MAY 24, 1979

NCC PREVIEW: HOW COMPUTER BOOM SHAKES SOCIETY/175

New-generation in-circuit tester takes on digital LSI/ 153

Cellular system opens line to more mobile-phone connections/ 158

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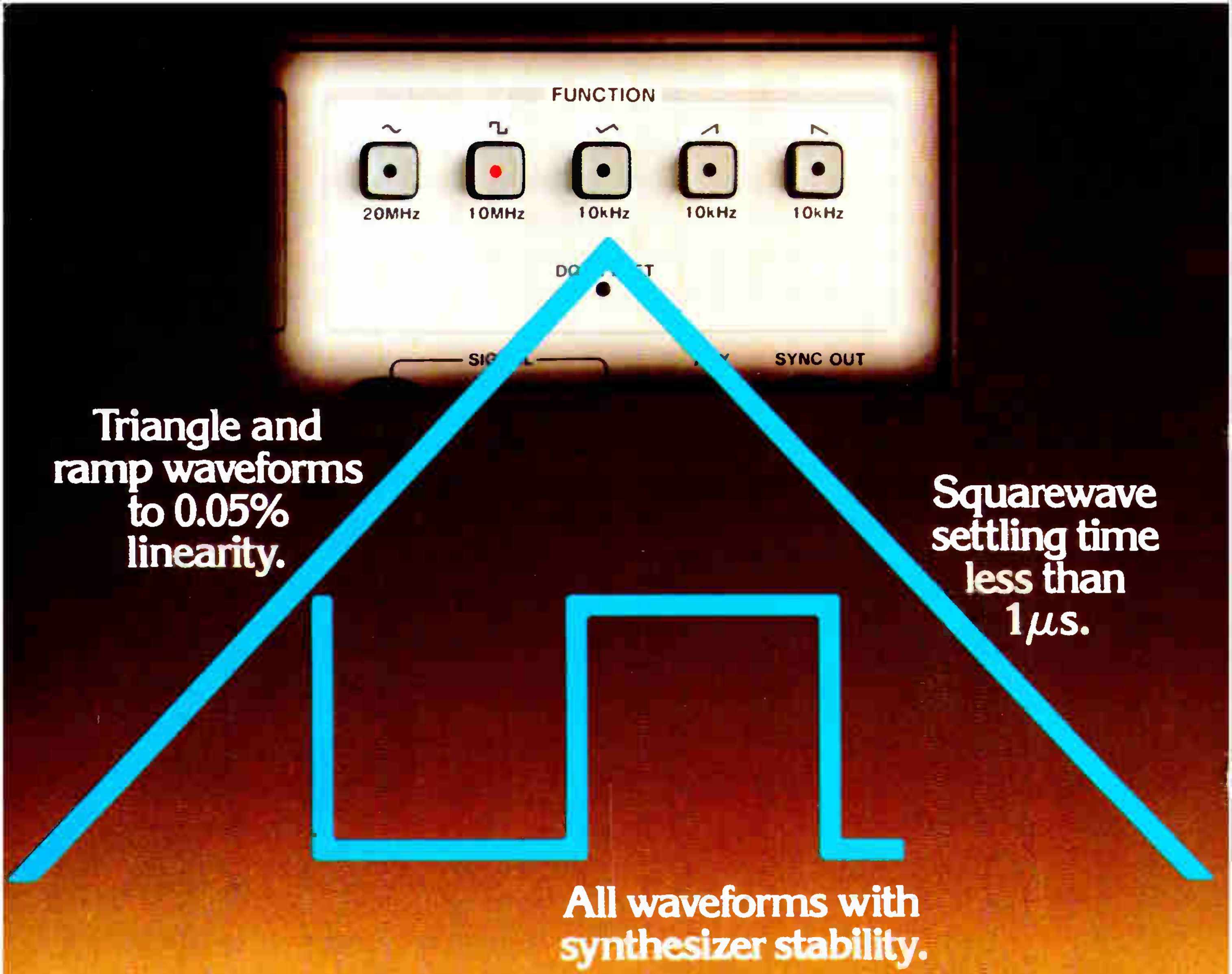

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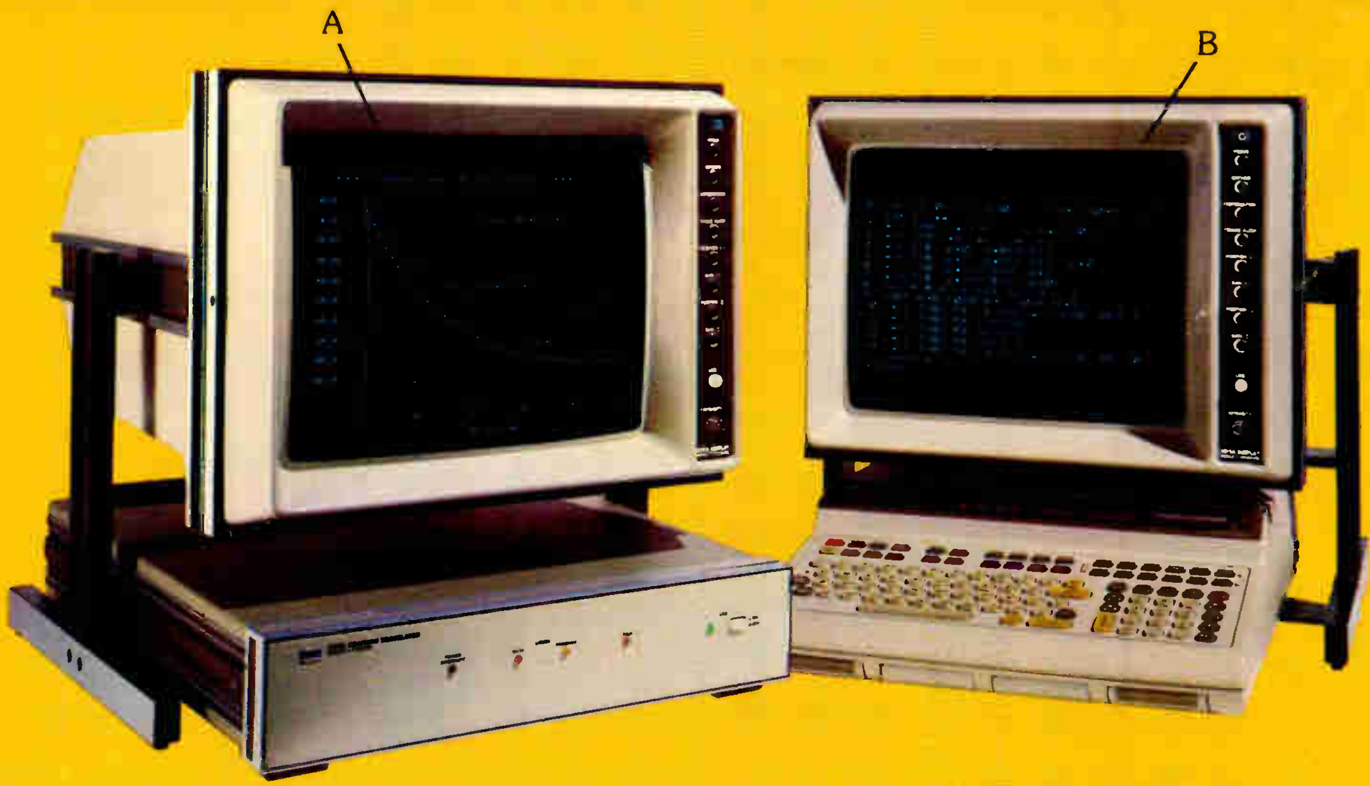

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088/12

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Electronics

The International Magazine of Electronics Technology

Vol. 52, No. 11 • May 24, 1979

Highlights

Cover: VLSI changes computer architecture, 111

Very large-scale integration is altering the hardware basis of computers. But to preserve the investment in software, the facade—the user interface—is for the most part being held constant, says this special report.

Cover is by Katrina Taylor.

Is there life in diffusion MOS yet? 88

Four Japanese companies are researching diffusion self-aligned MOS in the expectation of achieving submicrometer channel lengths with 2-or-more-micrometer photolithography.

Cellular setup reduces mobile-phone hangups, 158

Bell Laboratories' Advanced Mobile Phone Service uses decentralized, low-power transmitters and antennas to link calls made to or from cars to the regular phone lines. The same frequencies may be used by different transmitters, provided they are at a sufficient distance from one another.

NCC studies computers' impact on society, 175

Included among the more than 120 technical sessions at this year's National Computer Conference will be several aimed at providing people with a "greater consciousness of the social implications of the expanding use of computers," says NCC chairman Merlin G. Smith.

. . . and in the next issue

Putting Pascal to work . . . charge-coupled devices versus random-access memories . . . another in the codec series.

Electronics

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Publisher's letter

In a game of technological leapfrog, advances in large-scale integration and the introduction of new computer architectures have been springing across the electronics landscape. As a result, the concerns of the LSI designer are overlapping with those of the computer designer.

This trend is one of the key themes of the special report on new computer architectures (p. 111) prepared by computers editor, Tony Durniak. What goes on in silicon greatly affects computer architecture and vice versa.

"Oddly enough," Tony observes, "the very nature of the advances in semiconductor technology that have removed many of the computer design constraints have made engineering the computer more difficult than ever. So many more choices are provided by the semiconductor devices that architecture design is now more flexible than it was just 18 to 24 months ago."

The upshot is a change in the facts of life faced by the computer designer. For one, he must make greater use of computer-aided design to handle the enormous complexity of the LSI devices.

For another, the computer designer must now broaden his or her know-how to include semiconductor fabrication, as well as the usual logic design, in order to understand what's on the chip. Otherwise, it's awfully hard to design with LSI.

Another fact of life for the computer designer is the annual National Computer Conference to be held this year in New York starting June 4. A preview of the important technical sessions starts on page 175, a roundup of some of the new products on page 193.

Both the technical sessions and the product exhibits promise to make this year's NCC another big hit, thus underscoring again the major importance of this sector of the electronics industries. The impact of computing power is now being felt and across the board, from the personal computer all the way to the powerful mainframes. NCC dramatizes not only this broad application of computers but the advances in semiconductor technology that are making it all possible.

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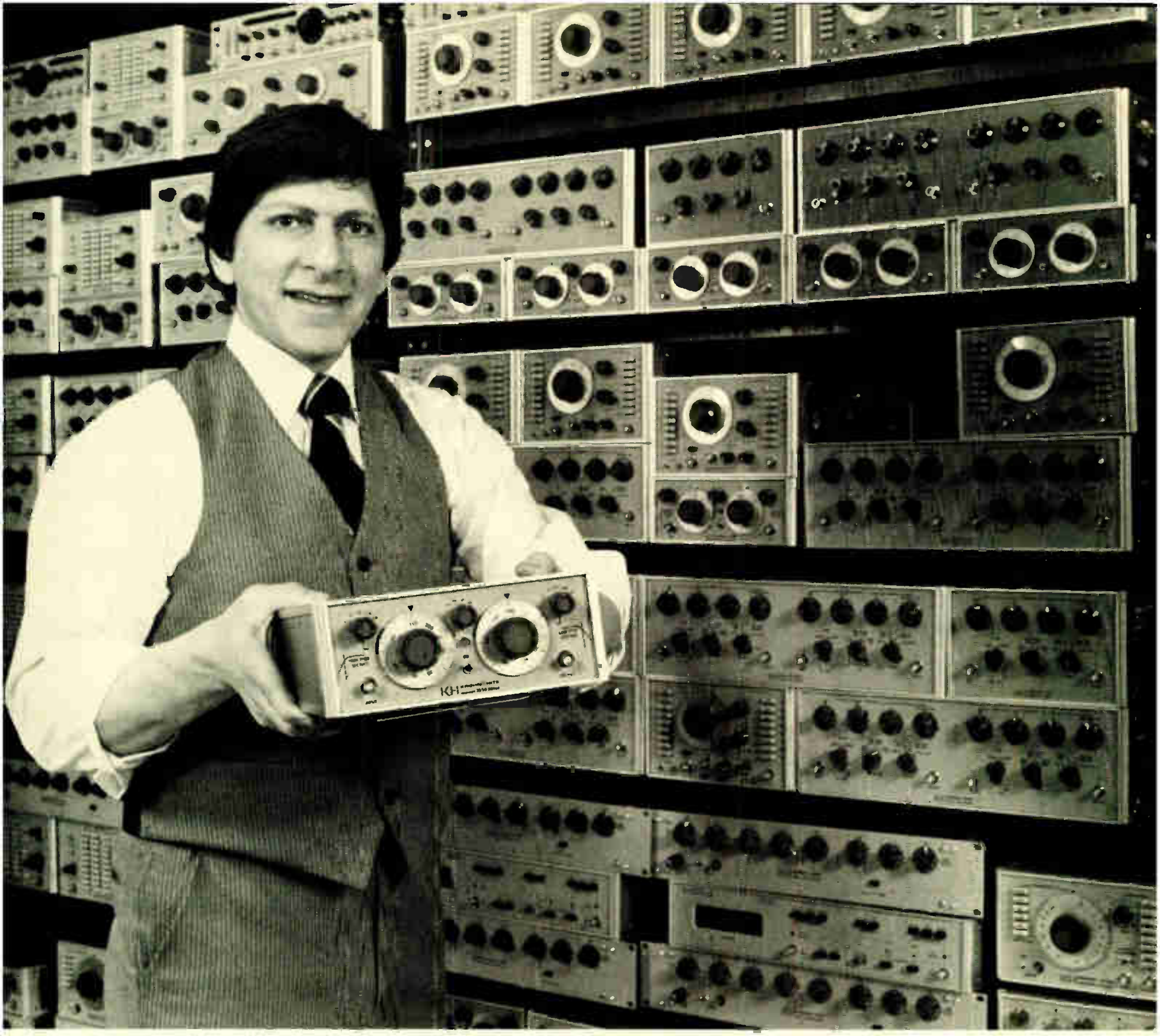

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Readers' comments

Browsing for antiques

To the Editor: In the article "Getting the most out of the 9900 for real-time control" [March 1, p. 40], I particularly enjoyed the discussion of the Cordic algorithm. I, and perhaps others, would appreciate it if sources can be given for this and other algorithms used to compute functions on handheld calculators that may be applied to the 9900 and other microprocessors.

When I simulated the Cordic algorithm program, I discovered two typographical errors. The line after label L20 should read "S R4, R3" rather than "S R3, R3," and the second SRA instruction after label L30 should read "SRA R5, R0" rather than "SRA R4, R0." Also, the values left in R_2 (sine) and R_3 (cosine) are scaled up by a factor of 32,768 from their true values.

Webb Simmons
San Diego, Calif.

■ **The author replies:** *The Cordic technique was originally devised by J. E. Volder, who published it in the IRE Transactions on Electronic Computers, Vol. EC-8, No. 3, Sept. 1959, p. 330, along with a companion article by D. H. Daggett on p. 335. Additional information can be found in a masters thesis published at the University of California at Berkeley in 1968 by Michael Liccardo entitled "An Interconnect Processor with Emphasis on Cordic Mode Operation."*

Early computer developers in the 1950s and 1960s experienced the same problems modern designers are facing with microprocessors—the need for fast and space-efficient algorithms. An awful lot of those algorithms are obscured with time. Whenever I have the time, therefore, I read the old journals looking for such algorithms that may have fallen into disuse.

And thank you for pointing out the typos.

On its own

To the Editor: Your International Newsletter of Nov. 9 [p. 63] described our company as manufacturing epitaxial power transistors for International Rectifier Corp. of Los Angeles. This is an error. International Power Semiconductors is an independent company making power transistors in TO3 and TO66 packages from mesa and epi chips.

T. J. Joseph
International Power
Semiconductors Pvt.
Seepz, Bombay, India

Ownership possible

To the Editor: A recent article, "Who's Who in Satellite Communications" [March 29, p. 92], states that the American Telephone and Telegraph Co. cannot legally own satellites at present and that the decision will be reviewed by the Federal Communications Commission in July 1979.

The FCC has restricted AT&T from providing private line services via satellite—except to the Federal government—until July 1979, but not from owning satellites. By choice, AT&T leases satellite circuits from Comsat General Corp.

R. F. Latter
American Telephone
and Telegraph Co.
Bedminster, N. J.

Electronic bandaids

To the Editor: I agree with your April 12 editorial [p. 24] that microprocessor technology could be used to improve nuclear reactor safety. The larger question remains unanswered: would these improvements make nuclear reactors insurable (i.e., would any profit-oriented insurance company be willing to gamble on their safety)? If they remain uninsurable, should they be allowed to operate?

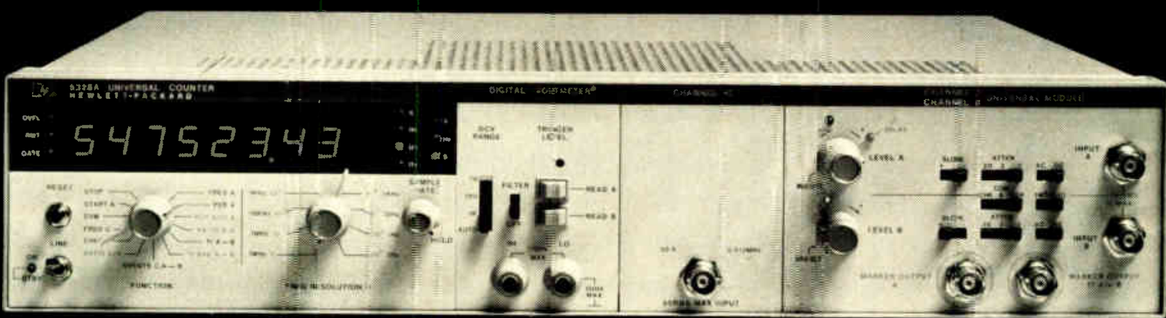
Technology should not be used to apply bandaids to radioactive wounds. Let us instead use our technical capabilities to enhance life instead of sugar-coating the most life-threatening poisons known.

Donald Weiss
Glendora, Calif.

Correction

The acquisition by Thomson-CSF cited in the April 12 Electronics Newsletter [p. 33] should have referred only to the RF division of Solid State Scientific Inc., and not to the entire company.

HP 5328A Universal Counter. The Right Performance At The Right Price.



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News update

■ Remember the system that will turn ac power lines into phone lines with a simple connection? Astech Inc.'s Phone Link I-II has been going great guns since its introduction last July [*Electronics*, July 20, 1978, p. 155], says Robert T. Dunne, president of the Bedford, Mass., company. "The orders have really been coming in—and we haven't placed a single advertisement yet," he says.

The patented technique connects communications signals to power lines by reactive coupling, using coils and transformers so that they reduce or completely eliminate noise. The user simply plugs an extension telephone into an ac outlet.

Phone Link I is hooked up to any telephone receptacle and any ac outlet. Phone Link II attaches a portable extension phone to an ac outlet in the building, coupling the phone to the power and phone lines. Each part of the system contains a receiver, transmitter, and signaling supervision logic.

So far, Dunne says, about 60 systems have been shipped at $229 each. "Most of the attention has been from producers," he says. "The Phone Link will be used mainly by manufacturers of systems." Dunne is waiting to hear the Bell Telephone System's thoughts about Astech's system, as well as those of private phone companies. "Our system will best be used as a telephone extension system," he notes. "The telephone companies are in the best position to put the system into consumer use. We'd rather go to the telcos, instead of just introducing Phone Link at retail outlets."

At the Basking Ridge, N. J., headquarters of AT&T, Albert J. Tutko, product manager for key systems, says, "Astech's phone link may have merit as far as residences go. I do think there's a market for this product—it's quite novel." AT&T is still evaluating possible applications.

Astech hopes to offer more features on the phone link in the near future. Included among them is an intercom network between any number of phone links, as well as a more compact system. **-Pamela Hamilton**


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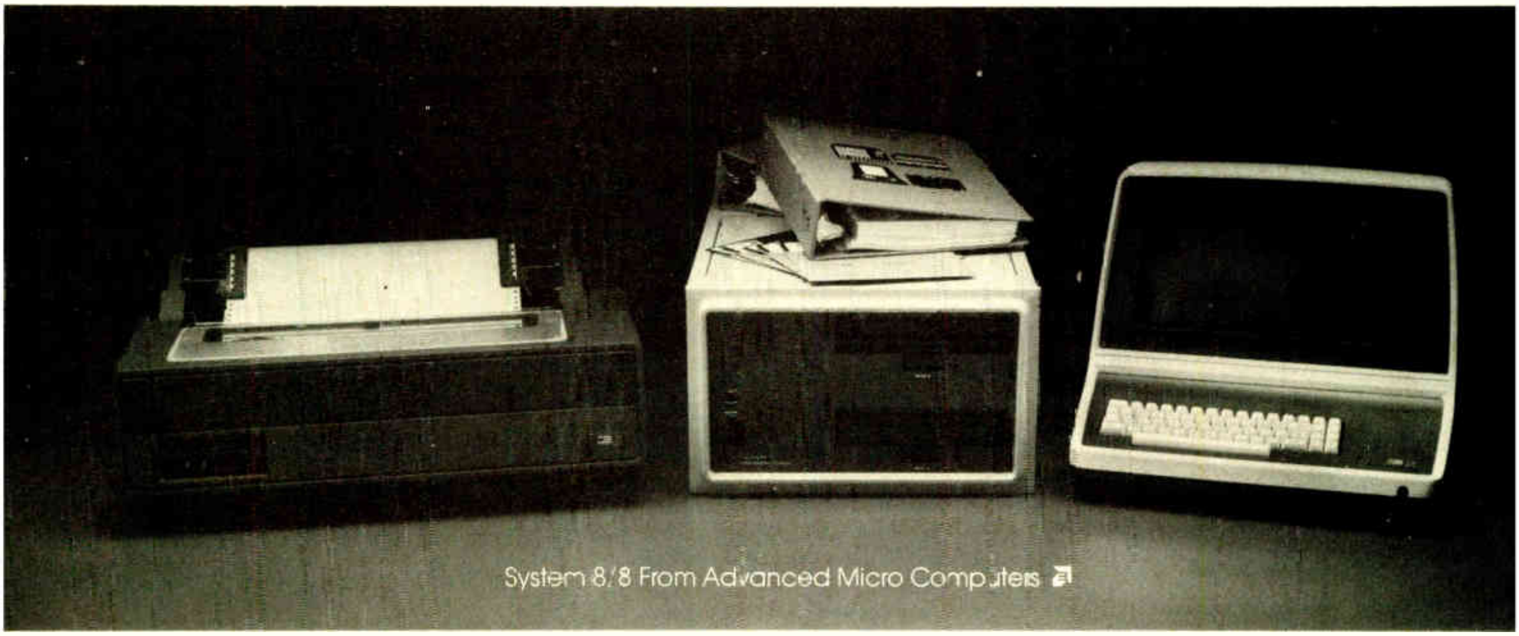

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People

Kruschke of Mostek predicts lots of IBM plug-ins coming up

Users of computers made by International Business Machines Corp. can look forward to a bonanza in the near future of "unique" products, from a number of manufacturers, compatible with their IBM machines.

That is the prediction of Gene Kruschke, large systems program manager for the Memory System group at Mostek Corp., Carrollton, Texas. The 45-year-old Kruschke, who left Intel Corp. to join Mostek in March, will oversee the Texas company's move into the IBM add-on memory marketplace [*Electronics*, May 10, 1979, p. 42]. After 11 years of experience with products aimed at IBM users, including a stint at Ampex Corp. and one at Intel, Kruschke says that decreasing solid-state hardware costs and the increasing sophistication of IBM users, among other things, is opening new opportunities for the makers of IBM plug-in devices. Continuing IBM price cuts in the memory area may help force the change to less traditional add-on products as well, the Mostek memory manager indicates.

The General categories of products to look for include hierarchical memories and various kinds of database and specialized processors. "There are all kinds of things you can do in these areas," Kruschke observes. "It's just a matter of sitting down for 15 minutes and you can come up with a number of ideas for products that could turn out to have a very high gross margin."

Unblessed. The Mostek official concedes that some new products may be difficult to sell at first because they lack the IBM blessing. But he adds that "users today are very sophisticated—they know exactly what they need and how to use it, so no one should be afraid of coming up with a unique product."

Will Mostek be among the firms introducing new types of products for the IBM marketplace? "We are looking at other products" in addition to add-on memory systems, Kruschke answers. But he declines to be more specific, indicating only that ideas can come from many places. "And not only could they be profitable, but they're a lot of fun to design with, too."

To compete with the giants in the bipolar PROM market employee quality counts most, says MMI's Federman

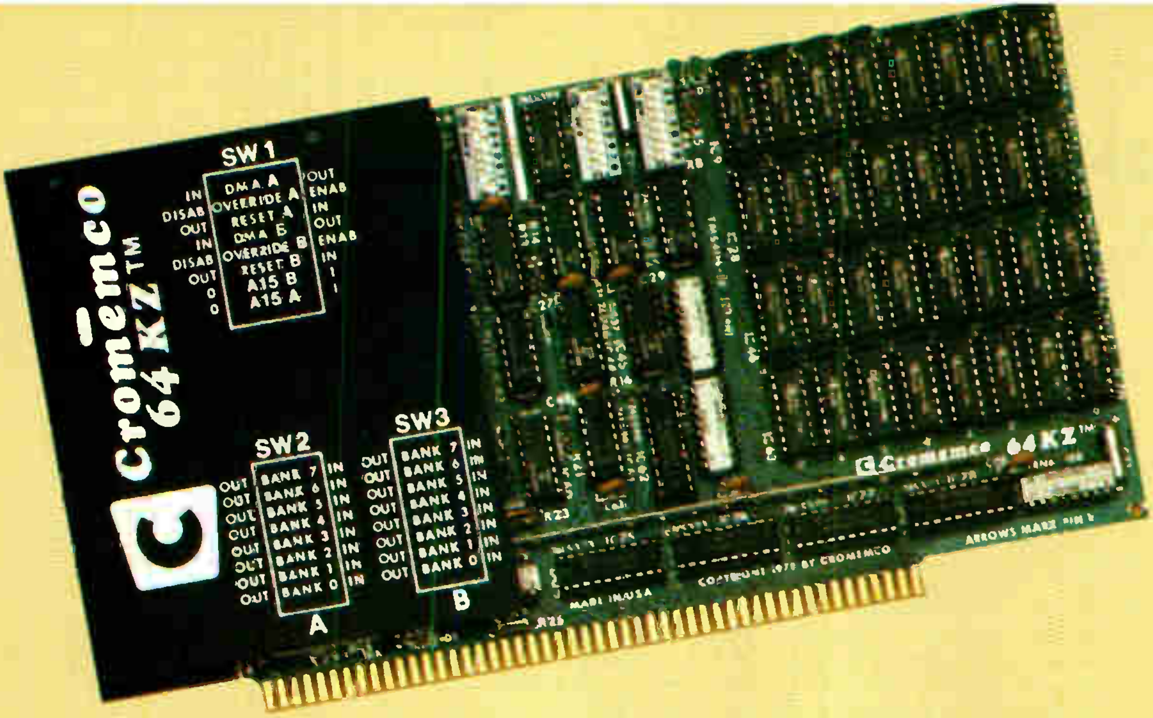
For nearly nine years, privately owned Monolithic Memories Inc. has been a strong contender in the bipolar programmable read-only memory marketplace till now it is in the top three. But as the market heats up with demand from the automotive industry, most industry observers believe MMI in Sunnyvale, Calif., could be squeezed out by titans like Texas Instruments and National Semiconductor.

MMI's new president, Irwin Federman, is undaunted. He feels the deck is not as stacked against his company as the numbers suggest—it had $30 million in sales last year.

Smaller chunks. Federman believes the battle in the short term will not be MMI against giant corporations. "Every large company is really an amalgam of several smaller ones," he explains. In his view, MMI will be competing with the bipolar memory division of large corporations, not the corporation itself, and "that's important because a division's ability to get corporate funding depends on its performance."

"It's not the numbers that really count, it's the quality of the people," he says. Profitability is securely tied to wafer yield, and higher yield is much more a function of employee quality than of capital equipment, he continues.

Thus, his primary objective as president and chief operating officer is to attain higher levels of quality from his employees. He wants everyone, from managers on down, to strive for excellence. And what is his



You can do surprising things when you have 64 kilobytes of fast RAM on one card

4 MHz FAST—AND EXPANDABLE

Here's 64 kilobytes of memory on one RAM card. Yes, we mean 512K bits of read/write memory on this single card.

And, yes, we mean it's fast. With 150-nanosecond chip access times — so the card can operate in fast Z-80 systems with no wait states. Repeat, no wait states.

EXPANDABLE ON TWO LEVELS

Not only does the new Model 64KZ give you a large, fast RAM but it is expandable on two levels.

First, through our Cromemco Bank Select feature, you can expand to 512 kilobytes in eight 64K banks.

Or, with our Extended Bank Select feature, you can expand memory space to as much as 16 megabytes.

This expandability we call your obsolescence insurance.

The legend on the card's heat sink is an easy reference for address and bank selection.

BENCHMARK IT

Obviously, the speed and memory capacity of this new card give you a lot of power.

You can see that for yourself in our new 7-station Multi-User Computer System which uses these Model 64KZ cards. This S100-bus system outperforms the speed of many if not most timesharing systems of up to 10 times the Cromemco price.

And yet where some of these much more expensive and cumbersome systems clearly slow to a snail's pace when timesharing, the Cromemco system using Bank Select switching runs surprisingly fast.

SEE IT NOW

See the new Model 64KZ at your computer dealer now. Study the literature on it. See how for only $1785 you can get around that ever-present barrier of memory that's too little and too slow.

For high reliability all Cromemco memory cards are burned in at the factory in these temperature-controlled ovens.

Cromemco Multi-User System shown with 7 stations

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Circle 15 on reader service card

Goal man. People are happiest when they are achieving, believes Irwin Federman.

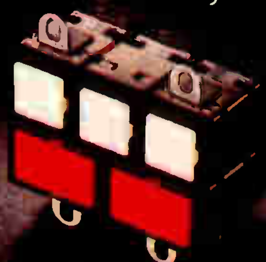
reward? Beyond the usual profit-sharing scheme, Federman, 43, who holds a BS in economics from Brooklyn College, N. Y., and a State of California certification in public accounting, feels the reward is a sense of achievement. "I've never run into anyone who isn't happier when they are achieving than when they're not," he explains.

It comes down to letting people themselves choose their incremental goals and counseling them not to risk failure by picking too grand a target. On the other hand, Federman thinks they should not be too easy on themselves. He quotes the English poet, Robert Browning: " 'A man's reach must exceed his grasp or what's a heaven for?' "

Before putting capital into a division, a company must study its return on investment, points out Federman, who was financial vice president at MMI for 7½ years. He feels that if MMI's performance is high while another corporation's bipolar memory division does less well, then the actual differences in capitalization would be less than a comparison of corporate-to-corporate assets would imply. MMI's size "imposes a requirement for us to be better than the competition, even though we are smaller overall," Federman concludes. □

You may not know how expensive a pushbutton really is until months after it's paid for.

The true measure of a pushbutton's cost isn't so much what you pay. It's how many times you pay it.



New full-guarded pushbuttons.

If you spend less in the first place, you could end up with a higher price tag from what you spend over and over in repair costs and downtime.

That's why it's worth it to specify the MICRO SWITCH Advanced Manual Line (AML) of pushbuttons, rockers, paddles and indicators. It's the most complete line of manual controls ever offered, designed to save you money from start to finish.

AML is easy to wire, thanks to single-level termination, simple snap-in PC board mounting and sub-panel mounting that uses individual, strip or matrix hardware (see inset). The result is low installed cost.

And of course, you get traditional MICRO SWITCH reliability and long life. Which means money savings over the long haul.

No matter how many words you use to describe the broad AML lineup, it all comes down to just two: cost effectiveness. For a panel that's pleasing to the eye as well as the budget.

If you'd like a personal demonstration just call 815/235-6600.

MICRO SWITCH is also ready to provide you with field engineers for application assistance and a network of authorized distributors for local availability.

AML. It's the closest a line of pushbuttons can come to paying for itself.

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A DIVISION OF HONEYWELL

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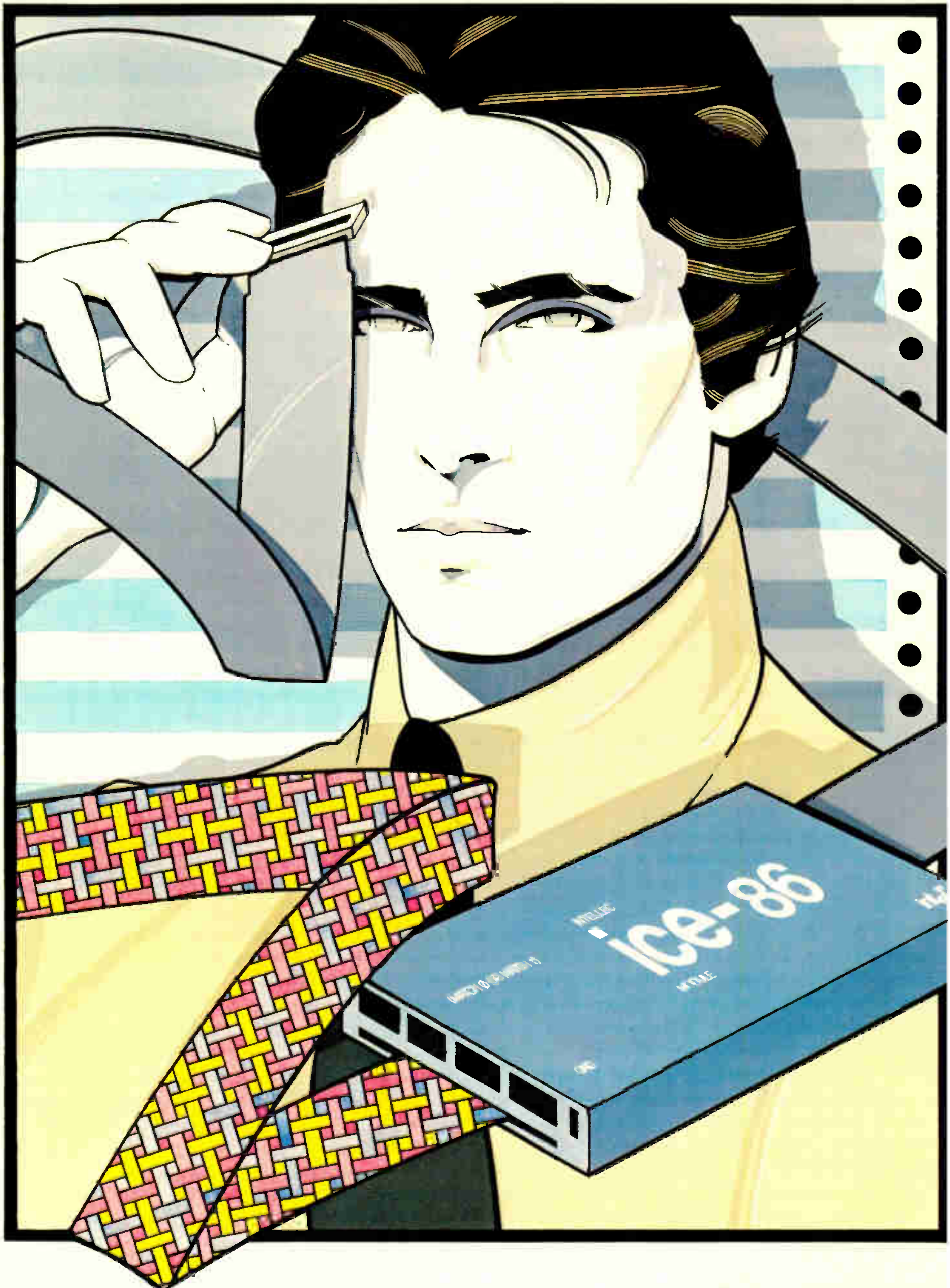
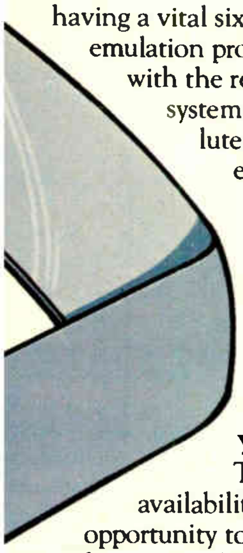

ice-86

Sixth Sense for 8086 Users.

Intel delivers ICE-86™ emulator, the designer's direct diagnostic connection to 8086 system development.

Intel's new 8086 sets the standard for 16-bit microcomputers. It delivers the Architecture of the Future today, high-level languages for programming and the Intellec® development system for unsurpassed support.

Now that support moves even further out in front. Introducing the ICE-86 module. Experienced microcomputer designers have learned that having a development system with in-circuit emulation — ICE — is like having a vital sixth sense. Only ICE emulation provides designers with the real insight in actual system operation absolutely necessary for cost effective, efficient product development. Now Intel delivers that sixth sense for 8086 users.



ICE-86™ puts the future in your hands

The 8086's early availability provides the opportunity to get your new products to market a year or more ahead of your competitors who wait for follow-on 16-bit microprocessors. Only Intel delivers the future today.

The Intellec development system with in-circuit emulation enables you to seize that opportunity. You can actually begin software development and debugging in an 8086 environment before any prototype hardware exists. Or you can use the ICE-86 module to begin simultaneous hardware and software development and integration while your system is little more than an 8086 cpu and system clock.

The ICE-86 cable plugs into your system cpu socket to provide emulation of system operation, up to the full megabyte of memory the 8086 can address.

Communicate in English, or symbolic references.

The ICE-86 emulator is actually a complex breakpoint and logic trace system supporting the most advanced symbolic debugging techniques. English-like statements or symbolic references entered at the Intellec keyboard eliminate the need to search memory maps, keep track of address changes or get bogged down in the details of system operation.

And the ICE-86 emulator's powerful logic analysis capability helps find the cause and correct the problem when bugs do appear.

PL/M-86 for the Architecture of the Future.

The most powerful microcomputer ever deserves the most powerful microcomputer programming language. That's PL/M-86, an extension of the world's most widely used development language.

PL/M-86 is an ideal example of the block-structured languages the 8086's futuristic architecture can support. It gives you 32-bit floating point arithmetic and 16-bit signed integer arithmetic. And it takes full advantage of the program-compacting features of the 8086, such as hardware multiply and divide and byte-string operations.

PL/M-86 is best for fast composition of large and complex programs. For those who prefer the efficiency of assembly language, there's ASM-86. And CONV-86 converts 8080/8085 code to the 8086.

The future is even brighter. Planned expansion of the Intellec system promises programming in Pascal and FORTRAN and the added flexibility of a macro assembler. It's true today and will be true long into the future—the 8086 is the best supported 16-bit microcomputer you can buy.

Modular programming is here.

The Intellec system gives you the flexibility of modular programming. You can develop routines in small, manageable modules, choosing the best language for each. Then using the Intellec system's powerful relocation and linkage capabilities, you can merge modules using symbolic references.

We optimized Intellec hardware for 8086 development, providing a dual diskette, expandable to four drives and 2.5 megabytes of memory. And we'll be expanding the Intellec system with a 7-megabyte hard disk, enough memory to extend the 8086's capabilities into the realm of large mainframe computers.

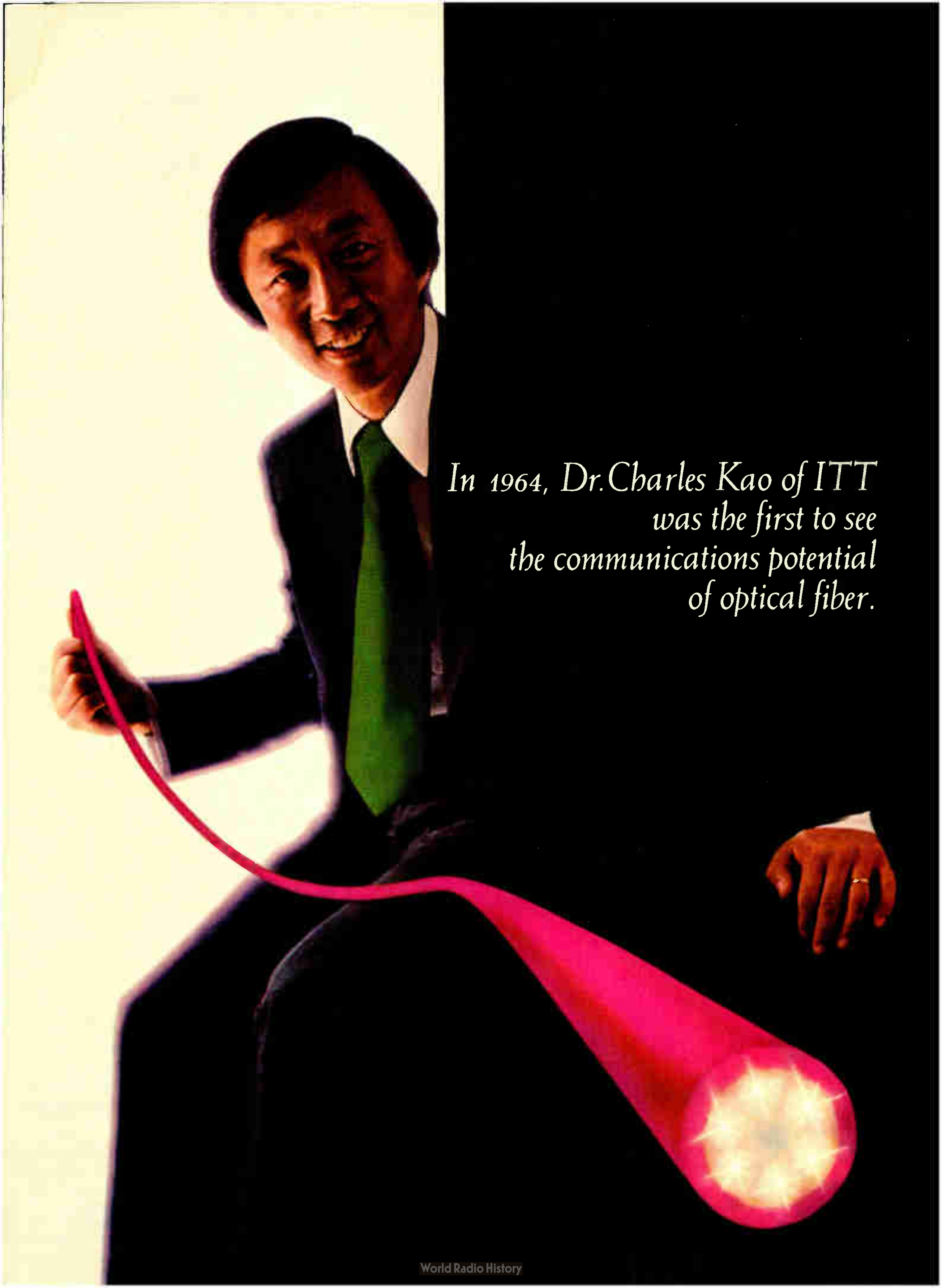
A manual for your success.

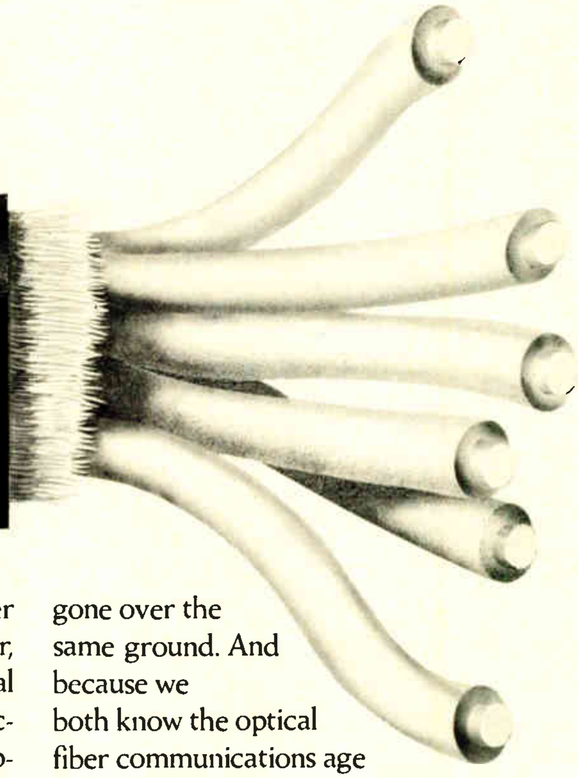
We've compiled an in-depth Success Manual for 8086 Users, detailing the Intellec Microcomputer Development System, ICE-86 and the full software package for 8086 program development. For your copy, contact your local Intel sales office. Or write: Intel Corporation, Literature Dept., 3065 Bowers Avenue, Santa Clara, CA 95051.

intel delivers.

