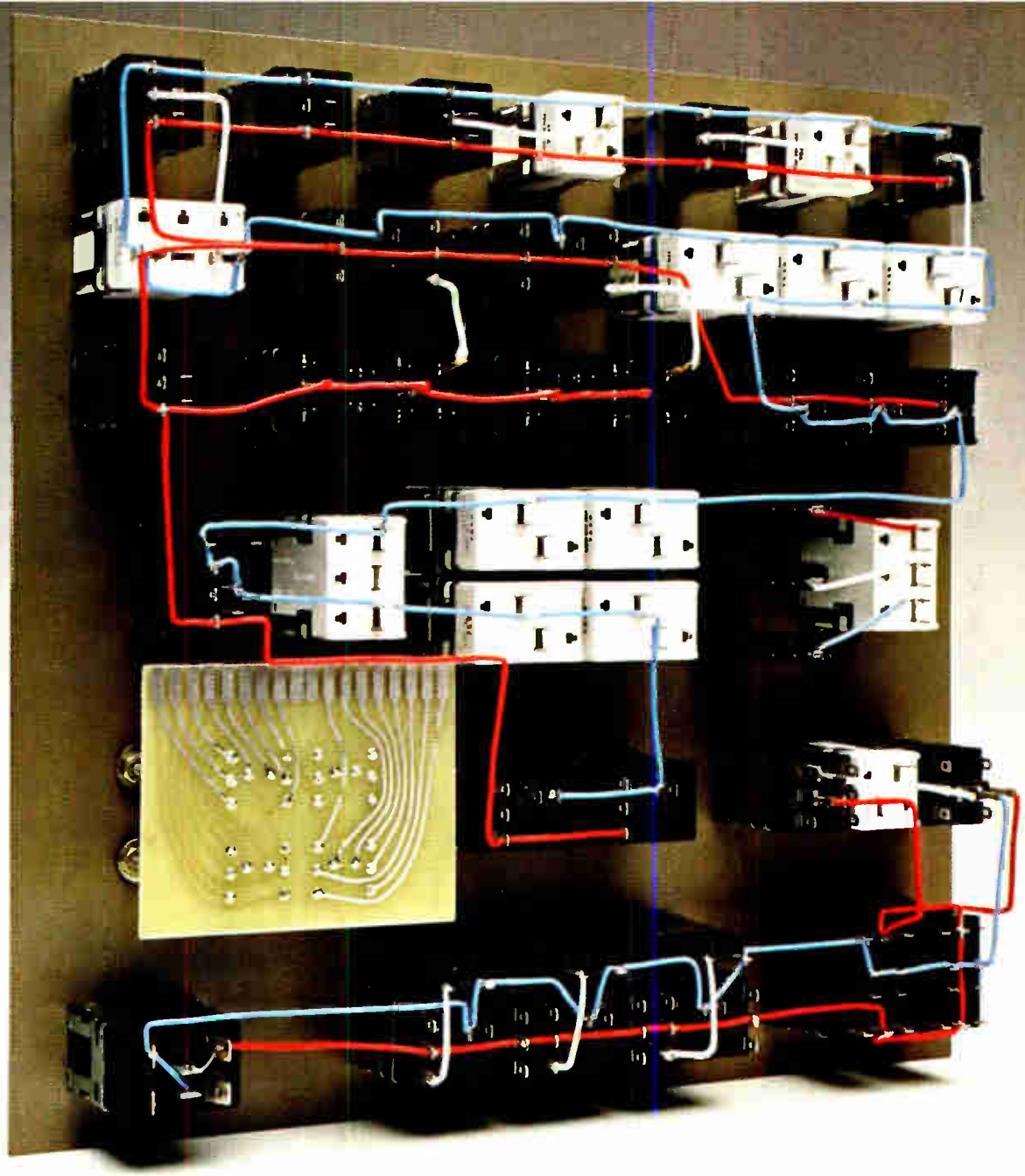
AML devices have been designed for appearance by industrial designers. Button height, bezel size, and the compatibility of the square and rectangular shapes combine to "harmonize" your panel. Because the AML line is so broad, you won't have to end up with different looking units to perform different functions.

Displays range from split-screen and hidden-color to a unique, three-segment lens cap indicator, all with transmitted or projected illumination, and a choice of lamps including a T-1¾ wedge base lamp, neon and LED.

The AML units have been designed to look good to electrical engineers, too.

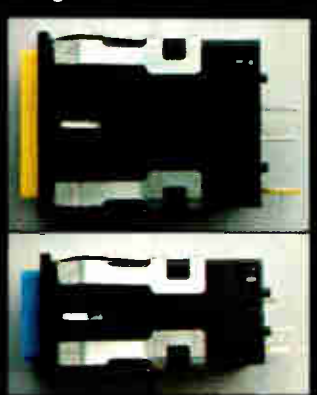
Particularly in flexibility. Three different electrically rated switches in the same size housing. You can choose solid state pushbuttons that operate at 5V or 6-16V with a built-in regulator, sink (TTL) and source (CMOS). Electronic control from logic switching to 3 amps, 120 VAC. And power control up to 10 amps at 120 VAC.

All AML units have been designed to offer the same shallow depth, to provide a unique



just as good when it's time to wire it.

single level termination. Which means easier wiring and a neat, "clean" appearance. You can either snap them in place from the front, or sub-panel mount them, using individual, strip or matrix mounting hardware.



There's no problem with international acceptance, either. Every AML device is designed to meet the requirements of IEC, CEE24, UL and CSA standards.

But we believe there's more to building better panels than just offering better pushbuttons and indicators. That's why we have MICRO SWITCH personnel available to help you solve your specific panel design problems on a personal basis. For more information, write for our "Control Panel Layout Design Guide." Or call your nearest MICRO SWITCH Branch Office or Authorized Distributor.

Either way, you'll end up with one thing. A pushbutton that works as well as it looks.

MICRO SWITCH

FREEPORT ILLINOIS 61032

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Alabama still has room for profitable growth.

For the third straight year, capital investments announced for new and expanding industries in Alabama were over one billion dollars. (Only one other southeastern state has ever announced new capital investments exceeding the billion-dollar mark in a single year.)

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Alabama has a labor training program that can supply you with qualified workers—at no cost to you for the state-supported training service. In 1975 alone, some 5,000 people were trained to meet industrial needs.

Chances are good that whatever else your needs might be— energy sources, available land, or navigable waterways—Alabama has that, too.

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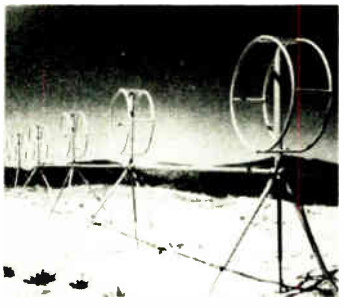

32.5°N

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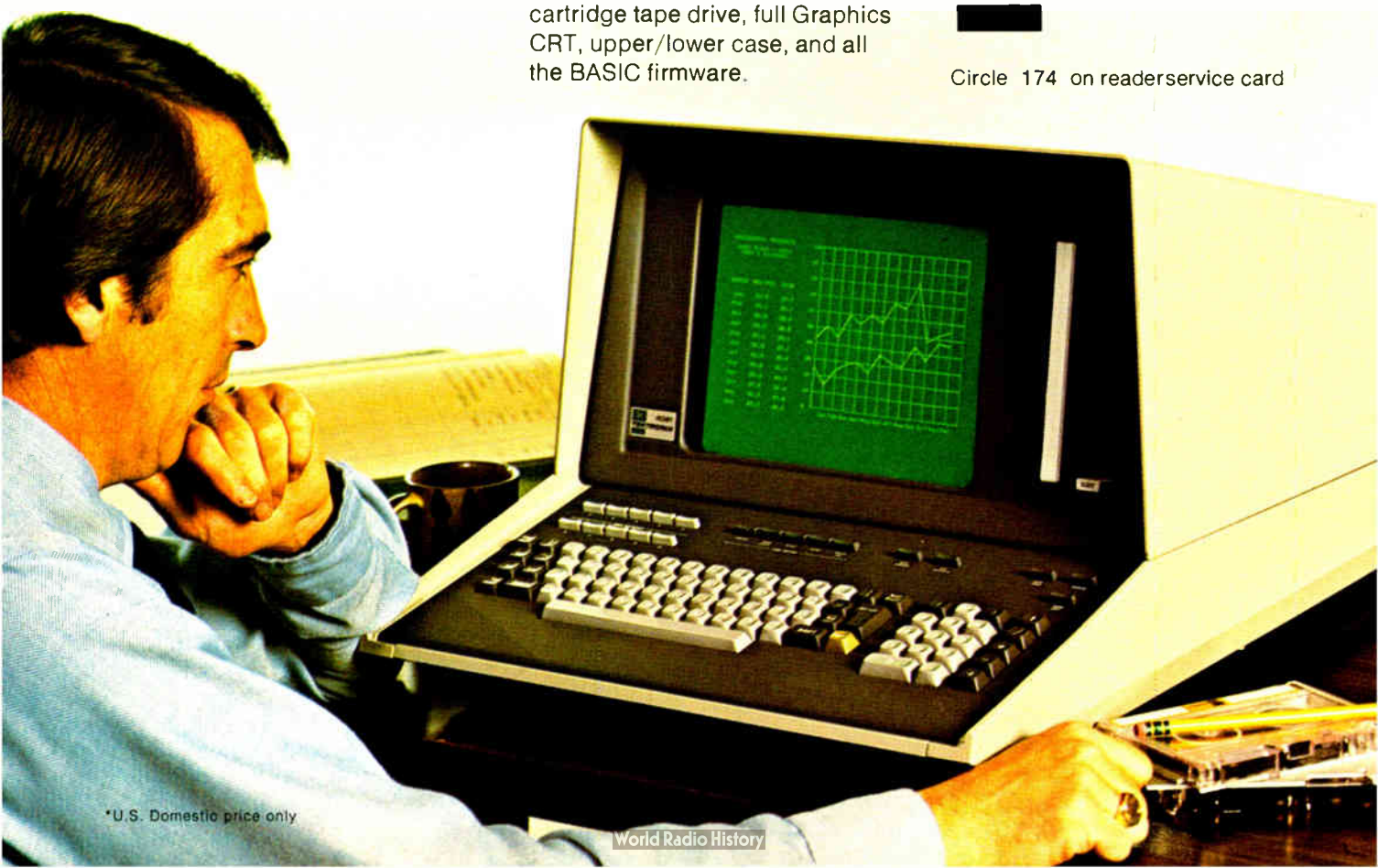


*U.S. Domestic price only

Data handling

Handling tape at 75 in./s

Floating-shuttle transport eliminates vacuum-column types, has constant tension

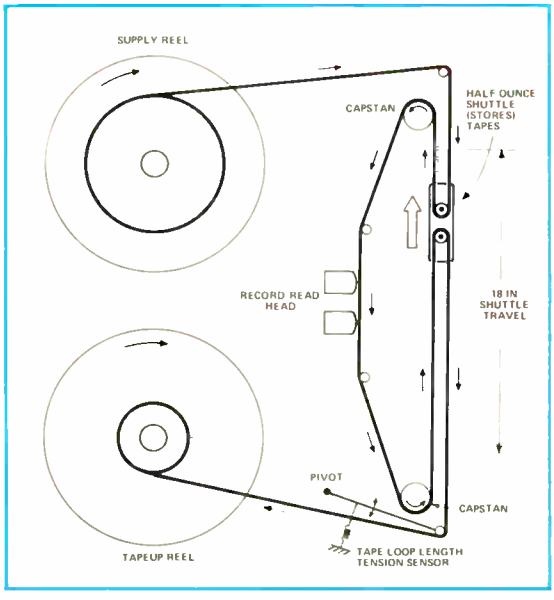
A high-speed floating-shuttle tape transport from Qantex can handle tape speeds up to 75 inches per second without the complexities of vacuum-column transports which were previously required for speeds above 45 in./s.

High-speed digital tape transports must stop and start the tape within milliseconds of the host computer's command. Although the capstan system can accelerate and decelerate the tape itself in the short time intervals required, it's difficult for the reel motors to do the same for the two heavy reels. Conventional transports use either mechanical or vacuum-column tape buffering to allow the capstan to get the tape off to a fast start, while permitting the takeup and supply reels to accelerate or decelerate more gradually.

For tape velocities from 12.5 through 45 in./s, tension-arm buffers of progressively increasing complexity have become standard. Beyond 45 in./s, because buffer inertia problems increase with the square of tape velocity, tension arm methods no longer solve the problem. Consequently, tape transport designers have been obliged to resort to elaborate vacuum-column buffering for 75 in./s and higher speeds.

Qantex's shuttle-buffering principle is actually an evolutionary step from the conventional tension-arm method. Since both tension arms swing in the same direction during acceleration and deceleration, the two arms could be replaced by a single arm carrying two tape-idling rollers. If this hypothetical single-tension arm were made infinite in length, then the two idler rollers would move up and down in a straight-line path, instead of an arc. Thus, Qantex dispensed with the single-tension arm altogether, thereby eliminating the mass of the arms, and arranged for the two tape idlers to be mounted on a lightweight framework that is constrained to travel up and down, in response to capstan acceleration and deceleration.

Displacement of the shuttle from its central, neutral position develops a signal that sets the nominal speed of the two reel motors. A further sensing device monitors tape tension, providing a control signal that increases one motor's torque and decreases the other's to provide constant tape tension under all modes of operation. The new tape transport is built with about 30% fewer parts than vacuum-column transports, for reduced weight, simpler design, lower power consumption, and improved reliability. The noise created by the vacuum column's rushing air also is eliminated, and so is the suction system, which has a tendency to pull dust and other particles into the vacuum chamber. In addition—because vacuum methods



don't work at low ambient air pressure—for unpressured aircraft applications, vacuum-column transports must be hermetically sealed in vacuum-tight enclosures, Qantex engineers point out.

The new transport handles tape reels up to 10½ inches in diameter, accommodating up to 2,400 feet of ½-inch magnetic tape. The unit records and reads bidirectionally at 75 in./s, equivalent to a data rate of 120,000 bytes per second at 1,600 bits per inch. Standard recording modes are 800 bits/in. NRZI, or 1600 bits/in. phase-encoded, providing either seven-track or nine-track operation.

In single quantity, the floating-shuttle tape transport is priced at $4,400, with prices decreasing rapidly for OEM-quantity orders. A militarized version of the transport also is available.

North Atlantic Industries, Qantex division, 200 Terminal Drive, Plainview, N.Y. 11803. Phone (516) 681-8600 [361]

Cassette transport operates at 10 inches per second

A digital cassette tape transport system from Braemar uses the company's developed CD-200 transport for a compact data recording system at a reasonable cost. The new system, called the CS-400, is ideal for microprocessor use, requires only one supply voltage (between 14 and 30 volts) and is totally TTL compatible. Operation is also feasible at voltages below 14 volts, the company says.

The CS-400's electronic package accepts and delivers serial digital data at TTL levels at an 8,000-baud rate. The unit operates at a nominal density of 800 bits per inch at 10 inches per second, with other speeds and densities optional. Its C-MOS circuitry assures low power consumption.

The system has two-channel capability, and both tape tracks are available for data. The active channel is determined via TTL command, and the user can write on one track,

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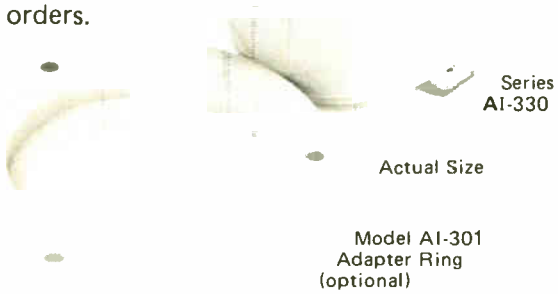

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For information circle 244 on reader service card

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switch channel, change direction, and continue writing on the other track, without having to rewind the tape.

The system uses the Manchester phase-encoding technique and provides ANSI-compatible data. For improved accuracy, the system uses Auto Sync, a decoding scheme with internal compensation for bit-to-bit variations. Auto Sync also allows the customer to record close to startup and obtain short inter-record gaps. Since Auto Sync is self-clocking and is operated from the data channel, the second channel is retained for data applications.

The price is $350 each in 1,000 quantities.

Braemar Computer Devices Inc., 11950 Twelfth Ave. South, Burnsville, Minn. 55337. Phone (612) 890-5135 [362]

Computer Automation adds direct memory access

Computer Automation Inc. has added a direct-memory-access capability to its distributed I/O systems, which now interface peripherals to the company's Alpha/LSI family of minicomputers. The new DMA I/O distributor is a single printed-circuit card (approximately 7 by 16 inches) that handles up to four different low- and medium-speed peripherals simultaneously, in any mix, serial or parallel. It is designed to enable existing peripherals to run in a DMA mode without having to rewrite application software or to discard existing I/O interface hardware.

Each peripheral is controlled by a microcoded processor (called a PicoProcessor) embedded in the peripheral connecting cable. The microcoding performs all device interfacing, protocol, formatting, and error-checking. The distributor thus converts each "intelligent cable" in the I/O Distributor system to DMA. DMA I/O also supports programed I/O or interrupt I/O to enable the user to run DMA or non-DMA without the need to purchase added distributors.

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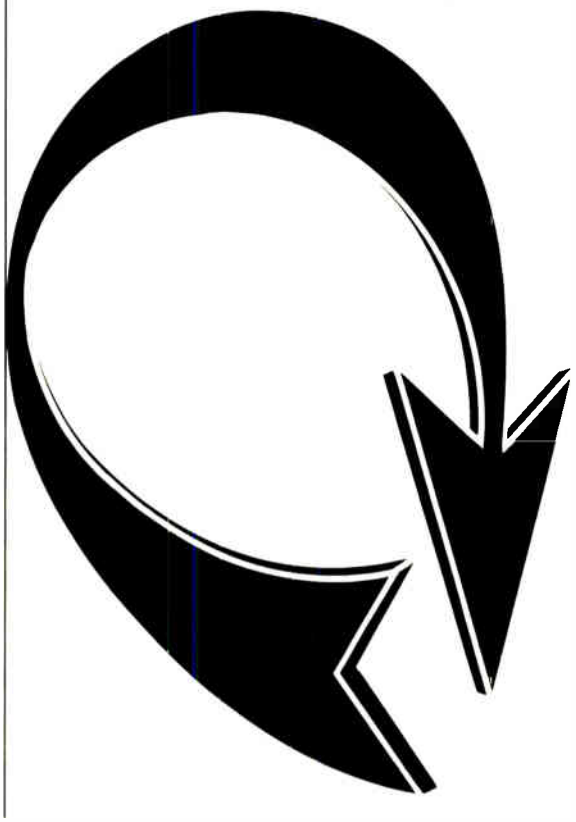

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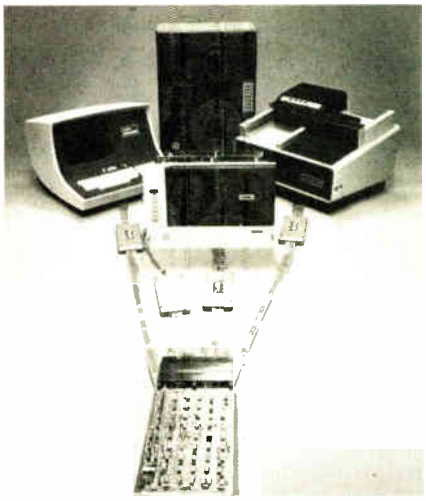
CONTROL DATA CORPORATION

Circle 179 on reader service card

New products



microprogramed, only a few different versions are required to interface to a wide range of standard and special-purpose peripherals. Intelligent cables containing the PicoProcessors are available for serial or parallel interfaces. The serial version communicates with such devices as Teletypes, terminals, modems, and special devices that might include keyboards, badge readers, and control panels. The parallel version interfaces with such standard peripherals as paper-tape readers and punchers, line printers, card readers, and various general-purpose devices.

Computer Automation, Inc., 18651 Von Karman, Irvine, Calif. 92664. Phone (714) 833-8830 [363]

Programable RAM aids microprocessor design

Memory contents can be altered in-circuit with a KPRAM (Keyboard-Programable Random-Access Memory) that is used in the development of microprocessors, minicomputers and other digital systems. Taking the place of a ROM or PROM, the unit contains a RAM, 16-key keyboard, address switches, and a display button for benchtop use. Hexadecimal byte data is entered into the KPRAM by keyboard and is in-circuit, byte-alterable. Memory address is selected by toggle switches. The data bus is three-state and de-

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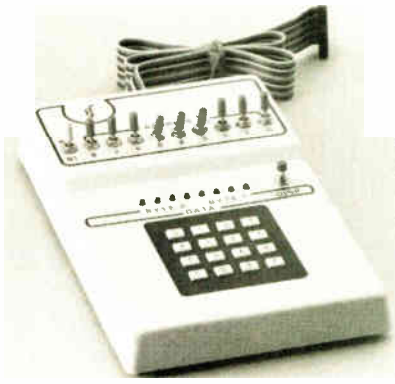
New products



pressed. Eight LEDs above the keyboard display information on the data bus continuously or display the contents of the memory on command. An optional power supply/battery pack, the BP-1, provides power backup and permits out-of-circuit programing. The KPRAM is available in four standard sizes: 256 words by 4 bits, 256 by 8, 512 by 4, and 512 by 8, with standard pinouts or user-wired adapter kit. Prices range from $225 to $325 for the KPRAM and $150 for the BP-1.

Sunrise Electronics, 228 N. El Molino Ave Pasadena, Calif. 91101. Phone Michael Byrne at (213) 793-7552 [366]

Compiler for Basic runs on 8080 microprocessor

The Micro Basic I software package includes a compiler, text editor, loader, debugger, and runtime support for use on the 8080 microprocessor. Using the well-known Basic language, the designer can program directly on the 8080 processor system. The software requires 32 kilobytes and can run on the Intellec Microcomputer Development System (MDS).

Ryan-McFarland Corp., 608 Silver Spur Rd., Rolling Hills Estates, Calif., 90274. Phone (213) 377-2353 [365]

High-level language for bit-slice microprocessors

A high-level programing language and compiler has been developed

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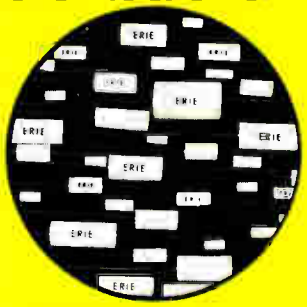

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ERIE TECHNOLOGICAL PRODUCTS, INC.
ERIE, PENNSYLVANIA 16501
814/453-5611

New products

for use on Advanced Micro Devices' 2900 bipolar bit-slice microprocessors. Called DAPL, the language covers simple bit patterns as well as register transfer and also provides error-checking facilities. Microprograms can be as large as 8,192 words by 256 bits, sytnax is free-form, and commands can help locate program segments at specific word or ROM boundaries, according to the manufacturer.

Zeno Systems, Inc., 2210 3rd St., Suite 110, Santa Monica, Calif., 90405. Phone (213) 396-6020 [364]

Head-per-track memory aimed at industrial uses

With a recording density of 3,320 bits per inch, the model 530C head-per-track disk memory is designed for random-access data storage in such applications as process control, power distribution, numerical control and key-entry devices. Also, it can be installed in mobile systems. Available with capacities up to 40 million bits on 512 data tracks, the unit consists of three primary assemblies. Each has an electronics module, power supply, and 512-track disk module. All three are in one compact cabinet, and the entire assembly can be mounted in a standard EIA rack.

General Instrument Corp., Rotating Memory Products, 13040 South Cerise Ave., Hawthorne, Calif. 90250 [368]

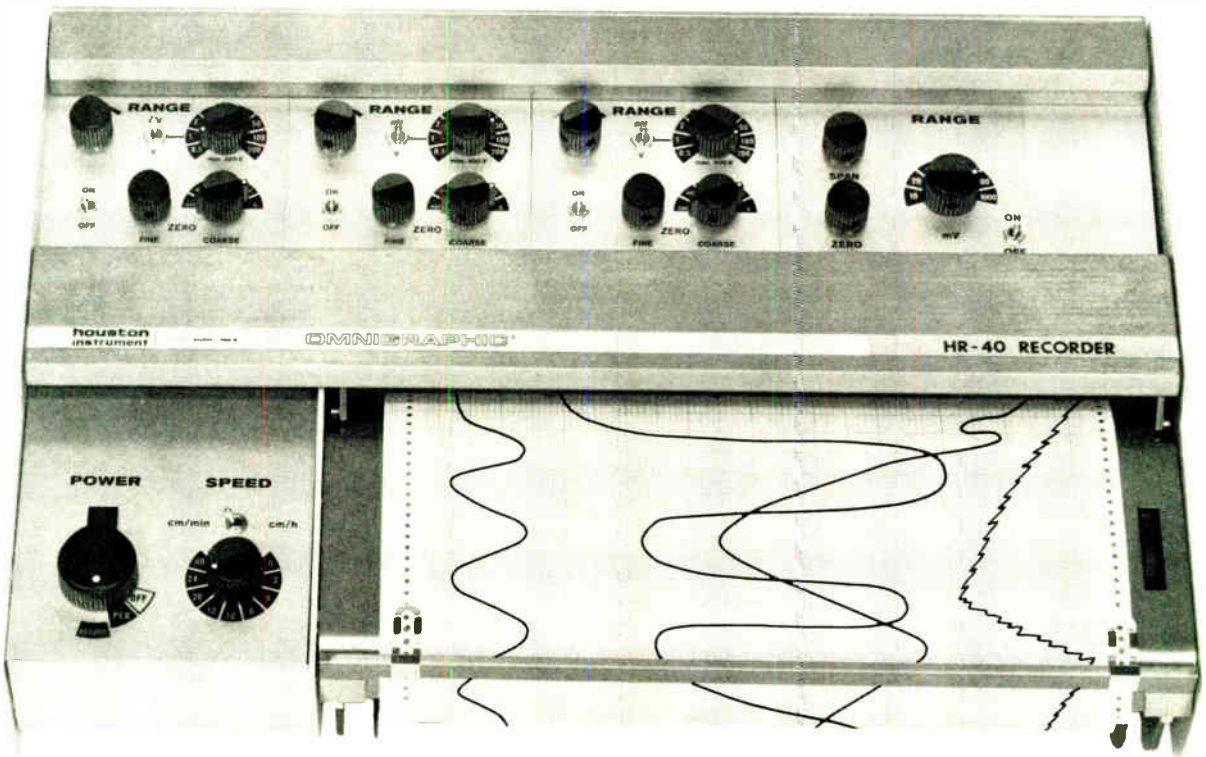
Dc-to-dc converter provides power backup for phone data

Switching and transmission equipment in telephone central offices operates from 48-volt dc batteries that are immune to power outages. But, most data-processing systems that record billing information run from commercial ac power and, despite backup ac sources, can lose data when power fails.

To prevent this, Pertec Corp. has designed a 48-volt dc-to-dc converter for the magnetic-tape transports it makes for these systems. The

HR-40

3 and 4 Channel Strip Chart Recorder



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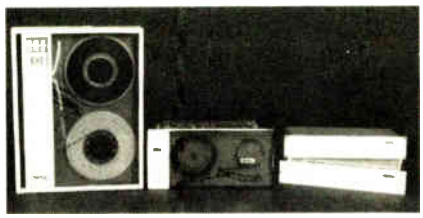
"the recorder company"

Circle 185 on reader service card

New products



converters, packaged either inside or remote from the transports, operate from the same batteries that power the phone equipment, and the converters may accommodate optional formatters and buffers.

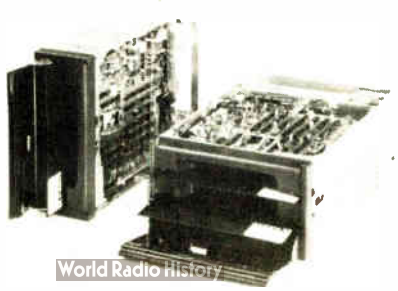
The Pertec units accept raw battery power and, through a high-frequency switching regulator, convert the 48 volts dc (±15%) to unregulated outputs of 5 v and 16–24 v. Regulators inside Pertec's transports use the 5-v input to run logic circuits and the 16-24 v for tape-deck motors. Additional cost of the converters is $300 each.

Peripheral Equipment Division, Pertec Corp., 9600 Irondale Ave., Chatsworth, Calif.

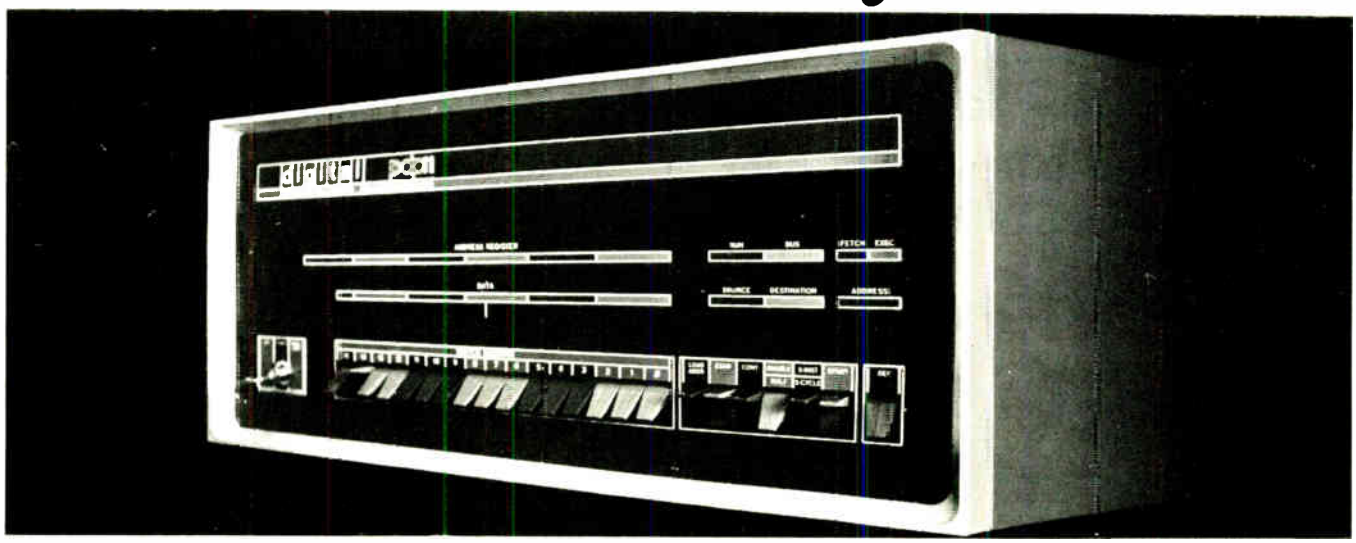
Loading mechanism protects flexible disk drive

Available in a single and a dual version, a flexible disk drive, the Facit 4231, is compatible with the IBM 3740. Track-to-track access time is 4 milliseconds maximum. A novel loading mechanism provides exact positioning of the disk, at the same time offering full protection against damage to the disk. The mechanism consists of a driving spindle and a moving, self-adjusting, lightweight cone. The cone moves toward the spindle upon which the flexible disk lies, adjusting it gently and accurately before securing it at the right position. In the dual model the loading, rotation, and access mechanisms and the drive electronics are common.