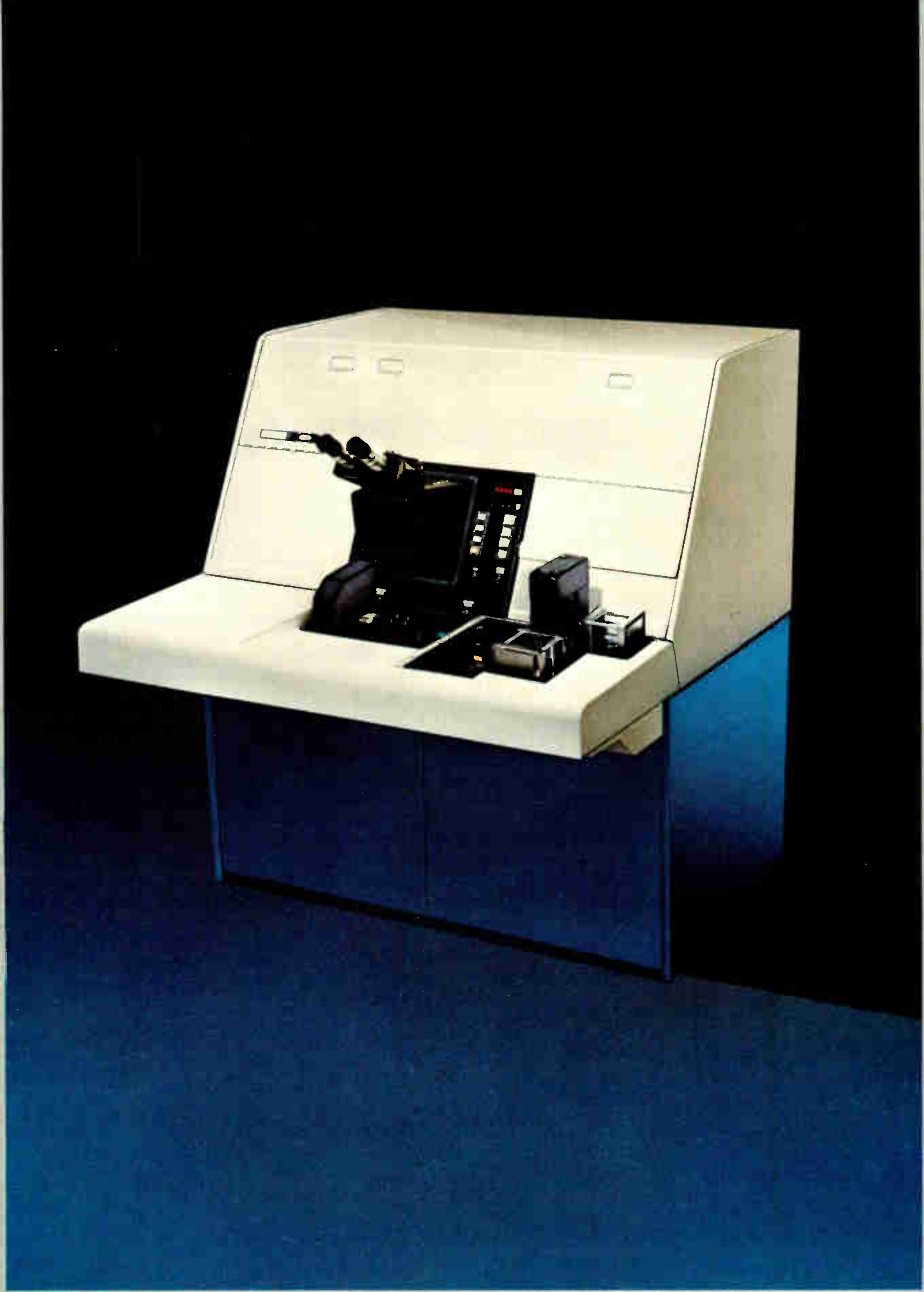
Circle #19 for information

"See us at NCC June 4-7, New York City. Booth #1420."


In 1964, Dr. Charles Kao of ITT
was the first to see
the communications potential
of optical fiber.



PROJECTION MASK ALIGNER



Introducing the Micralign® 200 Series. Higher throughput than step-and-repeat at a much lower price.

Perkin-Elmer designed the new Micralign Model 200 to be the most cost-effective projection mask aligner available. In performance, it achieves 2-micron geometries or better in production, distortion/magnification tolerance of 0.25 micron, and 4 percent uniformity of illumination. Options available include automatic wafer loading and automatic alignment. Soon to be available: deep UV optical coatings for still smaller geometries.

Compared to the leading step-and-repeat aligner, the Micralign Model 200 delivers outstanding performance for not much more than half the cost. It takes about a quarter of the floor space. It provides consistently higher throughput regardless of die size.

The Model 200's remarkable performance is the result of a number of major innovations.

Improved optical design and fabrication
We improved the optical design to provide increased resolution and depth of focus. Optical manufacturing tolerances are five times tighter to ensure precise overlay from aligner to aligner.

Near-zero vibration
We minimized vibration. We constructed the Model 200 with two frames—one inside the other. The inner frame, which carries the projection optics and carriage drive, is completely isolated from the outer frame.

We incorporated a superb linear motor carriage drive with air bearing slide. This drive does more than eliminate vibration. With the air bearing feature there's no contact and no wear. And no limit to carriage drive durability.

Built-in environmental control
We provided the Model 200 with a built-in environmental chamber. External air, supplied by you or from our optional air conditioning system, is blown through a HEPA filter and heating elements built into the Model 200 top cover. A positive-pressure, class 100 environment is carefully controlled to better than 1°F.

We included a separate thermal control for the mask, to compensate for mask run-out.

No mask contamination
We designed a sealed mask carrier for the Model 200. You put the mask in the special carrier right in the mask department. Seal it. When you load the sealed carrier in the Model 200, the cover plates are automatically removed. After use, the cover plates are automatically replaced.

Proven production capabilities
Perkin-Elmer, the leader in projection mask alignment systems, offers six years of proven production capability, with an excellent training and service record.

Get all the facts
These are just a few of the features that make the Micralign Model 200 Series a completely new concept in projection mask aligners. Get more details on how these and other improvements in design can translate into improvements in your production. For literature, write Perkin-Elmer Corporation, Electro-Optical Division, 50 Danbury Road, Wilton, CT 06897. Or phone (203) 762-6057.

PERKIN-ELMER

Circle 23 on reader service card

Editorial

Another variation on a theme

It's becoming an old story: the low prices and high quality of Japanese goods versus indecisiveness and divisiveness in the U. S. Add to this a Government policy—or nonpolicy—that seems to be based firmly on whichever way the wind is blowing, and the denouement seems inevitable: U. S. companies taking their technologies to new markets, or else quitting the competition.

A case in point is the experience of companies that manufacture components for television sets. A steady increase in sales of high-quality parts at highly competitive prices from Japan—and Taiwan—is causing consternation and reappraisal among the few American suppliers left in the business. Should they go offshore? Should they drop out of the entertainment end of the business altogether and marshal their forces for an attack on other sectors? Or should they just hang on, hoping either for eventual help from the Government or that the quality of the Japanese parts will fall off now that the manufacturers are establishing plants in the U. S.? (There are people, though, in the components industry who insist that Japanese parts never were markedly better than the made-in-U. S. A. versions.)

The quandary of the Americans is whether to work with an apparently unreceptive Government and a divided industry toward some sort of cohesive policy, while watching the market share erode steadily, or to absorb the losses and turn to more lucrative outlets. From the way things are going, it would appear that the latter is the only choice left.

Hey, where is everybody?

The technology and marketing strategy underlying the growing Japanese strength in electronics has taken two paths. One is the high-technology road of innovation, followed by exploitation of the native industry's ability to churn out a product and sell it to the world. The other is the ploy of recognizing in a new development the answer to a design problem and creating a need for an end product. The best example of the latter method is the transistor and the decision to use the then-new device in small, inexpensive radios that at one point seemed to be at the ear of every teenager in the world.

Now we may be watching another example of the transistor syndrome. The device in this case is a bit more sophisticated: the diffusion self-aligned metal oxide semiconductor, or DSA MOS. Japanese proponents of the technique praise it as the gateway to MOS devices with channel lengths that can run as short as 1 micrometer using the lithography of longer channels.

The rub is that the technology of DSA MOS is not new; nor is it unknown to American semiconductor firms (see p. 87). A paper on an identical technique was published some 12 years ago. A form of DSA exists today in V-groove MOS.

This could be a major opportunity for American semiconductor companies to outdo their Japanese rivals, four of which are doing DSA work. On the other hand, the Japanese enthusiasm for the technology may be misplaced; after all, many scientists have had occasion to go ahead with it but have decided not to. But it would be a good idea for all concerned to take at least another hard look at diffusion self-aligned MOS in the light of the growing excitement across the Pacific.

OHIO SCIENTIFIC DOES IT AGAIN

Ohio Scientific has taken its standard C3 computer and married it to the new Shugart 29 Megabyte Winchester Drive. The result is the C3-C. This new microcomputer now fills the vacuum that existed for computer users who need more mass storage capability than floppies can offer – yet until now, could not justify the additional cost of a larger capacity hard disk computer such as our C3-B 74 Megabyte disk system.

Winchester Technology

Winchester hard disk drives offer small business and professional computer users the logical solution to mass storage problems that are beyond the capability of floppy disks. In addition, Winchester disks feature a track seek-time that is much better than floppies and because they spin at eight times the rate of floppies, Winchesters have a shorter latency. Both of these points reflect one remarkable speed advantage Winchester disks have over floppies.

Coupled to the C3 Computer

Ohio Scientific's award winning C3 computer is a classic. It is the only computer series that utilizes the three most popular microprocessors – 6502A, 68B00 and Z-80. This tremendous processor versatility enables one to utilize a seemingly endless selection of quality programs available from Ohio Scientific's software library as well as from many independent suppliers.

And Advanced Software

For instance, there are single user, multi-user and network operating systems. A complete turnkey small business package, OS-AMCAP provides accounts receivable, accounts payable, disbursements, cash receipts, general ledger etc. OS-CP/M offers a complete FORTRAN and COBOL package. And there is WP-2, a complete word processing system. For information management, OS-DMS, features an advanced file handling system and program library that simplifies information storage and recall and routinely performs tasks which usually require special programming on other systems.

Yields the Microcomputer of the Future

With an eye toward the future, the C3-C, like all other C3's was designed with provisions for future generation 16 bit microprocessors via plug-in options. There are ten open slots for lots of I/O and multi-user operation. Truly, the Ohio Scientific C3-C is a computer with a future.

The new C3-C computer with 29 Megabyte Winchester Hard Disk.

OHIO SCIENTIFIC

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OEM pricing available

Meetings

1979 International Summer Consumer Electronics Show, Electronic Industries Association, McCormick Place, Chicago, June 3–6.

NCC '79—1979 National Computer Conference, IEEE, American Federation of Information Processing Societies, *et al.*, New York Hilton and Americana Hotels, New York, June 4–7.

Automated Testing for Electronics Manufacturing, Benwill Publishing Corp. (Boston), Radisson Ferncroft Hotel, Danvers, Mass., June 4–7.

ICC '79—International Conference on Communications, IEEE, Sheraton Boston Hotel, Boston, Mass., June 10–14.

Symposium on Applications of Ferroelectrics, IEEE, Sheraton-Ritz Hotel, Minneapolis, June 13–15.

Joint Automatic Control Conference, IEEE and American Institute of Chemical Engineers, University of Washington, Seattle, June 16–21.

International Symposium of the IEEE Antennas and Propagation Society, IEEE, University of Washington, Seattle, June 18–22.

PC '79—International Printed Circuits Conference, Circuits Manufacturing Magazine (Boston) *et al.*, Statler Hilton Hotel, New York, June 19–21.

Power Electronics Specialists Conference, IEEE, Bahia Hotel, San Diego, Calif., June 19–21.

33rd Annual Convention of the Armed Forces Communications and Electronics Association, Afcea (Falls Church, Va.), Sheraton Park Hotel, Washington, D.C., June 19–21.

Ninth Annual International Conference on Fault-Tolerant Computing, IEEE, Concourse Hotel, Madison, Wis., June 20–22.

Computers in Communications Conference, American Institute of Aeronautics and Astronautics (Los Angeles), International Inn, Washington, D. C., May 31–June 1. Program will be repeated at the Hyatt L. A. International Hotel, Los Angeles, June 25–26.

37th Annual Device Research Conference, IEEE, at the University of Colorado, Boulder, Colo., June 25–27.

16th Design Automation Conference, IEEE, Town and Country Hotel, San Diego, Calif., June 25–27.

Syntopican VII, International Word Processing Association (Willow Grove, Pa.), Palmer House, Chicago, June 26–28.

Second Joint Intermag—Magnetism and Magnetic Materials Conference, IEEE and American Institute of Physics, Statler Hilton Hotel, New York, July 17–20.

Video and Data Recording Conference, IEEE *et al.*, University of Birmingham, Birmingham, England, July 17–20.

IECEC—Intersociety Energy Conversion Engineering Conference, IEEE, Sheraton Boston Hotel, Boston, Aug. 5–10.

Pattern Recognition and Image Processing Conference, IEEE, Hyatt Regency O'Hare Hotel, Chicago, Aug. 6–8.

Conference on Simulation, Measurement and Modeling of Computer Systems, National Bureau of Standards *et al.*, University of Colorado, Boulder, Colo., Aug. 13–15.

International Conference on Parallel Processing, IEEE, Shanty Creek Lodge, Bellaire, Mich., Aug. 21–24.

Compcon Fall '79—18th IEEE Computer Society International Conference, IEEE, Capital Hilton Hotel, Washington, D. C., Sept. 4–7.

Second International Fiber Optics and Communications Exposition, Information Gatekeepers Inc. (Brookline, Mass.), Hyatt Regency O'Hare Hotel, Chicago, Sept. 5–7.

25th Annual Holm Conference on Electrical Contacts, Illinois Institute of Technology (Chicago), Palmer House, Chicago, Sept. 10–12.

Dielectric Materials, Measurement and Applications Conference, Institution of Electrical Engineers (London), University of Aston, Birmingham, England, Sept. 10–13.

Optical Communication Conference, IEEE, RAI Conference Building, Amsterdam, Sept. 17–19.

Ninth European Microwave Conference, Institution of Electrical Engineers, (London), The Brighton Centre, Brighton, England, Sept. 17–21.

International Symposium on Electromagnetic Compatibility, IEEE, Town & Country Hotel, San Diego, Calif., Oct. 9–11.

Short courses

New Developments in Facsimile Systems, Institute for Graphic Communication Inc. (Boston), Andover Inn, Andover, Mass., June 26–28.

First Brazilian Workshop on Microelectronics, Universidade Estadual de Campinas (Campinas, Sao Paulo), to be held at the university's Laboratorio de Electronica e Dispositivos, July 2–20. For information, contact Prof. C. I. Z. Mammana, LED/FEC Unicamp, Caixa Postal 6061, 13100 Campinas, SP, Brazil. In the U. S., contact, Prof. J. E. Greene, Department of Metallurgy, University of Illinois, Urbana, Ill. 61801.

Reliability Engineering Seminar, UCLA Extension, University of California at Los Angeles, Los Angeles, July 23–27.

Gallium Arsenide Integrated Circuit Symposium, IEEE, Sahara Tahoe Hotel, Lake Tahoe, Nev., Sept. 28–29.

MOSTEK 3870

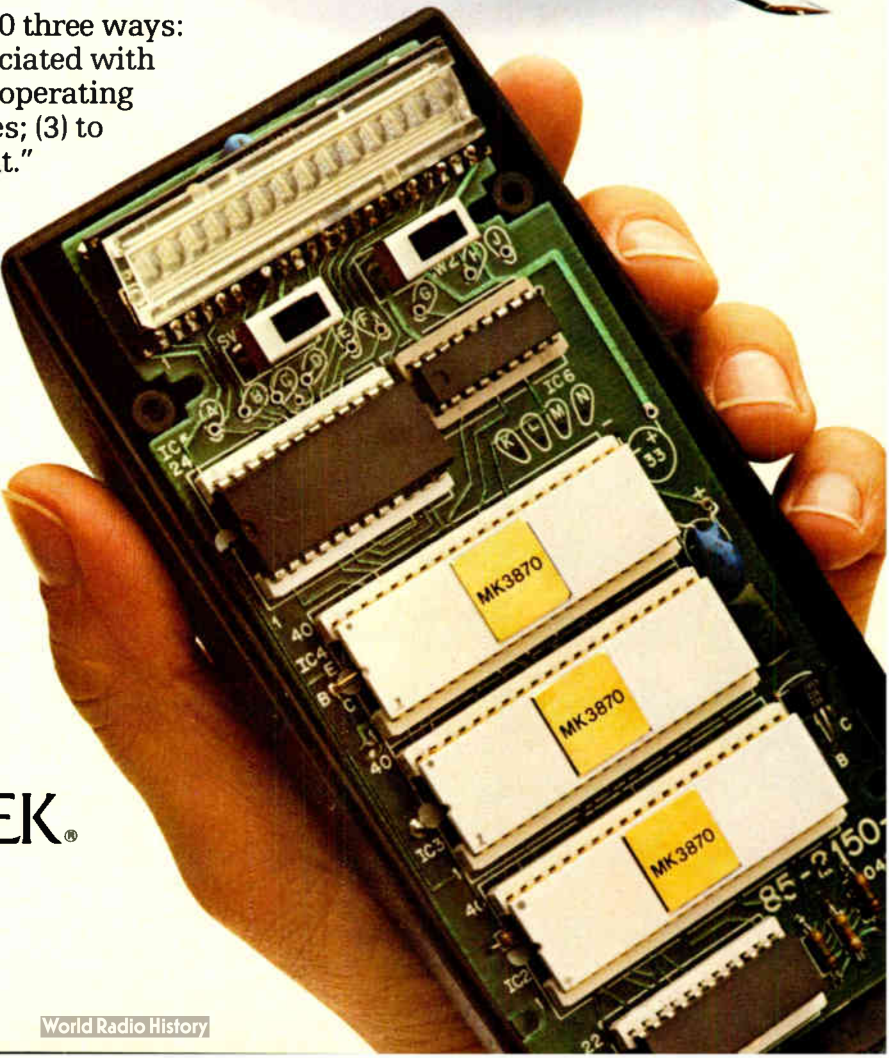
Three of them together make flying a breeze.

"Our OC-1401 navigation computer uses three Mostek 3870s to distribute the complex processing tasks. While one controls the keyboard and display, all three operate independently, calling on each other to perform the mathematical functions and subroutines necessary for computing in-flight navigational data." *Bruce Trump, Project Engineer, and Rod Brahman, Software Engineer, Heath Company.*

Toledo Scale: "We use Mostek's 3870 three ways: (1) to perform all the logic functions associated with A/D conversion; (2) to provide selectable operating features using multiple program switches; (3) to generate bit serial output in ASCII format." *Roger Williams, Engineering Manager for Electronic Products.*

Tokheim: "Using the 3870's 2K ROM memory, we incorporated two separate software programs. Now we can use the 3870 in a control console or individual gasoline pumps, depending on mechanical connections." *Earl Langston, Project Manager.*

There are hundreds of applications using Mostek's 3870 single-chip microcomputer. Get information for your design by contacting Mostek, 1215 West Crosby Road, Carrollton, Texas 75006; phone (214) 242-0444. In Europe, contact Mostek Brussels; phone (32) 02/660.25.68.



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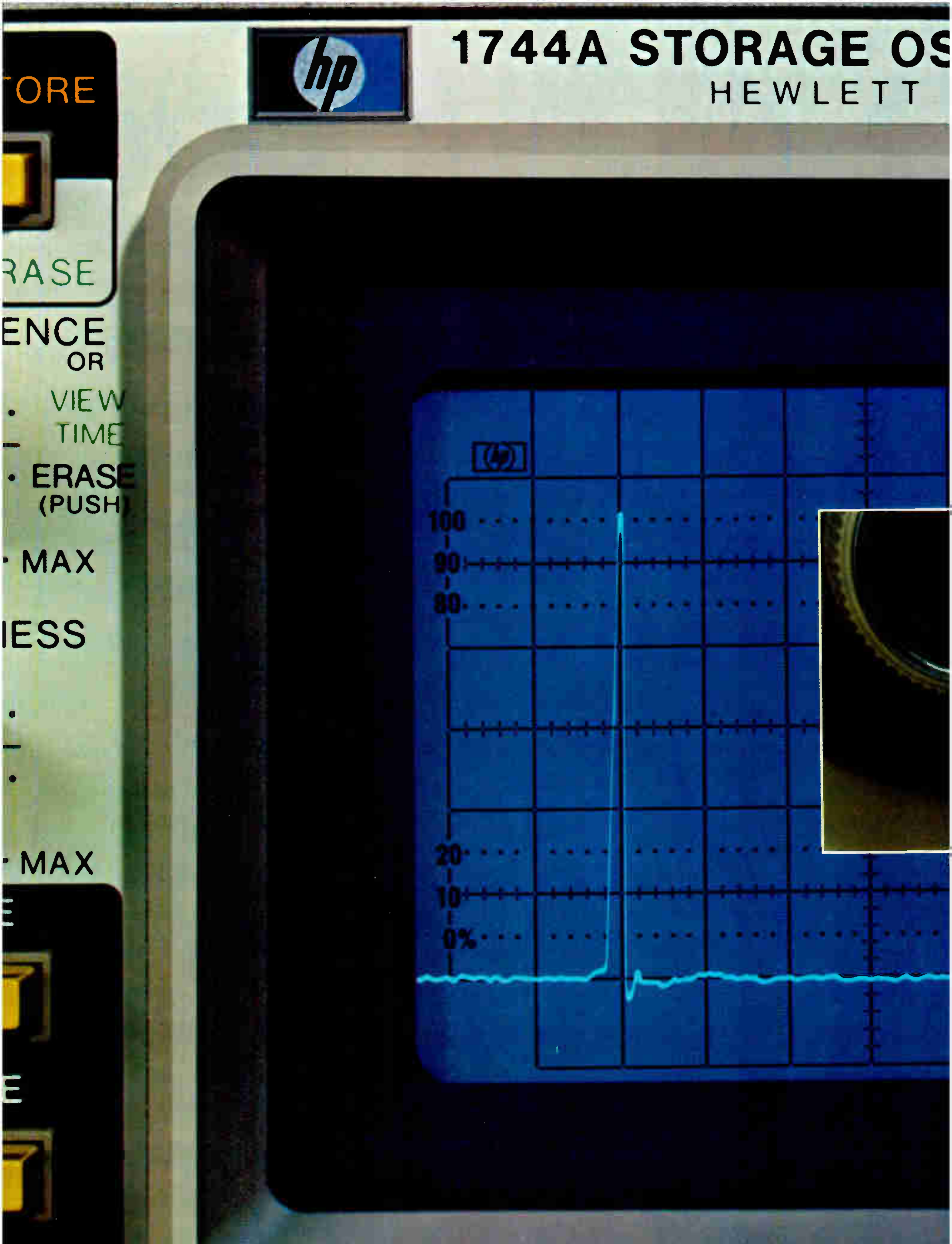
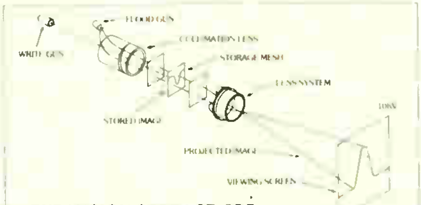


Storage trace as seen using a viewing hood.

For a 100 MHz storage scope that can capture its bandwidth and display glitches this sharply...

HP's new 1744A is the Answer.

The key to this storage scope's superior performance is HP's advanced CRT design. It's called Expansion Storage. And this faster-writing technique lets you capture single-shot and low-rep-rate events over a larger display area with greater clarity.



EXPANSION STORAGE CRT

Take a good, hard look. Any input signal within bandwidth specification will be displayed cleanly by the 1744A, even at the maximum writing speed of 1800 cm/μsec when using a viewing hood. That provides the sharpness you need for detailed evaluation of hard-to-catch waveforms. Our Auto Erase/Auto Store modes simplify your pursuit of these elusive signals. Auto Erase provides hands-off operation while Auto Store prepares the scope to snare the troublemaker the instant it occurs. Both are powerful tools for capturing the spurious spikes that disrupt your logic circuitry.

Catch that glitch. Expansion Storage technology combines a small storage mesh (about the size of a postage stamp) and an expansion lens system. This exclusive arrangement permits a writing speed of 1800 cm/μs and a fine spot size, which lets the 1744A write faster and further than any other 100 MHz storage scope. That gives you full-scan glitch capture capability over a broad range of sweep speeds and repetition rates.

A new view. Three channels are better than two. And with the 1744A you have pushbutton selection of a third-channel trigger view. Now you can view timing relationships between the trigger signal and the two vertical channels simultaneously.

Rounding out the 1744A's capabilities are these convenient measurement features: **Easy-IC Probes** to improve closely spaced probe connections and eliminate shorting hazards; a selectable input impedance (1 megohm/50 ohm) for general purpose probing or 50 ohm matching; and measurement sensitivity as low as 1 mv/div to 30 MHz on both channels without cascading. Priced at $5250*, the 1744A furnishes the state-of-the-art technology and performance needed today in digital design and trouble-shooting applications.

Call your local HP field engineer for further details. And for a lower cost, high quality storage scope where an extremely fast writing speed isn't required, ask him about HP's 1741A 100 MHz storage scope.

* Domestic U.S.A. price only

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Circle 29 on reader service card

ZILOG gives you across the board coverage.

Zilog's famous Z80 powers a growing family of over a dozen boards designed to give you dramatic savings in time and money.

Need a modest memory? Pick the Z80-MCB, microcomputer board with 4K or 16K bytes of RAM; sockets for another 4K bytes of PROM.

Two eight-bit parallel I/O ports let you drive digital display, plotters and printers. On-board is a serial port with an RS-232 or 20 ma. current loop for interfacing with modems, other computers or CRT's, plus baud rate clock and three user-programmable counter/timer channels.

If 16K is all you need, the Z80-MCB can easily eliminate the need for a second, separate, memory board.

Immodest memories too. The Z80-RMB, RAM memory board, lets you go from 16K to 64K bytes with automatically refreshed, dynamic memory. Add up to 8K bytes of PROM memory.

Need more PROM? The Z80-PMB, PROM memory board, lets you add up to 32K bytes.

Input/Output and then some. The Z80-IOB, a parallel I/O board offers you 64 programmable I/O lines and 16 handshake lines.

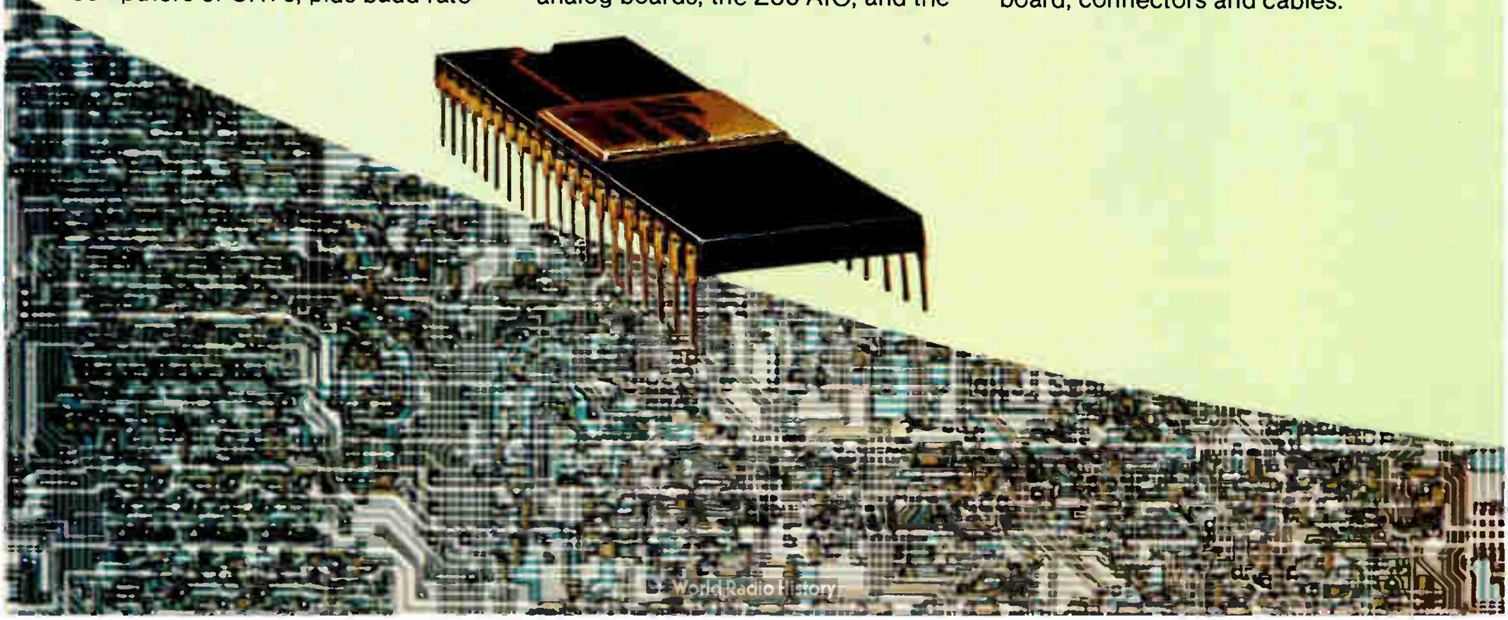
For your serial interface needs, there's the Z80-SIB. It gives you four independent, full duplex channels that can operate in either asynchronous or synchronous modes, as well as programmable baud rates independent of the system clock.

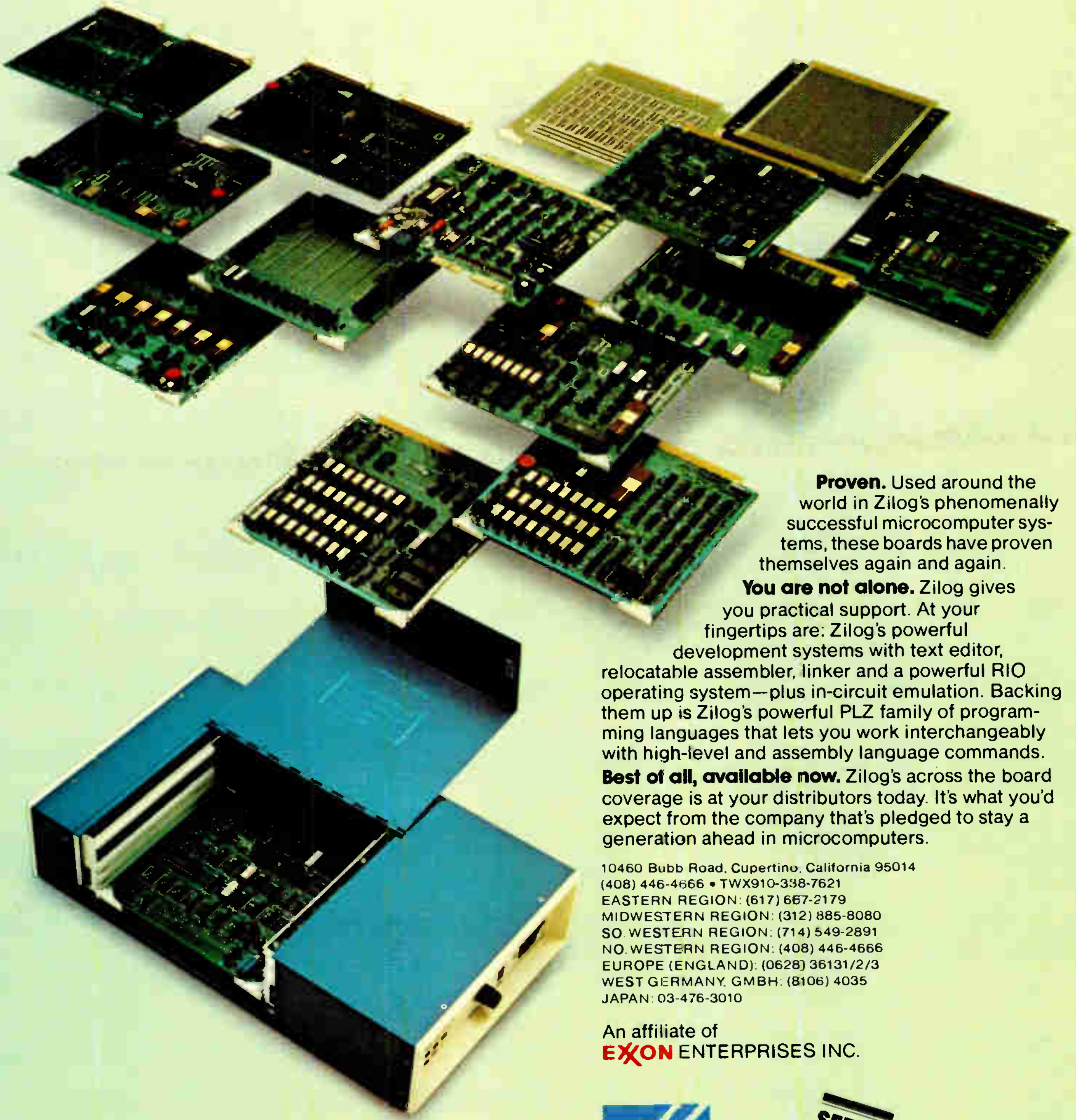
Analog flexibility. Two powerful analog boards, the Z80-AIO, and the Z80-AIB, permit up to 16 differential input channels (or 32 single-ended) with 12 bit resolution, 35 μsec conversion times. The Z80-AIO adds two D to A channels to this configuration.

The choices go on and on: There's a drawer full of options to help complete your system: the Z80-MDC, a combined memory and disk controller; the Z80-VDB, a video display board; the Z80-PPB, a powerful PROM programmer board; the Z80-PPB/16, a 16K PROM programmer board; and new boards keep coming.

Put the finishing touches on sooner. Zilog's SCE-4 enclosure saves design and engineering time by combining power supply, fan and controls in one, handsome, efficient, off-the-shelf unit. Four card slots allow for expansion. No need to spend valuable hours re-inventing the wheel!

Zilog can also supply you with matching card cages, a wire wrap prototyping board, an extender board, connectors and cables.





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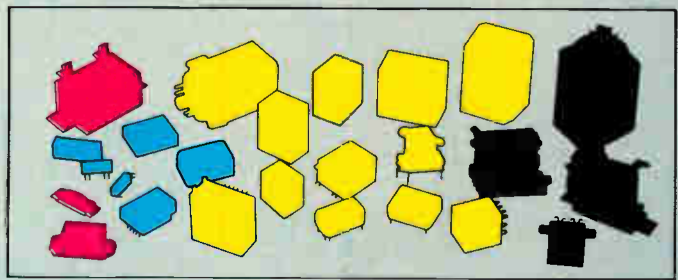

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Electronics newsletter

'Glitchless' d-a converter is faster, smaller

Expect early introduction of a new 12-bit "glitchless" digital-to-analog converter by Hybrid Systems Inc. of Bedford, Mass. Designed for display applications, the DAC-394 claims several advantages over its competition: gray-code output on the most significant digits for smooth, transient-free state-to-state transitions; freedom from the usual three or four adjustments of competing converters—and their drift; and up to 21 mA of output for shorter settling times than sample-and-hold, voltage-output converters (competing voltage-output devices typically settle in hundreds of nanoseconds, whereas the 394 typically takes 50 ns). **The unit is so fast that it will generate display data from computer input at an update rate of 20 MHz** while yielding full 4,096-line resolution.

TI home computer may appear at consumer show

Don't be surprised if Texas Instruments Inc. of Dallas introduces at least one version of its long-awaited personal computer in time for the Summer Consumer Electronics Show in Chicago next month. Incorporating TI technologies including **speech synthesis and software packaged in plug-in read-only-memory modules,** the machine is expected to have a color video monitor, which could boost the price by $400 to around $1,000.

RCA to price home computer at under $400

Anticipating a burgeoning market and price war in home computers, RCA Corp. will introduce its second-generation personal computer, VIP-II, at next month's Chicago show. VIP-II will sell for less than $400 and contains an RCA 1802 microprocessor, 8 kilobits of random-access memory, 12 kilobits of read-only memory for the unit's operating system and floating-point Basic language, and side-by-side ASCII and hexadecimal keyboards. **The unit has color and sound capability,** but requires an FCC-approved modulator for interface to a monitor or color TV set. VIP-II will be made and marketed by RCA's Electro-Optics division in Lancaster, Pa.

Intel to have 1-K-by-4-bit version of fast 2147

Just as Intel Corp.'s competitors begin to catch up with their versions of the industry-standard 2147 high-speed 4-K-by-1-bit static random-access memory, **the Santa Clara, Calif., company is about to spring a new attack on the bipolar memory market** with a 1-K-by-4-bit companion part. Called the 2148, the fully static device, which matches the standard 2147's access times (as short as 55 ns), is designed for control store and cache memories in mainframes and minicomputers as well as 4-bit-slice microprocessors.

Fast 64-bit array processor bows in Boston

What's billed as the largest commercial array processor, a 64-bit device, has been announced by CSP Inc., Burlington, Mass. **The largest commercial array processors until now were 32-bit machines.** The new MAP-6400 uses the large-machine standard IBM 64-bit format, which, with its 56-bit mantissa, allows arithmetic with accuracy to 16 decimal digits.

Battlefield stand-off missile technology being developed

Phase 2 of the Air Force's millimeter-wave radar seeker development program is due for completion by September. The program could lead to a new generation of **antiarmor missiles suited to the bad weather of the European theater,** where infrared seekers often fail. Millimeter waves can penetrate precipitation and offer high resolution, a must for reducing clutter. The $10 million program could also lead to "autonomous" missiles, which would continually search for targets and fire themselves.

Electronics newsletter

Univac to show new members of 1100 family

Fighting technology with technology, Sperry Rand Corp.'s Univac division will introduce new members of its 1100 family of 36-bit mainframe computers at the National Computer Conference in New York on June 4. Motorola 10800 emitter-coupled-logic bit-slice microprocessors are being used in pipelined multimicroprocessor architecture to make the low end of the Blue Bell, Pa., division's line **more competitive with Schottky-TTL–based IBM 4300 processors.** Univac is the last mainframer to respond to IBM's new generation of machines.

Also to be unveiled at the NCC will be Harris Corp.'s model 800. From the Fort Lauderdale, Fla., company's Computer Systems division, the new computer is based on a 48-bit central processing unit that is said to operate at some 1.5 million instructions per second and support up to 128 interactive terminals in a multitasking environment. System prices are expected to start at $300,000.

Meanwhile, although it won't be exhibiting at the NCC, Modular Computer Systems, also of Fort Lauderdale, Fla., **will unveil midrange additions to its Classic line of minicomputers during the first week in June.** The new units will fit between the entry-level 7810 single-board computer that starts at $3,250, and the top-of-the-line model 7870 that can have up to 2 megabytes of memory and sells typically for $96,450.

Apple II Plus to bow at NCC for small business

Feeling that the hobbyist computer market is saturated, Apple Computers Inc. is moving into the small-business computer market with the Apple II Plus machine to be introduced at the NCC. A modified Apple II, the II Plus incorporates an **on-board read-only-memory card containing Basic programming language in firmware and an automatic start-up mode** for whatever program is on floppy disk.

Addenda

Wang Laboratories Inc. of Lowell, Mass., is expected to introduce an enhanced version of its VS (for virtual storage) machine at next month's NCC. It should compete favorably with IBM's Series 4300. **An integrated word-processing/data-processing system is also said to be in the works,** and Wang's OIS (for office information systems) line should be rounded out at both the top and bottom. . . . Cray Research Inc. of Chippewa Falls, Wis., **will soon be making its own semiconductors because of shortages of supplier parts,** Cray officials say. Up to half of the company's requirements would be met by an in-house production facility. Those needs will be increased by a projected Cray model 2 system (see p. 120). . . .To soften an average 1.5% price increase for its 1980 TV sets, RCA Corp. has added three technical improvements to the 19-in. and 25-in. models. The 19-in. Auto Programmer set features a keyboard, microprocessor, and memory that lets the user preselect seven days of programming. **Also new are the use of charge-coupled devices, to increase picture resolution** from 260 lines to 330 lines, and an audio-processing circuit, which simulates stereo by frequency separation of the sounds sent to the set's two speakers. . . . The first major product from Intel Corp.'s Commercial Systems division in Phoenix will bow at the NCC. **An all-semiconductor replacement for fixed-head disk drives,** the FAST 3805 has a capacity of 72 megabytes. . . . Bubble-tec Inc. of San Ramon, Calif., has produced the first bubble-memory add-ons for the LSI-11. Using four 92-kilobit Texas Instruments Inc. bubble devices per board, **the $950 boards look just like fast floppy disks.** Another module controls up to 16 boards.

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New glass promises narrower line widths in photolithography

by Jerry Lyman, Packaging & Production Editor

Near-zero-expansion substrates of high-silica glass permit deep UV projection of 1-micrometer line widths

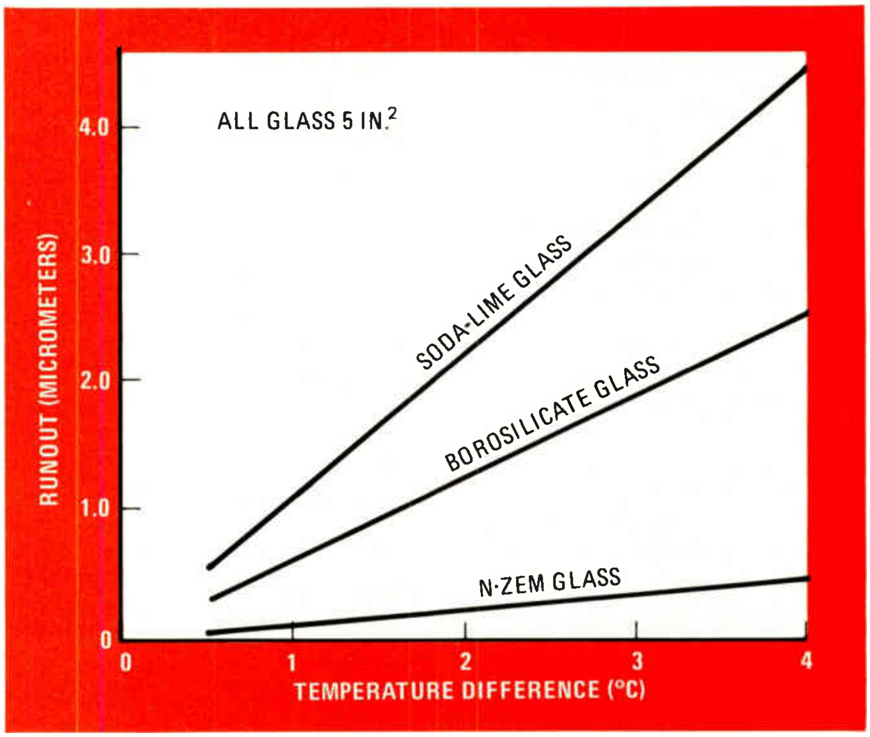
With the emergence of 64-K random-access memories, projection lithography using ultraviolet light appeared to have reached the end of the line. The technique, which focuses a circuit mask on a resist-covered wafer of the same size, could not seemingly produce line widths narrower than the 3 to 4 micrometers of the 64-K units.