Facit-Addo Inc., 66 Field Point Rd., Greenwich, Conn. 06830 [369]



Need DEC Memory?



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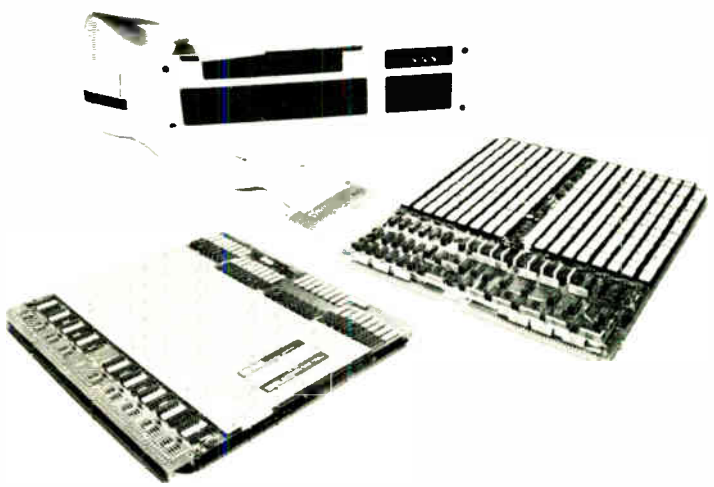
7805	16K NMOS in Add-on Chassis	PDP-11 FASTBUS	Up to 128K on the FASTBUS (64K in 5¼" Chassis) Includes Parity	$19,000 (64K words)
7711	8K/12K/16K NMOS Add-In	LSI-11	High density, High Performance	$1590 (16K x 16)



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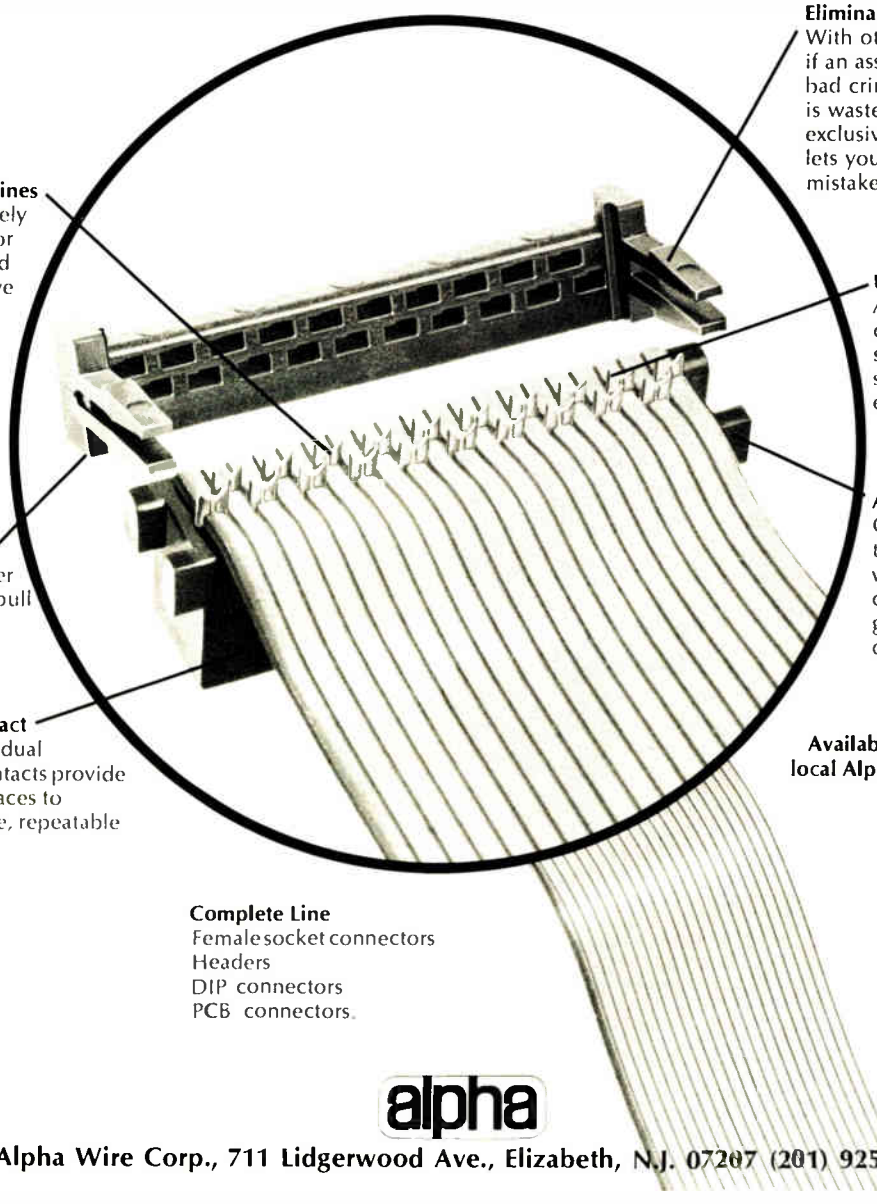
New ideas from a new source for flat cable and connectors

There are a lot of reasons why you should consider the newest source of flat cable connectors. To begin with, the newest source is one of the most experienced full line wire and cable manufacturers. So we know a lot about cable and how to connect it.

Let's start with our cable. It's compatible. Matches all flat-cable connectors designed for 0.050 in. (1.27mm) conductor spacing. Excellent teardown characteristics make it easy to cleanly separate the conductors—essential when cable has to be routed to more than one location. It can be folded back on itself without damage to conductors or insulation—ideal for intricate cable routing. Another bright idea: an exclusive footage indicator on the reel shows how much cable is left. And it's UL listed (style 2651). Complies with requirements of FR-1 flame test.

The connectors, (57 of them) are an integral part of our flat cable connection system. They also offer some bright new ideas as you can see:



Eliminates Waste
With other connectors, if an assembler makes a bad crimp the connector is wasted. Alpha's exclusive closing action lets you correct your mistakes.

Microetched Offset Tines
Grip conductor securely and prevent conductor damage. (All burrs and knife-sharp edges have been removed.)

Universal Adapter
And Alpha's bench press crimps all connector styles. Eliminates need for separate adapter plates for each connector type.

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Our unique design allows the cable to remain within the profile of the connector, affording greater flexibility in high density wiring.

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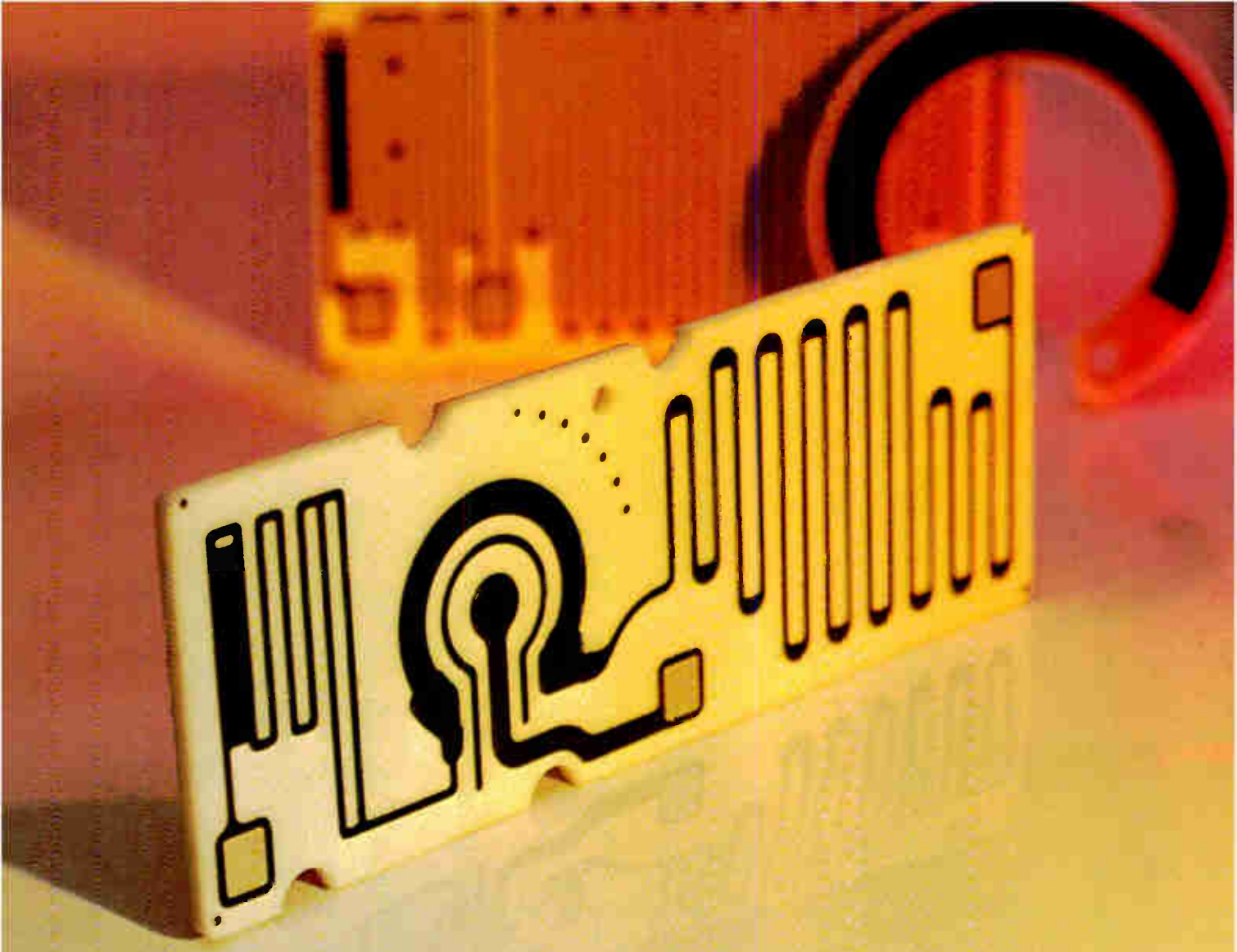
Alpha Wire Corp., 711 Lidgerwood Ave., Elizabeth, N.J. 07207 (201) 925-8000



For high-voltage applications, thick film manufacturers have 3 reasons for choosing Du Pont materials systems.

Excellent performance. Ease of processing. Technical service. Du Pont's compatible systems of thick film conductor and resistor compositions give you all these, and more.

Excellent performance

Du Pont's 9400-Series Resistors offer superior surface characteristics for variable resistors—a distinct advantage if you manufacture TV focus control potentiometers. Contact resistance variation is typically less than 2%.

And the 9400-Series provides resistivities of 100K to 10 Megohms per square, with excellent stability under continuous high-voltage stresses in excess of 10K volts per inch and pulses in excess of 50K volts per inch.

High yields

Excellent reproducibility of the 9400-Series Resistors helps keep your production running smoothly and yields high. Add a compatible, low-cost conductor—like Palladium/Silver 9308 or Platinum/Silver 9770—and you have a cost-effective system of materials for high-voltage applications.

...and service too!

Du Pont's experienced Technical Representatives guide you in choosing the right products to meet your high-voltage requirements. Then they help you optimize processing conditions to achieve the best performance from the Du Pont product system.

And they're backed up by skilled product specialists and a fully-equipped customer service laboratory, where products are tested under end-use conditions.

Whether you manufacture high-voltage components, resistor networks or hybrid circuits, Du Pont has a cost-effective system of thick film materials for your application. Call—toll-free—800-441-9475. Or write: Du Pont Company, Room 25159, Wilmington, DE 19898.

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Electronics

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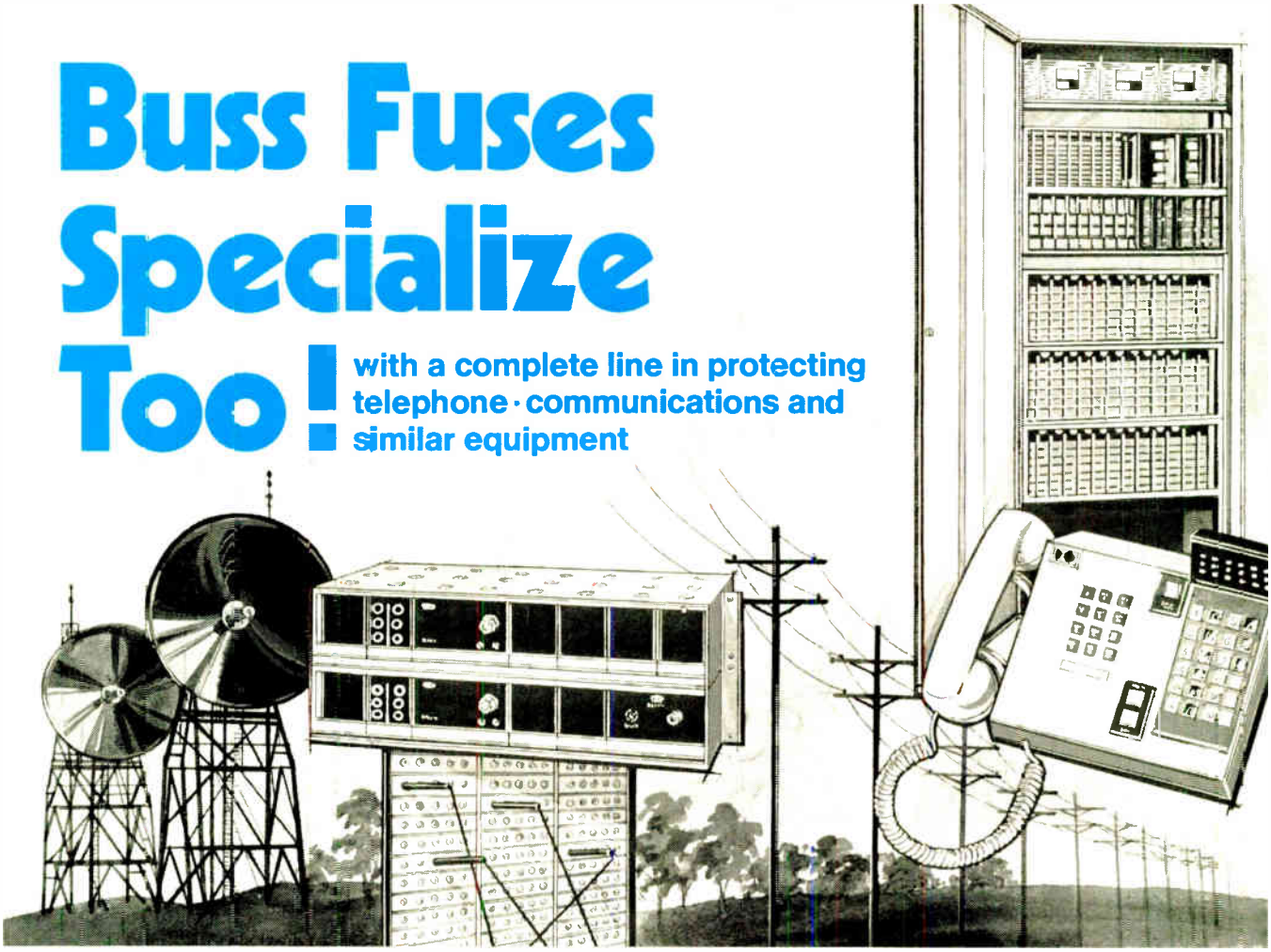


BUSS Series 70 FUSES

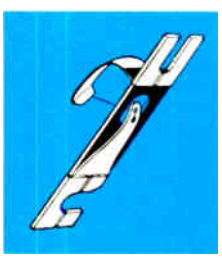
. . . signal indicating, alarm activating — designed to give positive contact on the alarm circuit. Indicating pin is color coded for quick identification of ampere rating. Available from 18/100 to 10 amp., rated 300 V or less.

BUSS HWG FUSEHOLDER

. . . especially designed to take Series 70 fuses. Bayonet type knob has hole for fuse indicating pin. Holder can be mounted from front or back of panel or cantilever from rear. Metal shoulder plate and strap on holder provides strength for mounting screws. Terminals can be wire wrapped or soldered. Rated 10 amp. 300 V or less.

BUSS GMT FUSES and HLT FUSEHOLDER

. . . for multiple circuit apparatus where space is at a premium. Holder takes mounting space of only 1/4"x1-15/32". Fuses are color coded and are signal indicating, alarm activating. Available from 18/100 to 10 amp., rated 300 V or less.



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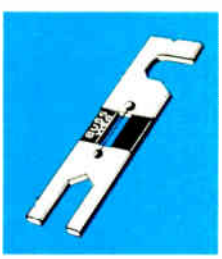
. . . visual indicating, alarm activating — designed to give positive contact on the alarm circuit. Fuses are color coded for type and ampere. Available from 18/100 to 5 amp., rated 90 & 100 volts or less.



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. . . insulated base has copper clad, tinned terminals slotted for #10 screws. Fuse link clearly visible for quick identification of open fuse. Ampere rating stamped on fuse for positive identification. Available from 1/4 to 10 amp., rated 32 volts or less.

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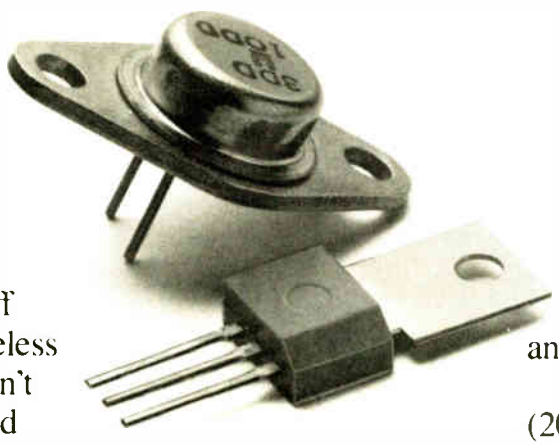

Up till now, gate turn-off SCRs have been pretty useless products. They simply didn't have high enough gains and low enough turn-off voltages to be practical for real-world applications.

But now there's Unitrode's new 8A GTO SCR.

Unlike other GTO SCRs, which need 1A or more to turn off 4 or 5A, ours can turn off 4 A with just a few milliamps — for a gain of nearly a thousand.

Unlike other GTO SCRs, our turn-off gains are virtually flat right up to 125°C.

Unlike other GTO SCRs, which need −30 to −70V for turn-off at the gate, ours need less than −5V.

Of course, our GTO SCRs will also give you the basic GTO benefit of simplified circuit design. Making them perfect for applications like ignition systems, DC circuit breakers, multivibrators, and inverters.

Unitrode fast switching (200ns) GTO SCRs are available from 50 to 400V in either TO-66 hermetic or TO-202 plastic packages and start at the lowest price in the business.

And that's the most practical part of all.

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UNITRODE

Semiconductors

Dual-setpoint timer is IC

Monolithic device aims at $75–$100 portion of market in control applications

Aiming at the high-volume, $75–$100 portion of the industrial timer/counter market now dominated by electromechanical devices, Siliconix Inc. has gone into production with what is described as the industry's first monolithic dual-setpoint timer.

Designated the DF215 and containing the equivalent of 2,000 transistors on a 104-by-112-mil chip, the device, says its designer, Christopher L. McAfee, uses p-channel, depletion-mode MOS to implement all the necessary logic for a single-or dual-setpoint timer or counter.

According to Siliconix' vice president of engineering, John Hulme, electromechanical systems now dominate the market for automatic interval-timing in industrial processing, commercial food preparation, automatic feed, fluid- or material-dispensing applications as well as test timing. They range in price from $50 to $350. To date, semiconductor equivalents of this function, usually in the form of standard TTL, p-MOS or C-MOS monolithic single-setpoint timers, have penetrated only the upper $200 to $350 portion of the market. "Although component costs on previous integrated-circuit approaches to this market," says Hulme, "have been relatively low—typically $2 to $3 for each decade counter implemented in standard logic and $8 or so for a monolithic device with several decades and a single setpoint—this is not adequate for most automatic control and timing functions that are to be found in industry."

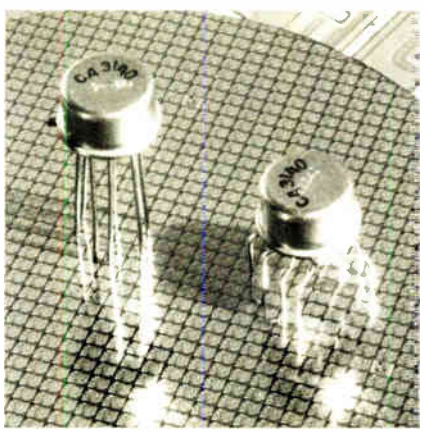
What is also needed are at least two control outputs, two setpoints, and range selectivity over several ranges. Consequently, explains Hulme, the total systems cost generally keeps such IC-implemented counter/timers out of the low $50–$200 end of the industrial timer/counter market.

What Siliconix has done is to combine an elapsed-time/event counter, setpoint-compare logic, time-base logic, multiplexed outputs, four decades of logic, and the capability of selecting any of four time ranges from 000.1 second to 99 hours and 59 minutes, onto a 28-pin device that will cost only $10.85 in 100-quantities and $9.90 in quantities of 1,000. The timer continually compares the elapsed time with one of two setpoints to produce one or two precise intervals on two control outputs. The DF215 counts either events or time intervals using a 50- or 60-hertz power line as a time base and, unlike timers with setpoint registers on the device, it will not lose the setpoint values if power fails. Other features include 16-millisecond accuracy, a single 8-to-20-volt power supply, low power (typically 50 milliwatts), and an internal oscillator for logic timing. The devices are available from stock.

Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, Calif. 95054 [411]

Rugged op amp has p-MOS input and bipolar output

Many uses are expected for an operational amplifier that RCA Solid State division has given a p-channel MOSFET input stage and a bipolar



New products

output stage with a wide output-voltage range. Called a BiMOS op amp, the model CA3140 is considered by RCA to be "the most useful op amp since the introduction of the 741 in 1968." Its versatility permits it to fill virtually all 741 sockets, as well as others.

The p-MOS input stage is similar to the one used in RCA's CA3130 but with the added features of internal compensation and high supply-voltage operation. The latter permits operation from 4 to 44 volts, dual or single supply.

According to RCA, the addition of bipolar diodes protects the input so effectively that, under simulated electrostatic conditions up to 1,000 volts, the CA3140 proved to be more rugged than any other device, including bipolar and J-FET-input op amps. Performance features for the CA3140 include: very high input impedance of 1.5 teraohms, typically; very low input current of 10 picoamperes at ±15 V, typically; low input-offset voltage of 5 millivolts, typically; wide common-mode input voltage range, −0.5 V below negative rail; and output swing to within 0.2 V of negative supply.

Applications include comparators, active filters, peak detectors, sample-and-hold amplifiers, tone controls, function generators, power supplies, portable instruments, long-duration timers and multivibrators, photocurrent instrumentation, ground-referenced single-supply amplifiers in automobiles and portable instrumentation, and operation in TTL systems. Prices range from 52 cents to $9.95 each, depending on whether they are standard, premium, or 100%-tested premium types.

RCA Solid State Division, Box 3200, Somerville, N.J. 08876 [412]

Voltage reference acts also as monolithic thermometer

Monolithic voltage references that are adjustable are invading the marketplace in increasing numbers [*Electronics*, Dec. 25, 1975, p. 94],

THE MATCHMAKER

Telefile introduces the only disk system flexible enough to match any minicomputer with any of the hot, new 3330-type drives. Big disk storage at a mini price.

Telefile now has available the most flexible large capacity disk system for minicomputers on the market today. The Matchmaker. It comes two ways:

As a disk system for users (DS-16-C) where we match your minicomputer with *any* of the latest 3330-type technology drives you want. Telefile supplies the complete package.

As an OEM disk controller. You can order just controllers alone (DC-16-C) and mix and match minicomputers and drives to satisfy your customer's whims and storage requirements.

Either way, disk system or controllers alone, you are assured of flexibility, performance features, and price no one else can match.

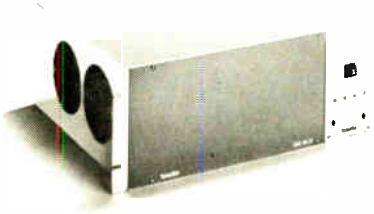
Each system stores up to 1.2 billion bytes.

You can match just the right drives to meet your storage capacity needs all the way from *13.3 million to 1.2 billion bytes per controller.* Each DC-16-C Matchmaker controller handles up to four drives. Minicomputers never had it so good.

Choose any of the latest drives.

You've seen them announced one-by-one and they're coming on strong. CalComp's Trident. Control Data's Storage Module. Diablo's 400 Series. The Ampex 9000's and Memorex 677's. Each builds upon IBM 3330 technology, which means higher storage densities and new circuitry for superior reliability.

To switch drives, simply change one controller circuit board. We've timed it at 63 seconds flat!



Compatible interfaces to eleven minicomputers.

We're designing a complete line of compatible interface boards to match up to many minis: Data General, DEC, Interdata, Keronix, D.C.C., Microdata, Honeywell, Lockheed, H-P, Varian, and Cincinnati Milacron. Simply fit our tailor-made computer interface module inside your computer chassis and you're in business. If you have another type mini, we'd be glad to design one for you.

Or you can design your own interface.

Your designers may want a piece of the action. Our general interface board makes it easy. Your board will tie in directly, bringing big disk storage to *any* 16-bit minicomputer.

A controller so small you can even hide it.

The Matchmaker is our smallest controller yet. It is totally self-contained right down to its power supply and cooling system. It's small enough to tuck away in a drive housing or in a rack above, below, or even *behind* the computer. Out of sight.

We'll even make you a faceplate.

If you want to show the Matchmaker off, we'll make a bezel to match your computer panel. Private label it and call it yours. There's no end to the flexibility.

Easy "front door" maintenance.

Five circuit boards slip right in from the front of the DC-16-C Matchmaker. A disk interface board, a general interface board, a command/timing board, a memory/address board, and an optional maintenance board for offline disk pack formatting and test exercising.

Unmatched features

- Contains 512-byte buffer for data rate matching
- Variable data search and read
- Block transfer of data up to mini-addressing capacity
- Offset positioning and data strobe controls
- Write protection to the sector level
- Sequential or staggered sector addressing
- Defective track relocation and alternate track addressing
- Overlapping seek capability
- Multi-sector operations across head and cylinder boundaries

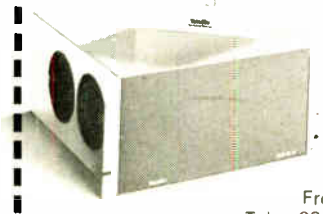
We wrote the book on disk controllers, and you can get it free.

For years, we've helped minicomputer users grow their disk capacities. Now our Matchmaker system is a quantum leap forward. A new in-depth, hot-off-the-presses Matchmaker technical manual gives you all the facts. Write for it. Prove to yourself that this is one disk controller no one else can match.