At Corning Glass Works in Corning, N.Y., however, projection lithography now has another lease on life, thanks to a new family of glass materials for the mask substrates of the chrome circuit patterns. The company is introducing the glasses this week at the Semicon/West conference of the Semiconductor Equipment and Materials Institute. Corning has three materials, each designed to transmit progressively shorter ultraviolet wavelengths and, hence, to produce progressively narrower line widths. According to Mark Slifkin, a sales and marketing supervisor in the Electronic Materials department, the glasses—known as near-zero-expansion materials, or N-ZEMs—could be used to produce line widths to between 1 and 1.5 μm.

Such narrow lines have been obtained with projection lithography in the deep UV before—by Japan's Canon Inc., for instance—but only using a prohibitively costly ($1,000) mask substrate made of fused quartz, whose low thermal coefficient and surface flatness made it ideal for finely detailed images [*Electronics*, April 26, 1979, p. 72].

Better way. Corning's new proprietary substrates are economical, considering other possibilities. The alternatives involve switching to completely different methods for exposing wafers—direct step-on-the-wafer or electron beam direct-writing systems. These methods are three to four times as expensive as projection lithographers (in the $550,000 to $1.5 million range) and have a much lower throughput.

Corning's N-254 N-ZEM material, a high-silica glass, is designed for deep UV applications. It, and Corning's N-365, have coefficients of thermal expansion of 7.5×10^{-7} length/length/°C, about the same as that of the expensive fused quartz and about six times less than the borosilicate glass conventionally used. (Corning's numbers refer to the peak wavelengths in nanometers the material is designed to transmit.) Another important feature is that the materials' surfaces are extremely flat—to within 2 μm within the



Expansions. Small temperature changes cause the glass used for making masks to run out, or expand, in its horizontal plane. A change of 4°C, which could be found in a semiconductor production facility, for example, causes runouts in a 5-in.^{2} plate of 4.5 μm for soda-lime glass, 2.3 μm for borosilicate glass, and only 0.4 μm for Corning's new N-ZEM glass. On a large wafer, a runout of 2 μm or more may cause misalignment of a high percentage of lines.

mask quality area, Corning reports.

"In today's projection printers, even a small temperature differential from mask to mask can cause considerable runout [expansion in the horizontal plane of the material], which in turn causes layer-to-layer registration errors," Slifkin says. Surface flatness is equally important; curved surfaces distort the projected image. "With these new glasses, an engineer can keep thermal expansion and flatness under control," he continues. (See graphical comparison of the thermal characteristics of the new glass and of the two glasses currently in use—soda lime and borosilicate, which are shown on the previous page.)

Canon's deep UV projection aligner can work with the N-254 materials. And it is suitable for the deep UV aligner being readied by Perkin-Elmer Co., Norwalk, Conn. The material transmits more than 70% of the light at 254 μm projected through it. Its price, when prototype deliveries start in the third quarter of 1979, will be about one quarter to one third the present price of a fused quartz substrate, which makes this material an economical alternative.

The N-365 material is designed to replace conventional mask blanks used for 3- to 4-nm line widths. It is as flat as and has a lower thermal expansion coefficient than conventional borosilicate glass, and its light transmittance is about the same as this material. It will be more expensive, though, at $150 per mask blank versus borosilicate's $40, the developers point out.

Corning's third glass in the family, the N-185, must be rated for research and development. It is designed for 185 nm, the deepest UV of any of the materials, but there is no commercial light source that operates at this wavelength. It will be about half as expensive as fused quartz is at present. □

Computers

TI adds faster 16-bit processor to triple throughput of previous mini

Texas Instruments Inc. continued its assault on the 16-bit minicomputer market last week when it introduced the 990/12 high-performance processor and two commercial systems built around it.

The 990/12 is a souped-up version of the 990/10, TI's previous top-of-the-line machine introduced in 1974. It uses faster TTL devices, a cache memory system, and other architectural improvements to triple the throughput of the 990/10, the Dallas company says. With pricing and performance characteristics expected to compete with the likes of the Eclipse S/250 from Data General and the PDP-11/60 from Digital Equipment Corp., the 990/12 and its associated systems are designed to fill out the top of TI's 990 family.

The move comes on the heels of new additions at the low end of the 990 family last February. It reinforces a growing recognition of TI as a serious competitor in the minicomputer marketplace [*Electronics*, Aug. 31, 1978, p. 92]. Top TI officials have identified distributed computing as one of three corporate thrusts designed to carry the company to its $10 billion sales goal by the late 1980s, and extensive software development efforts aimed at 990 family compatibility have done much lately to solidify TI's market presence. The company itself does not break out the figures, but according to estimates by Dataquest Inc., Cupertino, Calif., TI ranked fourth among minicomputer makers last year with total sales amounting to $320 million, up 46.1% over 1977.

Expanded set. Software compatibility with the 990/10 was paramount among design considerations for the 990/12, points out W. Joe Watson, computer systems division manager at TI's digital systems group operation in Austin. The 990/12 incorporates various new features—including an instruction set expanded from 72 to 140 instructions—which can be used for speed improvements at the expense of 990/10 compatibility. But the threefold throughput improvement is obtained by running existing 990/10 software on the 990/12.

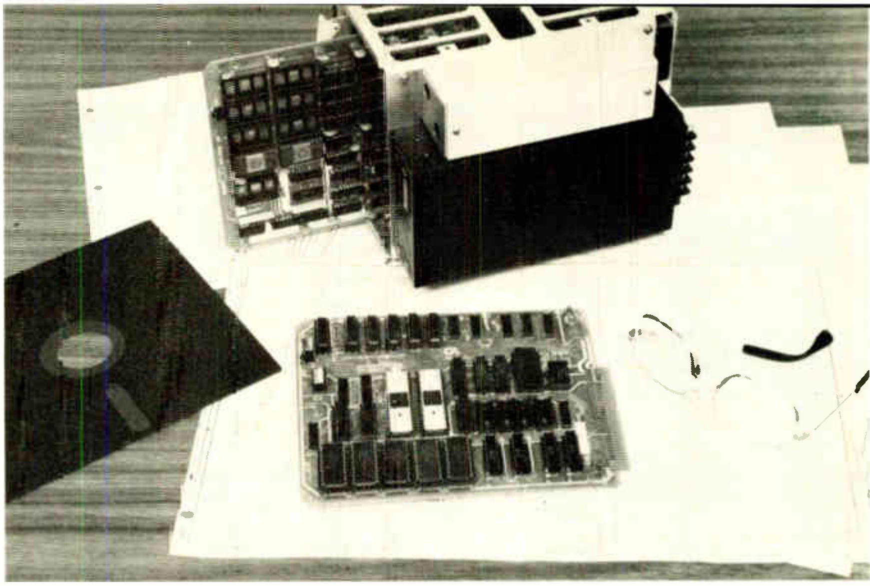
Though the company does expect to pick up some 990/12 box-level sales to original-equipment manufacturers, the new processor's development was targeted mainly as the engine to power new packaged commercial systems for sale to end users with large data-processing loads, Watson says. The new 990/12-based systems—dubbed the DS990 models 20 and 30—will use existing 990 peripherals, with maximum disk storage capacity extendable to 200 megabytes and 800 megabytes, respectively. Without cache, the 990/12 computer sells for $19,598 with 256 kilobytes; with cache the price is $22,948 in lots of 25. The model 20 is $64,500, the model 30, $77,400 for a single unit.

Like the 990/10, the 990/12 is mounted on two circuit boards, which will be housed in a new 17-slot chassis that can handle more power than the old 990/10 13-slot chassis. First demonstration of the new machine is set for the National Computer Conference next month, with initial box-level and system deliveries expected to begin in the fourth quarter.

Faster logic. The 990/12 uses TI's SN74S481, a general-purpose bit-slice machine implemented in Schottky TTL that is faster than the standard TTL SN74181 used in the 990/10. Also contributing to the basic 990/12 speed improvement is a large-scale integrated device custom-designed by TI's semiconductor group for interfacing the 990/12 with the computer's bus.

In addition to faster devices, architectural improvements contribute to the 990/12's increased speed. The 990/12 has a work-space cache consisting of 16 registers, for example, that in some cases eliminates the need for a memory cycle when an instruction is executed. That is in contrast to the 990/10, which houses its general-purpose registers in memory and thus requires a full cycle to access one. -Wesley R. Iversen

Don't fix a board: throw it away



Disposable computer. The processor board (foreground) is one of a dozen products in Computer Automation's Scout Naked Mini 4/04 series of 16-bit minicomputers.

Increasingly, in the low end of the computer business, it looks as if dollars per bits are eclipsing nanoseconds as prime buying standards. In other words, as technology matures, economic factors call the shots more and more. Banking on this trend, and encouraged by a yearlong market study that confirms it, minimaker Computer Automation, Inc. (noted for its low-price bent) is launching a 16-bit model it claims is as cheap to throw away and replace as to repair.

According to George O'Leary, marketing vice president of the firm's Naked Mini division, the goal is "to bring computer hardware down to the level of a consumable commodity." CA takes the wraps off its Scout Model 4/04 minicomputer next month at the National Computer Conference in New York. In a typical four-board configuration, it is slated to make original-equipment manufacturers shell out a unit price of less than $925 in large-quantity orders.

Split up. To get such a machine, the Irvine, Calif., firm has pushed its board computer philosophy down to the next level. "We've split the functions off a single board and parceled them out, one to each board," explains O'Leary. Advantages are not only a lower price tag per function, but operating simplicity that allows easy self-testing, which he calls the key to the approach.

On each of the 11 circuit boards (half-sized at 6.25 by 8.3 inches), a self-diagnostic capability signals go/no-go on a light-emitting diode near the outer edge when the test routine automatically executes at startup. It is implemented as firmware in a 4-kilobyte read-only memory contained on each board. (Since only 1 kilobyte is needed for the test, a user has the other 3 to play with.) "Keeping the system on line is as simple as sliding out a defective board and inserting a replacement rather than making repairs," O'Leary adds.

Array of options. CA has tried to keep the new hardware simple and compatible with its other mini lines, so the central processing unit uses the same MOS logic chip set. Offered with it are an array of such function boards as 32-kilobyte random-access memory, expandable, with 550-ns cycle time; RAM or electrically programmable ROM that can be selected in 4- and 8-kilobyte increments; remote console interface; and relay card. Others available are parallel input/output, serial I/O, analog to digital converter, with 12-bit resolution and 20-kHz throughput, extender card and prototype board. A chassis including a motherboard for mounting four or nine cards and two models of power supply (10 or 20 amperes at +5 volts dc) complete the new mini line.

The economic basis of the disposable hardware concept, by CA calculations, derives largely from the soaring cost of repair. Under the best of conditions, the firm figures it cannot test and fix a board that won't work, pay for paperwork, and get it back to a customer for less than $175. (This breaks down into about $100 for administrative paperwork, $50 at the least for repair, plus $25 for shipping and insurance. "And it doesn't reflect delay, inconvenience, and maybe down time," says O'Leary.)

So the CA price of about $200 per new board, for all except CPU and main memory, gives the OEM the throwaway option. Besides the advantage of simple modularity in design, the firm sees a manufacturing edge. It will be built on a new assembly line at the Richardson, Texas, plant where it was developed. This new unit, software-compatible with other CA lines, could not be produced at that price at the California location. -Larry Waller

Software

Microprocessors get big league languages designed to counter the high cost of programs

Microprocessors have begun to catch up with their bigger brothers in high-level software. With Data General Corp.'s May 15 announcement of Micron, MP/Pascal, and MP/Fortran IV, the microcomputer can bat in software's big leagues.

The Micron operating system [*Electronics*, May 10, p. 33] runs on the Westboro, Mass., company's microNova line of microcomputers. But it also can run on the firm's largest machines, the Eclipse line—and that's a key part of the development, the company points out.

Now it's possible for a program written on one of DG's smallest computers to run—at something less than peak efficiency—on a large minicomputer, and vice versa. Any computer in DG's line that uses its advanced operating system (AOS) is compatible with Micron and its Pascal, Fortran, and sundry utility programs. This provides the product line with considerable downward compatibility.

"The prices of our microNova computers have fallen 30% to 45% in the past 18 months, while the cost of software generation continues to climb. A single line of software costs twice as much to write as it did about five years ago, and costs could double again by 1985," comments Edward Belove, manager of microproducts software development at DG. "That means our users need powerful languages like Pascal where a single line accomplishes much more than a line of a simpler language."

Big talk. Micron is a subset of DG's advanced operating system, which accounts for its large-machine compatibility. Many members of the crew that developed AOS also worked on Micron. Many of the Micron utility programs they wrote are AOS utilities scaled to the small machine environment, thus bringing large machine features to microcomputer software.

More than half of the Micron utility programs are written in Pascal. Two of them are in Fortran IV, and the rest are either new or reconfigured from AOS systems or DG's disk operating system.

Several of the more than one dozen utilities are the sort used with a full sized minicomputer, but others are specialized—like Prom Burn, which allows any Micron-based program to be burned into programmable-read-only memory for dedicated applications. Among the other programs are an interactive text editor; Fixup, which spots bad data blocks in memory and rebuilds files and directories; a file editor; an interactive symbolic debugger; an English-language symbolic line interpreter; and a number of other file management routines. Price for the Micron system (3775) is $1,500; for MP/Pascal (3777), $1,000; and for MP/Fortran IV (3778), $500.

"With this software package, we've got what we feel is the minimum necessary for microprocessors to do a good job when compared with large machines. And we have built in lots of growth potential," says Belove. "But we haven't had to sacrifice any of the advantages of small machines to get the performance." **-James B. Brinton.**

Optics

Predistortion guards against errors

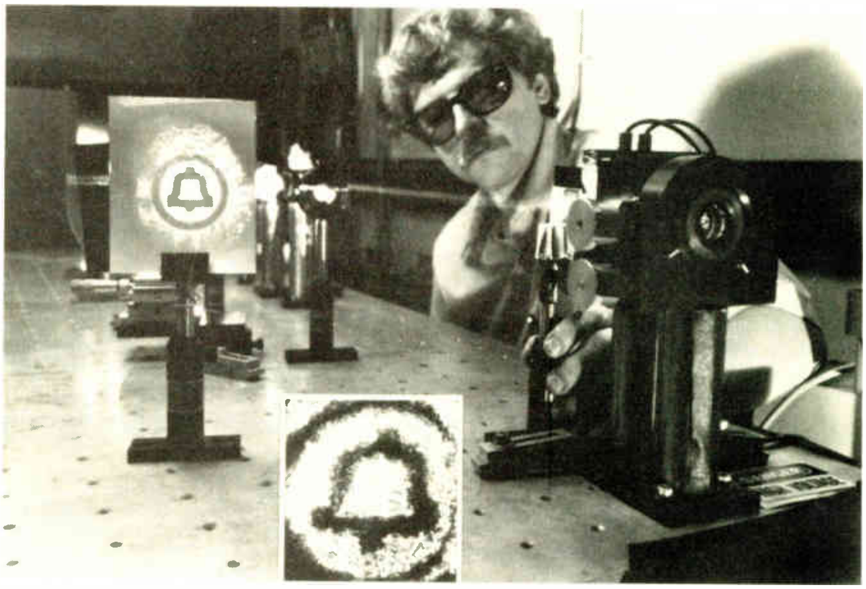
Mechanical and environmental interference with lightwaves in a length of fiber-optic cable can cause errors in the information being transmitted. If engineers had an advance idea of the nature of such effects—caused by heat or impurities, for example—they could compensate for them and limit errors.

In addition to its usefulness in low-error-rate light communications, this compensation, or predistortion, has applications in areas such as laser fusion research.

Predistortion and subsequent error cancellation have actually been accomplished by researchers at Bell Laboratories in Holmdel, N. J. Technical staff members David Bloom, Paul Liao, and Gary Bjorklund were able to straighten out an optical image distorted on purpose (see the inset of the photograph of the experimental system).

Backwards. To predistort the light signal to cancel out perturbation along its path, the Bell team first sends a "pilot" laser beam along the reverse optical path from that of the desired beam. The signal is distorted by the path into the conjugate, or mirror image of how the distortions will act on the real beam transmitted in the other direction.

After the path is traversed, the pilot signal is combined with two other reference laser beams in a nonlinear optical medium. For the mixing process Bell uses an appropriate material in liquid, solid, or gaseous state; research on the optimum mixing material for particular applications and different operating frequencies continues. By a complex mechanism, with the medium acting somewhat like a microwave frequency mixer, a fourth,



Distortion removed. The image—projected here by a lens—of the Bell System symbol has been passed through a piece of distortion-producing glass before being processed by the distortion correction device. The inset shows the distorted image before processing.

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Want to know more? Contact the Tektronix field office nearest you. To request the TM 500 catalog, call our toll-free automatic answering service: 1-800-547-1512. In Oregon, call collect: 644-9051. In Europe: Tektronix International, Inc., European Marketing Centre, Postbox 827, 1180 AV Amstelveen, The Netherlands, Tel: 020-471146 Telex: 18312.

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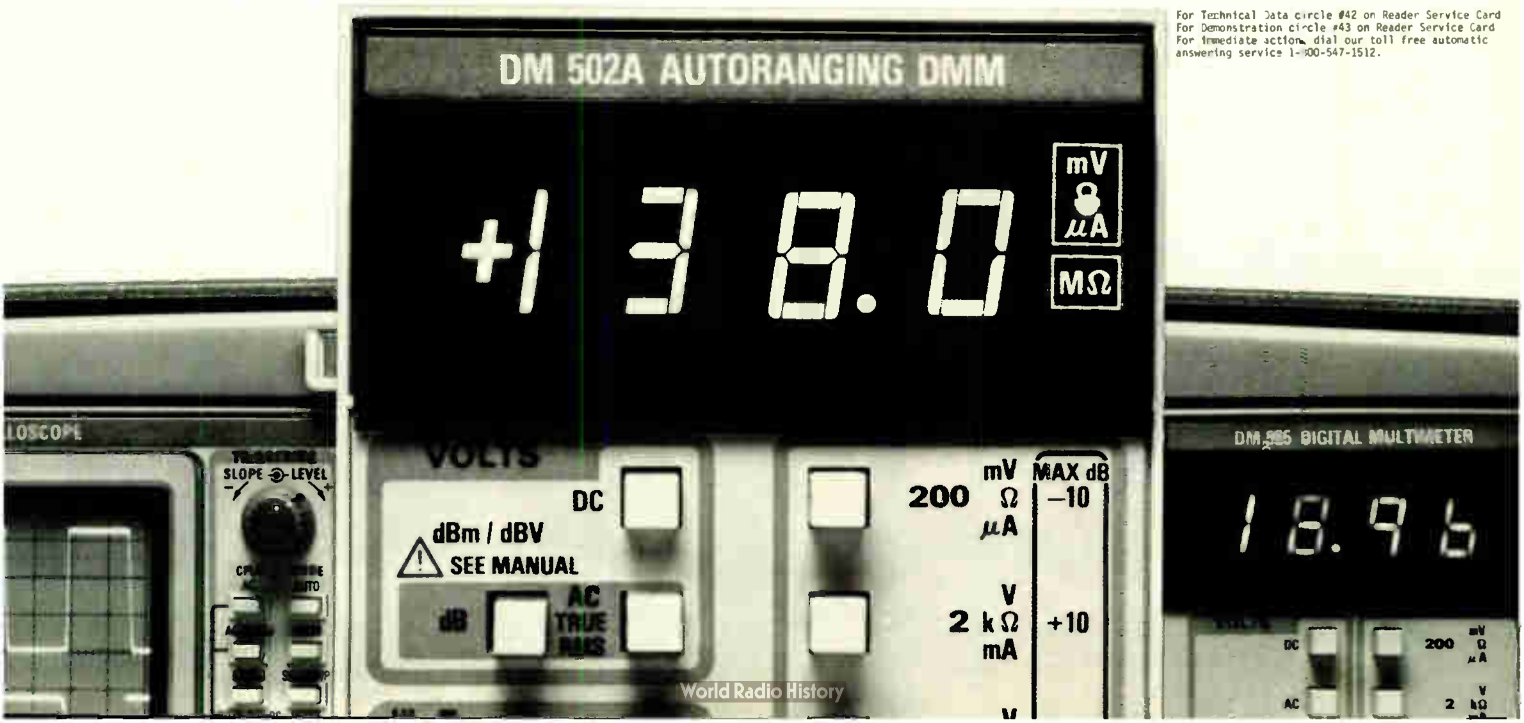

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predistorted laser beam is created from the pilot and reference beams. This fourth beam contains the conjugate of the distortions in the actual light path.

While the device is still in the laboratory stage and a long way from practical use, several applications are possible. For example, says Liao, the precisely aligned optical elements, such as lenses or prisms, that guide light in high-powered fusion research lasers tend to deform under the influence of heat generated by the beams. This distortion obviously reduces accuracy in directing the light.

Fire away. Up to now, the solution has been to limit the firing rate of the lasers. But this in turn limits the power generated. With the new predistortion technique it may be possible to precompensate the light and fire the lasers more often, researchers believe.

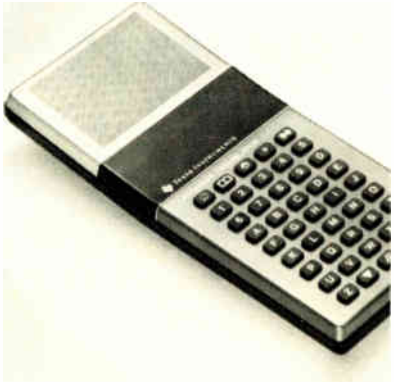
Further work at Bell, Liao says, will concentrate on optimization of the process and applying it to spectroscopy problems—in the area of properties of materials, for example. Others investigating these conjugate waves include Robert Fisher and Barry J. Feldman of the Los Alamos Scientific Laboratory's Carbon Dioxide Laser Technology group, Los Alamos, N. M. They hope to solve system alignment and amplification problems in the lab's laser fusion work. **-Harvey J. Hindin**

Consumer

Hand-held translator speaks out loud

Ever looked up a foreign-language phrase in an overseas restaurant, pronounced it, and got only a quizzical look from the waiter? Realizing that mere sympathy won't fill your plate, engineers at Texas Instruments Inc. have developed a hand-held unit that not only translates and displays foreign words and phrases, like other translators, but speaks them in the foreign tongue, too.

TI's language translator is the third to reach the market, following recent products introduced by Lexicon Corp. [*Electronics*, Dec. 7, 1978, p. 50] and Craig Corp. [*Electronics*, Dec. 21, 1978, p. 34]. It is, however, the first to talk, a feature made possible by TI's single-chip speech synthesizer [*Electronics*, Aug. 31, 1978, p. 109]. This is the same chip that is the heart of the company's popular Speak & Spell learning aid for children.



Fluent. Talking language translator, shown here in prototype without display, is calculator-sized and powered by four AA batteries.

Six chips. Besides the speech-synthesis chip, which has been modified to improve its diction, the talking translator contains a TMS 1000 controller and four 128-kilobit low-speed read-only memory chips. Plug-in ROM modules give the translator a 1,000-word vocabulary. Of the 1,000 words, 500 can be displayed and pronounced; the rest are displayed only.

The translator, to be unveiled next month at the 1979 International summer Consumer Electronics Show in Chicago, will retail at $250; shipments of English and Spanish versions will begin in September. The French, German, Japanese, and Chinese modules, priced at $50 each, will be available by the first quarter of 1980.

Other manufacturers have brought out talking consumer products like chess-playing computers, but they all use expensive multichip speech synthesizers. For this reason, TI has been flooded with requests for its chip. But it isn't selling—yet.

"We're busy enough making ICs for Speak & Spell, which we're now producing at the rate of 40,000 to 60,000 a month," reports Doug Lindgren, manager of the company's Consumer Specialty Products division in Lubbock, Texas. Should it reduce its backlog (or if National Semiconductor Corp., which is rumored to be working on a single-chip speech synthesizer, puts one on the market), that policy may change very quickly. **-John Javetski**

Medical

An rf solution to a beef cancer

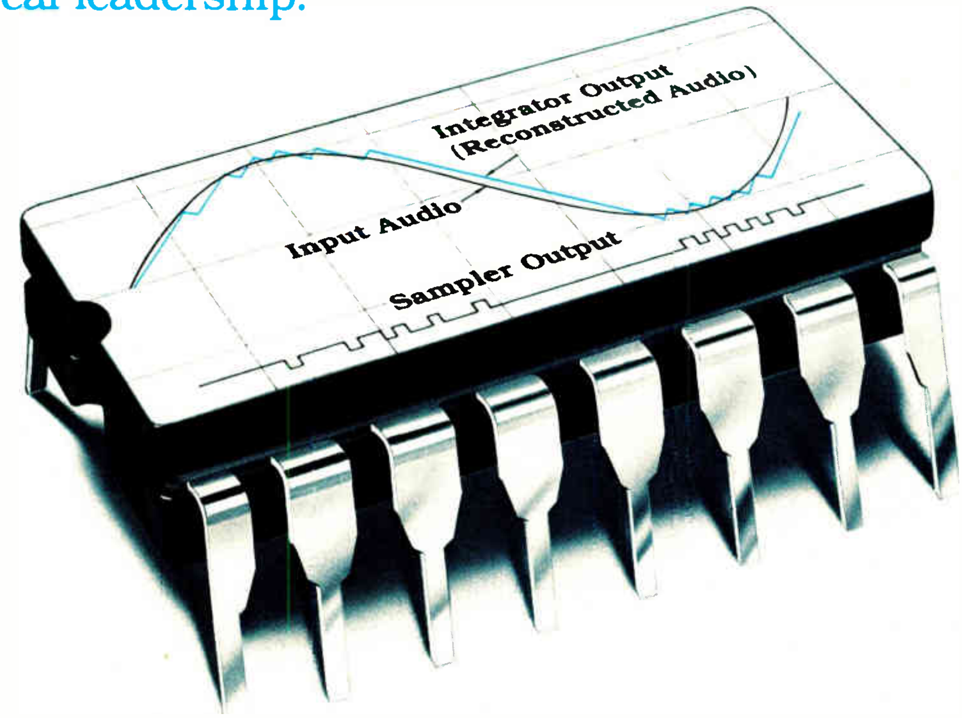
Cattle have better access to some forms of cancer therapy than human beings, particularly radio-frequency hyperthermia. While rf hyperthermia is still an experimental technique for human cancer patients [*Electronics*, April 26, p. 88], it's at home on the range today.

"Eventually, there may be more cowboys treating cancer than M. D.s," says James D. Doss, staff member of the Los Alamos (New Mexico) Scientific Laboratory. The reason is what is called cancer eye, a common affliction of the nation's beef herds.

The problem is an important one. From 12% to 17% of breeding stock in the Southwest may be afflicted with cancer eye—the leading cause of cattle carcass contamination in 1975, according to the Department of Agriculture. The disease, if untreated, is about 80% fatal; it starts in an eye socket and may quickly spread to tissue in the head and nervous system. Losses due to cancer eye may cost ranchers more than $20 million yearly—and may cost consumers even more, if the effect of these losses on the retail beef market is considered.

The treatments available have been about the same, and about as costly, as those for humans. So cancer eye has usually gone untreated. But now there is a fast, simple, and inexpensive treatment available that promises to cut these

Technological leadership.



Digitize voice fast, not furious, with one $6.95 CVSD interface IC.

If you've ever locked horns with variable slope delta mod for generating piece-wise approximations of analog signals you know how mean, ornery and expensive they can be.

Now there's a quick, easy, flexible and very economical way of voice encoding/decoding: the single chip, MC3417/3418 CVSD, or continuously variable slope delta modulator/demodulator.

What makes it unique, and so desirable, is its companding algorithm section which provides increased dynamic range by automatically adjusting integrator gain in the delta mod.

By sheer coincidence

This on-board circuitry monitors the past few outputs of the modulator in a shift register 3 or 4 bits long and indicates if it contains all ones or zeros, called coincidence. When coincidence occurs, this algorithm indicates too-small integrator gain and adjusts accordingly.

The effect of the algorithm is to sense signal level input and compand it. When using the CVSD as a decoder, the algorithm restores level variations. The bit stream is as if it were from a standard delta mod with constant level input, but the effective dynamic range is increased.

Use the unique CVSD as a building block for hard-wired encoding or decoding, do both alternatively with one part, or get full duplex capability with two parts. Whichever way you choose, you get flexible sampling rate to 250 kHz, selectable digital input threshold and 3-bit (MC3417) or 4-bit (MC3418) algorithm for low or high bit rates. The MC3517/3518 offers the same parts in mil temp range.

One chip does it all

It's so versatile we could run off the page with possibilities: voice from ROM to speaker or telephone, etc.; message generator; real-time voice recording on disk; intercom channel mux; secure voice; telephone line concentrator; game voice generation; ad infinitum, almost.

It's also I²L, laser-trimmed and CMOS compatible. And a pure delight to turn any kind of ∿ into any sequence of 10100110.

Contact Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036 for data.

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Hand-held cancer killer. Interior of prototype rf hyperthermia applicator shows miniature 2-megahertz oscillator and temperature-control circuitry. Unit can help manage up to 90% of cattle cancer-eye cases.

stock losses dramatically.

Doss's development, funded by the Department of Energy, grew out of a cooperative program with the University of New Mexico Medical School, Albuquerque—where Doss is a clinical associate—on rf hyperthermic treatment of animal and human tumors. When the results—significant regression of many tumors—were discussed with veterinary authorities, they pointed to the cancer eye problem, and Doss and his collegues went back to the lab in search of a solution.

Dashboard unit. About two years of work resulted in a system that, in some forms, is powered from the 12-volt cigar lighter socket on a pickup truck dashboard. Very like a pistol grip in appearance, the unit has two small protrusions extending above the trigger site. One is a miniature rf emitter; the other is a temperature-measuring thermistor.

Inside the hand-held unit is a miniature 2-megahertz oscillator. Also included is temperature control circuitry (see photo).

The animal is given a local anesthetic and the probe pressed against the tumor. Operating at about 2 megahertz, with up to 10 watts of power available, the device heats the tumor fast.

In seconds it brings the cancer up to the 50°C needed to attack it; the user then keeps the probe tips in firm contact for about 30 seconds. With the exception of an antibacterial spray, or some eye drops, that is the extent of the treatment.

Doss selected 50°C (about 122°F) because cancerous bovine tissue is damaged at such temperatures while normal tissue is well enough cooled by its blood supply to survive without injury. But to avoid excess heating, the thermistor closes a control loop that varies rf output to keep temperature constant at 50°C, according to the researcher.

Results. Remission occurs within a few weeks, typically two to four weeks. Cure rates in pilot studies by the Los Alamos laboratory were as high as 90%—an unheard of cancer remission rate, for animals or human beings.

As a result, there are now about half a dozen companies offering or about to announce commercial versions of the system, Doss says. Among the two largest are the Agricultural division of the Hach Chemical Co., Ames, Iowa, and MDR Inc., Phoenix, Ariz. There is even a unit from relatively small Apache Indian Enterprises, Inc., Dulce, N. M. Prices run between $400 and $600, and according to a Hach Co. spokesman, "are selling very well for new introductions to a traditionally conservative market." **-James B. Brinton**

Careers

EEs got 11.6% raises, AEA survey reveals, but some regions are boosting pay higher

If you are a nonsupervisory engineer with a bachelor's degree and did not get at least an 11% raise in the past year, you slipped behind the industry average, according to a recent nationwide salary survey covering 45,410 engineers.

The canvass by the American Electronics Association shows that combined salaries nationwide in that category rose 8.99%, while raises averaged an 11.56% gain. The difference between the two figures occurs because the first relates to all engineers from entry level to 24 years past their degree, whereas the second omits those at entry level. In terms of monthly salary, the average engineer nationwide earned $1,506 the 2nd year after receiving a bachelor's degree, $1,722 the 5th year, $2,026 the 10th, and $2,431 the 20th.

Of course, averages can be misleading, and significant regional differences must be taken into account. In the Pacific Northwest, for example, combined salaries rose 15.44% and raises increased 18.05%, but the monthly income figures were in the average range. AEA officials surmise that these figures reflect the tremendous expansion and additional hiring by electronics companies there. The survey, which covered 576 big and small electronics companies in eight categories—supervisory and nonsupervisory with either bachelor's, master's, doctoral, or no degrees—reveal these trends among nonsupervisory and supervisory bachelor degree holders by region:

- California. As might be expected, the San Francisco area had above-average increases, 9.52% overall and 12.04% in raises, but those for the whole state, with the Los Angeles and San Diego areas, were about average.
- Colorado. This region experienced only a 3.08% general salary rise and a 4.9% average raise. Furthermore, nonsupervisory engineers made slightly less than average. The super-

Cut the cost of digital system checkout with Biomation's DTO-1.

There's a whole new approach to test, calibration and maintenance of digital systems. It's Biomation's DTO, the first Digital Testing Oscilloscope. Here's how it works. The DTO's front panel functions very much like a traditional oscilloscope but provides additional capabilities. It automates testing without having to worry about software implementation. Simply step through your test sequence once using the DTO to record the entire program on a tape cartridge. Then DTO plays it back to guide technicians, even setting up the instrument's front panel to match the reference program. All in all, DTO provides a faster, easier, far more accurate approach to the otherwise time-consuming, error-prone task of system checkout.

DTO-1: For production test.

Now there's a better way to move new products out of engineering and into production accompanied by a comprehensive production test program. Just use DTO to record the test sequence you want technicians to follow. Step by step, it enables them to compare the system under test with your "known good" system, automatically flagging any discrepancies. Compare DTO with the test equipment you're now using.

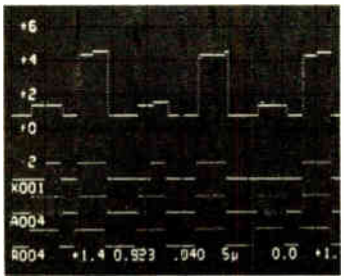
SYSTEM TEST CAPABILITY COMPARED

Testable system elements	Oscilloscope	Signature analyzer	In-circuit emulation with signature analysis	DTO-1
Power supplies	yes	no	no	yes
System clocks	yes	no	no	yes
Processor/control logic	no	no/yes	yes*	yes
Digital input/outputs	no	yes	yes*	yes
Analog I/O	yes	no	no	yes

*System must have a processor.

DTO-1: For calibration & repair.

The most sophisticated calibration and repair labs are using DTO to "document" digital systems they must service.



By developing a tape for each new piece of equipment and instrumentation, troubleshooting and recalibration is faster and more precise. The DTO's screen displays both reference traces and test traces simultaneously, highlighting any disagreement and enabling technicians to zero in on faults.

DTO-1: For facility maintenance.

When it may be weeks or months between repair and maintenance of complex digital systems, DTO brings technicans back up to speed in a hurry. DTO can be used to make a record of the system operation, so it remembers exactly how a perfectly functioning system operates. By following the test procedures and adjusting the system signals to match recorded logic traces, maintenance is virtually automated.

For details on how Biomation's DTO-1 can cut the cost of digital system checkout for you, write Gould Inc., Biomation Division, 4600 Old Ironsides Dr., Santa Clara, CA 95050.

Or, call for a demonstration. (408)988-6800

GOULD

To earn more, stay in school

How much are advanced degrees worth? According to the AEA survey, at the 2-, 5-, 10-, and 20-year junctures the average nonsupervisory holder of a master's degree will earn between $100 and $175 a month more than a bachelor's degree holder, whereas an engineer with a doctorate can expect between $350 and $400 a month more in salary.

On the supervisory side, the master's degree holder begins to earn over $100 a month more in the 10th year and over $200 more in the 20th. But a doctoral degree brings dramatic increases at first—over $900 a month difference at 2 years and more than $600 at 5, which drops to about $350 at the end of 20 years. About 20% of those surveyed were in supervisory positions, as defined by AEA, but 75% had advanced degrees.

Doctorate degrees for supervisors have a longer half-life, the survey indicates. On the nonsupervisory side, raises for holders of any of the three degrees average between $32 and $39 a month per year until the 21st to 22nd year after the bachelor's degree, when the engineer is presumably in his early 40s, when they tail off. For the supervisor, approximately the same thing happens to the $40-to-$48-a-month hikes for bachelor's and master's degree holders, but the doctorate's average monthly increase has not even peaked by the 34th year. All EE salaries, however, tend to flatten out to a plateau in later years.

visory employee began lower and nearly caught up in the 5th and 10th years, only to fall behind in the 20th.

■ New England. This region is about average both in percentages and absolutes. Here, the nonsupervisory engineer does well until the 20th year. The supervisory person is also ahead early but falls back in the 10th and 20th years.

■ Texas and Arizona. The Sunbelt, perhaps reflecting differences in cost of living, was generally below average—up 7.09% in income and 9.16% in raises.

The push for engineers has improved salaries for non-degree EEs, though they still trail degree holders (see "To earn more, stay in school"). Salaries for nonsupervisory EEs without degrees rose 11.7%, raises, 12.5%. **-William F. Arnold**

Peripherals

CRT signals drive printer directly using tube's gun to run matrix print head

A wide variety of small printers selling for about $1,000 or less have recently been introduced expressly for printing what is displayed on a cathode-ray-tube terminal. The printers need their own character generator and the analog circuitry the generator drives to control the pattern of dots. That is, all needed this circuitry until now.

The exception is a new printer introduced by Axiom Corp., a Glendale, Calif., maker of printers that use electrosensitive paper. Axiom's VP-850 is driven directly by the standard analog video signals that drive the terminal's CRT. These signals may be either in the CRT's standard composite video at 0.5 to 10 volts peak to peak or in its separate video and synchronization components. Ordinarily the signals would direct the tube's electron gun to scan a raster pattern and produce an image on the screen; the Axiom printer uses them to direct its matrix print head to reproduce the image, the company explains.

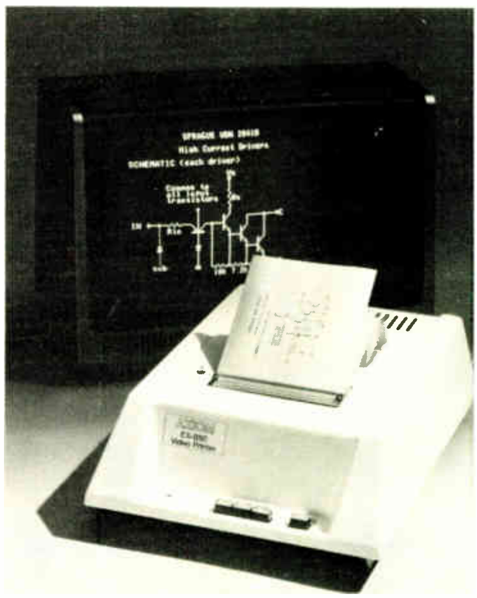
The standard 15,750-hertz video signal is sampled 1,350 times per raster line and stored until data from 24 raster lines has been accumulated in a random-access memory. This data—by now in digital form—is used to activate the 24 print wires in the matrix head, which prints on electrosensitive paper.

Simon J. Harrison, executive vice president of Axiom Corp., points out that tapping into the terminal's video signals also makes it easier to interface with graphics terminals. "It's especially good for graphics because it doesn't need graphics data to be converted into a standard ASCII code and reconverted into printer signals," he says. In fact, Harrison says any standard raster-screening pattern will work with his printer. But he concedes the printer cannot handle the vector-scanning techniques that are employed in some graphics terminals.

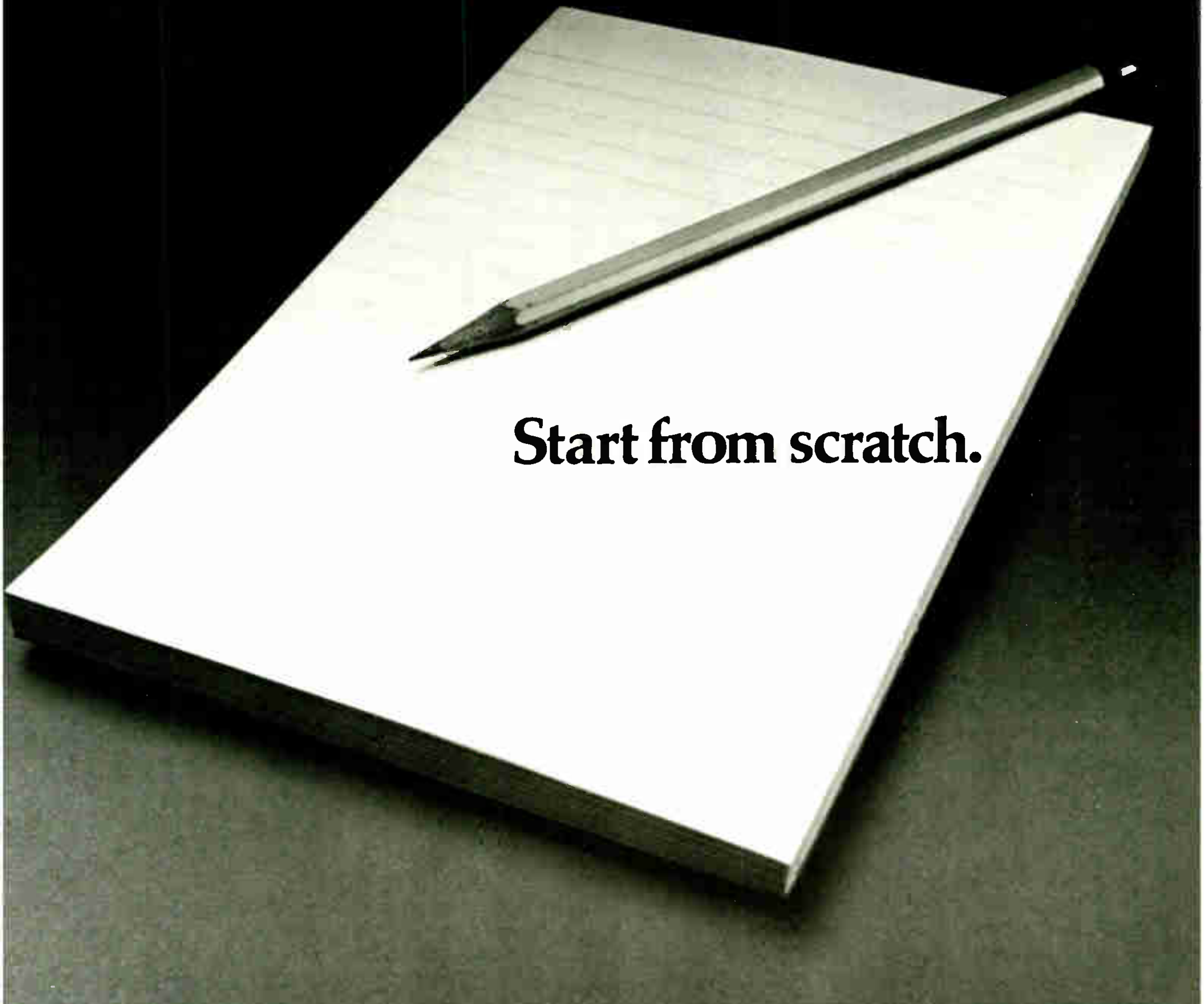
More uses. Other applications where the printer is especially useful are in data-line monitors that display all communications control characters, Harrison continues. As these control characters are normally not seen by the computer user, they are not included in the standard printer character generator. But they are useful when diagnosing data-communications problems, and Harrison says that his printer will be able to reproduce them.

Axiom has current annual reve-

CRT to printer. The Axiom VP-850 printer using electrosensitive paper operates directly from display signals to reproduce image.



There are only two ways for an OEM to design a mid-range computer system that precisely fits each application.

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Digital's PDP-11/34 gives you more design flexibility than any other mid-range in the world.

If that sounds like a bold claim, consider this. There are more than a million ways to configure a PDP-11/34 computer system.

That figure is not based on frivolous options, but on significant choices like CPU capabilities, memory options, peripherals, operating systems, languages, communications packages and network systems.