Telefile

Turning minis into maxis with moxie

THE MATCHMAKER



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Circle 195 on reader service card

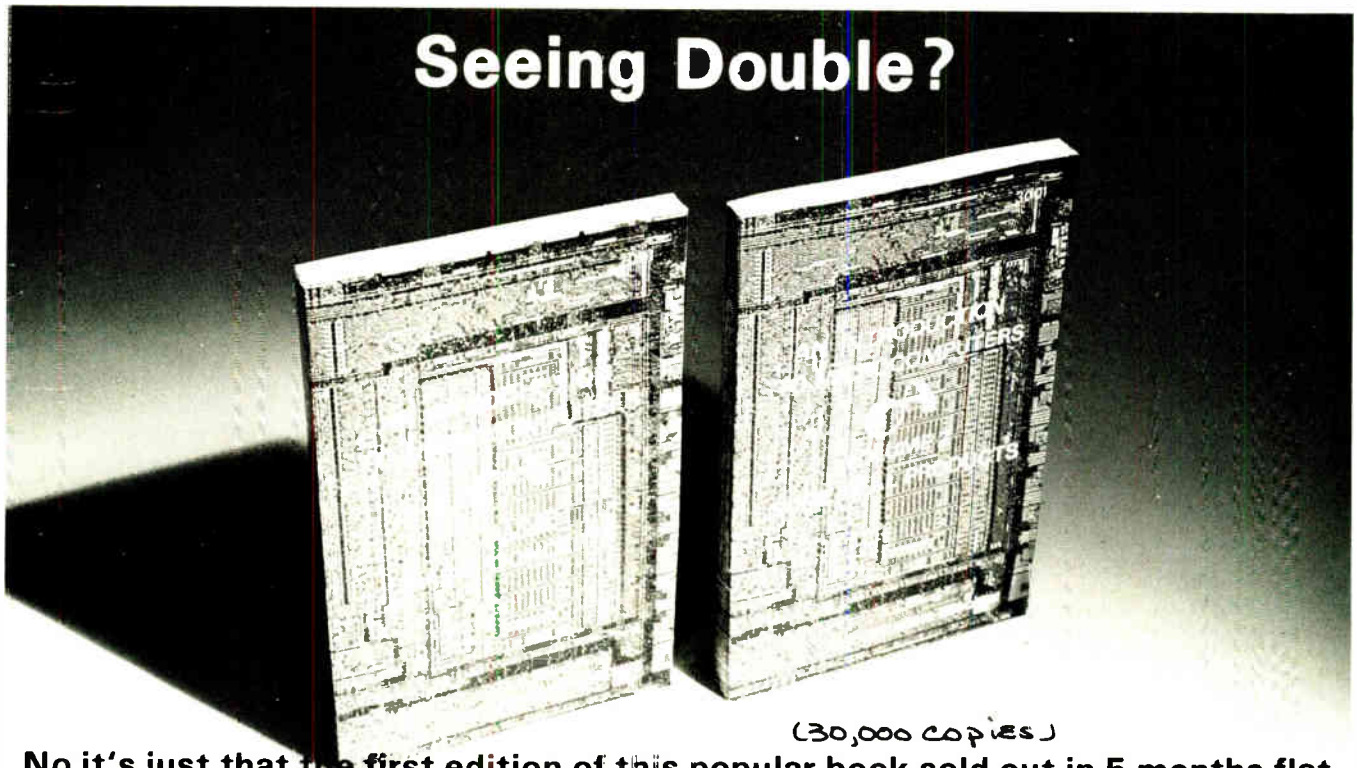
New products

and among the latest is a type that can operate also as regulator and thermometer. The REF-02 series provides a stable +5-volt output that can be adjusted over a ±6% range with minimal effect on temperature stability, which is 3 ppm/°C. The REF-02 can be used as a 5-v, 4-ampere regulator. In addition, the device has a temperature-transducer output pin, and the output voltage here is linearly proportional to the package temperature within a few 10ths of a percent, effectively permitting the unit to operate as a monolithic thermometer. A special bandgap design permits single-supply operation of the REF-02 over an input voltage range of 7 v to 40 v and a low current drain of 1 milliampere. Low cost, low noise (10 microvolts peak to peak), and low power (15 milliwatts) make the device suitable as a stable reference in portable instruments, digital voltmeters, and analog-to-digital and digital-to-analog converters. Prices range from $1.90 to $22 each, depending on specifications, for 100-999 pieces.

Precision Monolithics Inc., 1500 Space Park Dr., Santa Clara, Calif. 95050 [413]

Ultrasonic sonar system fits on a single chip

Just about all the components needed for an ultrasonic sonar system, not counting the transducer and the display, are included in the LM1812 transceiver. The novel monolithic circuit includes a 12-watt transmitter and a selective receiver that contains a 10-watt display driver. Operating from a 12-volt battery, the IC delivers pulses of about 200 kilohertz for a duration of about 800 microseconds to an external transducer and then listens for an echo. A particular feature of the device is that it does not need alignment with the transducer. Furthermore, the ultrasonic section prevents mode-hopping of the transducer so that, in a complete system, transducers can be interchanged without problem. Housed



(30,000 copies)

No it's just that the first edition of this popular book sold out in 5 months flat.

The second edition of AN INTRODUCTION TO MICROCOMPUTERS has been revised and expanded to two volumes, to keep up with the fast-moving microcomputer industry's pace of change.

Have things changed that much in just 5 months? You probably know the answer to that already: a flood of new and second-source CPU chips and a whole host of new LSI support packages. Nowhere else can you get all this vital information. VOLUME I — BASIC CONCEPTS surveys the subject, from elementary concepts to system configuration and design. In VOLUME II — SOME REAL PRODUCTS we take a long, hard look at the products available today and about to be announced tomorrow. If you're actually putting together your first system, you may find some help in the latest addition to the microcomputer library: 8080 PROGRAMMING FOR LOGIC DESIGN.

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VOLUME I — BASIC CONCEPTS, takes you by the hand, from elementary logic and simple binary arithmetic through the concepts which are shared by all microcomputers. It tells you how to take an idea that may need a microcomputer and create a product that uses one. This book is complete — every aspect of microcomputers is covered: the logic devices that constitute a microcomputer system; communicating with external logic via interrupts, direct memory access, and serial or parallel I/O; microprogramming and macroprogramming; assemblers and assembler directives; linking and relocation — everything you need to know if you are going to select or use a microcomputer. Volume I is equivalent to Chapters 1 through 6 of **AN INTRODUCTION TO MICROCOMPUTERS,** first edition, but with extensive new sections on chip slice products and serial I/O. Order publication number 2001. Date available: May 31, 1976.

VOLUME II — SOME REAL PRODUCTS, covers real microcomputers, in considerable detail. Every major microcomputer: 4-bit, 8-bit or 16-bit, is described, including some soon to be announced products. Major chip slice products are also covered. More than 20 microcomputers in all. Order publication number 3001. Date available: July 15, 1976.

8080 PROGRAMMING FOR LOGIC DESIGN, is a completely new book on a totally new subject: implementing digital and combinatorial logic using assembly language within an 8080 microcomputer system. What happens to fan-in and fan-out? How do you implement a one-shot? This book simulates well known digital logic devices using assembly language; next it shows you how to simulate an entire schematic, device by device, keeping the assembly language simulation as close to the digital logic as possible. But that is the wrong way to use a microcomputer; the book explains why, then shows you the correct way. This book describes the meeting ground of programmer and logic designer; it is written for both readers. Order publication number 4001. Date available: June 15, 1976.

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New products

in an 18-pin plastic DIP, the LM1812 sells for $12 in hundreds.
National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051. Phone Rick Joy at (408) 732-5000 Ext. 6381 [414]

IC multiplier can generate 32-bit word every 300 ns

Built for military and commercial high-speed processing applications, a monolithic 16-bit large-scale integrated circuit from TRW Inc. can perform a complete double-precision 16-by-16-bit parallel multiplication in 300 nanoseconds or less. The circuit contains more than 18,000 components on a silicon chip about ¼ inch square. The circuit can multiply two 16-bit words to generate a 32-bit word (double-precision). Inputs and outputs are fully TTL-compatible. The outputs have three-state control. A single 5-volt power supply is used. Emitter-follower logic is adopted internally because of its high speed and very low power consumption—1.4 milliwatts per gate. The 16-by-16-bit multiplier is expected to sell for about $250 in small quantities when production models are ready for the market near the end of 1976.
Defense and Space Systems Group, TRW Inc., One Space Park, Redondo Beach, Calif. 90278.

Zinc oxide varistor disks protect against transients

Eliminating the need to overspecify semiconductors or to install protection circuits in many applications, a line of zinc oxide varistor disks, series V94, protects vital circuitry or semiconductors from voltage/current spikes or turn-on transients on the supply line. The disks are easy to install across main power sources carrying rms voltages from 55 to 415 volts, with no circuitry change in most applications. They are available in a selection of 11 sizes. The disks are used extensively in contact

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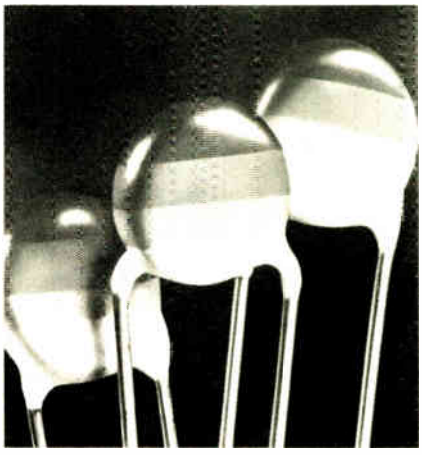
Circle 199 on reader service card

Circle 264 on reader service card

New products



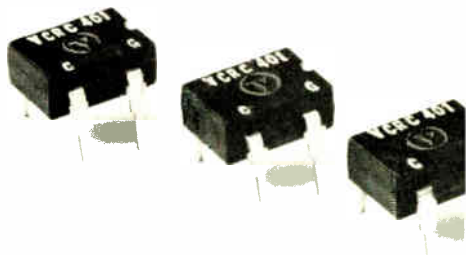
arc protection and transient suppression, in protecting solid-state relays, reducing lightning effects, and in inductive and transformer switching circuits.

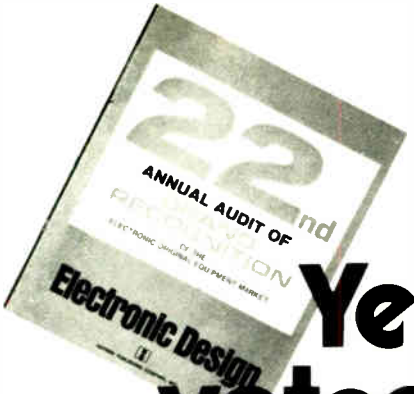
Mepco Electra Inc., A North American Philips Co., Columbia Rd., Morristown, N.J. 07960 [416]

SCRs come in miniature low-profile four-pin DIPs

Designed to simplify the layout of printed-circuit boards and to be compatible with automatic handling, testing, and insertion equipment, a line of SCRs developed by Varo Semiconductor comes in low-profile four-pin DIPs. The VCRC series has 200-, 300-, 400- and 600-volt ratings at 1.5 amperes. The gate-trigger current is 15 milliamperes. Principal applications are in power switching, power control, and ignition. Two of the devices will fit into a standard 14-pin socket.

Varo Semiconductor Inc., P.O. Box 676, 1000 N. Shiloh, Garland, Texas 75040 Phone (214) 272-4551 [417]





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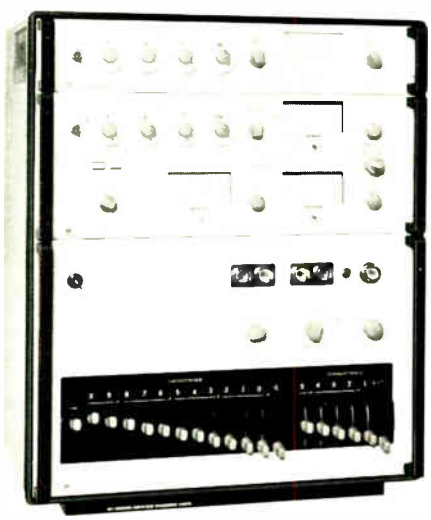

Precision Bridges

This line of products typically find their greatest use in standards labs, where scientists and engineers push the state-of-the-art in measuring electrical parameters. The 1621 Precision Capacitance-Measurement System shown here is capable of measuring capacitance in increments as small as 0.1 attofarads (10^{-1} pF).

Manual Bridges

Shown here is the 1650-B Impedance Bridge, probably the most popular bridge in use today.

RLC Standards

No bridge is complete without a standard and the GR 1408 Reference Standard Capacitor shown here is just one of dozens available from GR.

Automatic Bridges

GR introduced its first automatic bridge at the WESCON show in 1964. Several other models have followed since, with the 1686 Digital Capacitance Meter shown here being the latest addition to the product line.

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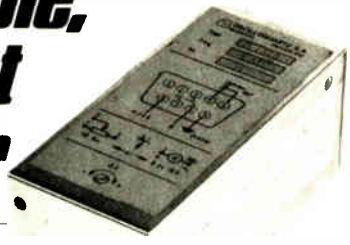

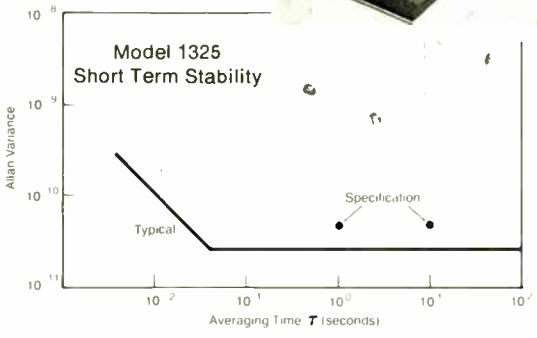

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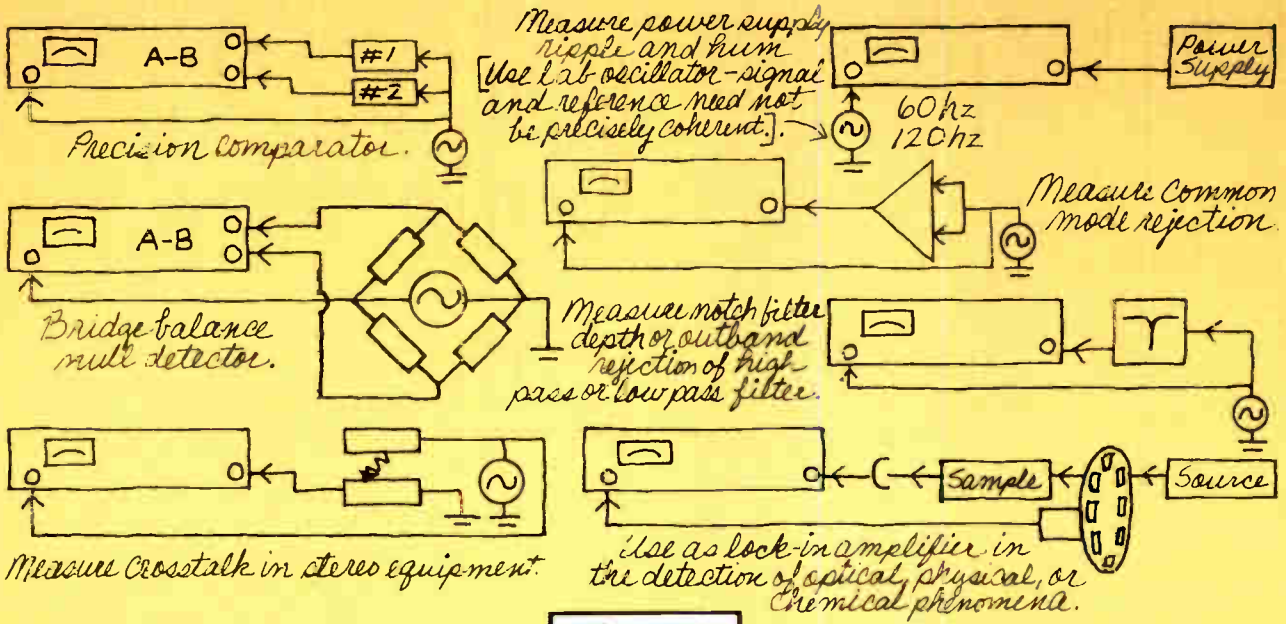
For further information or to arrange a demonstration, contact John Hanson at Ithaca, Box 818E, Ithaca, New York 14850. (607) 272-7640. TWX 510-255-9307.



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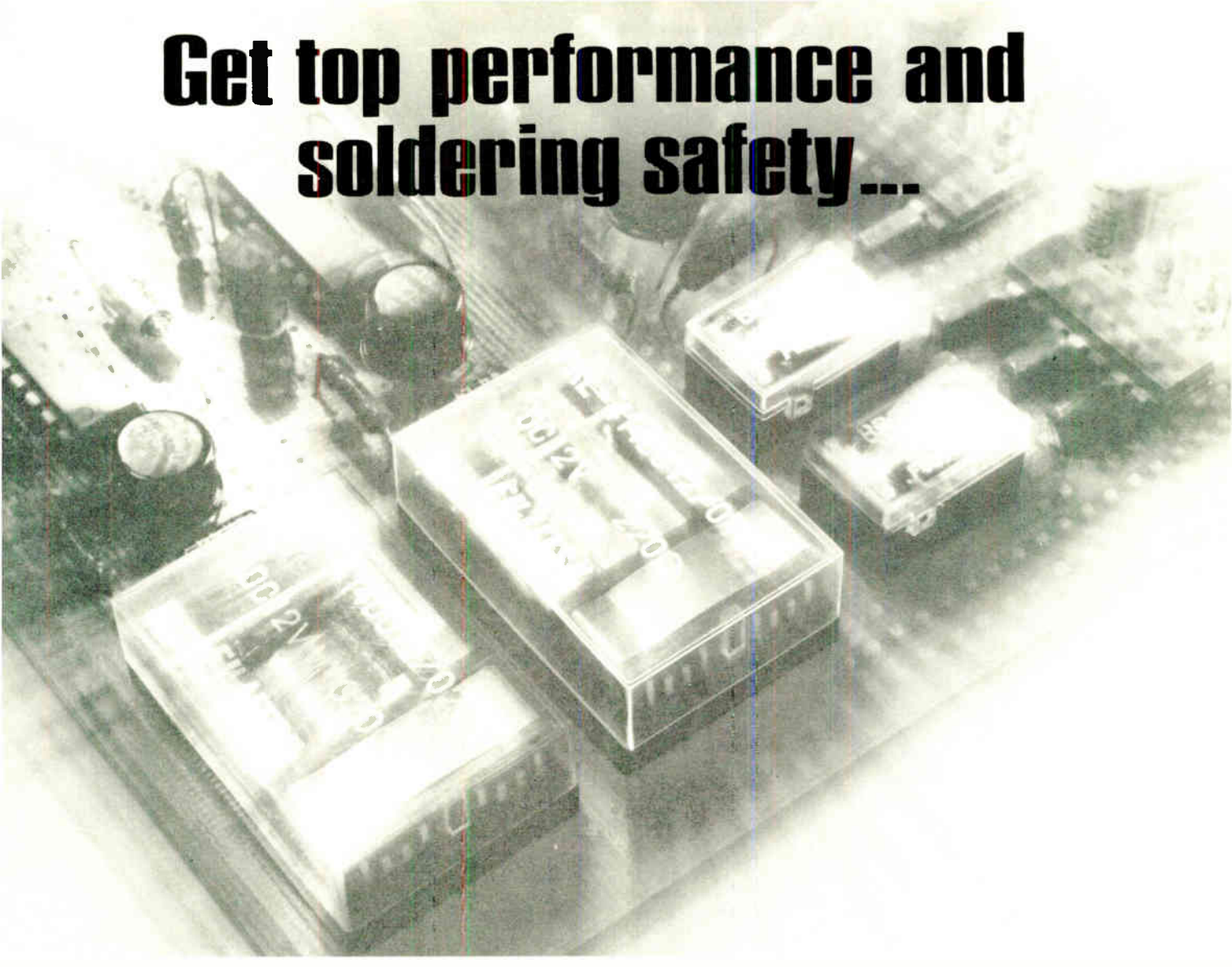

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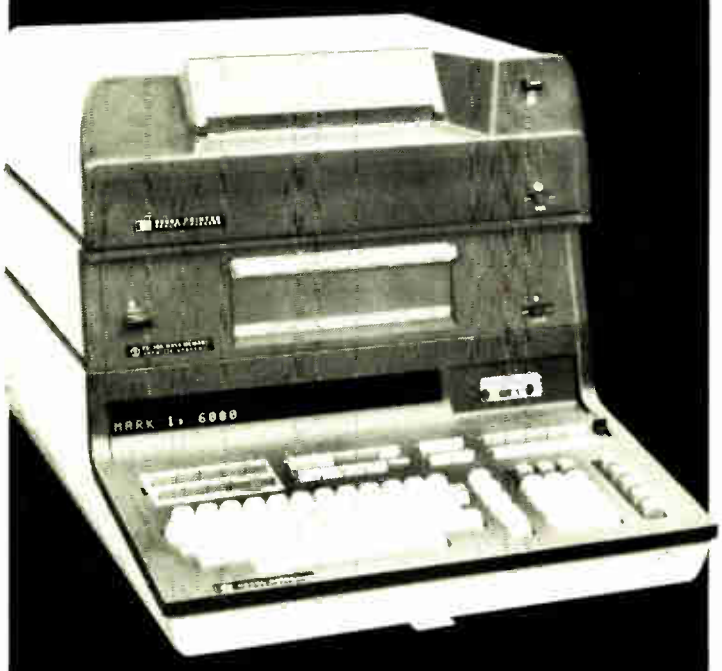

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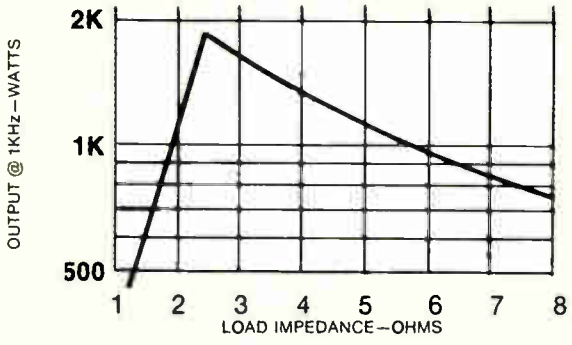

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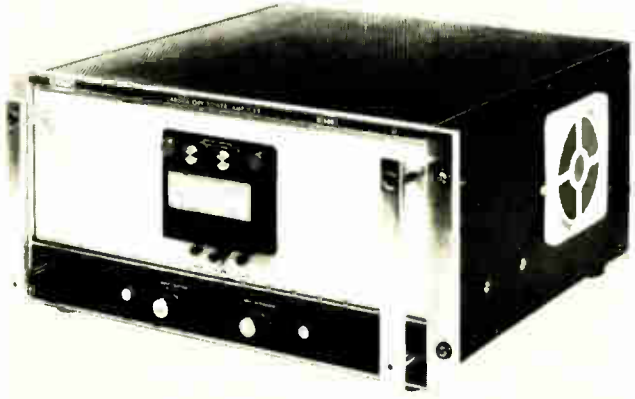

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Subassemblies

Analog Devices in new market

Company's data-acquisition entry is low in speed, cost; firm sees price dips coming

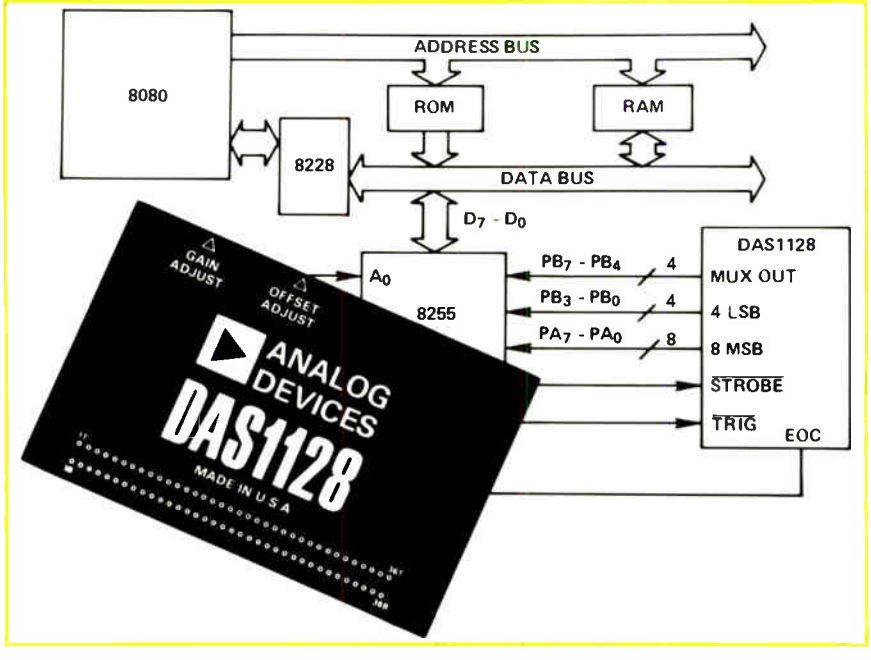
Introduction of a 12-bit data acquisition system by the modular instrumentation division of Analog Devices Inc. marks the company's first foray into that market. The DAS 1128 is a second-source product, essentially matching Analogic's MP 6912 unit in form, fit and function—but not in speed.

James O. Fishbeck, the division's marketing manager for modular converters, says the firm chose not to compete with the 6912's 100-kilohertz throughput rate because the market for modular systems with that speed is smaller than the market for the DAS1128's 50-kHz throughput. "The industrial and microprocessor-based markets that we're interested in don't appear to need that throughput rate," Fishbeck maintains.

The DAS1128 measures 3 by 4 by 0.375 inches. In size and pinouts, it's an alternate both to the 6912 and to products introduced earlier by Burr-Brown Research Corp. and Data Translation Inc., among others. "This market is just emerging," Fishbeck points out, "and prices are starting to come down. For those reasons, and because of our established name in data converters, we feel we can jump in a bit late but at a lower price than some of the other products." The DAS1128 is priced at $295 in 1–9 quantities.

The new entry provides everything required for multichannel high-speed data acquisition, including scanning, analog-to-digital conversion, programing, control and timing. It incorporates a 15-microsecond analog-to-digital converter, sample-and-hold amplifier, precision reference, high-stability buffer amplifier, and a 16-channel multiplexer. It employs an integrated-circuit successive-approximation register for the a-d conversion, and Analog Devices' own AD562 12-bit d-a converter chip.

Key specifications include a nonlinearity temperature coefficient of 2.5 parts per million per degree C, an 8 ppm/ C gain tempco for stability, and relative accuracy within ±0.012% of full-scale range at a 33-Hz throughput. The unit is available



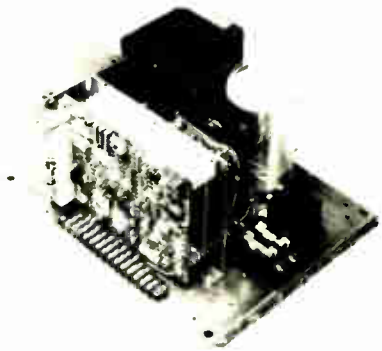
from stock, the company says.
Analog Devices Inc., P.O. Box 280, Route One Industrial Park, Norwood, Mass. 02062. Phone Lowell Wickersham at (617) 329-4700 [381]

Economy supplies offer automatic protection

A Black Knight line has been added to the economy series of power supplies from Adtech Power Inc. Operating from 115/230 volts, 47–120 hertz ac line, these units are available in ratings of 5 volts at 10 amperes, 12 V at 7 A, 15 V at 6 A, 24 V at 5 A, and 28 V at 4 A. Voltage adjustment is ±5%, and the units are regulated ±0.1% for line and load. Ripple of the units is 1 mV rms. Protection features include automatic foldback current-limiting overload and short-circuit protection, IC regulator protection, reverse polarity protection, and inductive load protection. An overvoltage protection crowbar is available as an option. Prices are $67 each for one and $54.05 each for hundreds.
Adtech Power Inc., 1621 S. Sinclair St. Anaheim, Calif. 92806. Phone George W. Mousel at (714) 634-9211 [383]

Amplifiers drive dc servo motors up to 1½ horsepower

Servo amplifiers, called the A6421 Saturn series, are designed for full four-quadrant operation in driving all types of dc servo motors with ratings up to 1½ horsepower. The servo amplifier has no dead band and



provides a true linear output. The high energy-storing reservoir of capacitors is capable of providing a proportional current output up to ±28 amperes and a voltage up to ±85 V dc. Two of the latest in the A6421 series are the A6421-9A, which operates from 120 or 240 V ac single-phase power; and the 9B, which operates from 240 or 480 V ac three-phase power. Both include power supplies, a preamplifier, and a compensation circuit. The A6421 series is designed for both speed control and position control in

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You can get these synchros in the following Bu/weps types:

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	26V 11CT4d
	11CT4E

We'll be happy to send you drawings and technical details on request. Also for Kearfott Size 5 Bu/weps CX, CDX and CT units, and Size 11 and 15 resolvers. Units with the same characteristics but different Bu/weps shaft variations are also available. Write for information to the Singer Company, Kearfott Division, 1150 McBride Avenue, Little Falls, N.J. 07424.

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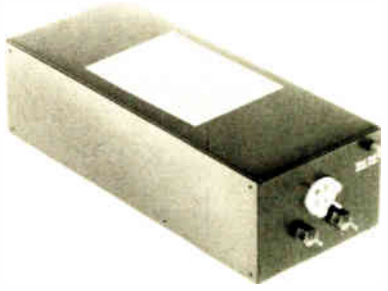
many industrial system applications. Westamp Inc., 1542 15th St., Santa Monica, Calif. 90404. Phone Jim Manda at (213) 393-0401 [384]

Switching regulated supply operates over military range

A high-efficiency series of power modules converts 115 volts ac, 400-hertz power to 50 watts of regulated dc power at voltages ranging from 5 to 50 V dc. According to the maker, Abbott Transistor Laboratories, the UN series is one of the few switching regulated supplies capable of operating over the full military range of −55° to +100° C. The modules regulate dc input voltages to 0.3% over their full input range of 115 V rms ±10%. Load regulation is 0.5% for no load to full load at constant input voltage. Ripple and



noise has been kept to 25 V rms, 100 mV peak to peak, over the range from 25° to 100° C, and other features include full rated output current from −55° to 85° C, derated to 80% of full-load rating at 100° C (baseplate temperature). Temperature coefficient is specified at 0.03%/° C maximum. The UN series is fully encapsulated and hermetically sealed. Price is $425.

Abbott Transistor Laboratories Inc., 5200 W. Jefferson Blvd., Los Angeles, Calif. 90016. Phone (213) 936-8185 [385]

Frequency error held under ±0.05% in v-f converter

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voltage-to-frequency converter offers pin-for-pin compatibility with many widely used v-f converters. The company also guarantees a full-scale frequency error of less than ±0.05%, plus a zero error of only 10 millivolts that may be trimmed to zero. The 4725 is expected to have applications in highly cost-sensitive applications such as analog-to-digital converion, and in motor speed control. Unit price is $29.50.

Teledyne Philbrick, Allied Drive at Rte. 128, Dedham, Mass. 02026. Phone Frank Goodenough at (617) 329-1600 [386]

Digital clock module includes power supply

A complete digital clock system from Fairchild, called the FCS8100, contains an MOS circuit, a display with alarm-set indicators, and a colon in a solid-state module that measures only 3.5 by 1.75 inches and is 1-in. thick. The module incorporates power supply and output drive circuitry for alarm and clock-radio operation. Only switches required by the application and a transformer with a 1.6-volt center-tapped secondary are needed to turn the unit into a functioning clock. Price of the clock module is

New products

$12 for quantities of 1,000.

Similar 0.8-inch-high clock displays also are available in either 3½- or 4-digit formats. They are priced at $5.60 to $6.25 each in 1,000-lots.