All of these options are in addition to a basic PDP-11/34 that is extremely flexible to begin with. Here are some of its standard features: a 16-bit microprogrammed processor, parity memory, direct memory access, vectored interrupts with four priority levels, hardware stacking, operator's console, multi-function ROM with virtual console capability, diagnostics and bootstraps, memory management, hardware multiply and divide, power fail/auto restart, and prewired slots for expansion options.

With the basic computer so flexible, and the system options so numerous, you can virtually design your own mid-range system with the PDP-11/34. Without having to start from scratch.

Choose the hardware you need.

Take the PDP-11/34 CPU, for example. You can pick and choose among 21 CPU options for the precise combination you want. The 11/34 offers a new superfast cache that makes a powerful system even more powerful. It can increase your program execution speeds by as much as 60%. Other options include a fast floating point processor, serial communications line interface, and real-time clock, to name just a few.

You can also choose from twelve memory options, including MOS, core or any combination. Digital's MOS memory uses industry-standard 16K RAM chips with a 500ns cycle time. And it's available on 128Kb or 256Kb boards.

Of course, there's more to a system than a CPU. And the 11/34 offers more.

You can choose from 6 disks, 4 tapes, 10 terminals, 8 printers, 6 card readers, and 9 kinds of I/O. Plus 10 different kinds of communications options that cover the broadest range of devices in the industry.

You can even pick your packaging, because the PDP-11/34 comes in eight models with two battery back-up choices and five different backplanes.

Given all these options, you can configure the perfect combination of hardware for your application. Without paying for more power than you need, or settling for less.

Choose from four operating systems and ten languages.

Even with the precise hardware in place, you're still only halfway to the precise system for your application. The software options of the PDP-11/34 will take you the rest of the way.

For real-time applications, there's RSX-11M. It's specifically designed for multi-programming and concurrent program development. And it offers you the power of an event-driven software system with dynamic memory management, multiple programming languages and a complete list of utilities.

If you don't need all the capability of RSX-11M, the beauty of the 11/34 is you don't have to get it. You can get RSX-11S instead. It offers you the same multi-task, event-driven real-time capability without the overhead of interactive program development.

And if your application calls for real-time, but doesn't call for multi-programming, you can call on RT-11. It's a single user foreground-background system that's designed for both program development and dedicated, on-line applications.

For timesharing applications, Digital offers RSTS/E—a powerful, flexible system that can handle up to 16 different users on an 11/34 at one time.

Then there are all the languages. Depending on your application and operating system, you can choose BASIC, Multi-User BASIC, MACRO-11, COBOL, DIBOL-11 (Digital's business/commercial language), FORTRAN, APL, RPG and FOCAL, with still more languages in development.

And finally, you have available an extensive library of applications software. You can pick and choose the exact OEM software tools that make the most of your hardware. And your application.

Then do what you want with your system.

With the PDP-11/34, you can vary your system according to the requirements of your customers. You can offer a wide range of terminals, peripherals and communications packages. You can make fine adjustments in design and manufacture.

In short, you can turn more good prospects into good customers simply by adapting to their individual needs. And you can do it without incurring the major losses in time and money that are involved when you design the complete system yourself.

The PDP-11/34 opens up a new world of flexibility in manufacturing and marketing your products.

It also opens up a new world of applications flexibility. With all its options, the 11/34 is ideally suited for applications involving instrument interfacing. And with all its programming tools, it's ideally suited for applications involving program development. The PDP-11/34 even gives you the flexibility to link your system with any other Digital system anywhere in the world through DECnet networking software. And that means you can offer your customers the benefits of distributed data processing using the broadest range of upwardly compatible systems anywhere.

The PDP-11/34. If you designed your computer from scratch, you wouldn't come up with a more precise mid-range system for your application.

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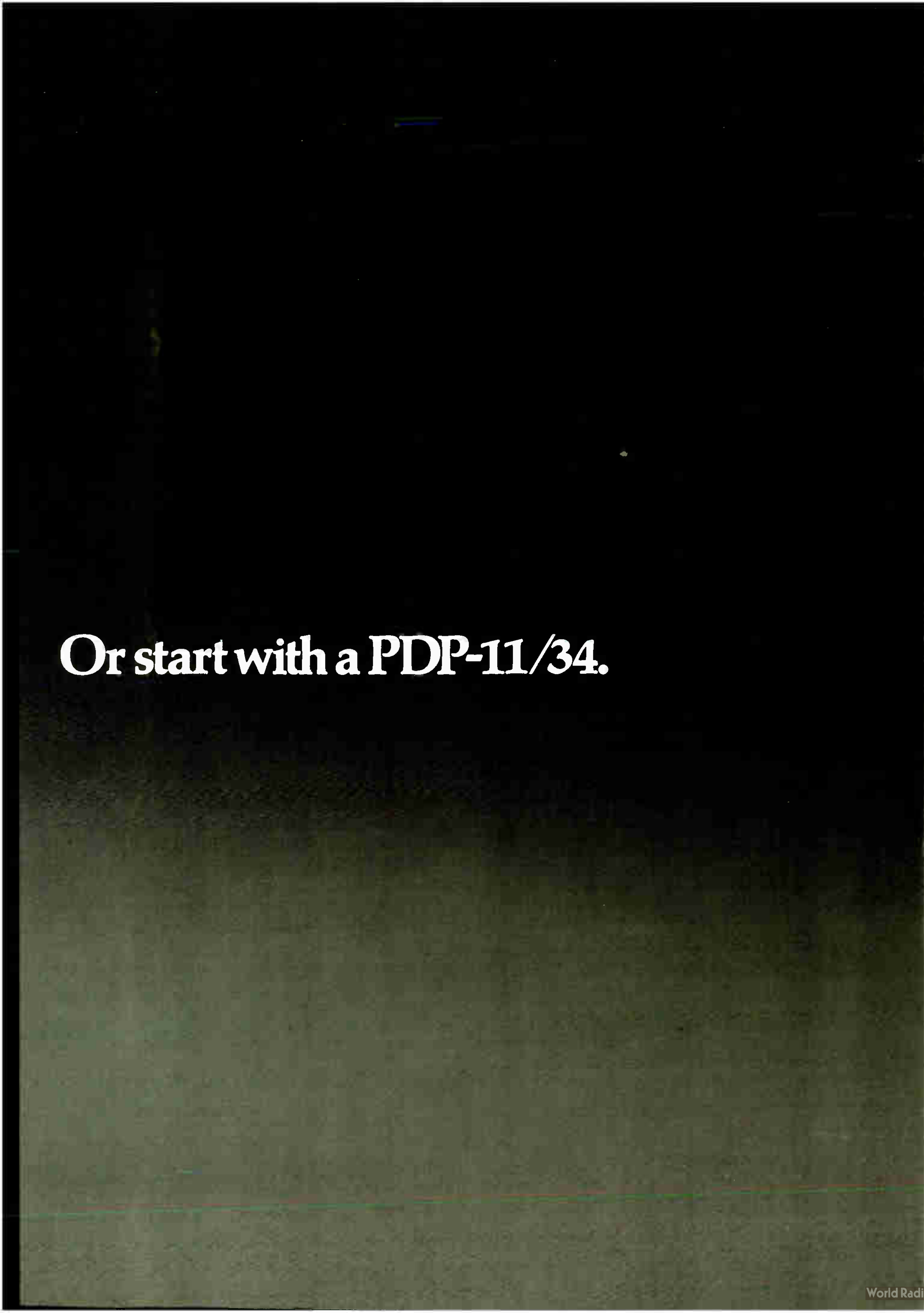

The PDP-11/34. Just look at the freedom it gives you.

Packaged systems*

11/34A CPU with 64Kb MOS memory, 1Mb disk storage, video or hardcopy terminal, RT-11 operating system.

11/34A CPU with 128Kb MOS memory, 10Mb disk storage, video or hardcopy terminal, RSX-11M operating system.

11/34A CPU with 128Kb MOS memory, 56Mb disk storage, video or hardcopy terminal, RSX-11M operating system.

11/34A CPU with 256Kb MOS memory, 67Mb disk storage, 9 track/45ips tape, video or hardcopy terminal, RSX-11M operating system.

*In some cases, available with other operating systems, less memory, and with core instead of MOS.

CPU configurations

MOS memory of 256Kb, 128Kb, 64Kb and 32Kb.
Core memory of 128Kb, 64Kb and 32Kb.
Optional cache memory.
Optional programmer's panel and serial line interface.
Optional floating point processor.
Optional MOS battery back-up.

Software

RSX-11M multi-user, multi-tasking operating system featuring program checkpointing, dynamic partitioning, and memory management.
RSX-11S execute-only operating system for monitoring and controlling multiple real-time processors.
RT-11 real-time, foreground/background operating system.
RSTS/E timesharing operating system.
DECNET II distributed data processing networking package.
FMS-11 forms generation software.
DATATRIEVE-11 data inquiry and report writing system.
DBMS data base management system.
RMS-11 record management system supporting ISAM, sequential, and random access file structures.
SORT-11 for re-ordering data based on key fields in the data record.

Languages

FORTRAN IV	BASIC PLUS	APL
FORTRAN IV+	BASIC+2	MACRO 11
BASIC	COBOL	CORAL 66
	DIBOL	

Memory

MOS memory modules of 256Kb, 128Kb, 64Kb, 32Kb and 16Kb.
Core memory modules of 64Kb, 32Kb and 16Kb.

Disks

RX02 1.0Mb. dual drive (diskette).
RL01 5.2Mb, removable.
RK07 28Mb, removable.
RM02 67Mb, removable.
RP05 88Mb, removable.
RP06 176Mb, removable.

Special I/O

IEEE interface with software.
Industrial control remote sub-system.
Industrial control master sub-system.
D/A control.
12 bit A/D converter, 16 channels.
48 channel multiplexer.
10 bit A/D converter, 16 channels.
Parallel I/O with direct memory access.
16-bit parallel I/O, program controlled.

Communications options

Full/half duplex synchronous interface for both byte and bit oriented protocols.
Full/half duplex synchronous interface for byte oriented protocols.
Full/half duplex NPR synchronous interface.
Network link, local or remote, DDCMP up to 1Mb.
Asynchronous 8 and 16 line multiplexer.
Programmable 16 line asynchronous multiplexer.
Synchronous/asynchronous 16 line multiplexer.
16 line modem control multiplexer.
360/370 channel interface.
Asynchronous serial line unit, with or without modem controls.

Tapes

TE16 800/1600bpi, 45ips, ½" magtape.
TU45 800/1600bpi, 75ips, ½" magtape.
TU77 800/1600bpi, 125ips, ½" magtape.
TU58 800bpi, ¼" cassette.

Video terminals

VT-100 video terminal, 80 or 132 columns, with extensive video attributes and detachable keyboard.
VT-52 video terminal.
VT-55 graphics terminal.
VT-62 block mode terminal.
VT-61 editing terminal.

Hardcopy terminals

LA-120 "smart," 120cps hardcopy terminal.
LA-38 hardcopy terminal, 30cps, with tractor feed, with or without stand.
LA-34 hardcopy terminal, 30cps, with roll paper feed, with or without stand.
LA-36 hardcopy terminal, 30cps, on stand.
LA-37 APL, hardcopy terminal, 30cps, on stand.

Optional cabinetry

10½" expander box.
5¼" expander box.
Cabinet with power control.
Short cabinet with power control.

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Circle Reader Service No. 34.

nues of about $3 million. To develop the printer, it worked with Seiko, the large Japanese industrial concern primarily known in the U. S. for its watches. The deal for the printers, and other products to come, was struck with Axiom because "of our our track record in electrosensitive printing," says Harrison. Seiko carried out the research and development and holds the patents, but it was Axiom that actually produced the workable products.

Initial production units and printer components will come from Seiko, with Axiom starting manufacturing in volume in several months. Prices will be comparable to those of what is already available. Samples will be available in about six weeks at a price of $1,200 each. In quantities, the VP-850 is to sell for $925.

-Larry Waller, Anthony Durniak

Phone answerer takes anybody's calls

The time is fast approaching when any telephone will function as an input/output device for a computer. Dialog Systems Inc., an affiliate of Exxon Enterprises Inc., will take a major step in that direction when it unveils one of the first speaker-independent voice-recognition systems to be offered commercially at next month's National Computer Conference in New York.

Giants such as Bell Laboratories and IBM are also working on speech recognition but have yet to reach the market [*Electronics*, March 1, p. 84]. Threshold Technology Inc., Delran, N. J., the leading supplier of voice recognition systems, says it too can supply speaker-independent units.

The secret of Dialog's independent 1800 is a comparison technique based on statistical analysis of the spoken words, according to Stephen L. Moshier, president of the firm and the system's developer. The machine's recognition vocabulary is built by taking 500 dialect samples from male and female speakers across the country. Each word is sampled 12 times and each sample's overall amplitude is measured and its frequency spectrum plotted at 31 points between 300 and 3,300 hertz. This produces 384 numbers, or elements, that describe the word.

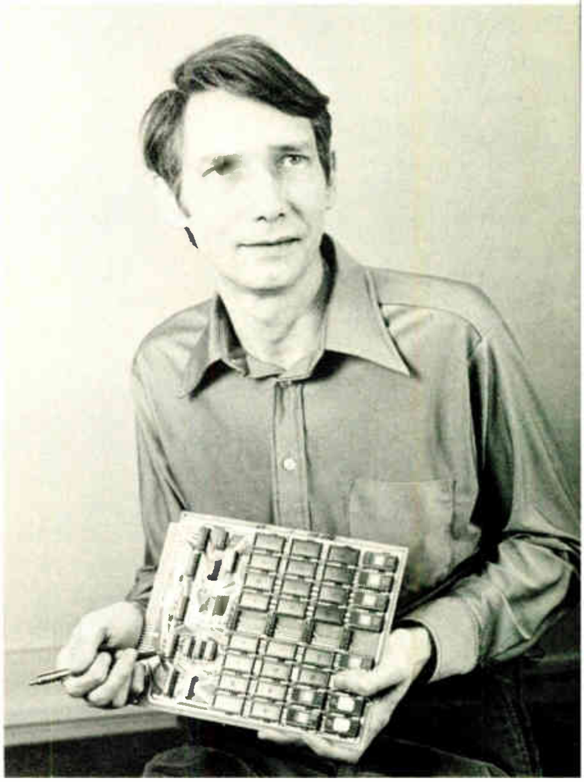
Sampling. The elements resulting from all 500 speakers saying the same word are combined to produce a set of 384 mean values and standard deviations, which are then stored in the system as the reference for that word. The incoming unknown word is similarly sampled, analyzed, and compared element by element with reference words using an algorithm that finds the probability density function for the unknown word. When this probability density is above a certain threshold—which can vary from word to word or system to system—the system declares the word recognized.

Dialog's custom 32-bit vector processor can compare all the elements of an unknown word with a reference word in 30 microseconds. To compare an unknown word with a 1,000-word vocabulary would thus take 30 milliseconds, fast enough to be considered real time.

A Digital Equipment Corp. PDP 11/04 minicomputer is used to answer up to eight phone lines, coordinate the processing of the incoming speech by the vector processor, and interface the results with the user's computer. A microprocessor-controlled speech-synthesis unit provides voice response.

Vocabulary. The 1800's basic vocabulary consists of 12 discrete words: the 10 digits "zero" through "nine" plus "yes" and "no." Special applications vocabularies are then added. For banking, for instance, 30 additional words are available, including "balance," "total," and "deposit."

"The advantage of our system is that you can use a telephone from anywhere to call a computer," says Thomas P. Cutler, senior vice president. He sees it as appropriate for applications in banking and in retailing, to replace mail orders and for traveling salesmen to enter orders. Although the systems have a hefty price range of between $60,000 and $100,000, Cutler asserts that they are quite cost-effective in their applications.



Dialog developer. Stephen L. Moshier, Dialog Systems president, says his system understands 95% of what's spoken to it.

-Anthony Durniak, Pamela Hamilton

Process control

Plants get distributed data processing

Some distributed data processing is wearing a blue collar these days, as specially designed, microprocessor-based communications hardware is linked to a data highway for process controls in automotive and chemical industry plants. Original-equipment manufacturers that specialize in programmable controllers for operating machine tools or chemical reactors are introducing peripheral equipment to link controllers with each other and with corporate data-processing centers.

"We are seeing more and more distributed control requirements," says Ronald Toke, marketing manager at Allen-Bradley Co.'s Programmable Controller Systems division, Highland Heights, Ohio. Adds Mike Bradley, marketing manager Texas Instruments Inc.'s Process Control group in Johnson City, Tenn., "Our customers are saying that they want this—it is the direction that the world is going in."

To stay ahead in the rapidly expanding $200 million market, OEMs are adding custom communications hardware to increase both production and productivity. Networks offer closer coordination than mechanical systems and automatically detect, diagnose, and alert personnel to breakdowns more rapidly than electromechanical relay-based alarms.

Next month the Modicon division of Gould Inc. will introduce the latest system—the $1,450 Modbus process control interface unit and assorted modems. The Andover, Mass., manufacturer says its Intel 8085 microprocessor interface, firmware, and software package can handle up to 32 controllers at transmission speeds of 50 bits per second to 19.2 kilobits per second.

Remote control. To ease industrial retrofitting, the system can be installed on existing telephone lines or over a dedicated cable with a "proprietary" subcarrier frequency of less than 100 kilohertz, says Albert J. Reinhart, Modicon's marketing manager. The special frequency has a high noise immunity, he explains, besides reducing programming complexity.

A master controller can download new or revised programming to various slave controllers in the network, offering a "remote operating capability," Reinhart says. However, slave controllers cannot directly communicate with other slaves.

Modicon's chief competitor, Allen Bradley, introduced its own microprocessor-based data-highway interface package in 1977; up to 64 controllers can communicate on its network highway. A Zilog or Intel microprocessor is the heart of the module, which also includes up to 16 kilobytes of programmable read-only memory and 1 kilobyte of random-

News briefs

French bring their teletext system to U. S.

The French are pushing their Antiope teletext system, which transmits information digitally and displays it on a television screen, in the U. S. Sofratev, the Société Française d'Etudes et de Réalisations d'Equipments de Radiodiffusion et de Télévision, is forming a U. S. subsidiary, AVS Inc., to handle both government lobbying—it is pushing for Antiope's adoption by the Federal Communications Commission as a national standard—and customer liaison. Also, Sofratev has completed an agreement with Microband National Systems Inc., New York, operator of a common-carrier microwave distribution system, to develop government, business, and commercial applications packages for Antiope. Microband, which will study the types of services it could offer over the next six to nine months, calls the Antiope-based services Inteltex. It will be distributed via omnidirectional microwave systems and interactive telephone lines.

Teradyne adds analog signal-processing testers

Teradyne Inc. of Boston this week introduced systems designed specifically for production testing and laser-trim adjustment of analog LSI components, including codecs, digital filters, and high-accuracy converters. The A300 family includes seven different systems ranging from analog and analog LSI systems to thick-film active trimming of analog hybrid circuits and monolithic laser-adjustable systems. A high-speed digital module—the M603—is included with the top-of-the-line models; it has up to 84 channels of drivers/detectors for clock rate testing to a minimum of 5 megahertz on combined linear and digital circuitry.

Prices start at under $100,000 for a minimal analog/analog-LSI test configuration to about $317,000 for a system with monolithic trim and digital test capabilities. A test system manager sells for $52,000. Deliveries will begin in mid-November. The test system manager Teradyne is introducing consists of a DEC PDP-11/34, a line printer, and one or more video terminals for editing, compiling, and other tasks.

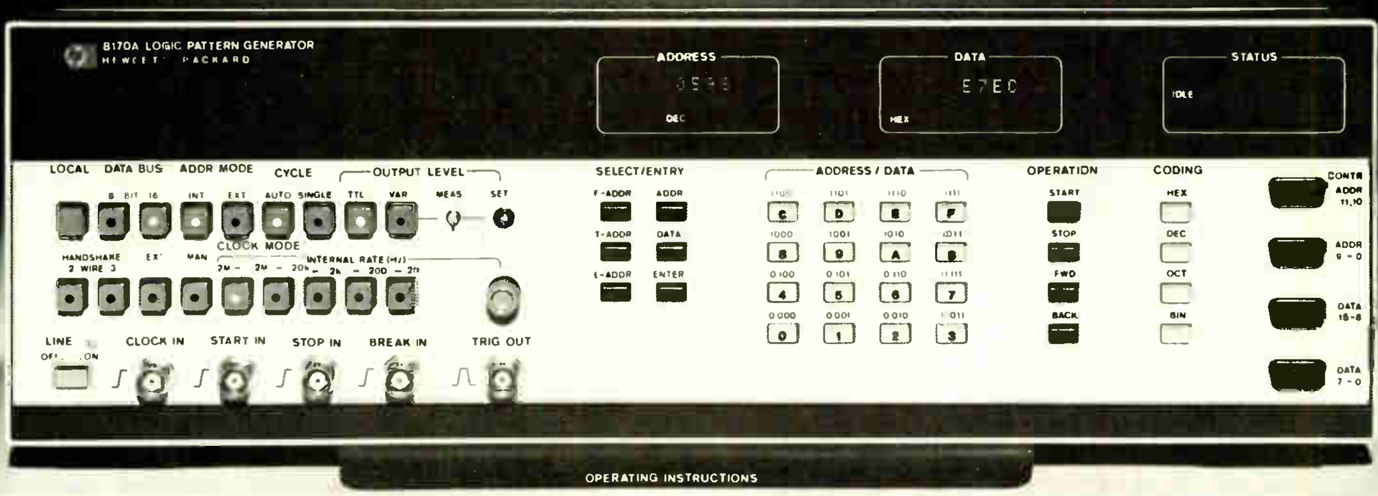
CalComp completes clearance sales

California Computer Products Inc., the Anaheim computer peripherals maker that has been selling off portions of its operations for the past several months, agreed earlier this month to sell the remainder of the company to Sanders Associates Inc., the Nashua, N. H., defense electronics firm. Sanders, through a subsidiary, will pay approximately $45.9 million in cash and stock, if CalComp shareholders approve the deal. The firm plans to continue CalComp's operations—now primarily the production of digital plotters and interactive graphics systems—under present management. CalComp, which had revenue of $119 million for the fiscal year ending June 1978, agreed in November to sell its hard-disk drive manufacturing division to Xerox Corp. It later sold its floppy-disk operation to Billings Computer Corp., Provo, Utah. CalComp's IBM-compatible peripheral marketing and service organization will be acquired by Braegen Corp., Cupertino, Calif., under an agreement also reached this month. CalComp should mesh nicely with Sanders' graphics terminal operation, which currently makes the model 3250 terminal for IBM.

Memorex ships microprocessor disk cache

Banking on charge-coupled-device technology, Memorex Corp. is beginning to ship solid-state model 3770 disk cache systems designed to speed data flow between disk storage systems and computers [*Electronics*, April 12, p. 34]. The Santa Clara, Calif., company says that the $55,000, 1-megabyte memory uses Intel 8080 and Advanced Micro Devices 2901 microprocessors to store and update the most used data elements in a computer's memory system so that access time can be as short as 2 milliseconds, compared with a minimum 27-ms access to a disk system itself.

Meet HP's new word generator... it imitates your system components for faster functional testing.



Hewlett-Packard's new 8170A Logic Pattern Generator can simulate a variety of components in your multi-channel digital system. It saves you the time and expense required to build specialized test equipment and to devise software for data simulation. And it speeds functional testing by giving you fingertip control of testing parameters.

Simulation of digitally controlled hardware. By simulating keyboards, tapes, printers or bus-compatible instruments, the 8170A simplifies at-speed functional testing of multi-channel hardware. The 8170A has a large 8K memory (32K optional) and gives you pushbutton selection of either 8 or 16 bit parallel outputs. Internal, manual, or external clocking allows dynamic testing at variable bit rates up to 2 MHz. With simple key strokes, you can start and stop data generation at any desired address, using whichever code you select. And you can step forward or back in single steps to any memory location for rapid debugging.

Bus Stimulation. Custom-built boxes with mechanical switches are no longer adequate for setting bus lines true or false for data simulation. The 8170A can simulate bus-compatible peripherals or instruments at speed for more complete system testing. Three-state outputs let you load the bus or effectively isolate the 8170A from bus activity. And the 8170A will generate data and data-valid signals in accordance with 2 or 3-wire handshake protocol.

ROM Simulation. Because of its external address capability, you can use the 8170A to simulate a ROM. Memory changes are easy to make, either through the front panel or under computer control via the HP-IB.** This means fast and flexible ROM simulation for low development costs.

Big memory, easy access, remote programmability and real-speed sequencing all help simplify functional testing of your digital systems. The price of the 8170A is $5430* and includes HP-IB and RS 232C interfaces. The optional memory to 32K is $545.* Ask your local HP field engineer for all the details.

* Domestic U.S.A. price only
** HP's implementation of IEEE Standard 488-1975

089/4

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Circle 57 on reader service card

access memory. The added complexity of the interfaces permits slave-to-slave data exchanges but precludes use of existing telephone lines. Transmission speed is 51.2 kb/s.

Modicon, Allen-Bradley, and other process-control manufacturers custom-design their communications gear. Explains Allen-Bradley's Toke, "The equipment is designed and manufactured to withstand vibration and temperature and humidity extremes, and at the same time it's easy to maintain."

Big competitors. By networking programmable controllers, Modicon and Allen-Bradley move into closer competition with such process-control heavyweights as Honeywell Information Systems and Foxboro, although those giants operate as system houses, supplying primarily hardwired systems for an entire plant. **-Larry Marion**

Materials

Silicon wafers in short supply

The booming semiconductor industry, which does not yet have the capacity to fully meet rising demand for its devices, faces a similar problem on the incoming end: silicon suppliers cannot make wafers fast enough, either. The result is that the long lead times for silicon wafers of all types and sizes, now stretching 26 to 30 weeks in many cases, probably will continue through this year.

That leaves chip makers in a bind. "When you plan that far in advance, it gives you two problems," explains John P. Gray, purchasing manager at National Semiconductor Corp., Santa Clara, Calif. "One is inflexibility, and two is getting it [the silicon] here on time."

Adds Charles E. Mack, director of material for neighboring American Microsystems Inc., "You can't afford too many rejects or you won't recover. It's essentially touch and go." Kenneth J. Howser, manager of material for Advanced Micro Devices Inc., in nearby Sunnyvale, calls the long lead times "a totally unacceptable situation."

Improvement. However, some relief is in sight. Monsanto Corp., the leading supplier of polished silicon wafers, says that its St. Peters, Mo., plant should be producing 30% more wafers by the third quarter of this year. Moreover, Wacker Siltronic, a subsidiary of West Germany's Wacker Chemitronic GmbH, expects to have its new Portland, Ore., plant up and running the first quarter of 1980, James Moreland, director of quality, says.

What's more, "my gut feeling is that there'll be a slowdown in the third and fourth quarter, which will help," says Stan Myers, vice president and general manager of the Silicon division of Siltec Corp., a Menlo Park, Calif. supplier. But National Semiconductor's Gray gloomily predicts, "I don't see a break in it before mid-1980 unless some kind of downturn occurs."

What caused this tight supply is a combination of simultaneous, overlapping factors, according to Robert Simko, vice president of Gnostic Concepts Inc., a Menlo Park market research company: fantastic growth rates in the U.S. semiconductor industry, changes in the type of processing toward very large-scale integration, and the fact that 4-inch wafers are not replacing 3-in. ones but supplementing them. Also, he notes, it takes a long time for a new silicon production plant to come on stream. **-William F. Arnold**

Companies

Gould-Fairchild deal filled with 'ifs'

The immediate result of Gould Inc.'s determined bid to take over Fairchild Camera and Instrument Corp., the $534-million-a-year Mountain View, Calif., semiconductor pioneer, is employment for a battalion of lawyers. The Rolling Meadows, Ill., conglomerate's open tender for 2.5 million Fairchild shares at $57 each has opened a Pandora's box of

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lawsuits and investigations following the rejection by Fairchild's board of two Gould bids, a $300 million cash and stock deal worth $54 a share and another for $57.

Not only have the companies filed suits against each other alleging violations of antitrust and securities statutes, but:

- The Federal Trade Commission has advised Gould, a $1.8-billion-a-year company, that it is sending subpoenas requesting information about "interlocking personal relationships."
- The Securities and Exchange Commission has informed Gould that it intends to hold an "informal investigation" of Gould's recent activities. Fairchild contends that Gould leaked its intention to acquire Fairchild to encourage stock purchases by speculators.
- Because of the size of the company that would emerge—$2.3 billion—the Justice Department and the Federal Trade Commission are reviewing documents.

Clash over plans. Gould officials refuse to discuss the merger except to say that they would leave current Fairchild management in control and merely exchange directors at the board level. But Fairchild officials maintain that Gould would use their company to become a dominant and illegal force in the electronics marketplace, controlling key industries with the vertical integration of component parts maker Fairchild with instrument assembler Gould, whose Electronic Products Group had sales of $413 million in 1978.

What are the chances that Gould will back off? The answer might be found in its persistence during past legal fights over acquisitions and in general business dealings. For example, its largest previous acquisition—it has completed 30 in the last 11 years—was that of I-T-E Imperial Corp., an electrical products manufacturer. That deal resulted in Gould's signing a consent decree with the SEC.

But success in the Fairchild bid might just satiate Gould's appetite. It had to borrow $50 million in the Eurodollar market and set up a $125 million credit line with 12 banks, contingent on certain limits on future acquisitions. **-Larry Marion**

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Washington newsletter

Semicon imports outpacing exports in growth percentage

U. S. imports of semiconductors, led by sharp percentage increases in integrated circuits, are growing at a faster rate than exports, even though the $156 million trade surplus in 1978 rose 3% from the year before. Imports climbed 31% to nearly $1.77 billion, according to new Commerce Department figures, while exports were $1.92 billion, or 28% more than in 1977. **There was a trade deficit in ICs of $917 million, 39% greater than the 1977 figure and continuing to rise,** indicating a potentially long-term problem. Semiconductors make up nearly two thirds of the U. S. trade in components of all types that produced a 1978 surplus of $327 million last year, down 54% from 1977 and the lowest in six years. Export totals passed the $3 billion mark, up 12%, whereas imports of nearly $2.7 billion climbed 35%. Japan remains the largest supplier, providing 19% of the total. Imports from Japan jumped 48% to $502 million, while U. S. exports to Japan of $172 million rose only 30%.

House, Senate split on VHSIC funding

Lying in a congressional limbo is the Pentagon's $36 million budget for fiscal 1980 for a triservice research and development program on very high-speed integrated circuits (VHSIC). It landed there early this month **when the House Armed Services Committee eliminated all program money, while its Senate counterpart increased funds by 35% to nearly $50 million.** When the House and Senate groups meet in conference later this year to settle differences in their military spending bills, Capitol Hill sources report, the Defense Research and Engineering directorate hopes the program may be restored to its original level. Requests for proposals to industry are already out, as anticipated [*Electronics*, March 15, p. 41].

New spy craft to monitor SALT to be ready by 1983

The Pentagon and the Central Intelligence Agency are rushing construction of a new signal intelligence satellite they plan to launch into geosynchronous orbit over the Soviet Union by 1983. It is being designed to intercept all telemetry data from Soviet missile test flights and thus will become a vital U. S. method verifying Soviet compliance with the terms of the Strategic Arms Limitation Treaty 2. In that mission, according to a Pentagon source, **it "will do away with our need for all ground intercept stations"** of the sort that the U. S. lost in Iran and still operates—with much less capability—in Turkey. The new satellite will team with photo-reconnaissance satellites, notably the KH-11 (which one official describes as "stretching the state of the art to its outer limits—a technological masterpiece"), long since positioned over the Soviet Union. The high promise of the so-called Sigint satellite is what prompted Defense Secretary Harold Brown's recent assurance that the U. S. will be able to check up "completely" on Soviet missile tests by 1983.

Who will operate geological satellite? Word due in summer

Watch for the Stereo-sat issue to come to a boil by late summer. That is the satellite that industry—primarily the oil industry—wants launched to collect geological data, a job now done by the Landsat satellites. However, Stereo-sat would provide more detail. The key issue is whether the Government or industry should build and operate the new satellite system, expected to cost $150 million to $200 million. **The Government wants to retain some control over the system because of the sensitive international aspects of collecting geological data on other countries.**

Washington newsletter

Air Force to convert 173 B-52 bombers to cruise-missile use

About mid-June, the Air Force will award the first production contract in a 10-year, $2.4 billion program to upgrade the offensive capabilities of 269 of its aging B-52 strategic bombers and to convert 173 of them into cruise-missile carriers as well. Boeing Co. of Seattle, which built the B-52s and has performed both the avionics and conversion research and development, is regarded as a cinch for the contract on both counts.

SALT **2, says one Administration official, "gives us tremendous flexibility to pursue a very large air-launched cruise-missile program."** That could amount to $6 billion in the end. As cruise-missile prime contractors, Boeing and General Dynamics Corp. will share the bulk of that bonanza over the next six years.

NTT action is not expected in short term

Although Japanese Prime Minister Masayoshi Ohira has made a commitment to President Carter to resume diplomatic discussions on opening procurement by Nippon Telegraph and Telephone Public Corp. (NTT) to U. S. and other foreign bidding, don't look for immediate results. Some U. S. officials point out that the government procurement code negotiated as part of the world trade talks in Geneva will not become effective until Jan. 1, 1981. **This enables the Japanese to drag their feet until then without losing their right to bid** at U. S. agencies.

U. S. job vacancies rise as NASA loses Cooper to SBS

The June departure of the National Aeronautics and Space Administration's Robert S. Cooper as director of the Goddard Space Flight Center to join Satellite Business Systems Inc. **will raise to three the number of technology policy vacancies the White House must fill.** Also departing as summer begins are Dale D. Myers as under secretary of energy and Air Force secretary John Stetson. While Cooper becomes engineering vice president for the McLean, Va., domestic satellite company, the Energy Department's Myers and the Pentagon's Stetson have not disclosed their plans. Myers, a former NASA executive and Rockwell International vice president, had difficulty dealing with Washington politics [*Electronics*, April 27, 1978, p. 60] and felt increasingly bypassed within the agency, insiders say.

Addenda

Richard B. Nichols, vice president, overseas, for the American Telephone and Telegraph Co., New York, will head a five-man team to China on June 6 to discuss the growth of telephone communications between the U. S. and the People's Republic of China. AT&T is the first communications company to be formally invited by the Chinese to talk about telephone service between the two countries, an AT&T official says. Telephone calls between the two countries have been increasing dramatically, and **AT&T is considering a cable link via its existing Pacific cable network.** Currently, China is serviced by Intelsat satellite. . . . The Defense Department **wants the computer industry's help** in its year-long program to refine its new standard higher-order language. This follows its final choice of Honeywell's "Green" entry over the "Red" language of Intermetrics Inc. of Cambridge, Mass. [*Electronics*, Aug. 3, 1978, p. 59]. Honeywell's Minneapolis Systems and Research Center and its Paris affiliate, Honeywell–CII Bull, got a 14-month contract for $650,000 for phase III of the development of the language. The new standard has been named Ada.

The Standard Edgecard Line

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.100″ x .200″	HWPC	Thermo-Set	20 through 50			22 through 50
.125″ x .250″	HWD	Thermo-Set	28 through 50			28 through 50
NEW! .125″ x .250″	HRK	Thermo-Plastic		10 through 50	10 through 50	
.156″ x .140″	HSD	Thermo-Set		6 through 43	6 through 43	
NEW! .156″ x .140″	HCB	Thermo-Plastic		6 through 43	6 through 43	
NEW! .156″ x .200″	HCA	Thermo-Plastic		6 through 25	6 through 25	

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Sample Listing

① **Jones, John J**
② Chmn & CEO, Microprocessor Div of Computers Inc, 1023 W Warner Ave, Dayton, OH 45479, Tel (513) 555-2000. ③ **Born:** Mar 26, 1926, Philadelphia, PA. ④ **Education:** MBA, Harvard Business School, 1950; BSEE, Univ of Ill., 1946; PhD (Hon), Yale Univ, 1977. ⑤ **Professional Experience:** Natl Bur of Standards, 1956-74, Adm Eng; Litton Ind, 1954-56, Sr Eng; NCR Corp, 1950-54, Eng. ⑥ **Directorships:** Computers Inc since 1975. ⑦ **Organizations:** IEEE since 1946, Sec Head 1972-73; AAAS since 1971; Midwest Ind Mgt Assn since 1974. ⑧ **Awards:** Fellow, IEEE, 1977; Public Service Award, City of Dayton, 1976. ⑧ **Patents Held:** 8 in computer circuits, incl Special Circuit for Microcomputer Chip Design 1975. ⑩ **Achievements:** founded Microprocessor Inc 1974; project manager on first application of microprocessors for standard interfaces 1975. ⑪ **Books:** 4 incl *Small Circuits and Their Applications* (editor), McGraw-Hill, New York, 1975. ⑫ **Personal:** married 1950 to Mary (Smith), children John Jr, Jane Anne, Kevin. ⑬ **Residence:** 344 W 34th St, Dayton, OH 45403, Tel (513) 555-4343.

① Name
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③ Date, place of birth
④ Degrees earned/institutions/dates
⑤ Previous affiliations/dates/highest positions
⑥ Current directorships/starting dates
⑦ Current organization membership/starting dates/ highest offices/dates
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Contents

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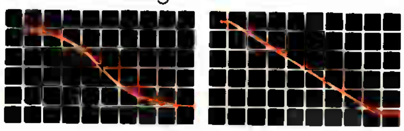

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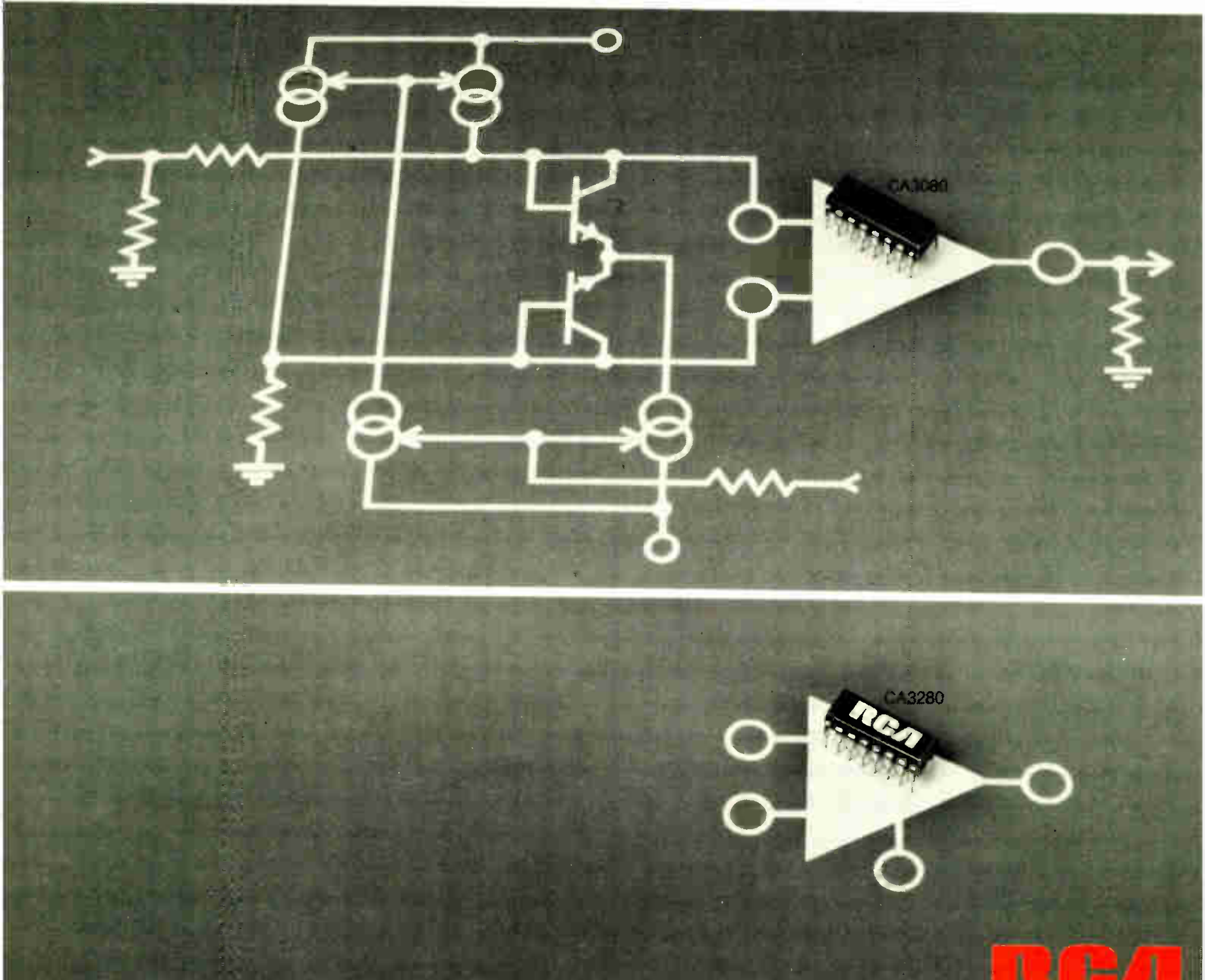


Circle 68 on reader service card

RCA

International newsletter

Japanese develop speech synthesizer on a chip . . .

The Musashino Electrical Communication Laboratory of Nippon Telegraph and Telephone Public Corp. has developed a single-chip speech synthesizer. The large-scale integrated circuit is designed to work with the lab's Parcor technique—so-called because it codes and decodes a speech signal using partial autocorrelation coefficients. This method is used in linear predictive coding schemes [*Electronics*, Aug. 31, 1978, p. 109]. The Parcor technique **analyzes human speech and codes it into sound-source (the vocal chords) and filter (the roof of the mouth) parameters.**

The synthesizer contains 3,500-gate logic circuits, a 350-bit random-access memory, and a 2,240-bit read-only memory on a 3.65-by-3.7-mm chip. The speech signal is synthesized every 125 μs in pulse-code-modulated form by operating the sound-source and filter parameters in a digital filter constructed with a 16-bit parallel multiplier and a 16-bit adder-subtracter. The chip, which needs a clock frequency of 1.28 MHz, is fabricated using the lab's enhancement-diffusion n-MOS technology.

. . . and normally-off GaAs MES FET that propagates in 77 ps

In a different area, the lab has come up with what it claims is the fastest normally-off gallium-arsenide MES FET. The metal-semiconductor field-effect transistor, intended for high-speed logic integrated circuits, has **a propagation delay of 77 ps and dissipates 977 μW at room temperature.** At 77 K, the device propagates in 51 ps and dissipates 1.9 mW. The lab was able to achieve this performance partly by controlling the uniformity of the material deposited in the active layer through a combination of anodic oxidation and etching.

Europe to have own communications satellites by 1980s

It looks as if the European Communications Satellite (ECS) system will start up in the early 1980s. Contracts covering the first decade of ECS operation were signed in mid-May by the European Space Agency (ESA) and Interim Eutelsat, the 17-nation consortium of telecommunications administrations. The former will handle the building of the satellites, and the latter will operate them and the associated ground stations. The first ECS is scheduled for a late-1981 launching, with a backup to follow 10 months later. Both will be built by the 14-firm MESH consortium headed by the British Aerospace Dynamics Group. **Along with 12,000 telephone circuits, each satellite will have the capacity for two television channels** intended for the Eurovision service of the European Broadcasting Union.

8-hour video cassette recorder from Europe to upstage Japanese?

Dutch electronics giant NV Philips Gloeilampenfabrieken hopes to outdistance Japanese competitors with a new video cassette recording system with 8-hour playing time, to be shown at next August's international radio and TV, exhibition, the Funkausstellung, in West Berlin. The system, called the V2000, was developed with West Germany's Grundig AG, which is expected to market its own version. Philips says it **will have the machines on sale next year** and will shift production to a new 750,000-unit-a-year plant near Vienna to be ready in early 1981. W. G. Maeyer, associate director of Philips' Main Industry Group–Video in Eindhoven, says the company will continue production of its present system, the VCR N1700, as a less expensive model retailing at about $250 below the V2000's proposed price of $1,250. Japanese firms at the Funkausstellung are expected to show playing times of up to 6 hours. Philips says it will sell the V2000 in the U. S. and Japan, as well as in Europe.