Optoelectronics Division, Fairchild Camera and Instrument Corp., 4001 Miranda Ave., Palo Alto, Calif. 94304 [387]

Two dc-to-dc converters run from 48-volt dc source

Designed for use in the telephone industry and in systems powered by a 48-volt common bus, two 110-watt switching-regulated dc-to-dc converters operate from a 48-v dc source. Both are off-the-shelf models; one has a triple output and the other, a single output.

Model 61315D offers three outputs of 4.75 to 5.25 v, 11.4 to 15.75 v, and −11.4 to −15.75 v. The 5-v output is controlled by the main switching regulator and the ±12- to ±15-volt outputs are series-regulated independently. The 110-watt maximum output power may be shared among the three outputs within current ratings of each individual supply, making current available where it is needed. The single-output converter, model 61005C, has an output of 4.75 to 5.25 v.

Both compact, convection-cooled models use an advanced 20-kilohertz transistor-switching design that minimizes radiated and conducted interference. Input voltage may range from 42 to 56 v dc for continuous operation.

Price of the model 61315D is $525; of the 61005C, $400. OEM and quantity discounts are available. Estimated delivery time is two weeks.

Inquiries Manager, Hewlett-Packard Company, 1501 Page Mill Road, Palo Alto, Calif. 94304 [388]

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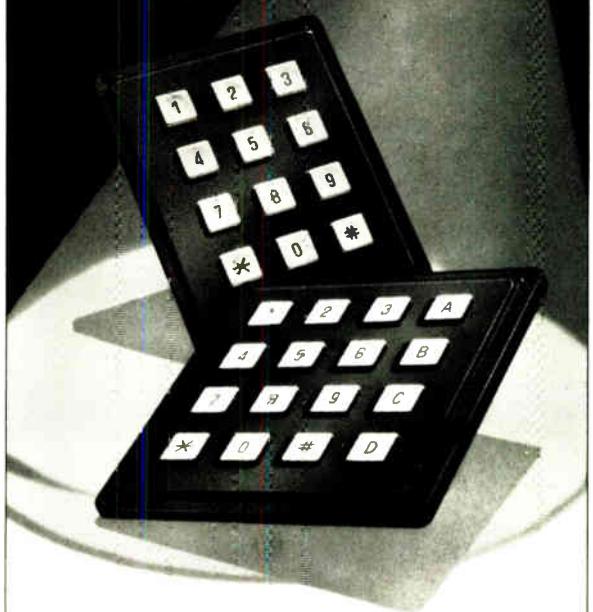

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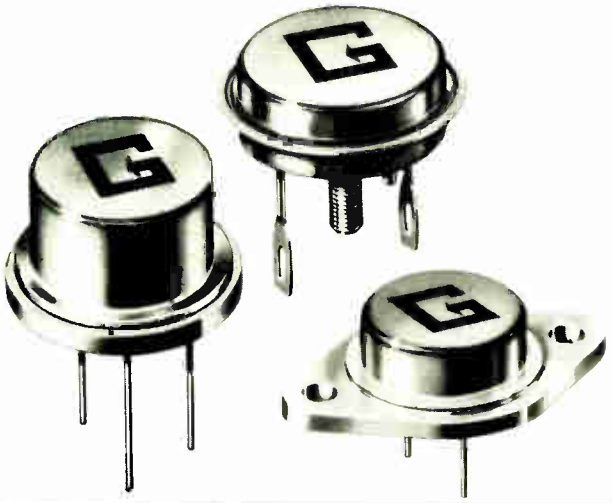

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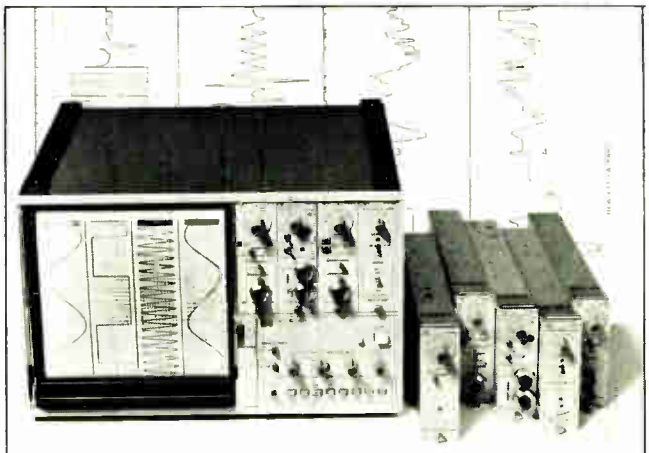

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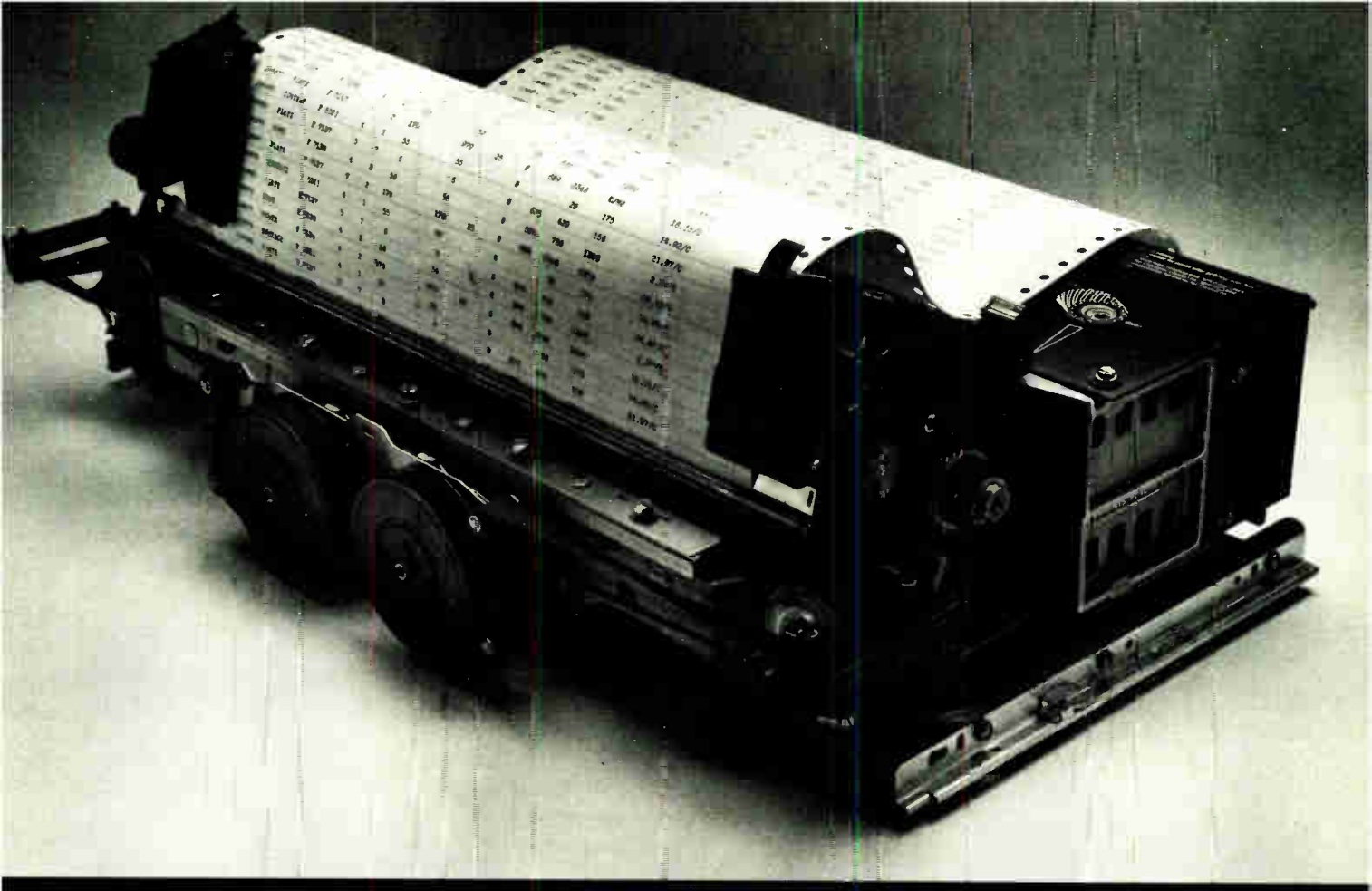

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We'd be ahead if we just stopped there, but the model 40 also offers you a number of other features. Like a choice of character sets, operator-adjustable form width and form length, parity error indication, and a built-in self-test feature, just to name a few.

For complete information, please contact our Sales Headquarters at: 5555 Touhy Ave., Skokie, Ill. 60076. Or call Terminal Central at: (312) 982-2000.

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Circle 217 on reader service card

New products/materials

Thermosets, plastic materials that undergo a chemical reaction when heated and take on a permanent shape, are used throughout the electronics industry for molding dual and single in-line components with epoxy, silicone and polyester coatings. Usually these materials are available in a two-part blended solid or powdered form. A novel one-component thermoset liquid resin molding process has been developed by Hi-Tech Industries for low-viscosity, low-pressure and fast-cycle electronic encapsulation. With the new process, polyester and epoxy DIP packages have been molded on metal lead frames in 18 seconds as against the three minutes needed to mold the same devices with conventional epoxy.

A patented nozzle design, together with specially formulated resins, are used in the new process. The new nozzle insulates the precatalyzed one-component resin system from the heat of the mold. Five one-part liquid polyester resins are available from Hi-Tech with physical properties for a variety of electronic applications. Tensile strengths of the liquid resin materials range from 1,160 to 5,870 psi. One of the new resins, Hi-Tech 4000, is already being successfully used by Unitrode Corp. of Methuen, Mass. as an encapsulant for 50- to 1,000-volt, 1-ampere silicon rectifiers which meet MIL-STD-750 and MIL-STD-202.

The new Hi-Tech materials are readily adaptable to most transfer- and compression-molding presses. The process eliminates resin pretreatment and reduces precuring. Hi-Tech and an outside firm are developing an adapter to modify existing molding machines to the new process for about $7500.

Hi-Tech Industries, Inc., 180-08 Liberty Ave., Jamaica, NY 11433 [476]

A new family of high-strength liquid composites combines the low viscosity and ease of handling of silicones with the high tensile and tear strengths associated with organic polymers. The materials from SWS Silicones Corp. are known as Silgan

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Using articles from the pages of Electronics, this book contains practical and up-to-date information on available microprocessor devices, technology and applications— ranging from the simplest 4-bit p-channel MOS system to the second-generation n-MOS 8-bit processor chips, and the new injection logic and Schottky TTL bipolar processor families needed for the toughest computer-based control applications.

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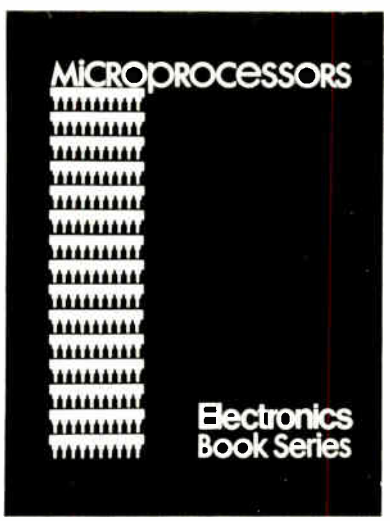

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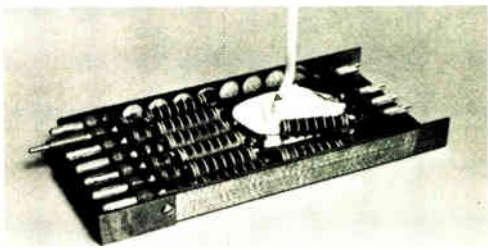

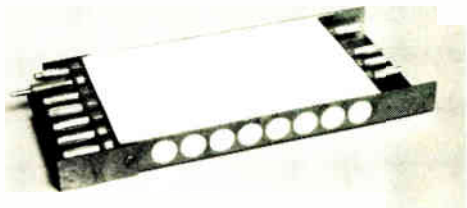

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SWS Silicones Corp., Adrian, Michigan 49221 [477]

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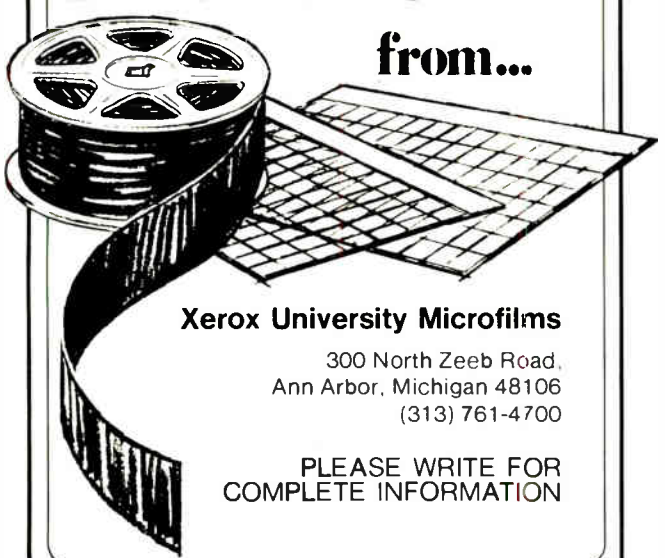

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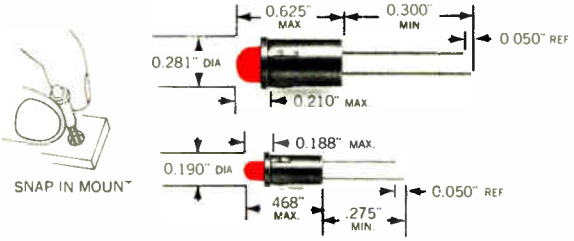

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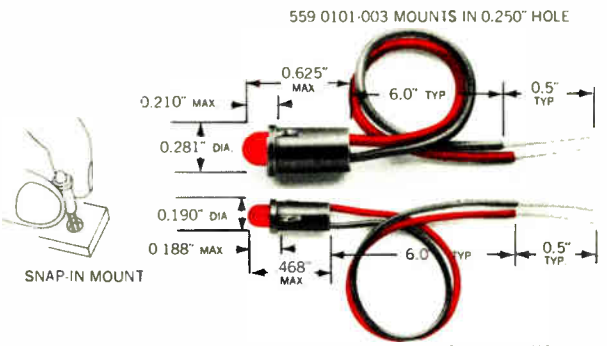

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Circle 221 on reader service card

Introduction to Microcomputers and Microprocessors, Arpad Barna and Dan I. Porat, Wiley-Interscience, 108 pp., $10.50.

If you're starting from zero so far as a knowledge of microprocessors is concerned, you could do worse than invest $10.50 in this book. It won't take you very far into the details of design, but it will provide a foundation from which to attack the manufacturer's detailed literature or the many articles now appearing in technical magazines.

From one point of view, the book is just a glossary of terms, arranged according to subject and stitched together to form a running text. After all, it's only 108 pages long, so you can't get much more than a quick runthrough on any one aspect of microprocessors. Nevertheless, what's there is clearly written and should be easily understood by anyone with a technical background.

For example, Chapter 3 covers basic programing techniques in nine pages. In that nine pages, the authors deal with the following topics: machine-language instructions, basic instruction sets, assembly-language instructions, macroinstructions, higher-level languages, subroutines, and flow charts. The individual treatment of each of these topics is therefore little more than an extended definition. But the authors do get to the kernel of each topic and explain it clearly.

Other chapters outline the basic structure of microprocessors, input and output, arithmetic operations, arithmetic and logic circuits, main memory, control units, and miscellaneous software topics. Each chapter concludes with a set of problems for use in a self-study program.

The book is rather light on references to other material, citing only six other titles. But anyone involved in electronics today can hardly miss the mass of material now appearing on microprocessors and could easily assemble his own file of articles.

Handbook of Circuit Analysis Languages and Techniques, Randall W. Jackson and Lawrence P. McNamee, eds., Prentice-Hall, 809 pp., $34.50

This book is actually a series of boiled-down user's manuals for the following circuit-analysis programs: Astap, Belac, Circ, Circus 2, Ecap II, Lisa, Martha, Sceptre, and Syscap. But although its scope is limited—it covers only the nine programs—it is still an excellent work. The editors have done an admirable job with the material, even to supplying informative historical background where appropriate.

Most of the major circuit-analysis programs are included, and the editors devote an entire chapter to each program, giving a bird's eye view of what each one is all about and how each one works. This sort of treatment has a number of advantages. The reader can compare the capabilities of the programs, as well as how difficult or easy they are to use. There are also extensive reference lists for further reading.

For the novice, the book provides

a painless way of familiarizing himself with CAD. For the fellow who's already into CAD, the book enables him to quickly compare other programs with the one he's using.

Recently published

Physical Principles of Semiconductor Devices, Harry E. Talley and Don G. Daugherty, Iowa State University Press, 367 pp., $16.50.

Systems Engineering Methodology for Interdisciplinary Teams, A. Wayne Moore, Wiley-Interscience, 431 pp., $27.50.

Frequency Synthesizers: Theory and Design, V. Manassewitsch, Wiley-Interscience, 524 pp., $27.50.

Introduction to Logic and Switching Theory, Nripendra N. Biswas, Gordon and Breach Science Publishers, 354 pp., $29.50.

Communications Channels: Characterization and Behavior, Bernard Goldberg, ed., IEEE Press, 762 pp., $22.95.

Microwave Circuits and Amplifiers, P. Grivet, Academic Press, 749 pp., $79.50.

Modern Guide to Digital Logic: Processors, Memories, and Interfaces, Editors of United Technical Publications, Tab Books, 294 pp., $9.95, $6.95 (paper).

Modern Electronics Math, Jerrold R. Clifford and Martin Clifford, Tab Books, $12.95, $9.95 (paper).

Troubleshooting with the Dual-Trace Scope, Robert L. Goodman, Tab Books, 224 pp., $8.95, $5.95 (paper).

CBer's Handy Manual, Tab Books, 48 pp., $1.50 (paper).

CBer's Handy Atlas/Dictionary, Tab Books, 64 pp., $1.95 (paper).

CB Radio Schematic/Servicing Manuals, Vols. 1, 2, and 3, Tab Books, 200 pp. each, $8.95, $5.95 (paper) each.

Build Your Own Working Robot, David Heiserman, Tab Books, 238 pp., $8.95, $5.95 (paper).

TV Schematics: How to Read Between the Lines, Art Margolis, Tab Books, 252 pp., $8.95, $5.95 (paper).

Microelectronics, Clayton L. Hallmark, Tab Books, 266 pp., $8.95, $5.95 (paper).

The Electronic Battlefield, Paul Dickson, Indiana University Press, 244 pp., $10.00.

French-English Science and Technology Dictionary (fourth edition), Louis DeVries and Stanley Hochman, McGraw-Hill Book Co., 683 pp., $13.50.

Computer Circuit Analysis: Theory and Applications, Frank A. Ilardi, Prentice-Hall, 406 pp., $17.50.

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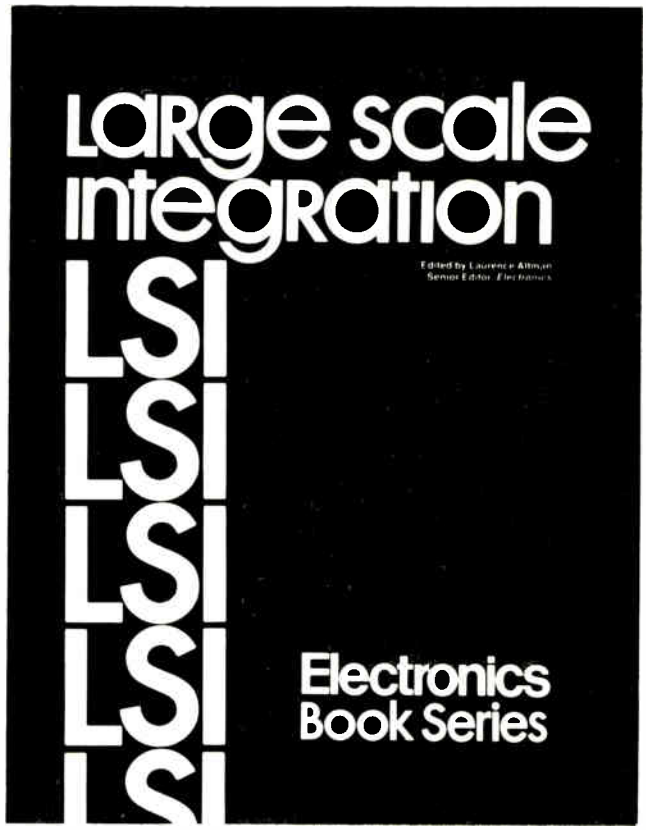

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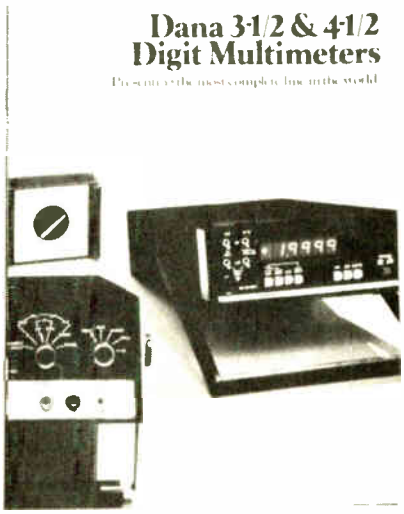

Multimeters. Dana's 4600 digital multimeter is highlighted in the company's 16-page color brochure on its line of 3½- and 4½-digit multimeters. A color-coded specification chart covering the line provides finger-tip access to equipment characteristics and comparative information. For copies of the brochure, write or call Mr. Chris Everett, Product Manager, Dana Laboratories Inc., 2401 Campus Dr., Irvine, Calif. 92713, phone (714) 833-1234. Or circle 421 on reader service card.

Error control. Introducing communications engineers to the principal features and benefits of error-control coding, a 12-page booklet contains both tutorial and product information. Forward error correction and error detection with automatic repeat request are compared according to application and channel and user requirements. Both block and convolutional encoders-decoders are described, with emphasis on the latter. Applications of error-control products to packet-switching networks are described. Linkabit Corp., 10453 Roselle St., University Industrial Park, San Diego, Calif. 92121 [422]

Resistors. Low-cost molded resistors, open wirewound types, sensors, cement boats, and vitreous enamel resistors are among the new developments listed in an expanded engi-

neering catalog on precision and power wirewound resistors. It is offered by RCL Electronics Division, AMF Inc., 195 McGregor St., Manchester, N.H. 03102. A new section of the catalog is devoted to RCL's Special Products division and includes engineering information on such diverse products as molded temperature connectors, bridge reference junctions, automotive temperature sensors, computer resistors, and chromel alumel reference networks. All dimensions are shown in both inches and millimeters. [423]

Busing devices. A 12-page design guide for multi-layer laminated busing devices assists the designer in preparing drawings for his busing system. Many design standards, suggestions, and specifications are included. Copies of the brochure are available from Bussco Engineering Inc., 119 Standard St., El Segundo, Calif. 90245 [424]

Flexible circuits. Fast-moving developments in the flexible-circuit industry are described in a 12-page color brochure from Buckbee-Mears. The brochure is designed to aid the engineer in creating the most efficient flexible circuitry for his specific applications. The design guide includes advice on circuit layout, conductor considerations complete with information on copper characteristics, various dielectric materials, and a description of the various manufacturing processes. Write to: Design Guide, Circuits Division, Buckbee-Mears Company, 245 E. Sixth St., St. Paul, Minn. [426]

New products

Remote multiplexing. Written for designers of data-acquisition systems, Burr-Brown's six-page application note AN-80, entitled "Remote Multiplexing," points out the advantages that multiplexing and digital transmission have over direct wiring and analog transmission. In comparing direct-wired analog transmission with digital multiplexing, the note discusses data quality and data integrity and gives a typical example as a basis for comparison of installation costs. Also detailed are the factors that must be weighed in installing remote multiplexing systems. These cover data integrity, touching on the effects of various network configurations and taking into account bandwidth considerations, error-detection techniques, and electrical isolation requirements. [425]

Soldering. A basic primer on the selection and use of solder has been prepared by the Solder Manufacturers Committee of the Lead Industries Association. The 16-page booklet recounts important solder applications in industry and suggests advantages of the process over alternative joining methods. The text also covers joint design, precleaning, surface preparation, and fluxing. Copies of the booklet may be obtained by writing to: LI Association Inc., Dept. A, 292 Madison Ave., New York N.Y. 10017 [427].

Photoelectric controls. Dozens of photoelectric applications for production and material-handling control are described in a 48-page handbook offered by Micro Switch, A Division of Honeywell, 11 W. Spring St., Freeport, Ill. 61032. The extensively illustrated booklet treats a variety of scanning, signal-conditioning, and electrical-output considerations. Nearly a third of the handbook is devoted to solutions of such problems as counting, height-monitoring, label-detection, translucent-object detection, penetration scanning, fill-level control, inspection, and prevention of conveyor jam-ups. [428]

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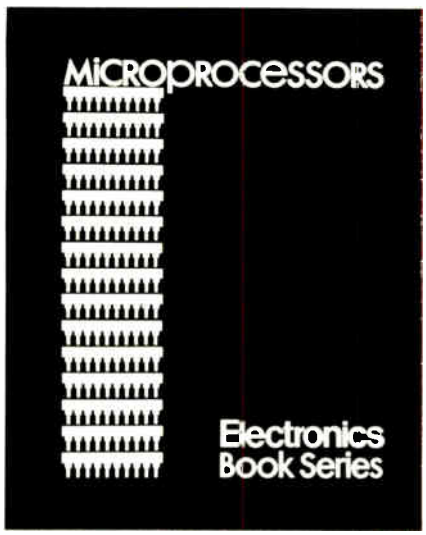

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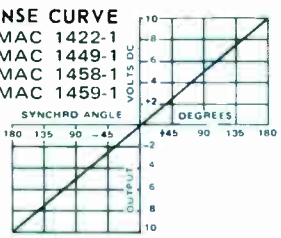

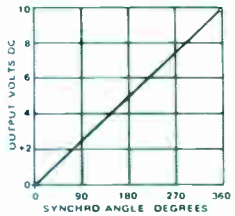

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MAC 1461-1

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  - Small size
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- Output short circuit protected
- Three wire inputs isolated from ground
- Package size may be altered at no extra cost
- Units can be altered to accept different line to line voltages or different operating frequencies at no extra cost
- Not affected by reference voltage or power supply variations.

UNIT	MAC 1422-1	MAC 1449-1	MAC 1458-1	MAC 1459-1	MAC 1460-1	MAC 1461-1
TRANSFER EQUATION	±IV/18°	±IV/18°	±IV/18°	±IV/18°	+IV/36°	+IV/36°
ACCURACY (+25°C)	½%	½%	½%	½%	½%	½%
ACCURACY (–25°C-+85°C)	1%	1%	1%	1%	1%	1%
L - L SYNCHRO INPUT (VRMS)	11.8	90	11.8	90	11.8	90
FREQUENCY (Hz)	400	400	60	60	400	400
FULL SCALE OUTPUT	±10V	±10V	±10V	±10V	+10V	+10V
OUTPUT IMPEDANCE	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω
L - L INPUT IMPEDANCE	>10K	>30K	>2K	>10K	>10K	>30K
REFERENCE VOLTAGE (VRMS)	26	115	26	115	26	115
OPERATING TEMP. °C	–25 - +85	–25 - +85	–25 - +85	–25 - +85	–25 - +85	–25 - +85
D.C. SUPPLY	±15V	±15V	±15V	±15V	±15V	±15V
D.C. SUPPLY CURRENT	±75MA	±75MA	±75MA	±75MA	±75MA	±75MA
BANDWIDTH	10Hz	10Hz	OPT.	OPT.	10Hz	10Hz
WEIGHT	6 oz.	6 oz.	6 oz.	8 oz.	6 oz.	6 oz.
SIZE	3.6x2.5x0.6	3.6x2.5x0.6	3.6x3.0x0.6	3.6x3.0x1.0	3.6x2.5x0.6	3.6x2.5x0.6

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Synchro Input: 90V RMS ± 5%LL 400Hz ± 5%
DC Power: ±15V DC ± 10% @ 50MA
Reference: 115VRMS ± 5% 400Hz ± 5%
Output: 10V DC full scale output on either channel @ 5ma load
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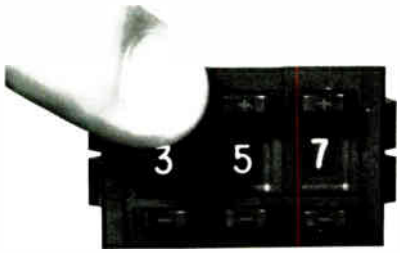

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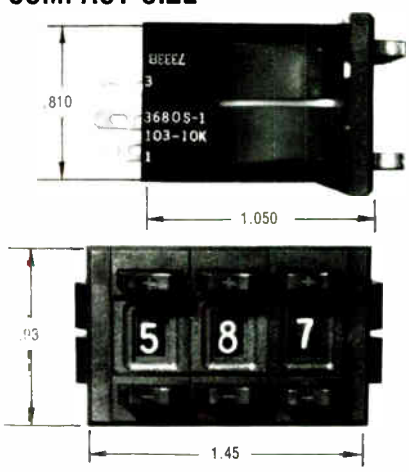

For more information, write or phone the "Panel Power People," **TRIMPOT PRODUCTS DIVISION,** BOURNS, INC., 1200 Columbia Avenue, Riverside, CA 92507. TWX 910 332-1252. Telephone: 714 781-5610.

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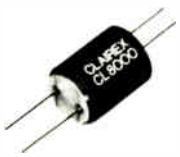

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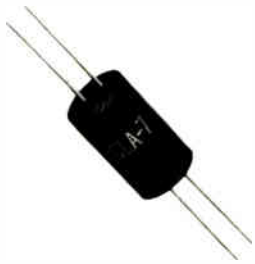

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