Siemens starts marketing its first personal computer

Anticipating sharply rising sales of personal computers in West Germany and elsewhere in Europe, Siemens AG has entered the contest for market shares with its PC100. Built around a 6502 central processing unit from Rockwell International Corp., the system has a capacity of 4 kilobytes of random-access memory and an 8-kilobyte read-only memory for the monitor program. Much like Rockwell's AIM 65 microcomputer on a board (but not a copy of it), the $1,000 computer, with a typewriter-like keyboard, a 20-character alphanumeric light-emitting-diode display, and a 120-line-per-minute thermal printer, **can be programmed to handle mathematical and scientific tasks, as well as simple jobs like storing phone numbers, appointment dates, and addresses.** In preparation is a video interface module that will permit black-and-white graphic representations on a TV screen.

The personal computer market is still in its embryonic stage in West Germany. But company analysts expect it to grow by leaps and bounds—increasing from 1,000 units expected to be sold this year to 3,000 next year and then to about 10,000 in 1982.

Racal ULA packs in equivalent of 880 gates

Racal Microelectronic Systems Ltd. is launching an uncommitted logic array (ULA) design service. The basis of the service is a complementary-MOS logic array having the equivalent of 880 gates and an 8-MHz clock speed and using a 3- to 5-V power supply. **The array needs only a single metalization to be customized.** Racal buys prediffused wafer slices from a North American supplier and completes final-layer metalization, packaging, and testing at its Reading headquarters. An advanced plasma-etched, ion-implantation process allows the use of 5-μm geometries, compared with 7 to 12 μm for most C-MOS processes. Use of silicon gates also permits high circuit densities and the formation of six polysilicon conductors within each cell during wafer fabrication—a technique patented by Racal—thus providing three interconnection layers while avoiding the problems of double-layer metalization. Racal claims very high chip utilization through the use both of horizontal, vertical, and even diagonal interconnection tracks and of a patented cell topology that is symmetrical about two axes. Two uncommitted logic arrays a 224-cell and a 440-cell device each with four transistor pairs per cell, are now being offered in packages of up to 40 pins. Racal is also offering an alternative cell design service and a related hybrid design service.

16 intelligent stations encircle NEC terminal

Nippon Electric Co. is marketing for August delivery a new computer terminal with up to 16 intelligent work stations, each with its own program and **capable of displaying up to 2,000 characters or 120 different kinds of Japanese characters (kanji) at a speed of 1 megabit per second.** Every station has its own microprocessor control unit. The central terminal can have from 32 to 96 kilobytes of memory and comes in two configurations: one a stand-alone type with two floppy disks that will support up to 8 work stations, the other a cluster type with a 15- to 30-megabyte disk that will support up to 16 work stations. The purchase price for the basic stand-alone system is about $16,000; for the basic cluster type, it is approximately $53,000.


Nikon

High-radiance LEDs operate at 1.3 μm for long-haul optic cable

by Kevin Smith, London bureau manager

Built with a microlens, the devices achieve a launch power approaching that of laser diodes

High-radiance light-emitting diodes have taken a back seat to solid-state laser diodes for long-distance fiber-optic communications systems. But for the latest generation of low-loss fibers, which operate at 1.3 micrometers instead of the 0.8-μm wavelengths now used, they could provide the needed emitter source.

Losses of only 0.8 decibel/kilometer have been reported at wavelengths of 1.3 μm in the latest pure-silica–based fibers, compared with 2 to 3 dB/km for fibers operating in the 0.8-μm band. But work on 0.3-μm emitters and detectors has generally lagged behind that on fibers.

Now Plessey Ltd.'s Allen Clark Research Centre in Caswell, Northants., is marketing an experimental double-heterostructure LED, designated type CXL011, with a 1.3-μm emission wavelength. Expected in another six months is a p-i-n diode detector and field-effect-transistor preamplifier combination, the last constituent needed for a second-generation long-haul fiber-optic system that could in theory operate at 30 megabits per second for distances up to 100 kilometers without repeaters using the best reported fibers.

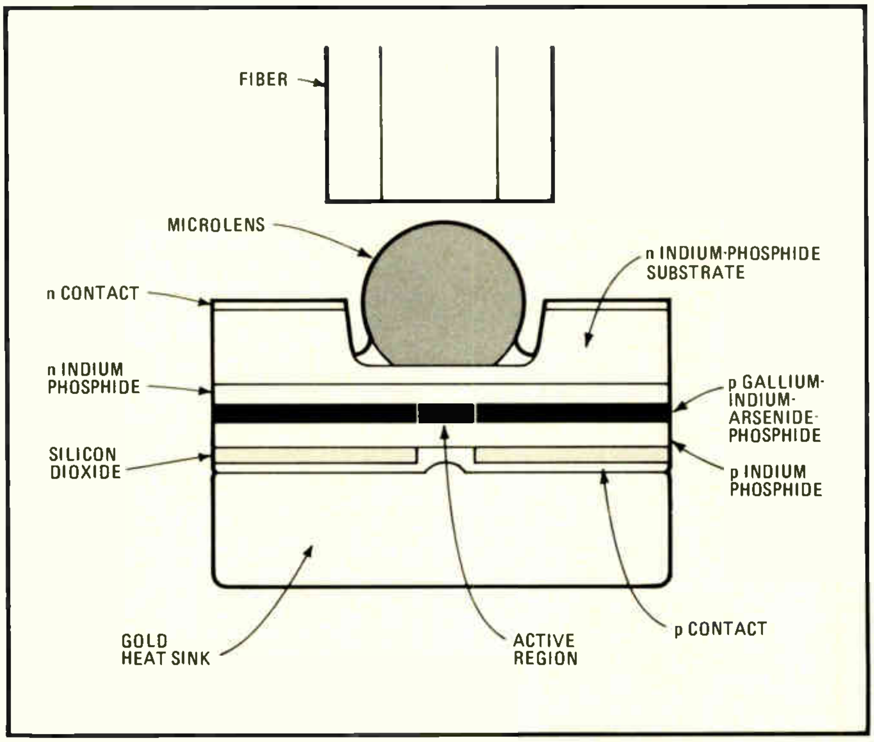
Advantages. George Gibbons, who heads the center's optoelectronics and microwave group, sees big pluses for LEDs over conventional laser diodes at these wavelengths. They have a proven operational life far in excess of the equivalent laser diodes. They are also simpler to use and less temperature-sensitive.

As backup, Gibbons says that basically similar high-radiance LEDs manufactured by the group have already clocked some 40,000 hours at 40°C since May 4, 1974. Furthermore, accelerated life tests indicate that the technology can comfortably achieve lifetimes of 10^6 hours.

Two problems have so far restricted LEDs to short-link applications. One, Gibbons says, "is the amount of power you can launch into a fiber from an LED. Lasers solve this problem by confining the lasing region to a narrow 2- to 3-μm-wide stripe that can be axially coupled into the fiber with high efficiency."

To achieve an equivalent degree of coupling, Plessey has perfected a microlens technology that it routinely uses on its high-radiance LEDs. As a result, Gibbons says, "we are coupling into our fibers almost the same power as the Japanese couple with their lasers."

The highest launch power of 206 microwatts was obtained from a lensed 18-μm-diameter device operating at 100 milliamperes dc. The best devices had an overall power conversion efficiency of about 0.4% when lens-coupled to a fiber with a 85-μm core and 0.16 numerical-



Microfocused. Spherical microlens enables Plessey's high-radiance light-emitting diode to couple into a fiber with a launched power close to that of laser diodes.

aperture step index. This efficiency corresponds to a launch power of 100 milliwatts at 25 mA dc.

The second problem is that a LED, unlike a laser diode, is not a monochromatic light source. Therefore dispersion, or differences in wave velocity, can cause distortions like pulse spreading, which limits the operational bandwidth. The CXL-011, for example, has a spectral line width of 110 nanometers, compared with 2 angstroms for a laser diode.

Fortunately, 1.3 μm is close to the wavelength at which dispersion in the glass is at a minimum. Says Bob Goodfellow, who developed Plessey's LED technology, "There is a saddle point in the refractive-index/wavelength curve at 1.3 μm, so the refractive index of the fiber is in effect constant for all frequency lines in the LED spectrum." Since the wave-propagation velocity is proportional to the refractive index, all line emissions take the same time to traverse the fiber.

Structure. Consequently, the bandwidth can be very large and will be limited only by multimode dispersion. The devices use the etched-well, layer-down, small-emission-area structure previously adopted for Plessey's high-radiance gallium-arsenide LEDs [*Electronics,* Dec. 23, 1976, p. 47 or 5E]. The 40-μm emission area of the gallium-indium-arsenide-phosphide and indium-phosphide layers allows for good coupling of LED and fiber and also permits efficient cooling and operation at high current densities.

The gain achieved by using a microlens is close to the ratio of the fiber core area to the emitting area—gains of between 13 and 18 have been obtained. But Plessey's first standard devices will be without lenses, since each has to be exactly matched to the fiber being used and the output from the lensless LED is adequate for characterization.

The Plessey lenses are 50- to 150-μm-diameter spheres of titanium-silica glass. Plessey grades the spheres to match different fibers and polishes one side flat. The degree of truncation is determined by computer to optimize coupling.

Although Plessey is putting its money on LEDs for early fiber-optic systems, the group is not neglecting laser diodes, and also on offer is a 1.3-μm-wavelength GaInAs-InP device, type CB010. It operates under short pulse conditions at a 1% duty cycle at power levels up to 5 milliwatts peak and can be used to characterize optical fibers.

West Germany

Computerized phone information system responds by voice to dialed inputs

For all their interest in pyramids and obelisks, none of the pharoahs could have imagined the kind of memorial created for them by a group of communications engineers at Siemens AG. The German acronym for their "phone number information service with voice output and computer search" is Ramses.

As the full term indicates, Ramses marries computer and communications technology into a directory system that stores telephone numbers and speaks the number wanted by the caller. It thus takes the place of the operators usually called by dialing Information. Since the Ramses directory is always accessible, waiting for a free operator is a thing of the past.

Ready. As far as the Munich-based electronics giant is concerned, the system is ready to go into service. The hardware—the computer, its peripherals, and the voice-output equipment—is available off the shelf, as it is already being used in other of Siemens' data-processing and communications systems.

The company is hoping that the Bundespost, the government agency that runs West Germany's public communications services, will start trying out Ramses on a regional basis this year. For the Bundespost, the advantage of the automated directory would of course be a savings in personnel.

At the heart of the system is a Siemens model 7.750 computer, the kind the company uses in its EWS electronic telephone switching system. The computer stores in its data bank the phone numbers of all subscribers in a particular region. In addition, the bank contains data on the subscriber's town of residence, his or her last and first name, the street on which he or she lives, and the house number.

Accessing the computer to obtain a certain number is simple and requires no special handset—both disk-dial and push-button types will do. Assigned to each digit between 0 and 9 are two or three letters, so that all letters in the alphabet are available to the user.

Input. To obtain the wanted number, the user simply dials or keys in the first three letters each of the subscriber's town, his or her last name and first name, and the street, plus the digits for the house number. The computer looks up the phone number, using this alphanumeric information, and gives it to the caller in synthetic speech implemented by a Siemens voice encoder.

For a small town, the first three letters of just the town, the last name, and the first name, are often enough information for the computer to identify the wanted party and the phone number. Only if several subscribers in a particular locality have the same last and first names, which frequently occurs in large cities, does the computer need more data. If it still cannot find the party, it connects the caller to the regular operator.

The Ramses directory has a display terminal and keyboard, both also of Siemens design, that serve for putting the subscriber data into the computer's data bank. The units also allow erasing or changing the data. Thus, in contrast to telephone books, Ramses can always be up to date.

The voice output is assembled from the stored words for "zero"

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through "nine" and from words that make up standard phrases like "the number is," "redial the data," "number not listed," and "will connect to operator."

Others are working on such a system, including Bell Laboratories in the U. S., which is testing one that provides Bell Labs' internal phone numbers when asked questions appropriately posed. It both recognizes human speech and responds in synthesized speech. -John Gosch

Great Britain

BPO takes mystery out of System X

Till this month, System X—the new generation of telephone switching and signaling systems being developed for Britain—has lived up to its name: the British Post Office and its major hardware suppliers have let out little of what they were up to until they felt they had enough to talk about.

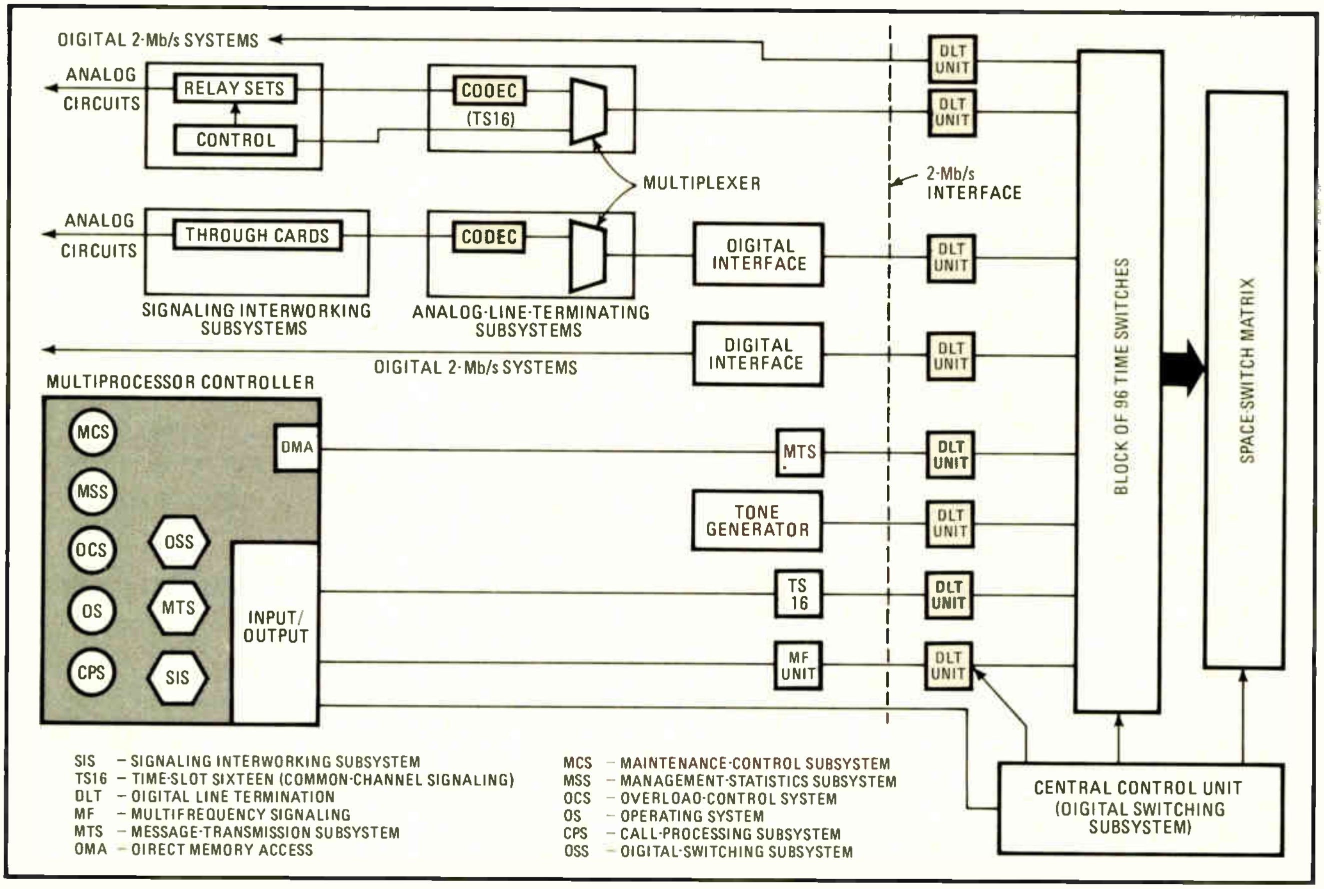
Now, at the May 7–11 International Switching Symposium in Paris, the BPO finally took some of the wraps off for the 2,000-odd telephone industry and administration people on hand from 48 countries.

System X, BPO director of telecommunications strategy Lionel Harris explained, is an integrated-services digital network that covers everything from small rural exchanges up to computer-based centers for service and record keeping. It melds into the same network both telephone and data-communications services.

Family planning. In planning the mammoth system, which they will start overlaying on the existing network next year and hope to finish sometime in the early 1990s, BPO telecommunications officials decided on a "family" approach. There are more than a dozen major subsystems (see figure), and each is designed with the whole family in mind. The same time-switching module, for example, turns up in very small local exchanges and in large international gateway exchanges. The hardware and software are modular so that operating features can be added or modified without redoing the overall system design.

There is also common-channel signaling, so that the new exchanges can communicate with older hardware as well as among themselves. And, of course, computer-controlled digital switching is used throughout for tandem and toll exchanges and concentrated-traffic stages in local exchanges. At the outset, reed-relay matrixes will be used for customer-line connections, with a digital version to follow by 1981.

To cover the network's switching needs as economically as possible,



Unwrapped. BPO's telephone switching and signaling system, dubbed System X, uses a modular approach to ensure compatibility and interchangeability. Circles in multiprocessor indicate software; hexagons indicate software handlers.

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the BPO has decided to standardize on three main types: large, for traffic initially up to 6,000 erlangs (an erlang is the average number of simultaneous calls during a given period) but capable of upgrading to 20,000; small, up to 1,000 erlangs; and very small, up to 60 erlangs. These are built around the same kinds of modules with one major exception—the processors are different for large and small exchanges.

In control. Large exchanges are controlled by multiprocessor units. Each one contains several central processing units, each with access to a central memory for program and data. This common memory is broken up into independent modules of 64,000 words. The units also use Intel 8085 and 8086 and General Instrument 1650 microprocessors, and the next-generation version will in fact be a microprocessor ring.

Although the overall system design allows for controllers incorporating up to 12 CPUs, the initial systems will have half that number. That limits throughput to about 160,000 call attempts.

For smaller exchanges, control is handled by a simplified unit, a boiled-down version of the full-scale multiprocessor. But the operating program and the system interfaces are similar, so that a large controller can take over the functions of a small one if need be.

Parts. In both large and small controllers, as well as throughout, the BPO says it is placing the emphasis on commercially available components. Custom large-scale integrated circuits, however, implement the codecs in digital switches, the multifrequency digital receivers, and the digital line-termination units.

Working with the BPO on System X are its three major suppliers: GEC Telecommunications Ltd., Plessey Telecommunications Ltd., and Standard Telephones & Cables Ltd., an ITT subsidiary. They have been involved in the project since the earliest planning, in 1975.

One of the first objectives was agreement on a set of standards, so that modules produced by different companies would be operationally identical and entirely compatible. The use of computer-aided design and manufacturing techniques wherever possible, together with the creation of a single manufacturing data base, is one way the BPO believes it can ensure conformity to standards and at the same time permit standards to be updated as technological evolution warrants.

Substantive development work for System X began in 1977, and the three manufacturers are now testing prototypes of the first modules. They have also begun producing equipment for post office trials. Actual production begins next year, with the first exchanges to go into service in 1981. Forty-five exchanges have been ordered to date [*Electronics*, April 13, 1978, p. 65].

The BPO is giving top priority to production of digital trunk and tandem exchanges—about 15% of the country's transmission network will be digital by 1982. Next will come the local and regional management centers.

The BPO's Harris says the goal is to have production designs for the entire system ready in 1983 and to have the system in place in all of Britain's major cities by the mid-1980s. Rotary switches, though will not disappear entirely before the early 1990s. **-Kenneth Dreyfack**

Around the world

Matsushita chooses JVC home disk

Matsushita Electric Industrial Co. has decided to urge would-be video disk makers to adopt the video-audio high-density disk system (VHD) as developed by Victor Co. of Japan [*Electronics*, Oct. 26, 1978, p. 67]. Top executives of Matsushita admit that the electronics giant is giving up its own mechanical VISC system in favor of Victor's grooveless, capacitive-pickup VHD for consumer disks, but the method is still being studied for industrial applications. Matsushita's announcement was timed to coincide with the decision by Victor, which is 50.7% owned by Matsushita, to unveil its prototype VHD-based disk at the June consumer electronics show in Chicago.

The Matsushita-Victor deal became the first such agreement since 24 Japanese electronics and record producers and 5 foreign firms created the Digital Audio Disk Conference (DADC) last year. DADC has yet to reach an agreement about disk standardization, but it hopes to do so by year's end.

An Israeli Bell System?

A Canadian company, Intel Consultants Ltd., has proposed the formation of a private corporation to manage Israel's telephone system, currently under control of the country's Ministry of Communications. Intel, based in Ottawa (and with no connection to Intel Corp. of Santa Clara, Calif.), says such a company could double the number of installations, eliminating the backlog of 200,000 phone orders. The proposal, made to deputy finance minister Yehezkel Flumin during his visit to Canada last month, suggests that all of Israel's telephone, telegraph, and telex services be turned over to the new company, to be called Israel Telecommunications Corp. The question of ownership is open.

Regnecentralen trying to reorganize to stay afloat

Regnecentralen, Denmark's only manufacturer of computer equipment, says it is optimistic it can work out a reorganization plan by the end of May so that it can remain in business. The company ceased debt payments in late April to get a breathing space in which to work out its capital problems. One possibility being considered is to split it up into component parts. Regnecentralen, with 1977–78 sales of $78 million but pretax profits of only $2 million, turns out hardware and software for the Danish and export markets.

Lockheed Aircraft Corp., which has undertaken to introduce Regnecentralen's equipment for U. S. phone company information services, sent representatives to Copenhagen to help work out the problems. However, a reorganization plan is being worked on that would keep the ownership in Danish hands.

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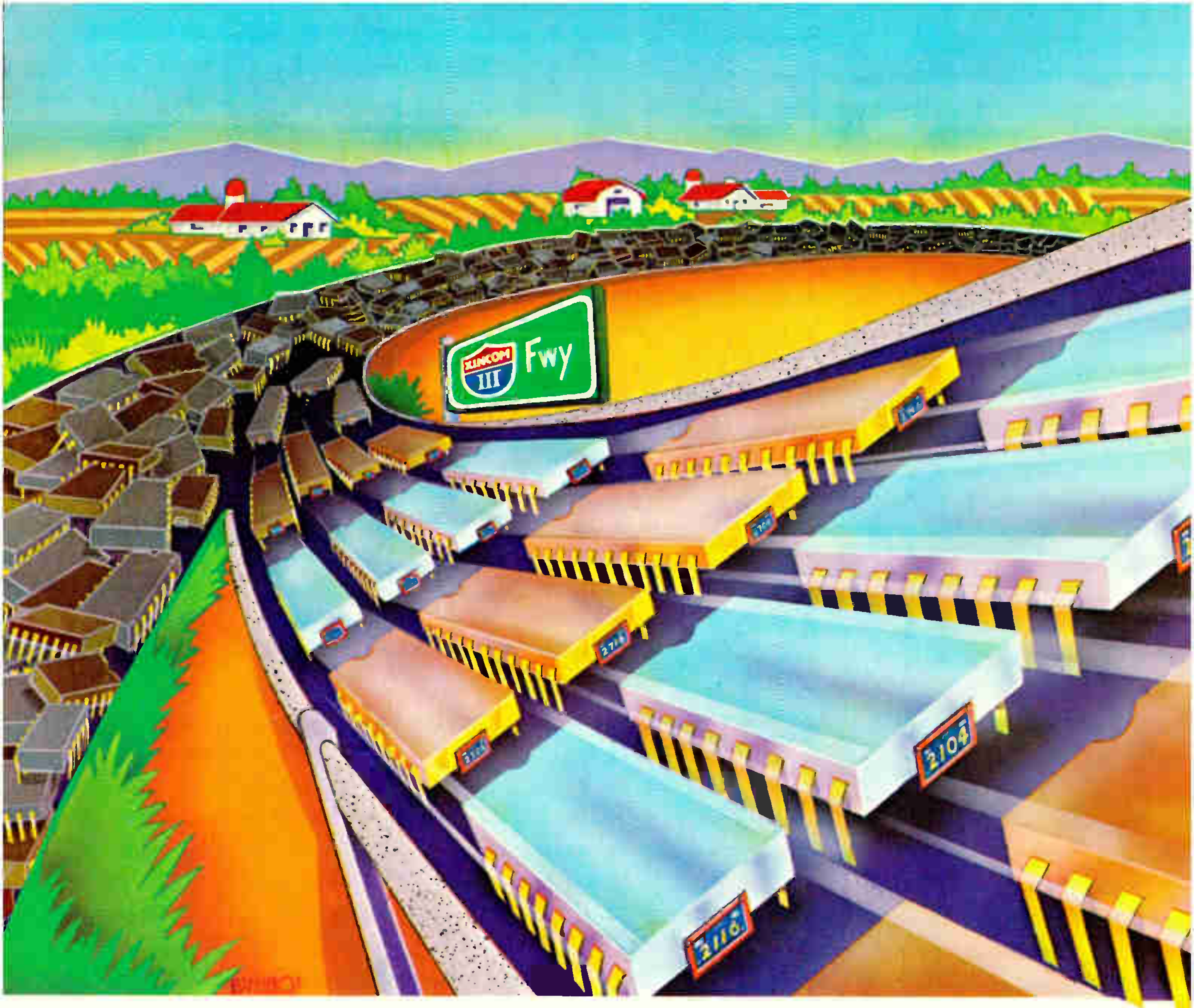
Circle #80 for literature

Circle #81 for demonstration



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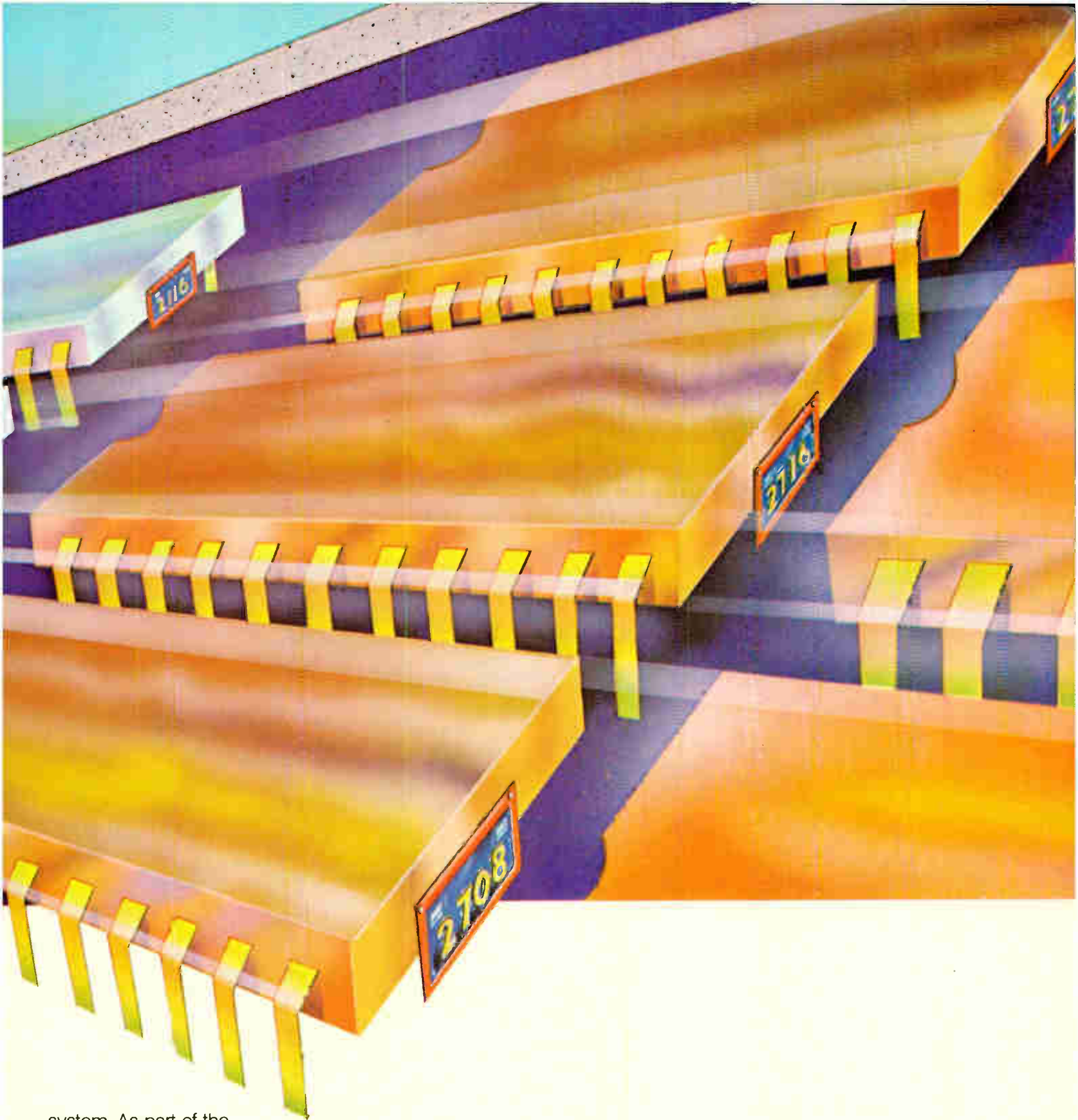

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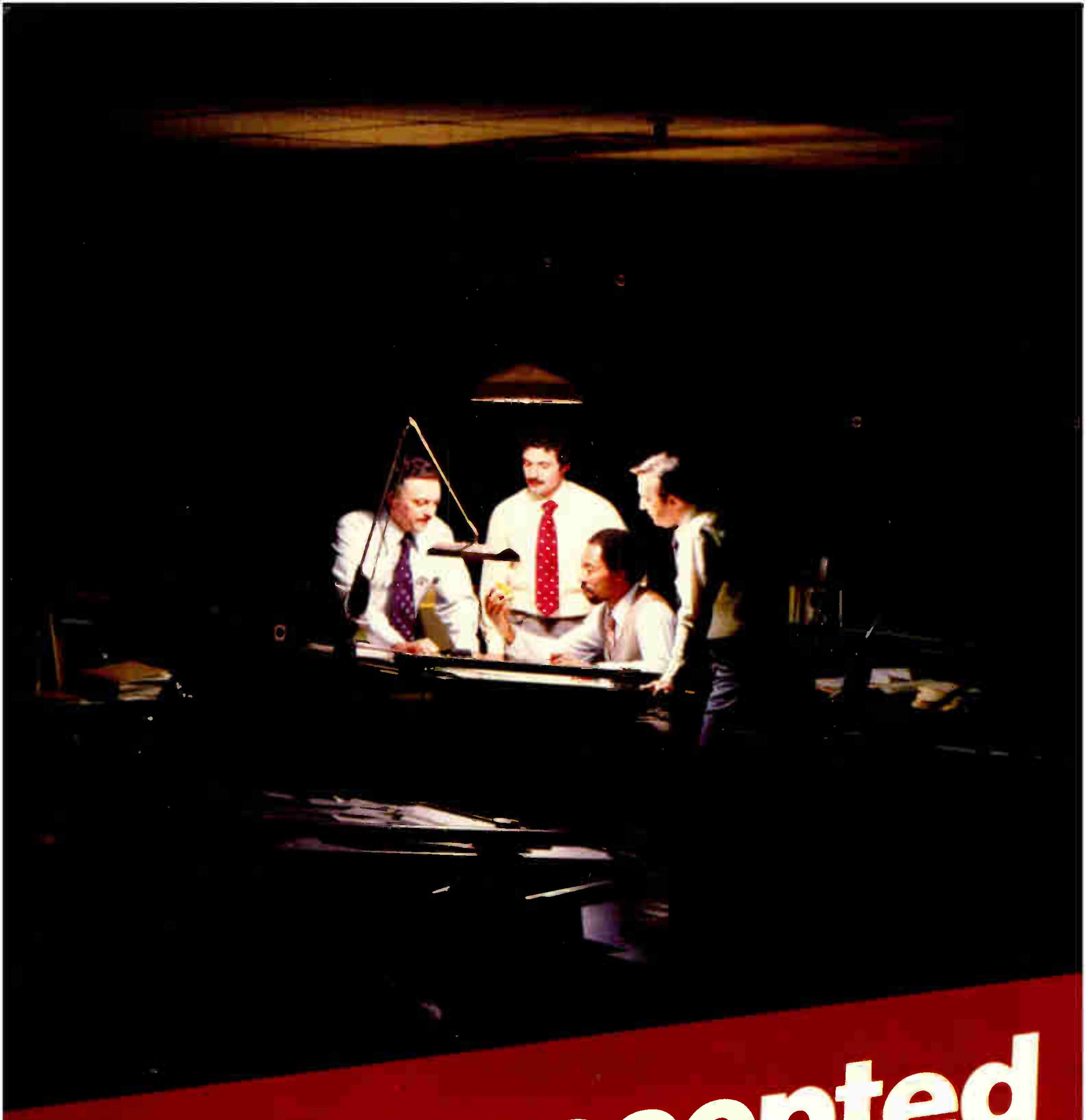

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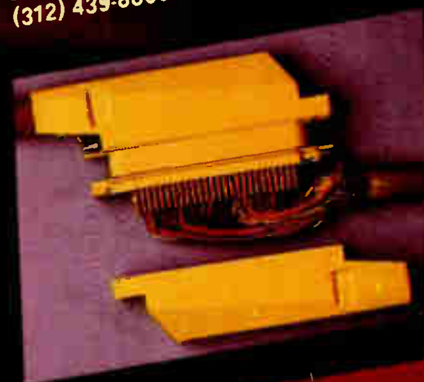

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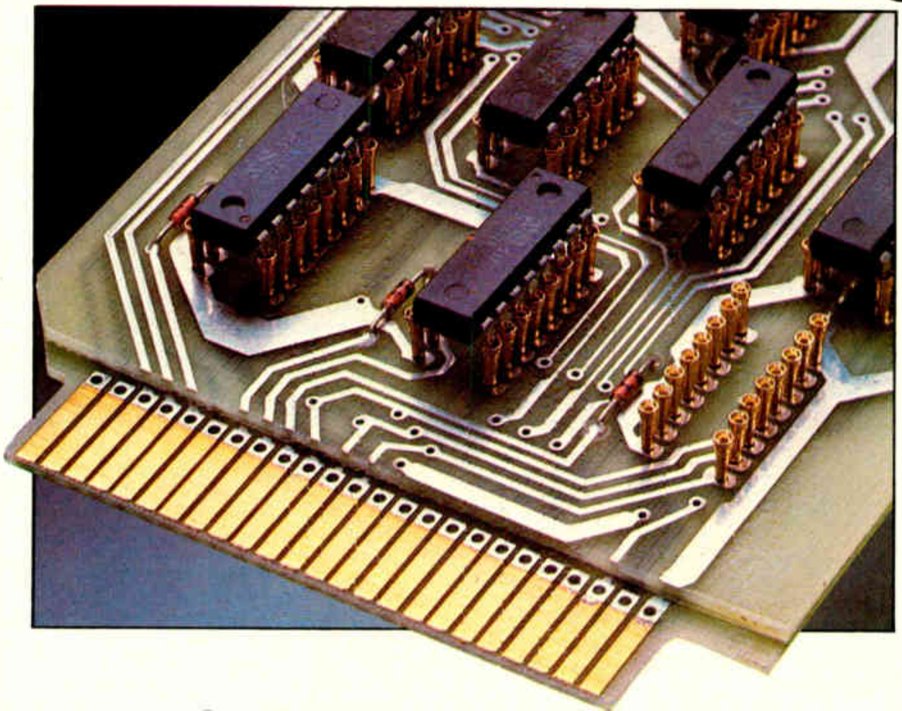
Expanding the parameters of press-fit technology



New press-fit I.C. socket offers lower cost, higher density and cooler operation.

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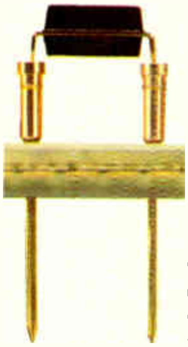

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Does DSA stand for better MOS?

Diffusion self-aligned process still being pursued in Japan for its speed and submicrometer channel lengths

by Raymond P. Capece, Solid State Editor

There is little doubt that U. S. semiconductor manufacturers keep glancing over their shoulders to see what the Japanese are up to. But despite their paranoiac watchfulness, the Americans could be overlooking an MOS technology that no fewer than four Japanese chip makers are actively engaged in developing.

Yutaka Hayashi, senior researcher and group leader at the Japanese government's Electrotechnical Laboratory in Tokyo, thinks they are. He is one of the early pioneers of the diffusion self-aligned MOS process, having written as early as 1969 on DSA MOS. In a nutshell, the DSA process can build fast MOS devices with tiny channel lengths—even less than 1 micrometer—without the lithography that ordinarily would be needed for such fine resolution. Yet, while Nippon Electric, Mitsubishi, Matsushita, and Sharp are developing fast static RAMs and DSA, only one U. S. chip maker is producing DSA-type devices—American Microsystems Inc., whose V-groove MOS process is a variation of the DSA structures that were proposed by Hayashi 10 years ago.

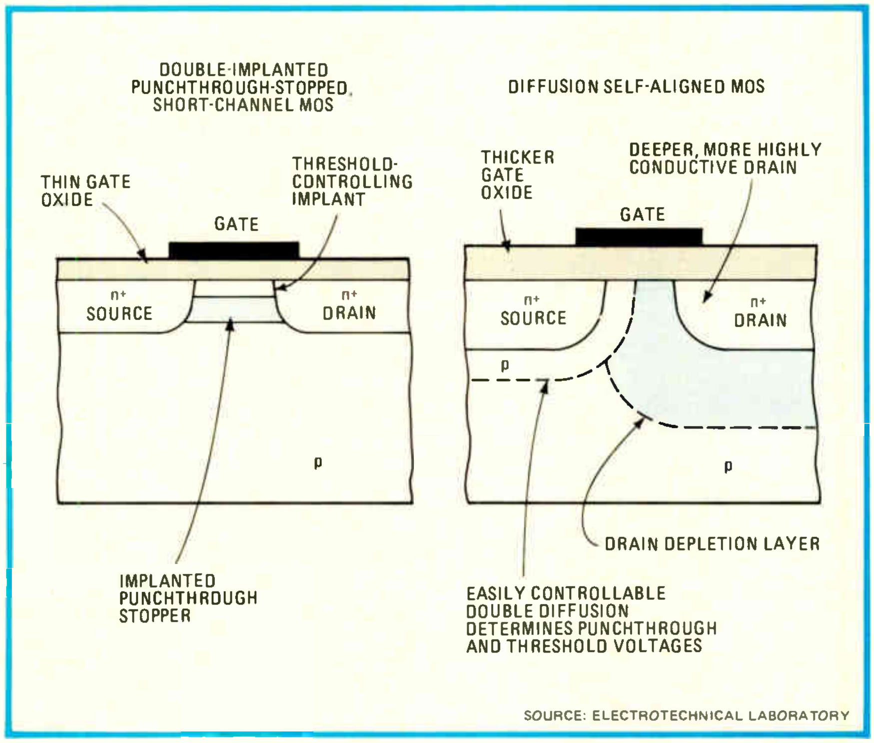
Channel length is a key speed-determining parameter of a MOS transistor. In a DSA device, it is fixed not by stringent lithography but by the more predictable process of diffusion. A look at DSA's checkered past will explain why interest in DSA MOS first waxed, then waned, and is now picking up again.

As far back as 1967, Signetics Corp. published a paper on a double-diffused MOS transistor that looked exactly like the DSA devices of today. Ironically, the Sunnyvale, Calif., company's goal was to build a transistor with a high breakdown voltage—and no one recognized that the first short-channel MOS structure had been proposed.

Over the next few years, additional work was done on the DSA process by Signetics, but it was all directed at high-speed discrete devices, not integrated circuits. At the same time, Hayashi and others working under a grant at the Electrotechnical Lab were researching several different DSA processes, including a V-groove approach. Nippon Electric and Mitsubishi picked up on the technology and began their own development. Japanese curiosity was piqued; still, the U. S. seemed uninterested in the DSA process.

Paul Richman, the innovative president of Standard Microsystems Corp., a Hauppauge, N. Y., MOS manufacturer, had taken note of the Signetics paper. "In 1973, the diffusion self-aligned process had appeal because it meant channel lengths of 1 micrometer could be built with 5-μm lithography equipment, which was the best available in those days," he notes.

Richard Pashley, Intel Corp.'s static RAM design manager, says he worked on a similar process called D-MOS several years ago. He agrees with Richman that the window for diffusion-type aligning has passed



DSA vs H-MOS. Diffusion self-aligned MOS transistors show advantages over standard MOS at submicrometer dimensions, where thin-oxide and punchthrough problems arise.

and sees a further serious drawback: "There's a huge Miller [effect] capacitance that slows the device down," he says, "and that can't be overcome."

Still, Richman concedes that DSA devices have other advantages, like higher breakdown voltage and punchthrough voltage than standard n-channel devices. Moreover, DSA could get equivalent performance with a much thicker gate oxide than standard n-MOS and thus a better yield. But the DSA process had certain kinks that, in Hayashi's words, "scared engineers away."

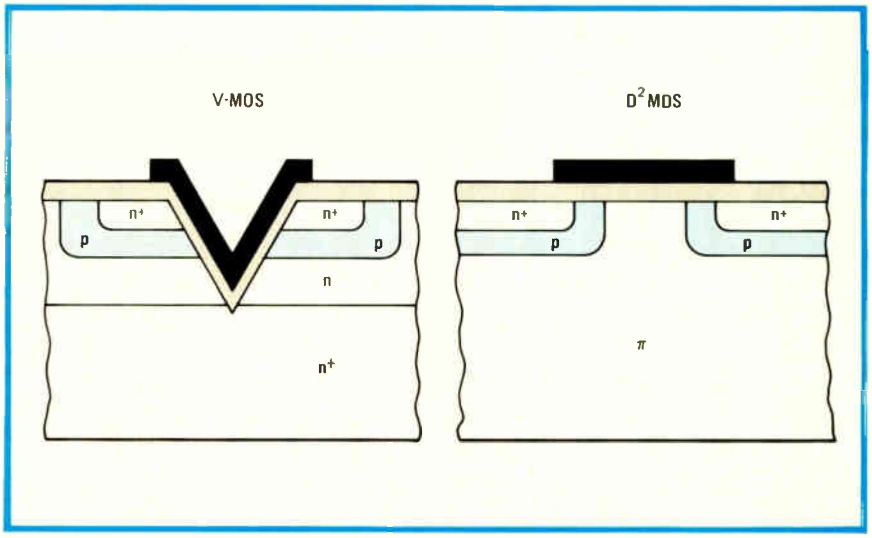
"First of all," Hayashi explains, "the devices are asymmetrical, and engineers prefer working with symmetrical MOS transistors," in which the drain and source electrodes are interchangeable and give the designers more freedom. He adds that while there is a symmetrical variant of the DSA device (nicknamed D^2MOS) that is even easier to build than the asymmetrical version, it performs less admirably in terms of transconductance and breakdown and punchthrough voltage—"but still better than H-MOS," he says.

Diffusion itself hurt DSA-MOS's image, Hayashi says. "The process people just look at it as more steps," but he points out that just isn't so. "H-MOS requires three ion implants, and the DSA process takes no more than that," he maintains.

Good listener. But someone had paid heed to what Hayashi said. During the time he spent at Stanford University, Hayashi befriended a fellow graduate student, T. J. Rodgers, who pitched a form of DSA he called V-MOS to AMI and is rapidly proving the commercial viability of a technology looked upon as unorthodox by competitive chip makers.

Rodgers had looked into planar DSA, and saw merit in using 5-μm lithography to get a 1-μm device—but the result was what Rodgers calls a "poor man's 1-μm FET." "It had the drawbacks of a 5-μm device in many respects, like high input capacitance," he explains. So he pursued the nonplanar V-MOS.

In Hayashi's opinion, Rodgers has chosen the toughest form of DSA. "In all probability, the yield of V-MOS will be less than any other DSA process," he says, "but it is also the one with the highest density and performance."



Other DSA. American Microsystems' V-MOS is a spinoff of planar DSA, faster and denser but tougher to make. Symmetrical variant D^2MOS is easiest to build but sacrifices performance.

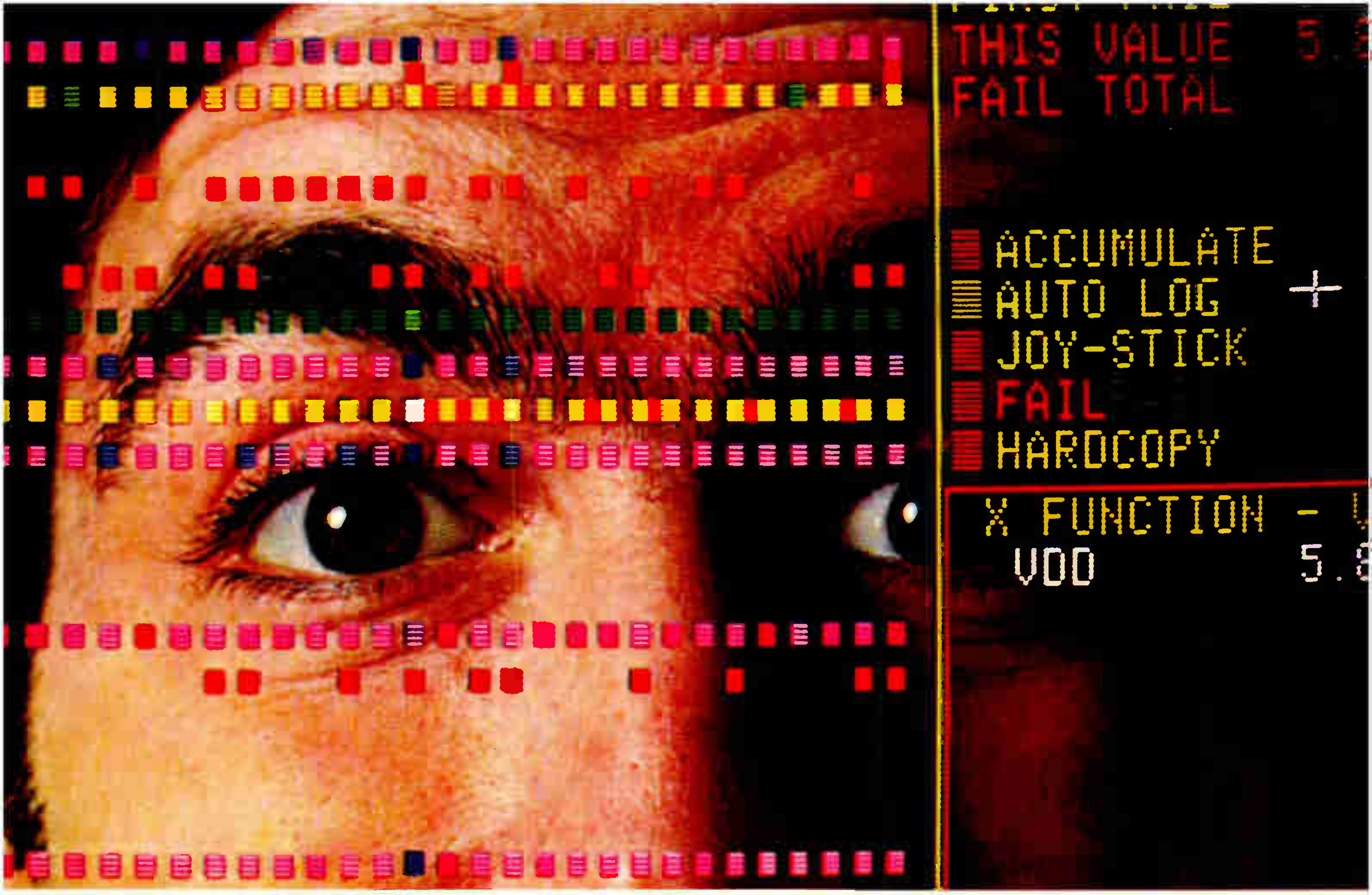
Like most American semiconductor manufacturers, the Japanese treat V-MOS like a plague; all their efforts are concentrated on planar DSA processes. The reason: the scariness of that groove, which requires anisotropic etching and growth of oxide and metal or polysilicon on its sloping walls.

But it must be noted that even the Japanese companies disagree about the present performance advantage of DSA MOS over an H-MOS-variety technology. At Nippon Electric, for example, 1-K static RAMs with typical access times of 10 nanoseconds have been built using DSA—but high-performance MOS has yielded the same device with a 15-ns access. "The gain of the DSA and H-MOS devices is about the same," says Hirohiko Yamamoto, manager of the fundamental technology section in the production engineering department of NEC's IC division in Kanagawa, Japan, "but right now H-MOS is looking better because of difficulty in threshold control of the DSA devices."

The mixed feelings derive from comparisons of today's processes, but the Japanese still see DSA in a long-term light. And that is precisely the point Hayashi wants to make. Having had to abandon work on DSA when his government grant ran out, Hayashi never saw his developments carried to the point where he really expects DSA to take off—in submicrometer-channel-length devices. "Which is easier to make?" he asks, referring to the figure on page 87, "—a short-channel MOS device with a 50-angstrom gate oxide, or a DSA device with a 200-angstrom oxide?" Hayashi had managed to characterize such a device with a 0.2-μm effective channel length and 200-angstrom gate oxide. Its advantages over a super-scaled H-MOS device of equivalent performance include:

- Higher drain breakdown voltage—the device can support a 10-volt supply.
- Thicker gate oxide, and hence better yield.
- Less sensitivity overall to variations in gate length.
- Higher conductance, or drive current capability.
- Less short-channel effect on threshold voltage.

American Microsystems' Rodgers concedes that at 1-μm lithography and smaller, DSA clearly holds a trump card: much higher punchthrough voltage. But he sees also a major manufacturing concern—control of the DSA transistor's thresholds, which are determined by the overlap of two diffusions. "Threshold control is still the major problem," he says. Standard Microsystems' Richman adds DSA shows advantages but concludes that "the feeling is the advantages aren't as great as they once were." □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Memories

PROMs enjoy a seller's market

Manufacturers line up for slices of $152 million pie as demand for programmable read-only memories exceeds supply

by William F. Arnold, San Francisco region bureau manager

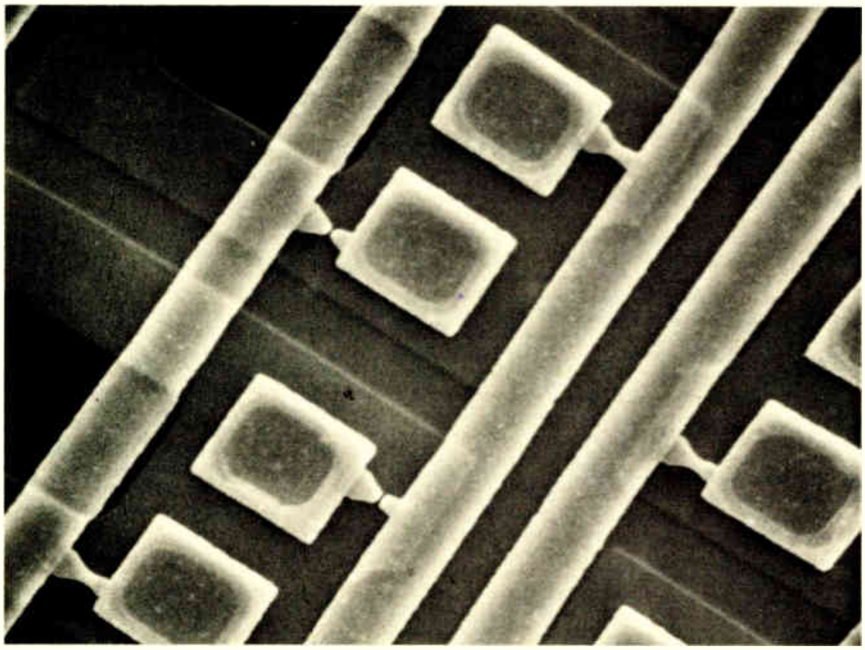
Even in the semiconductor industry, where "production limited" is a byword these busy days, the bipolar programmable read-only memory market raises eyebrows. Five years ago, the PROM was a sleepy little part serving low-density applications in minicomputer and peripheral systems. Wide awake now, it has become a series of higher-density devices serving a host of new applications.

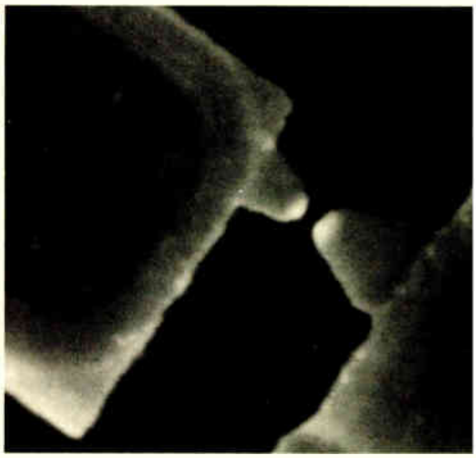
As a result, "the demand on us is two and a half times our capacity to supply," declares Ralph Kaplan, division marketing manager for Signetics Corp.'s Bipolar Memory division in Sunnyvale, Calif., the industry leader. At neighboring Monolithic Memories Inc., one of the top three makers, advertising manager Ray Gouldsberry put it this way: "The good news is that there's more business than we can handle; the bad news is that we can't handle all of it." Both executives say their companies have been allocating product for some time and predict the severe crunch will last for at least two more years.

Why the surging demand? Basically, the PROM market tracks the growth of high-performance microcomputers and minicomputers. PROM surveyors point to car makers' need to program engine-control microcomputers for various combinations of engines, transmissions, and rear axle ratios in order to meet increasingly strict government-mandated fuel economy and emission control requirements. "MOS can't do it because it's not fast enough to work with the microprocessors," observes Daniel L. Klesken, a vice president of Dataquest Inc., a Cupertino Calif., market research company.

PROMs are used to store microprocessor programs and special operating characteristics in "sort of a look-up table," he continues. They are also used in such applications as electronic odometers—in which a link is blown every 10 miles to store distance traveled. "Detroit wants the flexibility of PROMs and will go to ROMs later," Klesken says; their programmability gives PROMs cost advantages by easing inventory and lead time problems. The surging car market is dominated by 8,192-bit devices.

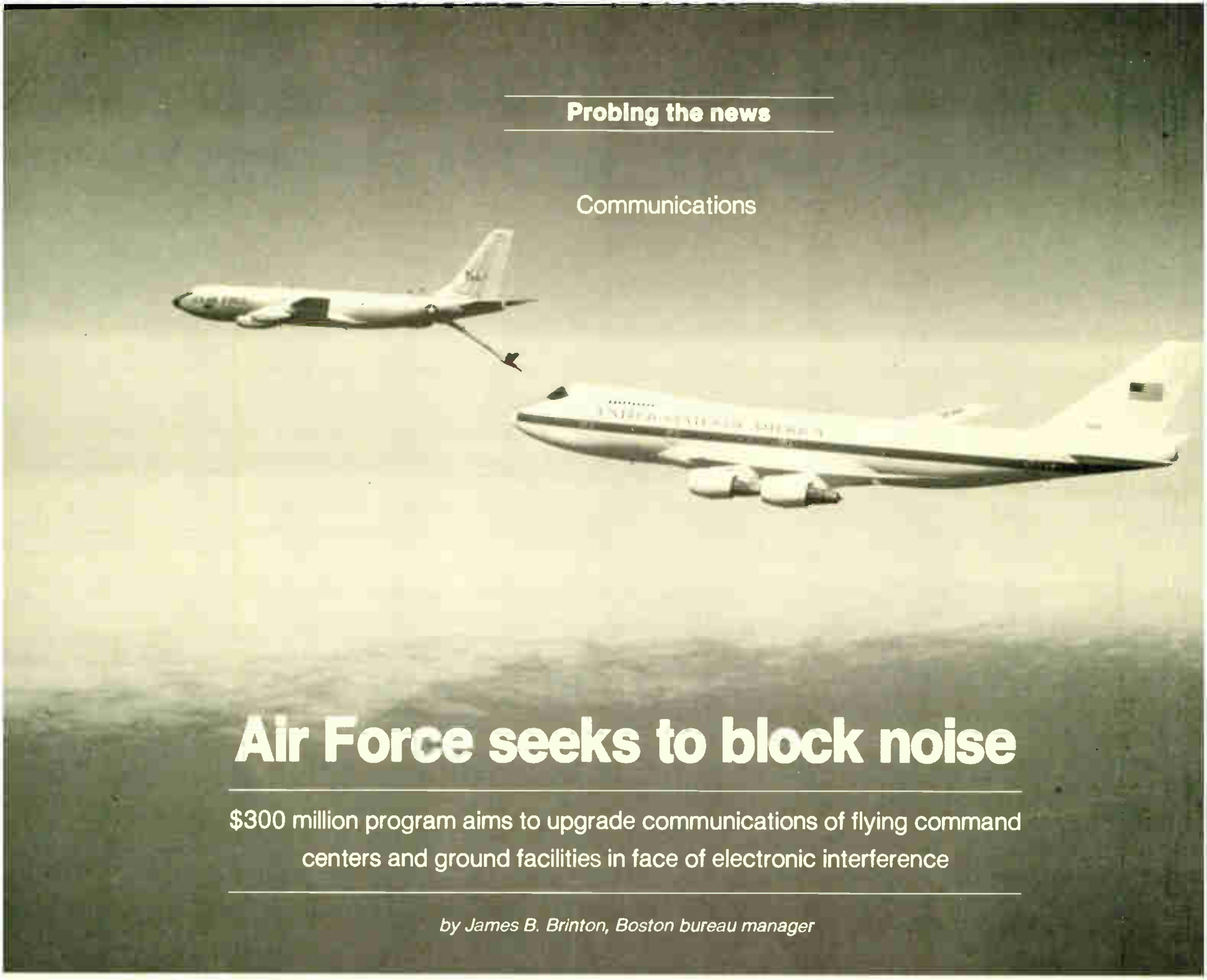
More markets. Other up-and-coming applications include numerical controllers and other industrial control products as well as consumer games, a market that began opening up two years ago, according to Rex





On the links. Photos of programmable ROMs from Texas Instruments show both intact and blown links. Left photo is 1,250× magnification; photo at right, a 4,500× enlargement, gives better idea of dimensions of opening, which is 0.03 to 0.04 mil.

Communications



Air Force seeks to block noise

$300 million program aims to upgrade communications of flying command centers and ground facilities in face of electronic interference

by James B. Brinton, Boston bureau manager

Speaking clearly. The Air Force wants better communications between ground and command post craft, the EC-135 and the larger E-4.

The Air Force is aiming at a vast improvement of its communications systems. It wants better penetration of ordinary airborne electronic interference and enemy jamming, and the ability to pierce the maelstrom of electronic signals that would result from a nuclear attack. In a multipronged effort, it is increasing the capabilities of its 23 EC-135 and four E-4 flying command centers, and of more than 220 ground centers originally developed as part of the 487L Survivable Low-Frequency Communications Systems (SLCS).

Designated 616A, the $300 million program could mean increases of 30 to 70 decibels or more in receiver sensitivity or transmitter output power. Eventually, the 616A equipment will find its way into more than 220 ground installations, many manned by Army personnel, as well as into the military's various command and control aircraft. The program's key phases include:

- Development of a secure, interference-free modem able to net the Air Force a 6- to 30-dB improvement in apparent receiver sensitivity.
- A 100-kilowatt radio transmitter for EC-135 Post-Attack Command and Control System (PACCS) aircraft to replace a transmitter one fifth that powerful.
- A 200-kW transmitter for E-4 Airborne Command Posts (ACP) ten times more powerful than the one it would supplant.
- A new receiving antenna to improve air-to-air communications under hostile conditions.
- A "combiner-piecer" that would use comparison and correlation techniques to net 12 to 30 dB more receiver sensitivity.
- An interference canceler, with a potential effect simply described as "immense."

Modem moving. According to Lt. Col. Gerald E. Kobelski, 616A program director at the Air Force Electronic Systems Division at Hanscom Field, Mass., furthest along is 616A's radiation-hardened, secure, interference-free modem. The new device would be capable of operating effectively in the face of 6 dB poorer radio-frequency signal-to-noise ratios in a normal environment, and in a nuclear-attack environment could offer about 30 dB better performance than the one used now.

Part of the modem effort has been qualification of a new series of hardened digital integrated circuits of the 54LS type. Fairchild, Motorola, Texas Instruments, and National Semiconductor all are expected to supply these circuits.

Now in initial production, the program is expected to generate about 200 modems at a price of $14.6 million. A second phase will see production of about twice that many, and bring total production outlay to $37 million. The prime contractor is the Westinghouse Electric Corp.'s Defense and Electronic Systems Center, Baltimore.

The second major part of 616A is a low-frequency/very-low frequency replacement transmitter for the EC-135 PACCS fleet. These aircraft are flying in several different roles as part of the military's overall airborne command and control system. Now they are equipped with a 20-kW transmitter that cannot deliver its full power at some combinations of frequency and altitude. The new 100-kW unit would have less difficulty, offering 7-dB more maximum output power.

The 100-kW transmitter is in its preproduction phase now and two firms are competing for the business. Both Westinghouse-Baltimore, and the former Collins Transmission Systems division (now part of Rockwell International Corp.'s Commercial Telecommunications Group in Richardson, Texas) built prototype/development phase transmitters that have just been evaluated as part of source selection. The prototype phase was a $200,000 effort; funding hasn't been set yet for preproduction although proposals have been requested.

For the E-4. The three E-4 Airborne Command Posts flying today use the same 20-kW transmitter now aboard the EC-135 fleet. Under part three of 616A these will be replaced with a new 200-kW unit.

Both the 100- and 200-kW transmitters operate at frequencies between 17 and 60 kilohertz using frequency-shift-keying and spread-spectrum modulation techniques. The 200-kW transmitter will use a dual trailing-wire antenna. An 8,000-foot wire will be the driven element, while another, 26,700 ft long, will act as a ground plane.

Since almost 90% of the power radiated by the antenna will be in the transverse electric, or TE, mode of propagation, the Air Force wants to maximize its ability to receive transmissions in that mode. But the Air Force historically has depended on the transverse magnetic component of radio emissions, or TM, mostly because TE-mode components tend to null out at ground level.

But for air-to-air, TE may be the way to go. It would be impaired by nuclear attack effects, but would bounce back more quickly than the TM mode, and the Air Force plans to take advantage of this. The Rome (N. Y.) Air Development Center, ESD, and the Defense Communications Agency, Washington, D. C., all have done conceptual work on using the TE mode.

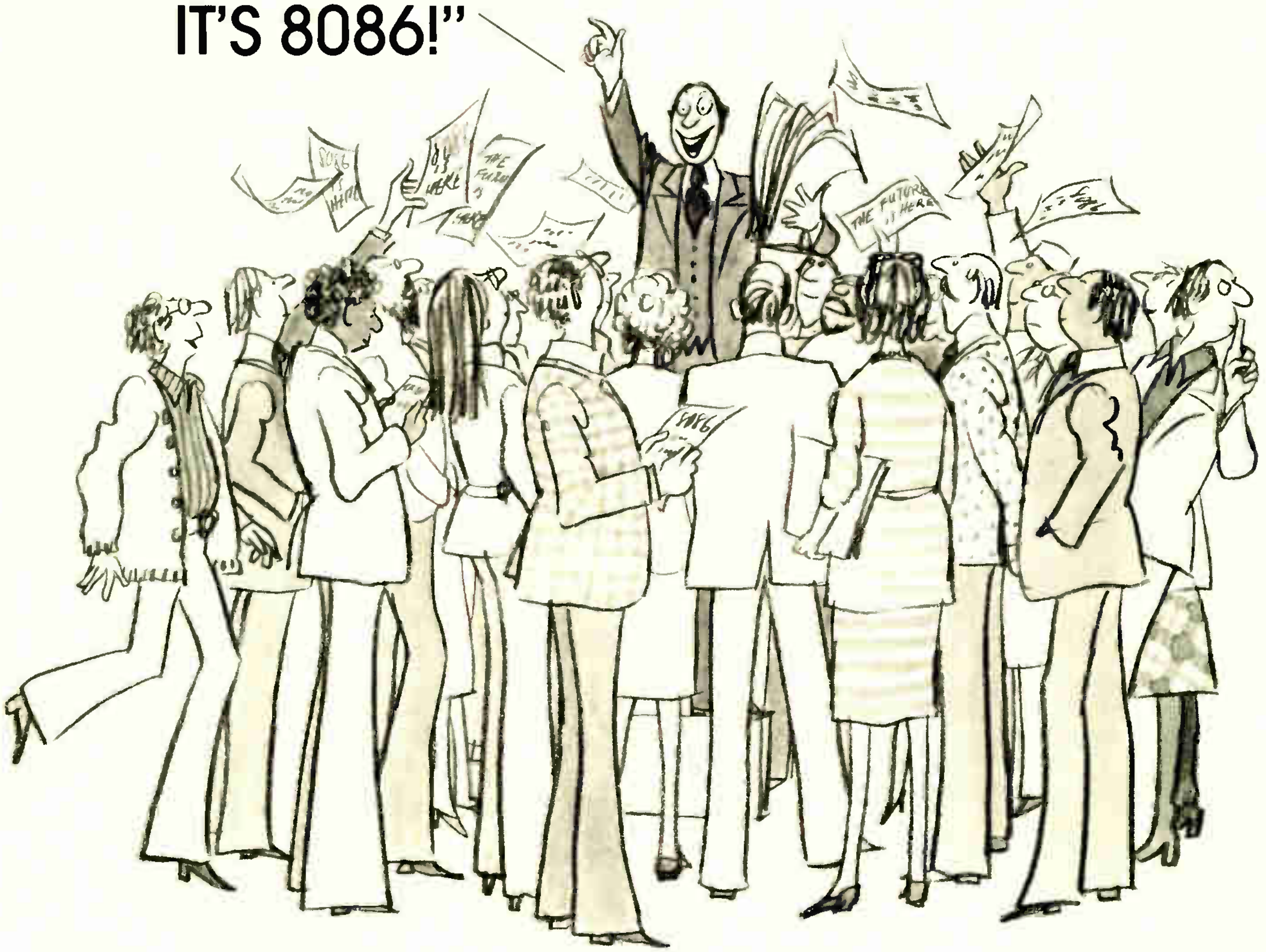
What is needed now is a receiving antenna sensitive to the TE mode, and downstream equipment to select and process the better of the two modes, either TE or TM. These requirements serve as a definition of the fourth and fifth sections of 616A, the TE-receiving antenna, and the TE/TM combiner/piecer.

Cancellation. Every engineer knows that a signal can be generated that will cancel another; that is the idea behind the Interference Canceler, the sixth part of 616A. "The electrical environment aboard any aircraft is noisy," says Kobelski. "You must deal with 400-hertz power-supply noise, your own radio-frequency interference, and, in an attack situation, enemy countermeasures. We now are recording the electronic-noise environment aboard a Cinclant [Commander in Chief, Atlantic Fleet] naval aircraft at antennas, processor site, work stations, and elsewhere. We hope to come up with a model of the situation which we can then present to industry for a solution."

There are two late phases to 616A: "guaranteed" full duplex communication (at present this two-way communications capability is intermittent under poor propagation conditions), and very low frequency links for bombers.

Both will build on the developments and capabilities of the earlier phases of 616A, with "guaranteed" full duplex a result of their implementation rather than a separate development. □

"I HAVE SEEN THE FUTURE AND IT'S 8086!"



There's a lot of noise out there about the 8086. A lot of noise. And all of it's coming from Intel.

But even with all the pages of advertising, all the claims, all the chest-beating, there's one little fact Intel forgot to mention.

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Microsystems

Standards panels near goals

Some sections of microprocessor guidelines may be approved this year as seven IEEE task groups dig away

by John G. Posa, Microsystems & Software Editor

Pick a microprocessor, any microprocessor. To its standard bus attach a software module using standardized instructions generated by a standard compiler. Tack on a floating-point math processor and plug the whole thing into another standard bus structure. Sound improbable? Possibly, but when the IEEE Computer Society's microprocessor standardization efforts produce concrete results—drafts of some sections may become standards this year—the dream of substantially reduced design time may one day come true.

These efforts were started almost two years ago by Robert Stewart, who has since been promoted to chairman of all of the society's standardization efforts. Now in charge of the microprocessor work is Gordon Force, a consultant based in San Jose, Calif. Force also heads his own subcommittee on a standard for a component-level bus structure called Microbus, the first draft of which appeared last summer [*Electronics*, July 20, 1978, p. 113].

The route to adoption is tortuous. First a proposal must be published in an IEEE periodical, then it may be revised. The next steps are submission to the microprocessor standards committee, the computer society standards committee, and, finally, the full IEEE standards board.

Different role. The IEEE is not considered by some as a standards-making body, but now electronics people are seriously reappraising that view. Indeed, at least one of the proposals—for floating-point math—will spur design of integrated circuits dedicated to perform in accordance with the standard. In California, Intel Corp. of Santa Clara and Signetics Corp. of Sunnyvale are known to be working on such chips, while Advanced Micro Devices Inc. of Sunnyvale, National Semiconductor Corp. of Santa Clara, and others are keeping an eye peeled.

"Western Digital asserts it has already implemented the standard in the microcode of its Pascal Microengine [*Electronics*, Oct. 12, 1978, p. 155]," says Dick Delp, chairman of the floating-point committee. He was principally involved with the design of AMD's Am9511 floating-point processor chip before he became a systems architect/engineer at Signetics. His group's standard, he says, "will be far, far different from the one that the 9511 implements." One among many differences is range of precision. "The 9511's is only $10^{\pm 19}$, which is just not large enough for scientific work," he says. For single precision, the new standard will handle $10^{\pm 38}$, and for long precision, $10^{\pm 309}$.

Delp claims that the format and standards for arithmetic have been formalized and only a couple of controversies are left to haggle over. For one, the proposal is very close to two existing standards. One was selected by Digital Equipment Corp.

IEEE COMPUTER SOCIETY MICROPROCESSOR STANDARDIZATION EFFORTS

Task No.	Task name	Status	Coordinator	Affiliation
P694	instruction set	ninth draft issued	Wayne Fischer	Kaiser Electronics Corp.
P695	relocatable software	inactive	Tom Pittman	Itty Bitty Computers
P696-1	S-100 bus	second draft issued	George Morrow	Thinker Toys
P696-2	microprocessor system-bus (formerly Multibus)	first draft this year	Bob Garrow	Intel Corp.
P696-3	microbus	first draft issued	Gordon Force	consultant
P696-4	future bus	first draft this year	Cash Olsen	Signetics Corp.
P697	hobby and small business hardware and software	inactive	Norm Schneidewind	Naval Postgraduate School
P754	floating-point arithmetic	first draft this year	Dick Delp	Signetics Corp.
P755	high-level languages	Pascal activity split off, goals redefined		
P770	Pascal	will review revised BSI proposal this fall	Bruce Ravenel	Language Resources Inc.

a decade ago for its PDP machines, and the other is the so-called KSC standard. Intel uses the KSC standard on its iSBC 810 floating-point math board, and needs a standard for its upcoming 8087 coprocessor chip [*Electronics*, April 26, p. 33].

The KSC and DEC standards have much in common. Both use 23 significant bits, 8 bits for the exponent, and 1 for sign. But it remains to be seen which particulars will be plucked from which standard. "It will take a year," says Delp.

Four subcommittees are devoted to bus structures. Besides the component-level Microbus, there are two to clean up the S-100 and Multibus *de facto* standards.

Work on the future bus began a year ago. "We haven't yet pulled a draft together," says Cash Olsen, that subcommittee's chairman. But it expects to have a publishable work soon, possibly this fall. What will the bus of the future look like? "We envision a single serial bus with multiple independent processors using the bus to satisfy their needs for communication and data," says Olsen, a central applications manager at Signetics. "We foresee very loosely coupled networks."

Because hardware changes so rapidly, Olsen and his workers are first going after a solid protocol, "one that can attend to three different application areas: low-end consumer, mainframe-to-peripheral, and mainframe-to-mainframe," he says. "Twisted-pair would be the cheapest, but cable television couldn't use it," he says, "Fiber optics seems like an excellent way to go, especially in light of the enhanced noise immunity. But it doesn't seem best for the consumer—at least for a while."

Making progress. Two of the four software groups are going strong. One is on assembly-language instruction sets, headed by Wayne Fischer, a project manager at Kaiser Electronics Corp. in San Jose. It has suggested guidelines for the appearance of instruction mnemonics, operand sequences, assembler directives, constants, character strings, and statement comments and labels. "We're not trying to define a style of programming," he says, "and our standard will be architecture-independent."

Probably the most intense of all the panels is the one devoted to the language Pascal. The effort is now a joint one, with American National Standards Institute members present, and the meetings often draw more than a hundred persons. The subcommittee chairman is Bruce Ravenel, who formed a company called Language Resources Inc. after helping to engineer the 8086 at Intel. Language Resources builds and licenses Pascal compilers for microprocessors (and their manufacturers, in some cases).

"Extensions to the language will be a problem," admits Ravenel. Many users, like Texas Instruments Inc., find that Pascal does not meet their requirements. They are faced with a choice between two arduous tasks: add their own extensions, which is dangerous, or design a new language, which is difficult. Members currently agree to stick close to the Wirth/Jensen revised report [*Electronics*, Feb. 15, p. 96]. "The British Standards Institute will come out with a new proposal in six months or so. There's a good chance it will be suitable, and there will be an IEEE standard shortly thereafter."

Recently, the standards activities have received outside input. On May 10, Hermann Schmid addressed the computer society with a presentation entitled "A Framework for Top-Down and Technology-Independent Microprocessor Standardization." Schmid, a senior engineer at General Electric Co. in Binghamton, N.Y., says a top-down approach to the IEEE's efforts will ensure a more organized methodology and produce effective long-range results. A subcommittee is now being organized to consider Schmid's proposal.

"The approach is not intended to undo everything that has been done by the computer society thus far," Schmid contends. "It uses their output as input and provides them with new tools to simplify their work. With a top-down approach, you define what you are going to do, you write a set of requirements, and you do a detailed design of constituent modules and put these modules into a library. Later, you design from the modules, and the time needed to design, say, an interface is reduced from months to days." □

Electronics abroad

China is no pot of gold

Though opportunities for U. S. firms are inviting, experts agree that estimates are overoptimistic

by Benjamin A. Mason, New York bureau manager

Amid the tangible results of the official U.S. visit to China led by Commerce Secretary Juanita M. Kreps there stands something that cannot be reduced to paper, but is important nonetheless. The progress made embodies the determination of the People's Republic of China to do business with the U. S.

Some electronics manufacturers have already moved into the market, and with improving commercial and trade relations there will be opportunities for more companies—provided they know how to go about it.

Already a community of advisers and consultants on China trade is flourishing, and discussions with them often raise an important point: many U.S. estimates of the business opportunities there vastly overstate the market. "You have to look at China as a reasonable addition to other international sales. It won't revolutionize your position," says Jerry Levine, president of San Francisco-based Mentor International Inc., a consultant in international electronics business.

In fact, the Department of Commerce has steadfastly maintained a restrained view of China's market size, says Allen J. Lenz of the department's Office of East-West Policy and Planning. His estimate for 1985 hard-currency imports is $22 billion to $25 billion; the optimists put it as high as twice that much. This year, imports from the U.S. are expected to total $1.25 billion.

What the optimists overlook are the factors limiting the growth of China trade. There are three main ones: China's ability to absorb Western technology efficiently, its ability to significantly increase exports to hard-currency areas, and its ability and willingness to borrow.

The seminar at which Lenz spoke, "Doing Business with China," held in New York on May 10–11, is an example of the advice that interested companies can find (see "China trade: all kinds of help are available"). It will be given again in Los Angeles at the end of the month. On June 6, the American Electronics Association will sponsor a similar seminar in Palo Alto. For electronics manufacturers, such events are of more than academic interest. The Chinese want American electronics technology and products, as a Chinese official made clear recently in New York [*Electronics*, May 10, p. 44].

Clearly, China must establish priorities in the mammoth moderni-

China trade: all kinds of help are available

For the businessman just dipping his toe into the waters of China trade, there are many enthusiastic swimmers out there willing to lend a helping hand. What follows is a representative list; a bit of research and asking around will uncover other, similar resources.

The National Council for U. S.–China Trade, 1050 17th St. N. W., Washington, D. C. 20036, is a corporate-sponsored storehouse of information and promoter of trade. Dues are $750, $1,500, or $3,750, depending on company size. It publishes **The China Business Review,** a bimonthly clearinghouse of information. A business subscription is $60 a year.

The People's Republic of China division, Bureau of East-West Trade, U. S. Department of Commerce, Room 4044, Washington, D. C. 20230. Ask for the informative booklet "Doing Business with China."

Document Expediting Project, Exchanges and Gifts Administration, Library of Congress, Washington, D. C. 20540. Behind that unassuming name, an unexpected treasure: unclassified analyses by the Central Intelligence Agency of a wealth of China-related topics. Write for a price list.

"Doing Business with China" seminar, Law & Business Inc., Harcourt Brace Jovanovich Inc., 757 Third Ave., New York, N. Y. 10017. Already held in New York, it will be given again at the Los Angeles Bonaventure May 30–31. The fee is $250; it includes a book also entitled **"Doing Business with China,"** which is available separately.

China Trade seminar, American Electronics Association, 2600 El Camino Real, Palo Alto, Calif. 94306. This seminar, which will assess market opportunities and offer practical advice, will be held June 6 at Rickey's Hyatt House in Palo Alto. The fee is $125 for members, $175 for others.

The China Trader, P. O. Box 288, Westport, Conn. 06880. Julian M. Sobin, an old hand at the China trade, interviews 24 businessmen, academics, and Government officials on 12 hours of cassettes costing $300.

Consultants. There are many of them. The one mentioned in the main text is Mentor International Inc., 712 Montgomery St., San Francisco, Calif. 94111. Another, on the East Coast, is Friendship International Corp., 4200 Prudential Tower, Boston, Mass. 02199, run by Lee F. Sobin, like her husband a veteran China hand.

zation process drive it is mounting—and recent events indicate that that is under way. Still, electronics business is likely to be a key element, no matter what readjustments are made. One reason is China's need to earn export credits. Its trade deficit with the U. S. is as bad as or worse than its trade deficit with other countries with which, in fact, it does a greater volume of business.

Therefore, the attempt to build up export industries will continue unabated, says Edith Terr, assistant editor of the China Business Review. China could be the next big offshore manufacturing center for electronics firms in the industrialized companies. An important caveat, Terry says, is that the Chinese may well want technology and know-how transfers as part of such deals. Moreover, if the activity is a joint venture, the Chinese are likely to stipulate a payout of goods or profits to make the business wind up in their hands, say "Doing Business with China" participants Benjamin P. Fishburne II and David C. Buxbaum, both lawyers with Chinese experience.

An important source of export earnings will be nonferrous metals and petroleum, says seminar participant Lynn Feintech, a Bank of America economist. These industries need to be expanded, as do the ports and rail systems. Thus there could be opportunities for makers of industrial electronics.

The Chinese push to establish their own electronics industries opens the door to the makers of production machinery and test equipment, says Mentor's Levine.

Not right now. Advanced semiconductor technology in fact may run into sticky going. Of the possibility of such a production facility set up in China, Levine says "They'd love it, but it's the last thing our Government will approve."

As trade develops, exporters are likely to find that China will have hard currency available only for the highest-priority items, the Bank of America's Feintech says. Consequently, payment in goods is likely to be important.

Other participants in the seminar report that licensing is assuming growing importance. "It has a bigger future than the sale of products or joint ventures," says Arthur T. Downey, a lawyer and former deputy assistant secretary of commerce for East-West trade. However, he added, the licensee is representing all of China, so the fees should be fixed accordingly.

In many ways, China still remains a mystery to Westerners, even businessmen who have been dealing there for years. For example, codification of laws is minimal, which can make negotiating a contract both tortuous and tedious. Reportedly, the Chinese are working on codification, with a tax code and something analogous to the Uniform Commercial Code perhaps the first to come.

Seminar participants say the codes are likely to appear piecemeal—although they acknowledge that that is an educated guess. Indeed, most of the points that follow, made at the seminar and by other experts, may be guesses too:

- Look for a 10% to 15% growth in China's foreign trade, now totaling about $21 billion, says another seminar participant, Robert R. Derenbeger, professor of economics at the University of Michigan.
- Although there is no legal code yet, there are standard contracts for import and export agreements, says Jerry Levine.
- Negotiations may be protracted, and preliminaries are important, for the Chinese want to come into the talks with a good understanding of the equipment available and the technology, Levine says. It is fatal to mention prices until near the end.
- The Chinese do not want to entertain visiting firemen; they want to host scientists and engineers.

Electronics manufacturers who have looked into exporting goods, particularly high-technology items, to other Communist countries are already aware that the paperwork can be considerable. China is no exception.

But the conclusion of the wide-ranging trade agreement between the two countries will make trade easier—as will granting by the U. S. Congress of most-favored-nation status, which could well follow. Still, the wise U.S. negotiator will insist upon a *force majeure* clause covering inimical Government action. □

Components

TV parts makers face offshore threat

Some turn from entertainment to industrial markets; technology insulates IC makers from the fray

by Larry Marion, Chicag bureau manager

Now that the wave of takeovers of American television assemblers has subsided, the battle has shifted to a new ground: the TV component market. With competitors from Japan and Taiwan inevitably gaining market share, U. S. manufacturers' views of the threat range from containable to disastrous.

What colors the estimate of a given American company is its position in the technology spectrum. Thus, while the Motorola Semiconductor Group, an integrated-circuit maker, is relatively unruffled as assemblers seek such advanced features as electronic tuning, a component maker like CTS Corp. is quite concerned. The upshot is that some of the lower-technology companies are shifting to industrial markets and others, for instance Airco Speer Electronics Inc. of Bradford, Pa., and the Centralab division of Globe Union Inc., Milwaukee, Wisc., have simply withdrawn from the television business.

Motorola says it will maintain its position by focusing on the tuner and changes to the chassis as sets become display monitors for the home computer and entertainment center. In fact, commercial marketing manager Stanley Katz says, "We see opportunities in TV."

CTS of Elkhart, Ind., on the other hand, one of the few remaining domestic manufacturers of smaller commodity components, is steadily losing ground to offshore production. Sales of its variable resistors for consumer products were down almost 33% in 1978 compared to 1976, dropping to $41.8 million from $61.6 million in 1976. About three quarters of this business is sales to the assemblers of televi n receivers.

"If Japanese-owned companies achieve worldwide domination of the television industry, CTS will probably be forced to withdraw," the company warns. Another source close to the company says "The situation will erode fairly rapidly. In five years, there will be no U. S.-made components in TVs." CTS is moving more than $10 million in manufacturing output to its new offshore plants in the next 18 months, says Robert D. Hostetler, executive vice president.

On the other hand, Stackpole Carbon Co. of St. Marys, Pa., which turns out such parts as flyback cores, resistor nets, and interference materials, is one of those that moved toward industrial customers. "We fought them for a while," says corporate marketing manager R. Dauer Stackpole, "but our government apparently isn't interested in saving jobs."

Domestic assemblers concede their future sets will contain a higher percentage of foreign-made components, because of the high quality and low prices. Charles Quinn, vice president for materials at RCA's Consumer Electronics division in Indianapolis, says the percentage of offshore components will increase because RCA buys on a "worldwide basis of price, performance, and proximity to assembly plants," and "the quality of offshore components is quite good."

Distributor. John G. Twist says that when U.S. makers try to be price-competitive, "the Japanese always underbid."

Big loss. There are other factors. For example, industry sources say that CTS lost millions of dollars in annual sales when Warwick Electronics was sold to Sanyo Electric Manufacturing Corp., the American subsidiary of Sanyo Electric, and the new owners refused to buy American parts. Attempts to sell to other manufacturers such as Matsushita were thwarted, too, claims John G. Twist, once one of the top distributors for television components. His sales to Matsushita will fall to $130,000 this year compared to $4 million to Quasar in 1970.

"We've heard of a number of instances where the domestic manufacturers attempted to be price competitive, but the Japanese always underbid," says Twist. He "has never found Japanese quality to be superior." Carroll G. Killen, senior vice president for marketing at Sprague Electric Co., North Adams, Mass., says "We didn't so much lose in this market as we were prevented from gaining business."

But domestic manufacturers have been unable to surpass the production efficiencies and quality of Japanese firms by a significant margin. A former domestic resistor manufacturer concedes: "In 30% to 40% of our product line, the Japanese are building an equivalent part for a lower price." □


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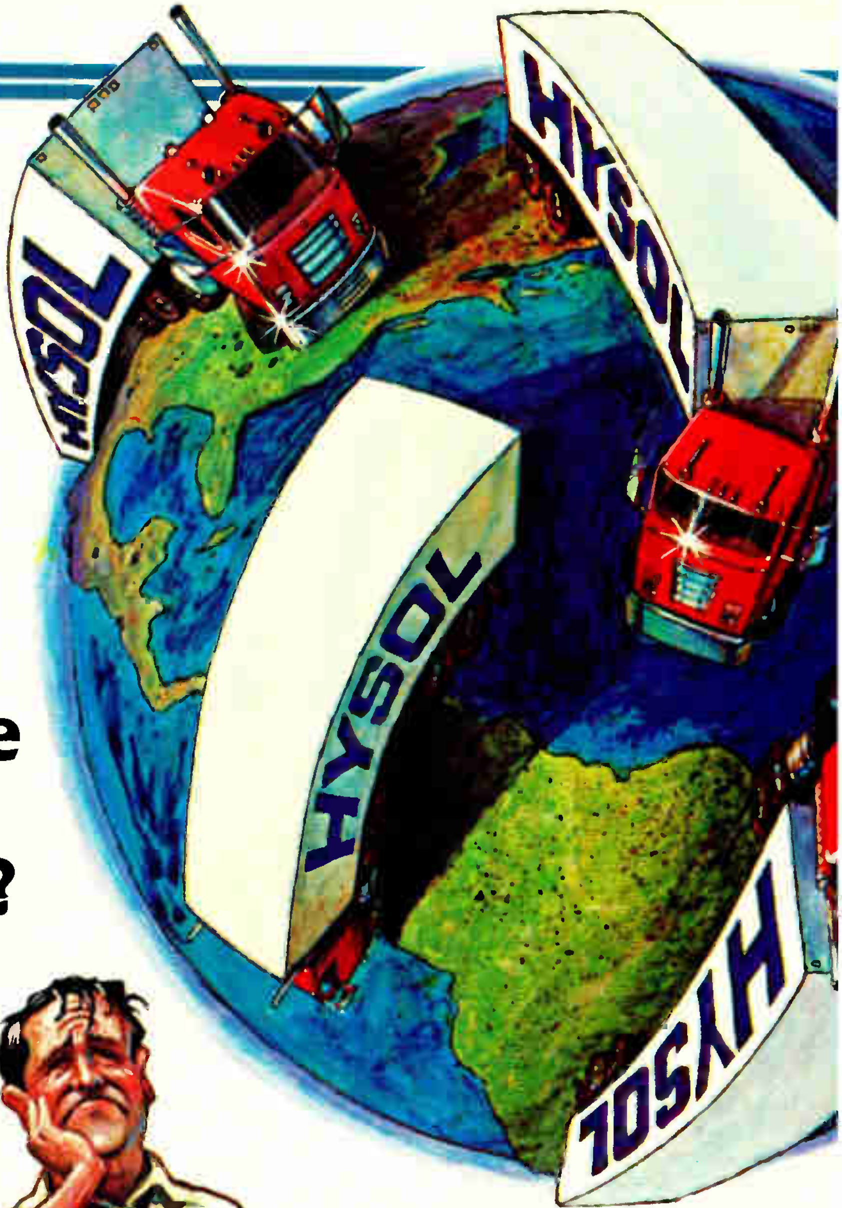

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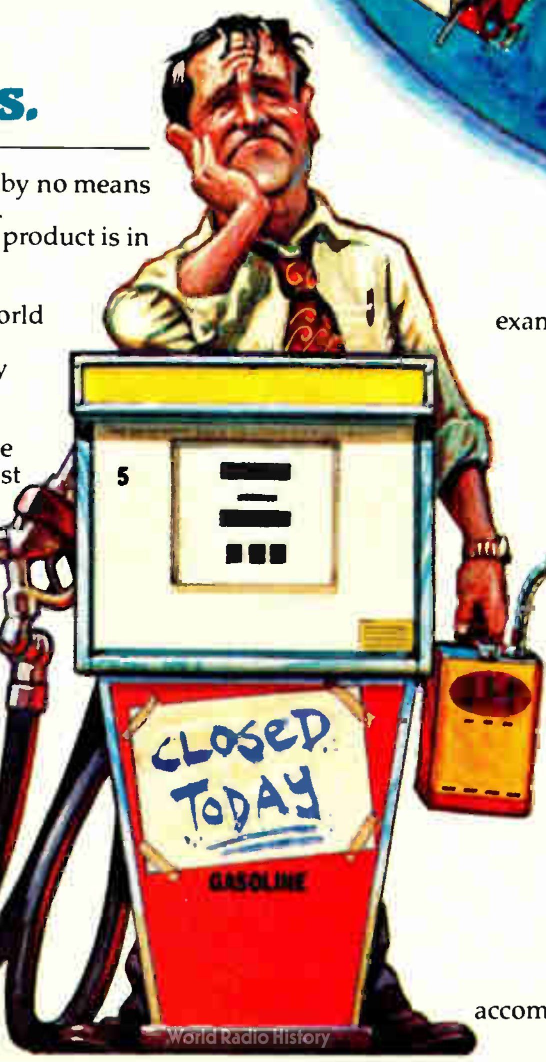

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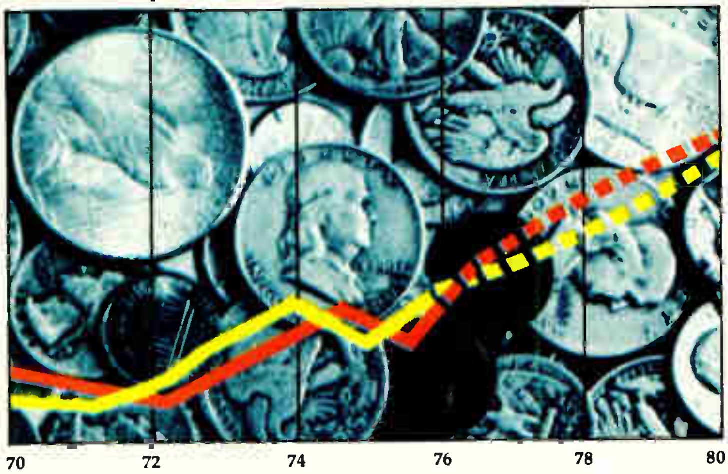

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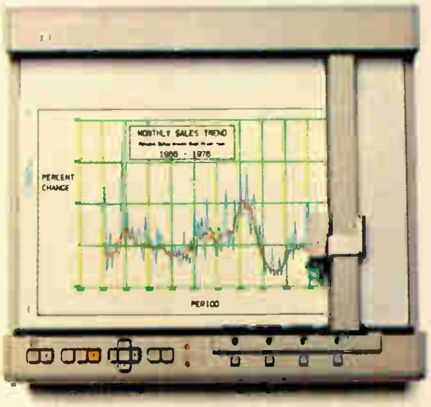

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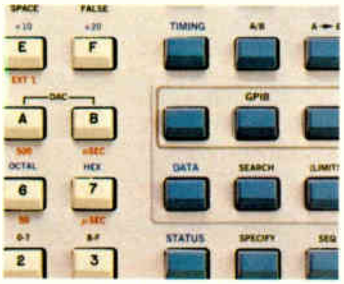

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GOULD

Circle 110 for information

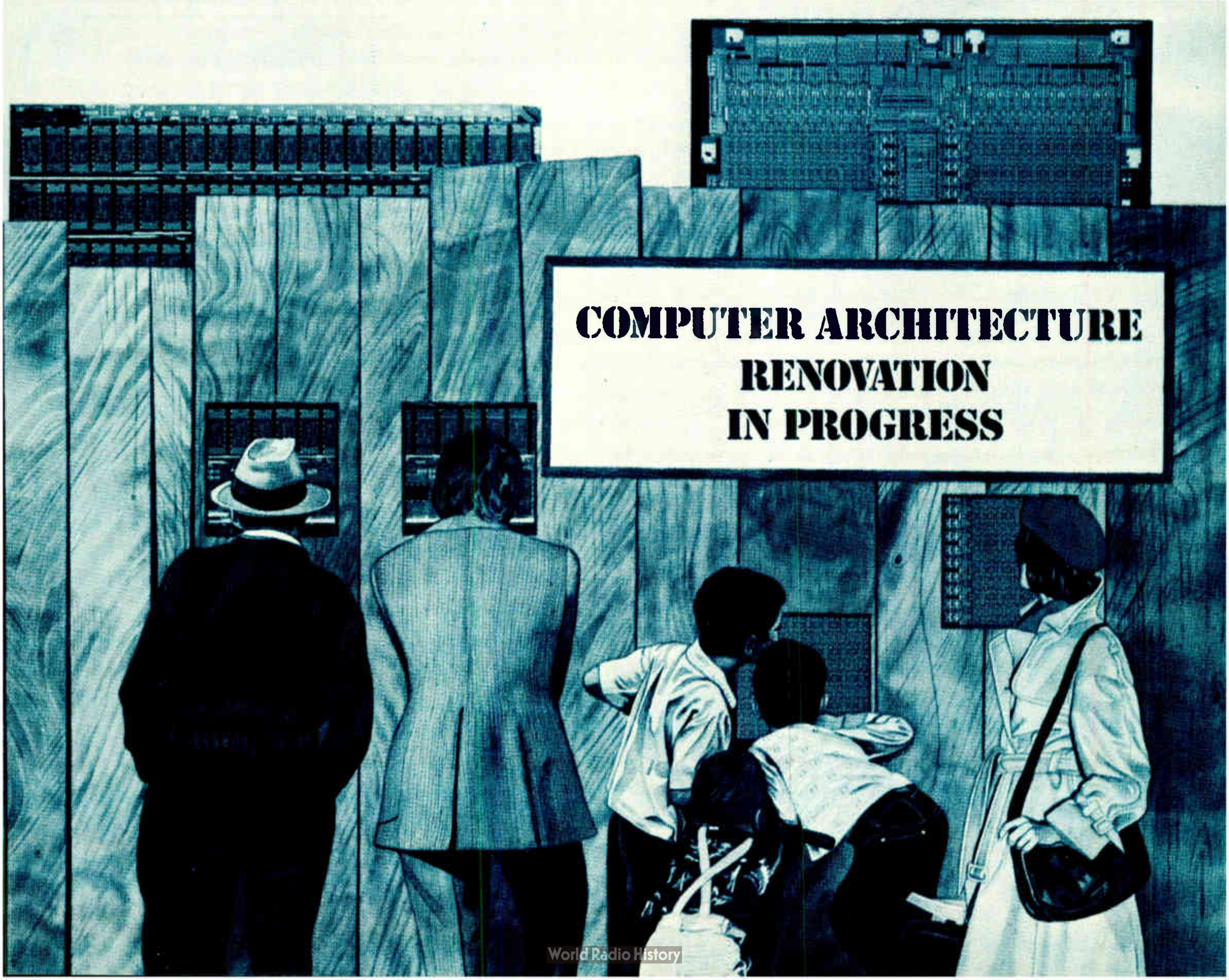
VLSI shakes the foundations of computer architecture

Computer engineers struggle to keep the user interface stable, while coping with changing tools and techniques, says this special report

by Anthony Durniak, *Computers Editor*

□ Behind a facade of stability, the computer industry is renovating its architectural and hardware structures. End-users are for the most part being insulated from the alterations, but as large- and very large-scale integration appears in logic and memory circuitry, it is drastically changing how computers are engineered.

The new integrated circuits are having the most impact on the hardware structures or so-called microarchitecture of a computer—the configuration of registers, control circuitry, arithmetic and logic units, memories, and their interconnecting buses. What once was made up of multiple semiconductor chips is now, very often, a single chip. Moreover, the denser, faster, and less expensive memory and logic offered by LSI is open-



ing up new engineering opportunities by reducing the influence of cost as a design factor. As a result, computer engineers are finding it harder than ever to define what the basic design elements should be.

"Every single part of [this] architecture is changing," says Gordon Bell, vice president for engineering at Digital Equipment Corp. "We're on the verge of being out of control in terms of our ability to assimilate the changes and respond to the opportunities present today."

The computer engineer's role, techniques, and tools are also being transformed as their hardware designs are integrated into semiconductors. The companies they work for will become amalgamated also. Joint development efforts between computer and semiconductor makers will become more common, and even mergers and acquisitions are predicted.

But, through all the changes in the hardware micro-architecture, there has been a concerted effort to maintain a stable facade or, as Bell puts it, "hold the interface with the user constant." Computer users or programmers are generally not aware of the buffers, ALUs, and buses, but see instead the instruction set, the types of data that can be manipulated (fixed or floating point, etc.), and the principles of operation—what is often called the *macro*-architecture (see "A rose by any other name)". Any changes at this level force a user to reprogram, or at least convert, the job the computer is to perform.

Obviously this type of change is undesirable since a tremendous amount of software that has been developed by both users and vendors would have to be scrapped. So, although a few see the need for entirely new macro-architectures, more want to keep those that already exist. In fact, some advocate an industrywide standard macro-architecture.

A rose by any other name . . .

One obstacle to measuring change in computer architecture is the variety of ways in which key terms are both defined and labeled. The framework employed for this report uses three layers called macro-architecture, micro-architecture, and implementation, as suggested by Barry Borgerson, Sperry Univac's director of research and technical planning and chairman of the Association for Computer Machinery's special interest group on architecture. Table 1 aligns this terminology with two other descriptive systems: one invented by Gordon Bell and Allen Newell for their 1971 book "Computer Structures: Readings and Examples," and the other prepared by G. A. Blaauw and F. P. Brooks for their forthcoming book, "Computer Architecture."

Electronics	Macro-architecture	Micro-architecture	Implementation
Bell & Newell	Instruction Set Processor	Processor-Memory-Switch and Register Transfer	Device level
Blaauw & Brooks	Architecture	Implementation	Realization
Meanings as used in this report	the machine a programmer sees, consisting of the instruction set, data types, addressing scheme, etc.	the hardware organization and logical design	the selection of semiconductor components

The latest trends

These architectural trends are evident in the past 18 months' spate of new computers:

- To support the widely used System/370 macro-architecture of the mainframes in its line, IBM Corp. introduces two 4300 processors that use gate arrays for the first time to implement a new micro-architecture.
- The variety of hardware micro-architectures that support the IBM System/370 macro-architecture further increases as the ranks of the so-called IBM-compatible computer vendors swell.
- The new 900 series from Burroughs Corp., Detroit, Mich., supports its macro-architecture with a new micro-architecture based on multiple processing modules operating concurrently.

While these machines rely on a smoothly evolved macro-architectured but radically change the internal hardware structures, some manufacturers are taking what may be a last opportunity to introduce a top-down change before the software inertia becomes so great:

- With its VAX/11/780, Digital Equipment Corp., Maynard, Mass., reveals an entirely new 32-bit macro-architecture.
- Hewlett-Packard Co., Palo Alto, Calif., shows a new 32-bit macro-architecture with its HP-300 and puts 90% of its micro-architecture onto three chips.
- At the low end of its product line IBM unveils the radically different System/38 having a 48-bit address that is capable of handling a staggering 281 trillion bytes of memory.

Whatever the degree of change represented by these new systems, they are only the harbingers of things to come in the construction of computers. The new bus-oriented designs exemplified in Burroughs, NCR, National Semiconductor, and Magnuson machines have the flexibility for future performance enhancements and the application of new device technologies. At the same time, they insulate the user's software interface with the macro-architecture from the change. Moreover, the special processors used in many of the new machines for front-end communications, input/output channel control, and systems control and maintenance are seen as predecessors of larger multiple-processor systems that could include units dedicated to particular programming languages, data-base management, and so on.

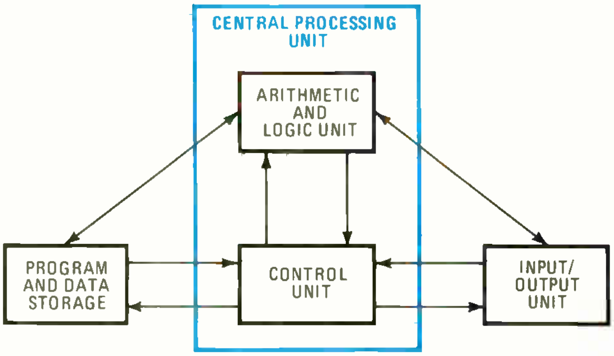
While computer engineers balance the need for macro-architecture stability against a madly changing micro-architecture, logic designers are dealing with the even foggier border between the micro-architecture and its circuit implementation. Large-scale and very large-scale integration "crosses critical architectural boundaries," warns Tony Vacca, electronics technology department manager at Control Data Corp.'s Research and Advanced Design Laboratory in St. Paul, Minn. "You can evolve from small-scale integration to medium-scale integration without new designs. But with VLSI you have to be more careful."

That the design boundary can be crossed successfully is illustrated by the HP-300, in which the entire central processing unit's micro-architecture was partitioned on just three custom complementary-MOS-on-sapphire chips

In the beginning

Computer architecture has had a rather tumultuous history in the short time it has been around. But for all the turns, advances, and changes made in the 30-odd years since the first electronic digital computer was switched on, a common architectural thread ties them back to these humble beginnings:

- Howard Aiken built his electromechanical calculator, the Mark I, at Harvard in the early 1940s. It contained several basic micro-architectural features still in wide use. Externally programmed with punched paper tape, it used the equivalent of registers to present inputs to the calculator portion of the machine, which employed the equivalent of an accumulator to hold the results.
- The first electronic digital computer, the Eniac (Electronic Numerical Integrator and Computer), was built at the Moore School of Electrical Engineering at the University of Pennsylvania in Philadelphia in 1946. It also separated programming steps from data. Some 6,000 multiposition switches and numerous patch cords were used to set the programs for the machine, and only 20 10-decimal digit numbers could be stored. J. Presper Eckert, who designed Eniac along with John Mauchly, recollects that the concept of storing the program electronically was born "out of desperation" at having to reset the switches and patch cords every time the machine was reprogrammed.
- The next machine developed at the University of Pennsylvania, the Edvac (Electronic Discrete Variable Automatic Computer), advanced this approach. John von Neumann, who worked on Edvac, is generally credited with having had the idea of storing both the data and the programming steps in the same memory. The resulting micro-architecture bears his name. Such a von Neumann structure, as shown in the figure, has a single memory unit that holds both programs and data, a central processing unit consisting of an arithmetic and logic unit and a control unit, and the input/output devices. With few exceptions, the computer architectures that are around today still have this basic structure.



(Fig. 1). This feat was due solely to the arrival of high-density semiconductor technology.

IBM decided to give its designers freedom of choice in crossing the border. Its gate-array approach combines the advantages of volume semiconductor processing with the opportunity to "personalize," as it were, the master slice of Schottky TTL gates into innumerable variations (Fig. 2). These chips supply the circuitry in both the System/38 and the architecturally different 4300.

As the architectural boundaries are penetrated, computer makers and semiconductor manufacturers will also have to reexamine their relationships.

The two-way street

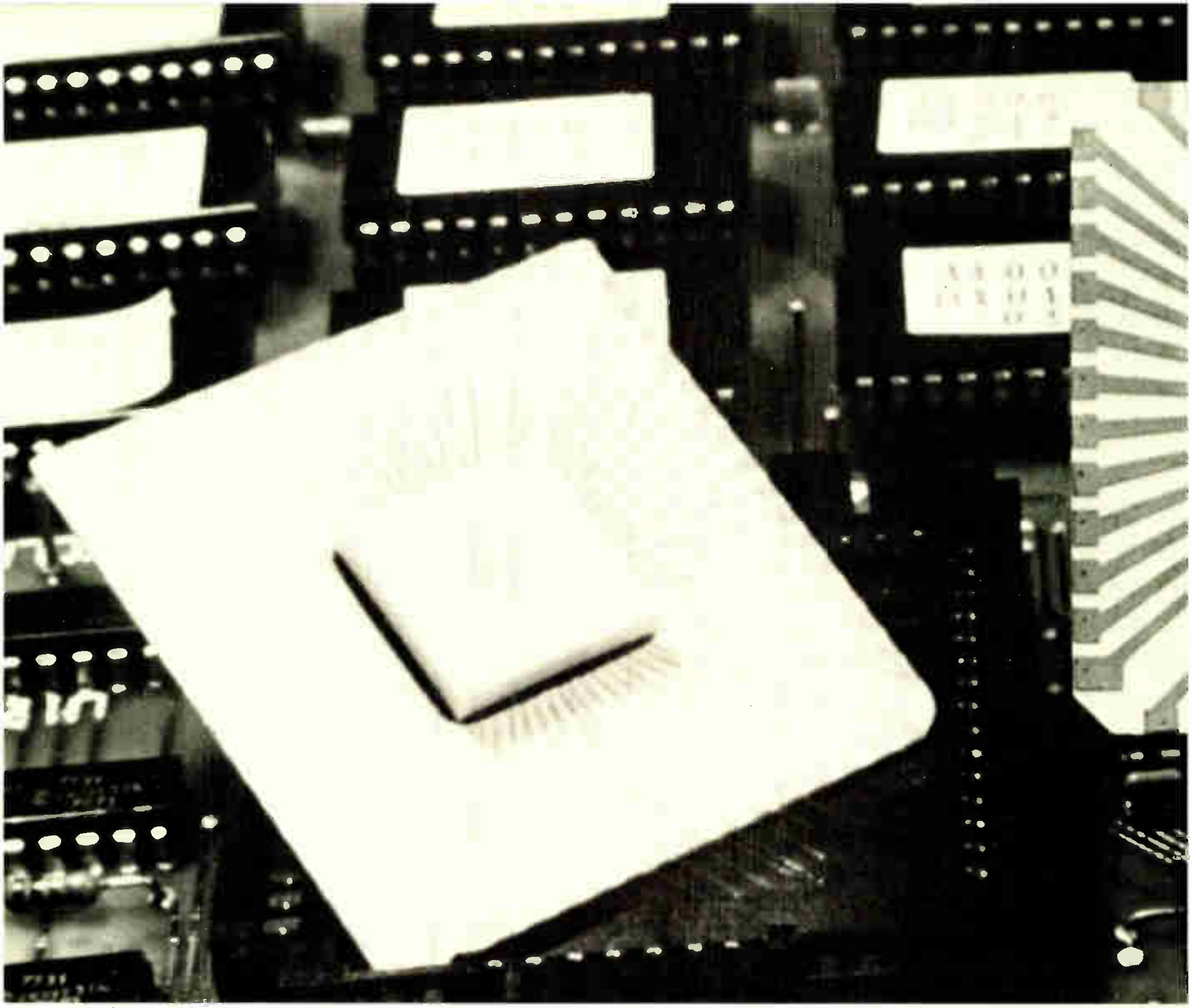
"The available component technology dictates the current computer micro-architecture," says Richard Chueh, director of engineering at National Semiconductor Corp.'s Large Computer Systems division in San Diego, Calif. "But this is a two-way street. Future component technology is directed by the computer architectural demands."

Although there is already cross fertilization of design ideas between computer and semiconductor manufacturers, the development of denser integrated circuits will force even more intimacy upon them than now exists. Some industry participants are already involved in joint development ventures, and some even predict business mergers will be necessary as computer architecture and semiconductor fabrication meld in the next generation of devices. Control Data Corp. and Fairchild Camera and Instrument Corp's joint development of a family of 100K ECL gate arrays reflects the changing relationships.

Because the hardware engineering is no longer insulated from software production and the logic design is merging with semiconductor fabrication, the engineer's training and experience are broadening. "In the past it was easier to compartmentalize the design," says E. David Crockett, program director for advanced computer systems at Hewlett-Packard's General Systems division in Santa Clara, Calif. "Now you have to have a design team that can talk about everything. Companies with a great distance between their logic and chip designers will not achieve high-density circuits, I feel."

To prepare their development staffs for the future, computer companies are increasing the proportion of software programmers and exposing logic designers, chip designers, and wafer-fabrication engineers to each others' disciplines. Computer-aided design tools are being installed to relieve the engineers of the more tedious design tasks, eliminate bread-boarded prototypes, and simulate and test circuits. These automated techniques supply the rapid turnaround that future designs will require if they are to be locked quickly into a single chip of silicon.

Overlapping this technical upheaval are the computer market conditions. Lower-cost hardware has expanded both the applications of and the demand for computers, so that the industry is growing by leaps and bounds. Minicomputer firms, for example, are estimated to be growing between 25 and 30% this year [*Electronics*, Jan. 4, 1979, p. 107]. The mainframe vendors are just opening a new product cycle with their new architectures, which is expected to boost their growth to 15 to 17% from the usual 10 to 15%. Industry analysts say these conditions are expected to continue as the computer makers turn to the new technology and architectures in order to be able to offer their customers more capable, more reliable, and simpler-to-use machines than ever



before at the same price they pay now—or less.

There is a parable that warns that a house built on sand is unstable (Matt. 7:26). It is a lesson computer engineers were quick to learn.

They have continually been altering the various layers of their architecture to absorb the changes in the silicon chips that form the industry's foundation. But at no time since the invention of the transistor has the silicon foundation been shifting more rapidly. And never in the relatively short history of computers has there been so much inertia tending to stabilize the macro-architecture that users see—the equivalent of the roof of a house. Forced to balance stability against mutability, they are changing the way in which they engineer computers.

New ground rules

"The semiconductor industry gave computer architects a whole new set of ground rules in terms of cost justifiable architectures," observes James A. Katzman, one of the founders and chief architects of Tandem Computers Inc., Cupertino, Calif.

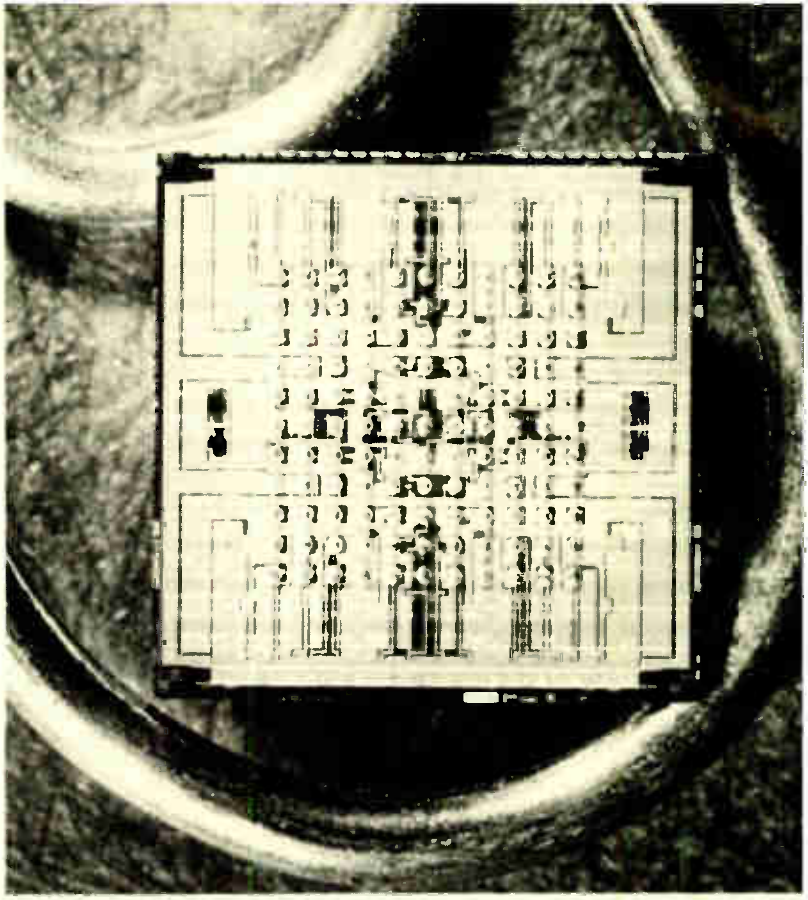
The rapid pace at which semiconductors have gotten denser, faster, and less expensive has changed the price/performance range of computer products. "Five or six years ago there was nothing that could be called hardware between $50 and $10,000 in price. But in the last two to three years the space has been filled in rather liberally," notes Richard J. Clayton, vice president for computer systems development at DEC. "When we look back 10 years from now, I think we'll find this period was the peak of the acceleration of the rate of change."

Random movement

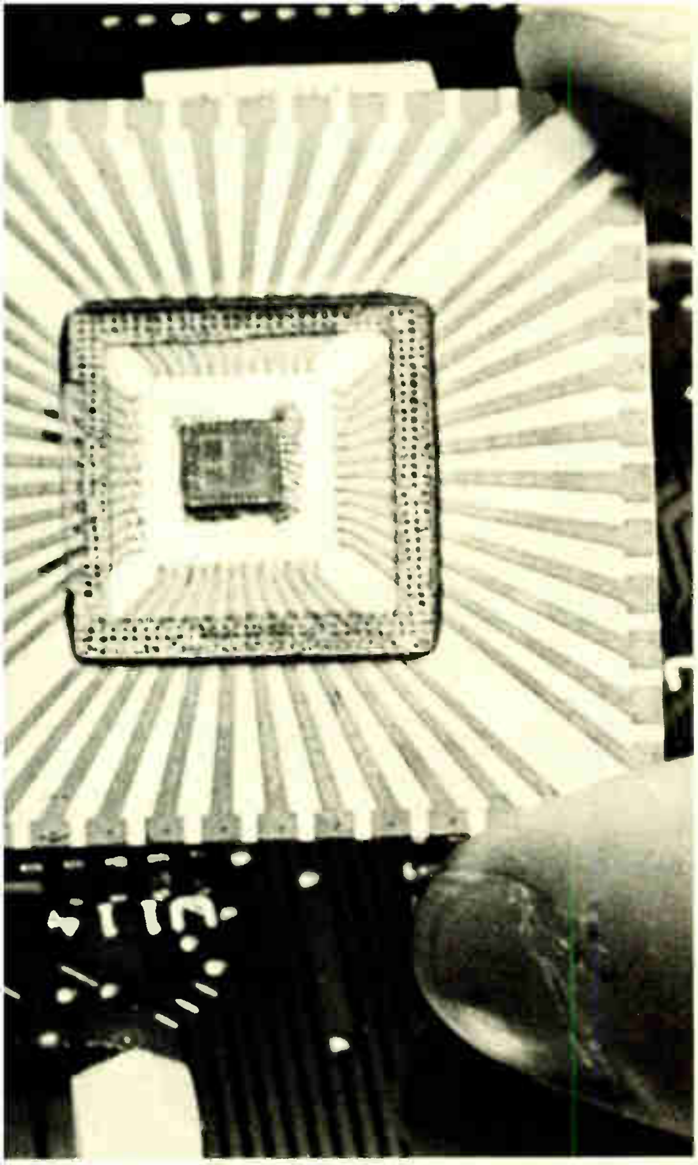
Shifting the fastest today is the area of logic circuitry as both semiconductor and computer manufacturers attempt to integrate it on a large and eventually very large scale. And this promises to cause the greatest change in the way computers are engineered, because the definitions of what constitutes computer architecture and semiconductor fabrication are being confused.

Each of the various elements of a computer—such as the registers, arithmetic and logic unit, instruction decoding logic, and address calculating circuits—has till now been implemented from chips containing only basic AND and OR gates. A three-phase clock circuit, for instance, might consist of three chips, an ALU might consist of several full-adder chips, and register files would be split up between several integrated circuits.

With large-scale integration, however, it is now possible to put several of those elements onto a single chip.



2. Flexible choice. Rather than use custom chips, IBM is turning to gate arrays as a means of using LSI logic and yet preserving architectural flexibility. The same master slice is used to make this chip for the 4300 (shown above) and others for the System/38.



1. Component or computer? Chips such as these custom large-scale integrated circuits used in Hewlett Packard's HP-300 computer are making it harder for computer engineers to define architectural boundaries. Three of them make up the central processing unit.

Microprocessors are of course the extreme example. They compress the entire central processing unit—registers, ALU, control circuits, and in some cases even memory—into a single chip, which as a result also supplies many of the micro-architectural details, such as the size and location of registers, the width and routing of data and control lines, and the construction of buffers and instruction pipelines, if any.

Because so many of these micro-architectural concerns are now part of the chip design, it has been difficult to come up with an LSI logic chip that could be widely used. Obviously a chip that used one company's micro-architecture would be useless to another company. And unless many people can use a chip, the production volumes will be low and production costs high.

The microprocessors that are such a good example of placing an entire micro-architecture on a chip also emphasize its drawbacks. In addition to their own micro-architecture, these microprocessors have their own macro-architecture and instruction set and thus are not well suited to implementing an existing computer architecture. Mostly microprocessors have been used as specialized processors for input/output, communications, and peripheral control.

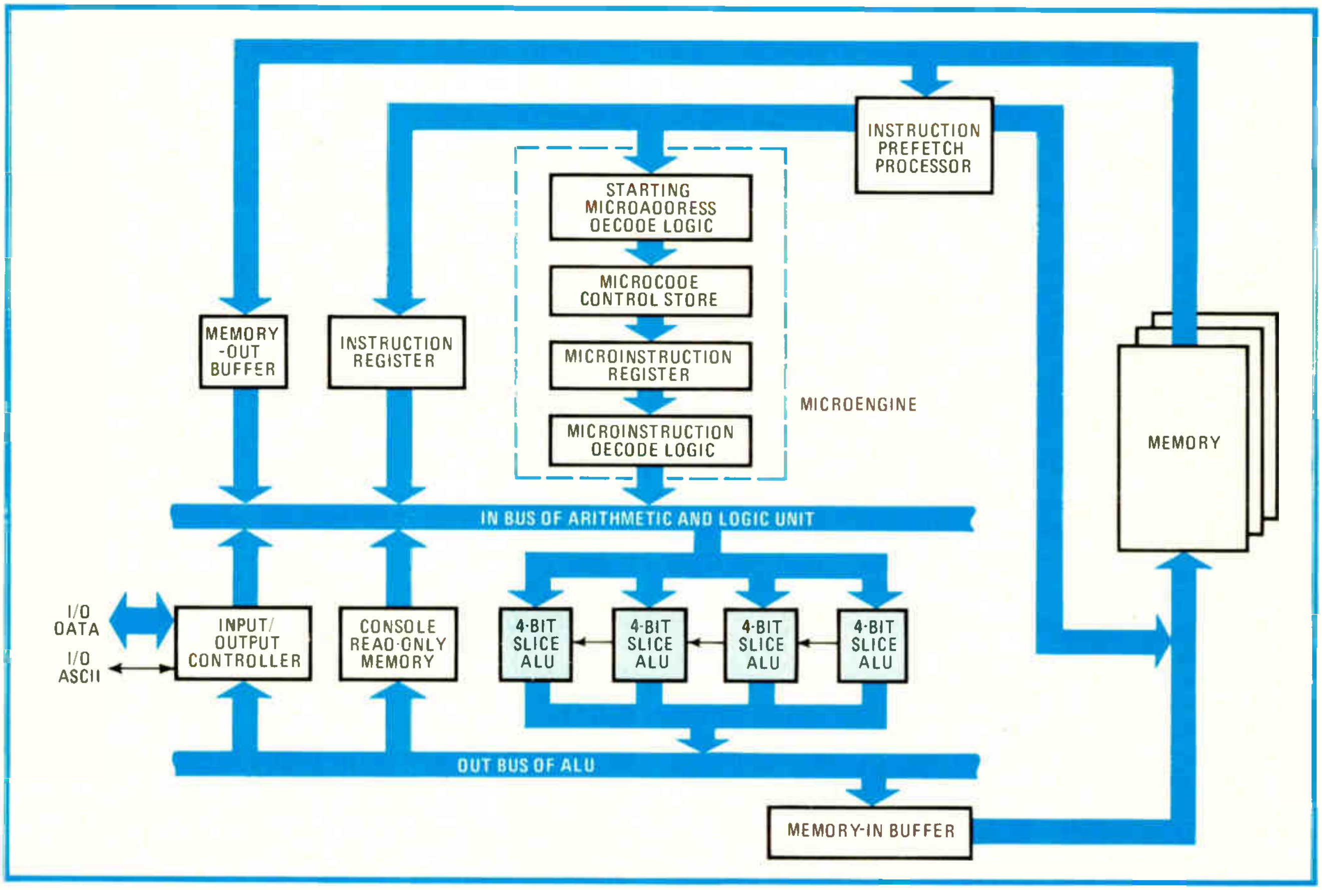
So computer engineers and semiconductor designers are searching for new ways to apply large-scale integration effectively to computers. Among the chip techniques more popular with computer designers today are: bit-slice microprocessors; programmable logic arrays and the newer programmable array logic; gate arrays; and of course, custom circuitry.

Bit-slice microprocessors essentially contain only the arithmetic and logic functions of the central processing unit; they lack the control portion. They operate on a "slice" of data, typically 4 bits at a time. The bit slices leave computer architects free to route their data and address paths as they wish and to pick the widths of the paths and the location and organization of registers and other micro-architectural elements.

Bit-slice flexibility

Moreover, the bit-slice units have no instruction sets the way microprocessors do. The designer microcodes the bit-slice to interpret the instruction set specified in the computer's macro-architecture. And to manage the microcode, most companies market a micro-instruction sequencer as a standard companion part to a bit slice.

Available since about 1975, the bit slices are just starting to show up in large numbers of computers. DEC, for example, used the Advanced Micro Devices 2901 in



3. Sliced-up architecture. Data General's new Nova 4 is an example of how the arithmetic and logic unit portion of the micro-architecture can be simplified by bit-slice microprocessors. Prefetched instructions are decoded by the micro-engine control portion.

its DECsystem-2020 [*Electronics*, March 16, 1978, p. 44]. Because of the low power consumption of the 2901's Schottky TTL, DEC boasts that the 2020 uses less power than a 1,000-watt portable hair dryer. And the advantages of the LSI-based process show up in the bottom line as well—the 2020 sells for $150,000, less than many of the small mainframe computers with which it competes.

Modular Computer Systems Inc., Fort Lauderdale, Fla., also uses the 2901 in its Classic computer introduced last year [*Electronics*, March 16, 1978, p. 48]. According to Howard H. Hayakawa, marketing products manager, the parts allow them to get the entire CPU on a single circuit board. But he remembers how tough it was to make the decision in 1976 to go with a technology that was just emerging. "We felt we could take the risk of there being no second sources, and we lucked out."

The 2901 bit slice is also the basis of Data General's latest Nova 4 line of minicomputers [*Electronics*, Jan. 4, 1979, p. 206]. But, as Carl Carmen, vice president of engineering at the Westboro, Mass., company, notes, although these parts reduce the chip count, there are tradeoffs. "We feel we lose a little flexibility in bit-slice implementation. But those restrictions can be dealt with by microprogramming and our concept of a micro-engine." The micro-engine, Carmen explains, is a sophisticated control portion of the computer that interprets the instructions, then fetches and decodes the appropriate microinstructions in a pipelined fashion (Fig. 3).

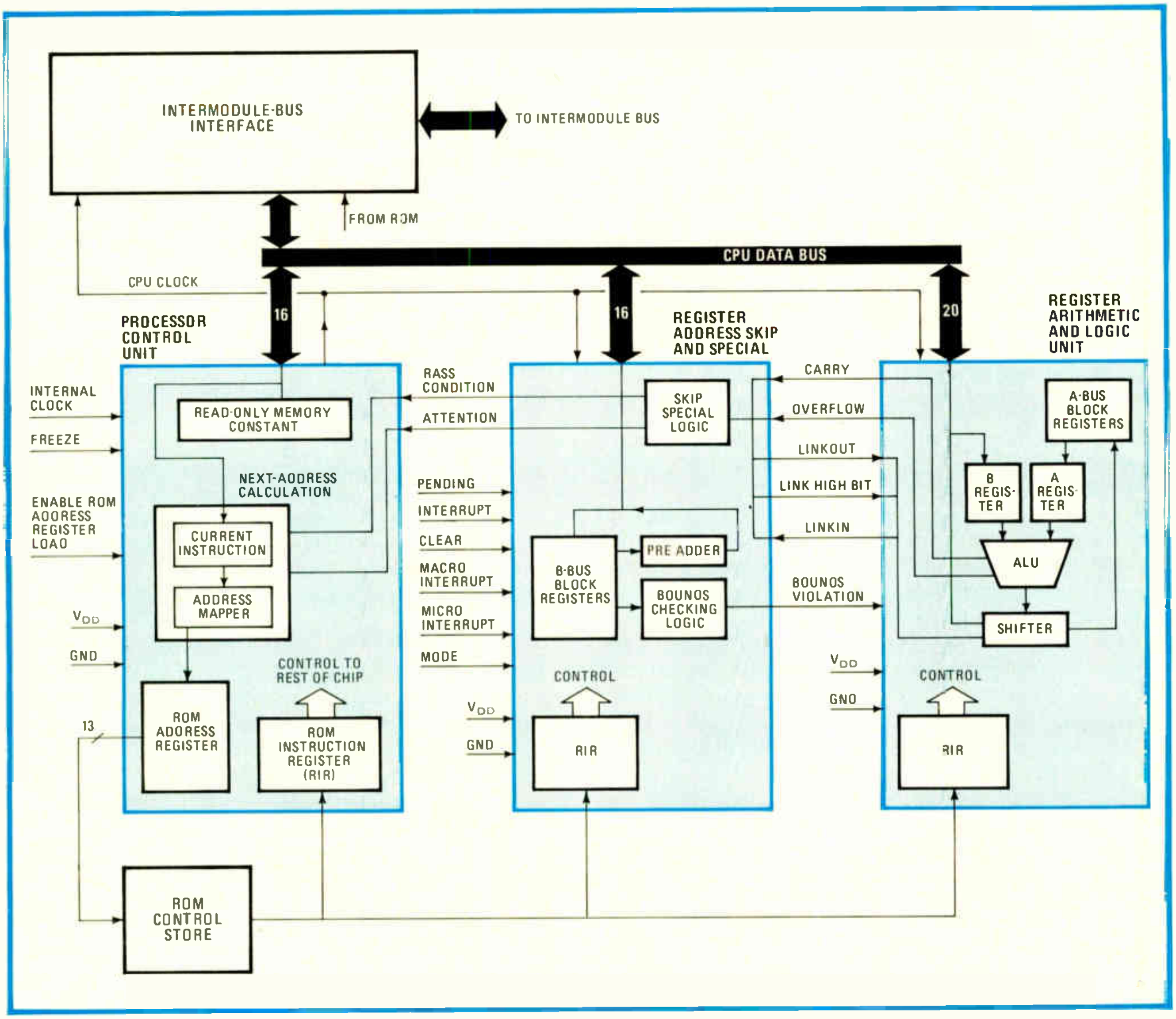
But bit-slice parts are not right for all applications. Even though parts are available that can handle a clock speed of 16 megahertz (a 62.5-nanosecond cycle time), the required microcode may make them too slow for larger machines.

And for all their flexibility, bit-slice microprocessors impose architectural constraints on the designers. "There may be design assumptions made in the bit slice that might be inconsistent with the architecture you have in mind," cautions Brian Utley, System/38 project manager at the Rochester, Minn., facility of IBM's General Systems division. "Therefore the application will be less than optimum. There will either be too much overhead, or the bit slice will be no good at all."

Programmable array pluses

Another attempt to produce a LSI logic device with wide applications has been programmable logic arrays and the newer programmable array logic. An early effort at avoiding custom LSI chip design [*Electronics*, Jan. 10, 1974, p. 74], PLAs contain two arrays of diodes. The first array forms a set of AND gates and creates the Boolean product in a logical expression. The outputs of this array are attached to the second array, which forms OR gates and performs the Boolean sum of the products.

Since the interconnections of both arrays can be modified, the user can customize or "program" the logic array to perform logical functions equivalent to some 400 to 16,000 gates. The modification was first done with masks at the semiconductor production level, but



4. Blurred boundaries. As this diagram of the HP-300 shows, what were once clearly micro-architectural details of the central processing unit (black lines) have been partitioned and integrated onto three custom chips, indicated by the colored blocks.

later versions, called field-programmable logic arrays, used fusible links that could be blown by the user.

A new and increasingly popular version is the programmable array logic [*Electronics*, July 6, 1978, p. 46]. Instead of giving the user two variable arrays of logical functions, the PAL lets him program only the first array. Although this limits some of the flexibility of the part, it allows the PAL to be programmed with the same standard programming units used for programmable read-only memories.

The PALs are just beginning to surface in commercial products, one of the first of which is Computer Automation's model 4/10S slave computer (see NCC product preview, starting on p. 193). This peripheral processor executes the same instruction set as the Naked Mini 4/10 processor to which it is attached, giving the user the benefits of parallel processing without requiring separate programming. And the PALs reduced the number of chips required to build the bus interfacing logic, according to George White, manager of special project development at the Irvine, Calif., company.

Data General's Carl Carmen says such arrays are "useful tools along the way to using LSI. They allow you to be half-pregnant," because they give you LSI without requiring a custom-designed chip.

The custom route

Another way to take advantage of large-scale integration in computers is with a custom chip. Hewlett-Packard took that route in its HP-300. Here 90% of the CPU's logic was partitioned among three custom C-MOS-on-sapphire chips (Fig. 4). Engineering manager Jake Jacobs says the functional partitioning was chosen over a bit-slice approach because "it minimizes the effect of interchip propagation delays"—an important consideration for the HP-300's speed.

The resulting chip set consists of a processor control unit (PCU) that fetches and interprets the microprogramming; a register, address, skip, and special unit (RASS); and also a register and arithmetic and logic unit

(RALU). Together, the RASS and RALU form the data paths and manipulation portions of the CPU. And instead of eight circuit boards the computer now fits on two.

But, as these HP parts illustrate, what once was clearly micro-architecture has now become the composition of the chip. And although HP was able to design the chips for use in the HP 3000 Series 33 computer, they will not have widespread standard applications.

In order to use LSI logic, computer engineers must decide whether to choose a standard part such as an array or bit slice and give up some architectural flexibility or to go to the expense of making a custom chip in order to exercise total architectural control.

The designer's dilemma

"As density increases, parts are somewhat less standard than before," acknowledges Humbert Cordero Jr., manager of processor development at IBM's Systems Products division in Endicott, N. Y. "That's the dilemma all designers now have to consider. Do they want to use standard components such as bit slices or do they want to cast custom silicon? They both have cost/performance advantages; it is a design resources tradeoff."

IBM is attempting to reach a compromise with its master-slice gate array. This device is an array of multiple-input NAND gates with the interconnections between them being customized by changes in the top layers of metalization on the chip [*Electronics*, March 15, 1979, p. 105] "The master slice is a solution to the dilemma on the side of flexibility," Cordero says.

The flexibility of these gate arrays is seen in the fact that IBM uses the same master slices to make entirely different circuits for two architecturally different computers—the 4300 and the System/38. Using a computer-aided design system that takes logic diagrams and converts them into chip layouts, designers can individualize two of the chip's three levels of metalization. And to eliminate the cost of making a mask, IBM generally uses an electron-beam tool to write the metalization patterns directly onto the wafers to be processed.

Brian Utley, project manager for the System/38, says the master slice "changes the whole topology of the design process." Rather than having to choose between a functional partitioning of the logic or a bit-slice approach, Utley says this scheme allows designers to "aggregate or split functions from chip to chip as partitioning efficiencies dictate."

Following the leader

Although IBM's gate array is not the densest possible and is considered large and power-hungry by some in the industry, it is attracting attention because of its implications. Many see it as the best solution for achieving architectural flexibility at a reasonable cost in the immediate future.

"A development like this puts our feet to the fire—not just those of the computer makers but of the semiconductor makers as well," says John W. Poduska, vice president of research and development at Prime Computer Inc., Wellesley Hills, Mass. "IC makers have been wondering what to do with their dense chips—they know they can put 5,000 gates on a chip, but the marketing question is how to structure them."

The fact that IBM chose gate arrays may set off a round of follow the leader, he says. "Also, and very importantly, what IBM does is legitimized by the very fact that IBM has done it. This has affected the computer makers for years, and now the master-slice logic is doing the same to the semiconductor makers."

Indeed, the number of companies turning to gate-array approaches is increasing. And they are getting involved in it as never before. To get what it wanted, Control Data had to develop a very dense (100K) emitter-coupled-logic family jointly with Fairchild Camera and Instrument Corp. for its Cyber family of computers. Fairchild now markets it as the F200K family of components, and CDC's Service Bureau Corp. subsidiary offers a computer-aided design package for it [*Electronics*, March 30, 1978, p. 39].

The only other commercial computer maker currently to use gate arrays is Amdahl Corp., Sunnyvale, Calif. Its V/6 IBM-compatible computer is built from ECL gate arrays manufactured by Japan's Fujitsu Ltd. and Motorola Inc. from Amdahl masks, according to Lin C. Wu, Amdahl's director of machine technology.

Involvement in gate arrays

But the semiconductor houses are preparing for what they see as a $10 million market for gate arrays by 1980. Motorola has been marketing an ECL gate array and recently took the approach one step further with its Macrocell array [*Electronics*, Feb. 15, 1979, p. 113]. Instead of just gates, Motorola's Integrated Circuit division in Mesa, Ariz., places functional islands such as a full adder, dual half adders, multiplexers, and encoders on the chip. Then the computer designer, using a computer-aided design system, describes the interconnects of the functions that Motorola converts into final metalization layers.

Other semiconductor manufacturers getting into the gate-array act include RCA Corp.'s Solid State division, Somerville, N. J., Signetics Corp., Britain's Ferranti Ltd. and Plessey Ltd., France's RTC–La Radiotechnique Compélec, NV Philips Gloeilampenfabrieken of the Netherlands, and Siemens AG [*Electronics*, April 27, 1978, p. 84].

Still, nothing is perfect. "If you go to gate arrays, you have to have high confidence in your design," cautions William P. Ward, director of advanced development at Systems Engineering Laboratories Inc., Fort Lauderdale, Fla. "There's also the second-sourcing problem with arrays. You need other sources and there are few."

Although there is much support for gate arrays as a bridge between computer architectures and the semiconductor world, it may only be a temporary solution. The increasing density of the chips is blurring the distinctions between components and computers—so much so that it may result in an upheaval in the computer and semiconductor industries. Right now the "symbiotic relationship between the semiconductor makers and computer manufacturers works well, but in four or five years things will not be so rosy," predicts Computer Automation's White.

Because both memory and large amounts of logic can now be crammed onto one chip, the semiconductor

The Manchester group

A major influence on computer technology and architecture since its inception has been Manchester University's Computer Science department headed by Tom Kilburn. Kilburn not only holds a string of basic computer patents but is credited with having written the world's first computer program, which ran on the ground-breaking Manchester Mark I computer in June 1948.

But it is as a team that Kilburn and co-workers like David G. B. Edwards in hardware and Ralph A. Broker in software (who now holds the chair of computing science at Essex University) have made their mark on large-scale computing on both sides of the Atlantic. Following his own inventive instincts, Kilburn has been concerned to push the state of the computer art, rather than "creating a stable computing environment," so that "the group has supplied a flood of ideas to the computer industry at large"—and to British industry in particular.

The Manchester group has worked closely with Ferranti Ltd. first and later with International Computers Ltd. (ICL), which absorbed Ferranti, on five generations of computers, starting with the Manchester Mark I. The Mark I went into operation ahead of U. S. systems because of a Cathode Ray Tube storage device invented by Manchester University's F. C. Williams as an elegant solution to the problem of storing computer data. It was the first computer in the world to be offered for commercial sale—marginally ahead of the Univac in February 1951. Its Williams Storage Tube technology, incidentally, was also licensed to IBM, which used it till the advent of core memory. Most recently the group's MU5 was the principal design influence on the ICL 2900 series launched in October 1974 and developed at ICL's West Gorton factory.

A landmark machine was the Atlas computer developed by the university in collaboration with Ferranti. When it went into operation in December 1962, it was the most powerful computer in the world—roughly four times more powerful than a contemporary IBM 7094. Begun in 1956, the 48-bit machine was designed to meet the then-unique combination of requirements of high-processing speed (then considered a cycle time of 1 microsecond), multiuser capability, and the attachment of a large number of peripherals. The techniques developed to meet these objectives were landmarks in computer architecture, engineering, and programming.

Key micro-architectural techniques in the Atlas included instruction pipelining and memory interleaving. The macro-architecture was influenced by the development of virtual memory and paging, while the software world gained the concept of the operating system.

Now the Manchester group is embarked on the MU6G, a 64-bit general-purpose super-minicomputer that will fill a performance slot between DEC's VAX 11/780 and Prime's model 50 computers. The emphasis will be on the efficient use of high-level languages and a high communications capability. Future performance increases, says Edwards, will come from parallel processing. Under way is a data-flow computer project to solve the software problems of loading multiple processors. **-Kevin Smith**

manufacturers will be making basically architectural decisions in the future if the computer makers let them. "But they can't figure out our future programs, because that's not the business they're in," says White. "The result is they will lock us into semiconductor instruction sets, making our decisions for us."

The impact of this problem varies, of course, with the size and positioning of the computer companies. Most mainframe manufacturers and the largest minicomputer vendors—DEC, HP, TI, and Data General—have in-house semiconductor facilities to develop what they need. And others will have to follow—or at least set up a joint development effort with a semiconductor company.

Marriages in the making?

Dan Robinson, general manager of National Semiconductor's Computer Products group, foresees "marriages between computer houses and semiconductor houses. Most computer companies have a lag in hardware technology—they don't have the tools or packaging techniques that IBM put into the 4300."

National Semiconductor is practicing what it preaches. It has begun design work on an ECL gate array, primarily to meet the needs of its Large Computer Systems division, Chueh says. Although the subsidiary of a semiconductor house, the Computer Systems division has up to now been purchasing most of its ECL from outside National.

Control Data, which already follows the joint development route, will do more joint work, according to Vacca, especially because of what he sees as a manpower shortage. "At the same time as the semiconductor industry is grappling with the large problems of VLSI, they're short of people," he says. "Together we can make a team and the computer companies can take part of the responsibility. We're at a point where no one group can carry the thing to the product stage."

To the smaller computer companies, such joint ventures—or complete business mergers—may be the only road to survival. Without such arrangements, the smaller companies must wait for second-sourced parts or gamble on new technologies.

Doug Powell, director of strategic marketing for Motorola Semiconductor's Systems division, agrees that the industry is "crashing the technological barrier as it puts memory and processor on a single chip." The result is a "changing industrial environment that's as clear to see as a freight train at night. It will cause a realignment of the computer and semiconductor industry and encourage more people to work with other people."

But he warns that semiconductor houses have to be careful about which products result from such joint efforts. "We work closely with the computer houses but the computer companies don't work closely with each other. Therefore we have to be careful we don't develop what in essence is a custom part for one company."

Some of the larger computer companies have also noticed this attitude of the semiconductor companies and say that as a result they have to develop their own semiconductors in order to use LSI for logic circuits.

"We've lost the attention of the semiconductor industry," says Barry Borgerson, director of research and

Running out of silicon?

Although many in the computer industry are concerned with how best to protect their architectural freedom while at the same time exploiting large-scale and very large-scale integrated circuits, some are already worrying about what's next.

"What do you do when silicon won't do anything else for you?" asks Steve Nelson, a senior logic design engineer at Cray Research's manufacturing headquarters in Chippewa Falls, Wis.

In earlier generations, simply moving from one circuit technology to another—from vacuum tubes to transistors, for instance—resulted in a dramatic improvement in computer performance. But as Nelson notes, the operating speeds of supercomputers such as the Cray I are approaching the theoretical limits of silicon—and of the speed of light itself.

"We may only get another 50% improvement in speed out of silicon, and that's not much compared with the orders of magnitude we've seen with earlier technological steps," the 30-year-old electrical engineer says. In his opinion, in fact, designers may be facing a dry spell. "We're in a lull—our demands are beyond silicon, and other technologies such as gallium arsenide or Josephson junctions aren't ready yet."

The solution, then, will simply have to be more innovative architectures. "We'll probably be forced to go to multiprocessors," he says.

But multiple processors imply more control, and control means software. Nelson, a veteran of three years of hardware design at Sperry Univac and three years of systems software work at Bell Telephone Laboratories, says others should get a similar mixture of experience and training. "To design the right architecture today, you have to understand software."

technical planning at Sperry Univac, Blue Bell, Pa. "We've had to get into the semiconductor business for survival." Univac has constructed a wafer fabrication plant at Eagan, Minn., and there and at its corporate research facility at Sudbury, Mass., is developing gate arrays in both ECL and Schottky TTL, as well as a variety of device technologies including C-MOS on sapphire and gallium arsenide.

Similarly, NCR Corp., Dayton Ohio, has opened three microelectronics facilities, and Burroughs Corp. operates semiconductor programs.

DEC has already in effect put its PDP-11/34 minicomputer on a single board thanks to a custom-designed chip set made in house. Called the LSI 11/23 [*Electronics*, March 15, 1979, p. 88], the computer shares the control, arithmetic and logic, and memory management functions of the micro-architecture among a three-chip set. DEC is also quietly at work on a custom Schottky TTL gate-array chip that will be useful for shrinking larger members of the PDP-11 line, insiders report.

Data General, which already makes its microNova microprocessor in house, early this year unveiled an upgraded version of the microprocessor. It forms the basis of a new product family that boasts triple the performance of the previous products and occupies one third the space [*Electronics*, March 1, 1979, p. 182]. And Carl Carmen says they are exploring gate arrays as well.

Thanks for the memory

Although the changes in logic circuits are promising the biggest alterations in the way computers will be engineered tomorrow, the most fundamental changes in computer architecture to date have been a result of the evolution of semiconductor memory during this decade. And the semiconductor memories have infiltrated computer structure in a number of places, often replacing more costly logic circuits:

- Affordable and fast read-only memories and programmable ROMs have encouraged the widespread use of microprogrammed computers, replacing hard-wired logic with so-called soft architectures.
- Fast random-access memories (RAMs) have replaced flip-flop circuits as registers, allowing architects to increase the number of registers used in a computer and easing the user's programming task.
- These same memories also make registers wider, widening data paths and improving machine throughput.
- Pipelined micro-architectural structures that provide various performance improvements take advantage of the fast RAMs, using them as buffers in the pipeline.
- Fast bipolar RAMs are also entering memory cache units designed to limit the number of accesses to main memory and thus speed up the machine.
- Also, of course, main memory, once the most precious commodity in a computer, is now relatively inexpensive.

And as the memory parts become faster, denser, and even less expensive, their use will continue to increase.

This increased use of memory is most noticeable in the main memory area. An IBM System/370 model 148 mainframe, for example, was limited to 2 megabytes of memory, which in 1976 sold for $170,000 a megabyte. The 4341 processor introduced this past January to replace it can support as much as 4 megabytes of memory. And the memory sells for just $15,000 a megabyte.

The shifting memory has had an impact on more than just hardware. "The new silicon is buying us more flexibility in software design," says Prime's Poduska.

For example, the higher-level languages that users find more efficient require more hardware. But the new larger memory, Poduska says, lets the computer absorb the approximately 20% storage penalty inherent in the use of those languages.

The additional main memory serves no useful purpose, however, unless it can be addressed—a problem that influenced a number of the recent macro- and micro-architectural changes.

A case in point is the 16-bit address so popular in minicomputers. It can obviously address only 2^{16}, or 65,536, bytes of memory. Although that was thought to be enough in 1969 when DEC's PDP-11 computer was introduced, DEC and other manufacturers were chagrined to discover several years later it was inadequate.

Memory mapping

One solution would be to increase the length of the address, but that entails a reworking of the macro-architecture that would make it incompatible with previous machines. Instead, most vendors in recent years have changed the micro-architecture to handle memory mapping. Because this change in the micro-architecture maps the macro-architecture addresses into new addresses usable by the computer's memory, a user need not change the addresses in his programs—the machines are compatible. Continuing to use DEC as an example, the PDP-11/70 introduced in 1975 is a 16-bit computer compatible with the addressing scheme used by the rest of the PDP-11 line. But because of memory mapping, it can reference up to 2 megabytes of main memory instead of the previous limit of 64 kilobytes.

To further buffer users from the physical limitations of a computer's memory, virtual memory schemes have been used. By integrating the management of the main memory with that of such peripheral memory as disk drives, the virtual memory system lets each user of the computer think he has more memory than the machine physically holds. Although controlled by a computer's operating system software, virtual memory requires a computer's architecture to be modified to support it. Some of the most dramatic new computer architectures to surface in recent months owe their uniqueness to how they approach memory addressing and virtual memory.

Why a 32-bit address

One primary reason why DEC's VAX 11/780 macro-architecture went to 32 bits for its basic instruction and address length, for instance, was to enlarge the amount of memory that could be referred to [*Electronics*, Nov. 11, 1977, p. 36; July 6, 1978, p. 98]. Since 32 bits can form over 4 billion different addresses, users can reference their data without wasting the time involved in mapping or memory segmentation management techniques. At the same time DEC coordinated the design of the virtual memory software with the design of the micro-architecture, adding features to the hardware to facilitate the translation between a virtual address and the physical storage address. The most significant of these additions occurs in the address translation hardware, in which a set of processor translation caches made of high-speed RAMs store the translation of the most recently referenced address. This makes access to memory faster since frequently used locations in memory can be referred to directly.

Although the macro-architecture uses a 32-bit address length, the micro-architecture uses a 30-bit address, permitting up to 1 billion bytes of memory to be used. Currently, only 2 megabytes of main memory are offered with the machine—and if the programmer addresses more memory, the virtual memory software stores the extra information on disk drives. But this combination of macro- and micro-architectural planning gives DEC the freedom to increase the amount of memory physically offered with the VAX 11/780 without affecting the user's programming. The 32-bit architecture also provides higher arithmetic accuracy and offers new data type and instruction flexibility.

Similarly, a larger 28-bit address in the HP-300 macro-architecture [*Electronics*, Oct. 12, 1978, p. 39; Feb. 1, 1979, p. 108] lets users address some 270 megabytes of memory. In its micro-architecture, a 24-bit address allows up to 16 megabytes of hardware main memory to be added, although the product is currently sold with a maximum of 1 megabyte of memory. Once again, architectural planning leaves room for future memory expansion without forcing the user to reprogram the computer.

The System/38 example

An example of how changing the memory addressing can affect users is the System/38 small business system from IBM's General Systems division. Designed to replace the popular, but aging, System/3, the System/38 is sold with software to help a user move programs written for the System/3 to the System/38's instruction set and macro-architecture. The company emphasizes this conversion capability, but IBM insiders concede the System/38 has a radically different architecture [*Electronics*, Nov. 9, 1978, p. 81; March 15, 1979, p. 105].

Once again, a primary design consideration in the System/38 was the ability to address large amounts of memory. So the IBM architects chose a 48-bit address that can produce a staggering 281 *trillion* bytes of memory—some 16 million times more than IBM offers on its largest System/370 mainframe. Also, as will be discussed later, the System/38 has a new instruction set, an expanded choice of data types, and a more flexible memory management scheme.

System/38 project manager Brian Utley says IBM attempted to make its macro-architecture a high-level one, having "minimal bonds to the system's physical attributes." The memory addressing illustrates this. Although the macro-architecture can refer to a huge 281 *gigabytes*, the micro-architecture uses a 21-bit address and currently supports just 1.5 *megabytes* in hardware. Obviously IBM can add more storage as the price of semiconductors comes down, but the macro-architecture's addressing should suffice for quite some time to come, saving future users from converting their software.

Memory has also had a significant architectural impact in the control portion of the central processing unit. The improvements in read-only memories have encouraged the widespread use of microcoded machines since 1970. And with random-access memories becoming as fast as ROMs, the trend is to put microcode in them to make the design still more flexible. Microcode translates

Time to rethink

While the movement in semiconductor technology to larger scales of integration poses architectural dilemmas, some also see it as offering a unique opportunity.

"Designers typically scale down discrete designs to fit large-scale integration," says E. David Crockett, program manager for advanced computer systems at Hewlett Packard Co.'s General Systems division in Santa Clara, Calif. "But if I can put 10,000 gates on a chip, it's time to reexamine the architecture."

"Perpetuating the existing designs isn't bad unless that blinds you to other ways of doing things," says Crockett, a 17-year veteran of the industry. Too many designers today "view the new technology as just another pass at their existing designs rather than an opportunity to rethink things"—and Crockett has had the opportunity to supervise many designers. Like many others in the business, he started his career at IBM. After eight years there, he left in 1970 to work at Computer Synectics Inc. of Santa Clara and later at Memorex Corp. He joined Hewlett-Packard Co. in 1972 as department manager for systems management and was named research and development manager at the General Systems division in January 1976. He assumed his current position somewhat under two years ago, in September 1977.

Rather than worry about the ability to assimilate the rapid rate of change he has seen in the industry, Crockett seems to revel in it. "This is the most exciting period of time I've ever seen," he declares.

the instruction set used in the macro-architecture into the control signals understood by the hardware in the micro-architecture. Placing the microcode in RAM control storage instead of the ROM makes it easier to change the micro-architecture without affecting the macro-architecture. Such machines are therefore viewed as having a "soft" architecture.

"There'll be a lot more of these soft processors in the next five years," predicts Aaron H. (Wes) Wester, a product manager at the Computer Systems division of Texas Instruments' Digital Systems group. "They offer standardized hardware that can still be customized."

Microcode at IBM . . .

IBM exploited the microcode concept in the design of its 4300 low-end mainframe computers [*Electronics*, Feb. 15, p. 85]. The estimated $200 billion investment in software for the System/360 and /370 mainframe computers creates an inertia that ties IBM's Data Processing division hand and foot to macro-architecture compatibility—a problem the General System division chose not to face in its radically different System/38.

"The objective of the 4300's Extended Control Program Support/Virtual Storage Extended mode of operation was to improve the machine for VSE control programs while not changing the interface the user sees," says Cordero of IBM's Systems Products division, which manufactures the 4300 machines. Cordero, who supervised the three-year development of the 4341, adds that "that kind of architectural flexibility required flexible hardware. That implies a significant amount of control store."

So where some low-end System/370s had only 32 kilobytes of control store, the new low-end model 4331 has 128 kilobytes of control store and borrows an additional 16 kilobytes of main storage for its microcode. The more powerful 4341 has a total of 56 kilobytes of control store and borrows 108 kilobytes of main storage.

If imitation is the sincerest form of flattery, then IBM must be busting its buttons. Not only has the number of companies that emulate its macro-architecture doubled in the past year or so, but most of them do it with microcoded machines.

. . . and elsewhere

National Semiconductor Corp. of Santa Clara, Calif., has two sets of machines that run IBM software. Its San Diego Large Computer Systems division manufactures mainframe style computers that are marketed as the Advanced System line by Itel, the San Francisco-based leasing company. Heavily microcoded, these machines emulate the larger members of the IBM/370 mainframe line.

Last year, National's Computer Products group introduced its minicomputer-style System 400 [*Electronics*, May 11, 1978, p. 81]. Oriented around a bus, the System 400 consists of multiple 32-bit microprogrammed processors made from eight National IDM2901A bit slices, functioning either as an instruction unit or input/output processor, a special microprocessor-based service processor, and up to 16 256-kilobyte memory modules (Fig. 5). As Daniel N. Robinson, director and general manager of the group points out, such an architecture is totally dependent on the available chips. "The 400 is a totally writable control store. That would barely have been possible to do 5 years ago and impossible to do 8 to 10 years ago."

Magnuson Systems Inc. [*Electronics*, May 25, 1978, p. 93] also uses a heavily microcoded, bus-oriented machine. Notes Carl Amdahl, architect of the system and the company's vice president of engineering, "Our architecture is the best to maintain compatibility because of the ability to add hardware easily to the bus and easily microcode the machine."

Semiconductor memory in the form of high-speed registers has also had a direct influence on the various levels of architecture. Because fast RAMs could replace more expensive flip-flop circuits for this function, the

No free lunch

"People are misdirected into thinking computer architecture is a free game—but it isn't," states Gene Amdahl. The architect of IBM's System/360, Amdahl is now chairman of the Sunnyvale, Calif., manufacturer of IBM-compatible computers that bears his name. He feels more companies should follow his lead in adopting the IBM System/360 and 370 mainframe computer macro-architecture as a standard and in designing hardware architectures that can run it.

For all his involvement with the IBM System/360, Amdahl admits it is "clearly not an optimal architecture." But, he says, "Architecture does not exist for the sake of architecture. It is first and foremost an activity to satisfy the needs of the users who will buy the machines." He draws an analogy with the early days of electricity when each utility company had its own plug configuration, voltage, and frequency in an effort to maintain a monopoly. "I've yet to find a case where monopoly is in the best interest of the consumer," he says.

Just as the country's electric utility system was standardized, Amdahl feels the computer industry has "reached and exceeded the point where we need a standard. As it is now, we can't change architecture much because customers can't afford the software change. Even IBM can't change it much." And Amdahl's philosophy is "if you can't change—adopt."

In his opinion, the fact that so many companies have followed his lead into the IBM-compatible field is evidence that companies can compete successfully even if the highest layer of architecture is standardized. "There is more opportunity where there exists a broad market that's accessible. And the need for enormous resources is less if you deal in a market where you don't have to make everything a customer needs," he says.

Nor will such architectural standardization cause the technology to stagnate, Amdahl predicts, because additional features "that are attractive to the marketplace can be added to the standard."

"Everybody benefits from such standardization," Amdahl concludes. "The only one who doesn't benefit is somebody who decides not to participate. I think that standardization's inevitable."

number of registers could be increased. In computers designed for multiprogramming, for example, multiple general-purpose registers permit faster context switching. When programs are switched, the contents of the register set need not be saved in main memory and reloaded with the contents of the new job. Instead, each program is assigned its own set of registers.

Pipelining approaches

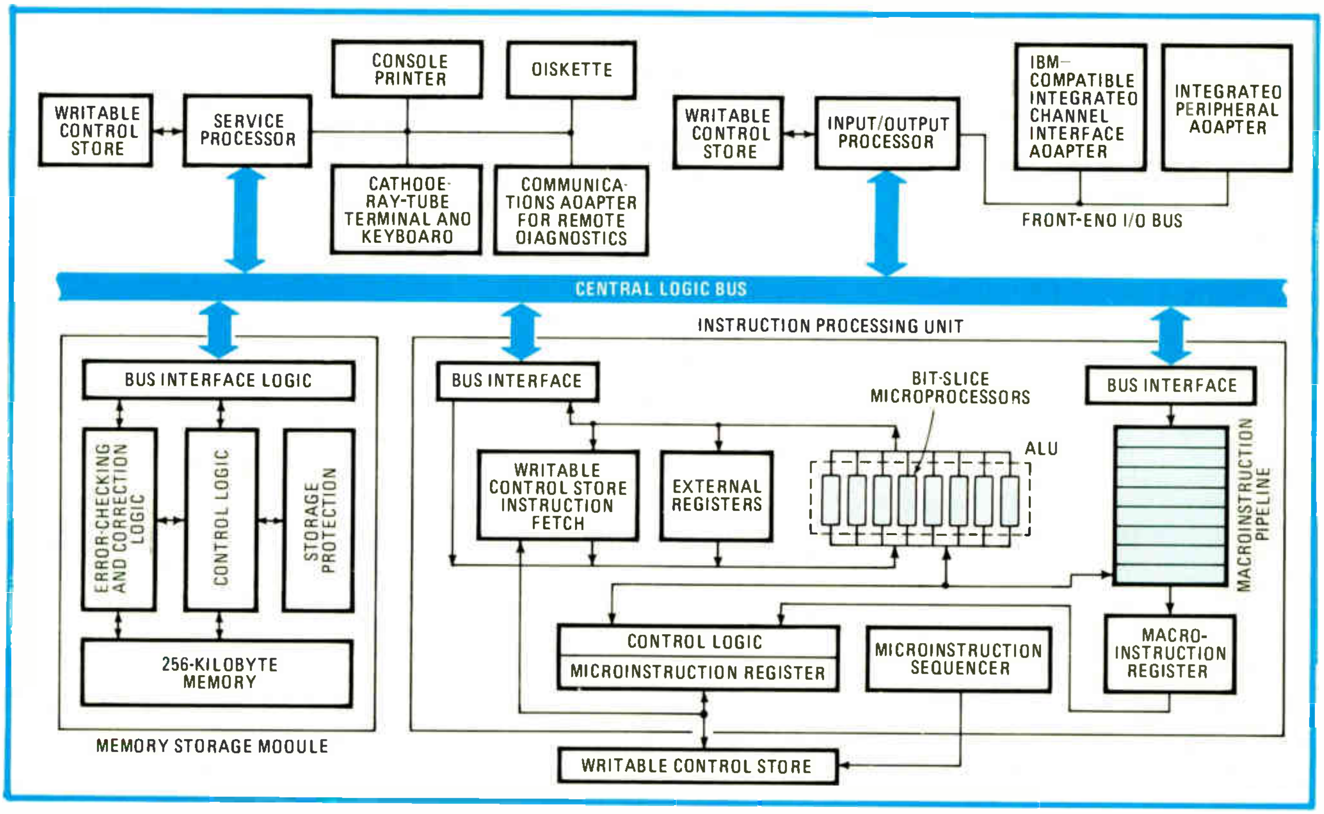
Pipelining is another micro-architectural technique that owes its current popularity to the shifting semiconductor price/performance curve. The pipelining technique lets one instruction be fetched and decoded while a previous one is being executed. Instruction pipelines can become a hindrance, however, when the program branches to an instruction other than the next one in line. To circumvent this, parallel pipelines are used—one for the current instructions and others for the most likely branch instructions. As Prime's Poduska notes, "With cheap registers, there's no reason to stop at just two pipelines."

This pipelining approach was used by IBM in 1977 in its top-of-the-line 3033 mainframe computer. Similar architecturally to the System/370 model 168, the 3033 is an example of how a change in such micro-architectural details as the pipeline and memory cache can speed up a machine without affecting the macro-architecture. As seen in Fig. 6, the three sets of instruction buffers in the 3033 can each hold four double-word instructions, whereas the two sets of instruction buffers in the model 168 held only two instructions each. Similarly the operand address and operand register sets in the 3033 are three times larger than in the 168. As John S. Liptay, senior engineer at IBM's Data Systems division in Poughkeepsie, N. Y., notes, the register size could be increased because IBM was able to "get a lot more complex function essentially free," by making use of more modern semiconductors.

Data General improved the performance of its Nova 4 line by using a high degree of pipelining, Carmen notes. Up to 16 instructions can be prefetched into the pipeline for decoding by the so-called micro-engine while another instruction is being executed. A big advantage of using this technique is that it "permits us to achieve higher throughput without having to change the circuit family we're using," Carmen says. And not changing circuit families "saves us the expense of retooling with new test equipment both in the factory and in the field."

Richard Chueh of National Semiconductor's Large Computer Systems division, says that the availability of registers also allows designers to include wider data paths in their micro-architecture. "Each data path means another register. But since registers are cheap today you can implement wider data paths." Besides speeding the transfer of data within the machine, the wider data paths "let you replace logic with memory," Chueh says. "Instead of doing an operation on 8 bits at a time and having logic keep track of where you are, you can do operations on 64 bits at a time."

Once again, several recent computer systems are excellent examples of the widening of the data paths. IBM's 4341 has 64-bit-wide data paths when the older 370/148 had only 32-bit paths (Fig. 7). Perhaps the most extreme example of the use of registers is Control Data's Cyber 203 supercomputer. Designed for high-speed processing of large arrays of numbers, the Cyber's



5. Microcoded emulation. Though compatible with IBM's macro-architecture, National Semiconductor's System/400 micro-architecture is different. Multiple microprogrammed instruction, I/O, or service processors can connect to the bus with up to 16 memory modules.

micro-architecture includes a bank of 256 general-purpose registers [*Electronics*, Feb. 1, 1979, p. 42]. Configured as duplicate banks, this register file can perform two read and one write operation in a single 20-ns clock cycle.

But National's Chueh points out that the limited supply of fast RAM registers is also an example of how the current relationship between the computer and semiconductor makers is not working as well as it either should or could. "Semiconductor houses are only interested in high-volume parts" and feel registers are not used in large enough quantities, Chueh says. "But," he adds, "the semiconductor makers don't realize the importance of the registers to computer architects. The registers are what determines the cycle time of the CPU, and if they're not fast enough, they can be a bottleneck." In fact, he says, they are so important, "I'd be willing to pay anything for them."

As a result, Chueh notes, many mainframe manufacturers have begun manufacturing such parts in house. Even National Semiconductor was slow to move. It decided to build fast register chips only after its Large Computer Systems division asked for them, he says.

Cache for speed

Another micro-architectural element that has felt memory's impact is the high-speed cache memory that is inserted between the somewhat slower main memory and the CPU. "There has always existed an imbalance in speed between the CPU and the memory," Chueh says. Engineers have gotten around the problem by using memory interleaving and instruction pipelining and prefetching. These architectural techniques "all cost logic," as Chueh notes, but now fast memories can improve speed by putting cache between the memory and the CPU.

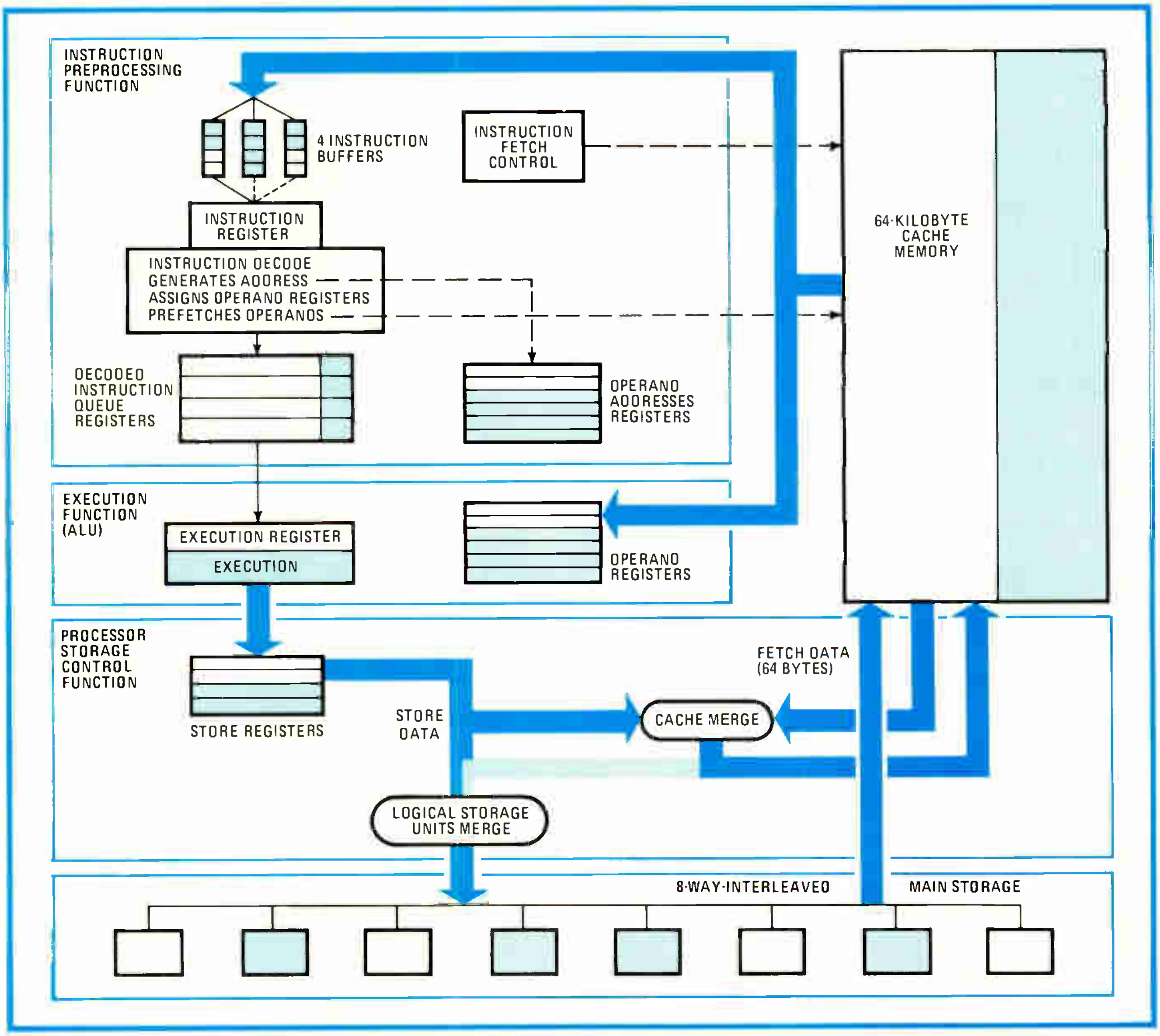
Prime raised its top of the line with the model 750, introduced in January [*Electronics*, Jan. 18, 1979, p. 174]. A major architectural contributor to the improved performance was 1.6 megabytes of cache—some four times as much as was used in the earlier model 400. Prime's Poduska sums it up: "We're throwing silicon at problems."

Similarly, cache memory helps IBM's 4341 processor outperform the older System/370 model 148. The 4341 has an 8-kilobyte cache memory, the first time such a small IBM mainframe used the technique.

As may be apparent, many of the newer computer architectures discussed here amalgamate several of the micro-architectural techniques prompted by semiconductor technology. Some additional new architectures also illustrate how these various elements can be melded into improved machines.

Burroughs Corp., for example, unveiled its 2900 and 3900 machines earlier this year to replace its older 2800 computers [*Electronics*, March 15, 1979, p. 16]. Collectively called the 900 series, the new machines have up to five times the performance of the older 2800, at only a 27% increase in purchase price while using about half the power and half the space of the previous units.

Although supporting the same software as the 2800, the 900 series has an entirely different micro-architecture, which Burroughs describes as "micro-modular concurrent." As seen in Fig. 8, the CPU is configured



6. Architectural expansion. As the shaded portions indicate, IBM's 3033 processor expanded many of the micro-architectural elements of the 168. Existing instruction buffers doubled in size and an extra one was added, the cache was doubled, and register banks were enlarged.

from eight different processing elements operating in parallel:

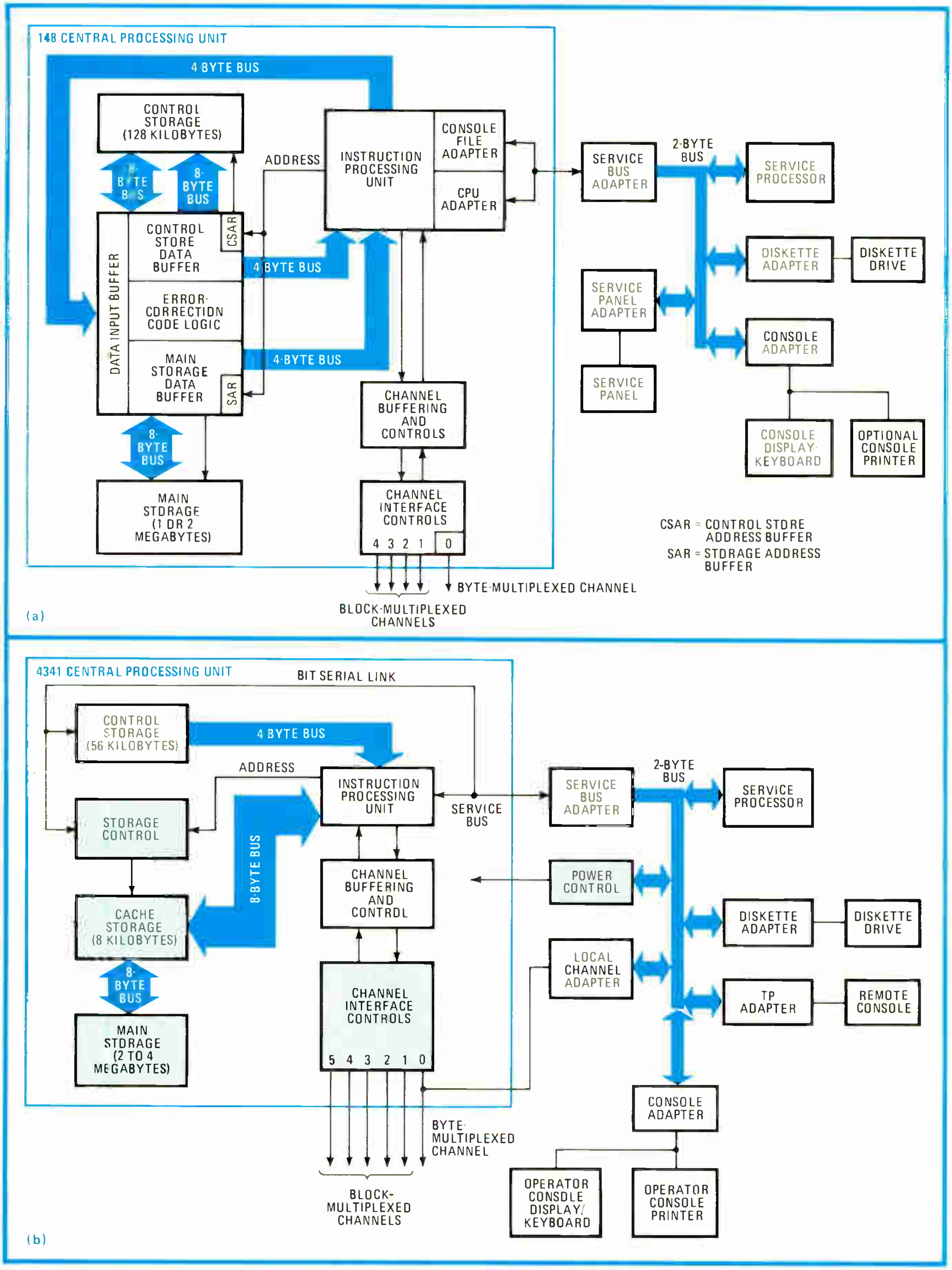
- The program module prefetches and decodes the machine's instructions.
- The process control module includes the microcode control store and steers the execution of the operation.
- The execution module performs the operations.
- The memory access module performs data transfers.
- The data buffer acts as a cache.
- The memory control module coordinates memory requests from the memory access module and the I/O processor.
- The I/O processor moves data between main memory and the peripheral devices.
- The data-link processors control the peripherals.

According to Robert Merrill, vice president and group executive for Computer Systems group, the 900's architecture includes separate control and data lines interconnecting the modules that operate in parallel to each other. "Such an architecture lets a machine operate three to four times faster than the older model with the same clock rate," because the older architecture was "too sequential and depended on one instruction following another."

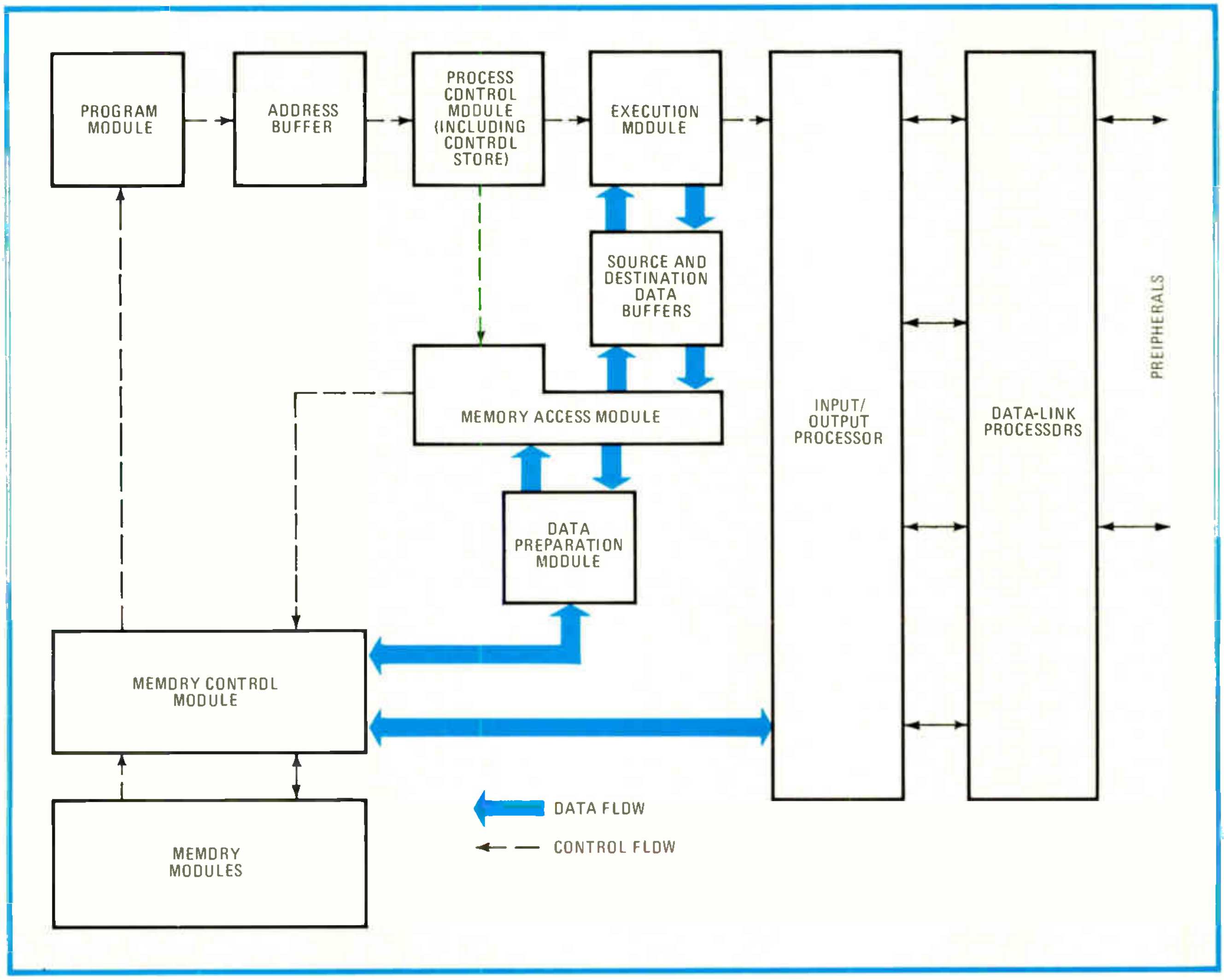
A major contributor to making such a parallel processor architecture possible in a small-scale mainframe was the price/performance of semiconductors. "The bit slice and advanced Schottky transistor-transistor logic were certainly important in reducing the costs of this approach," Merrill says.

Additionally, the use of microcode "lets us partition a problem into concurrent problems that can be done in parallel," Merrill says. He explains that part of this results from study begun by Burroughs in 1968 to find out what type of program code was being executed by customers and where concurrent operations could improve performance.

The availability of high-performance semiconductor



7. Stable facade. Still compatible with System/370 computers like this 148 (a), IBM's new 4341 (b) processor has a new micro-architecture. Cache memory has been added, the data path widened, main storage doubled, and a special power controller attached.



8. Parallel structures. Eight different processing modules make up Burroughs' new 900 series computers. Since they can all operate concurrently, this micro-architecture permits the 900 to operate faster than earlier models with the same clock rates.

logic families has also helped engineers at NCR Corp. design an unusual architecture. The Dayton, Ohio–based firm went to a bus-oriented design in its Criterion series mainframes in 1976 [*Electronics*, May 13, 1976, p. 38].

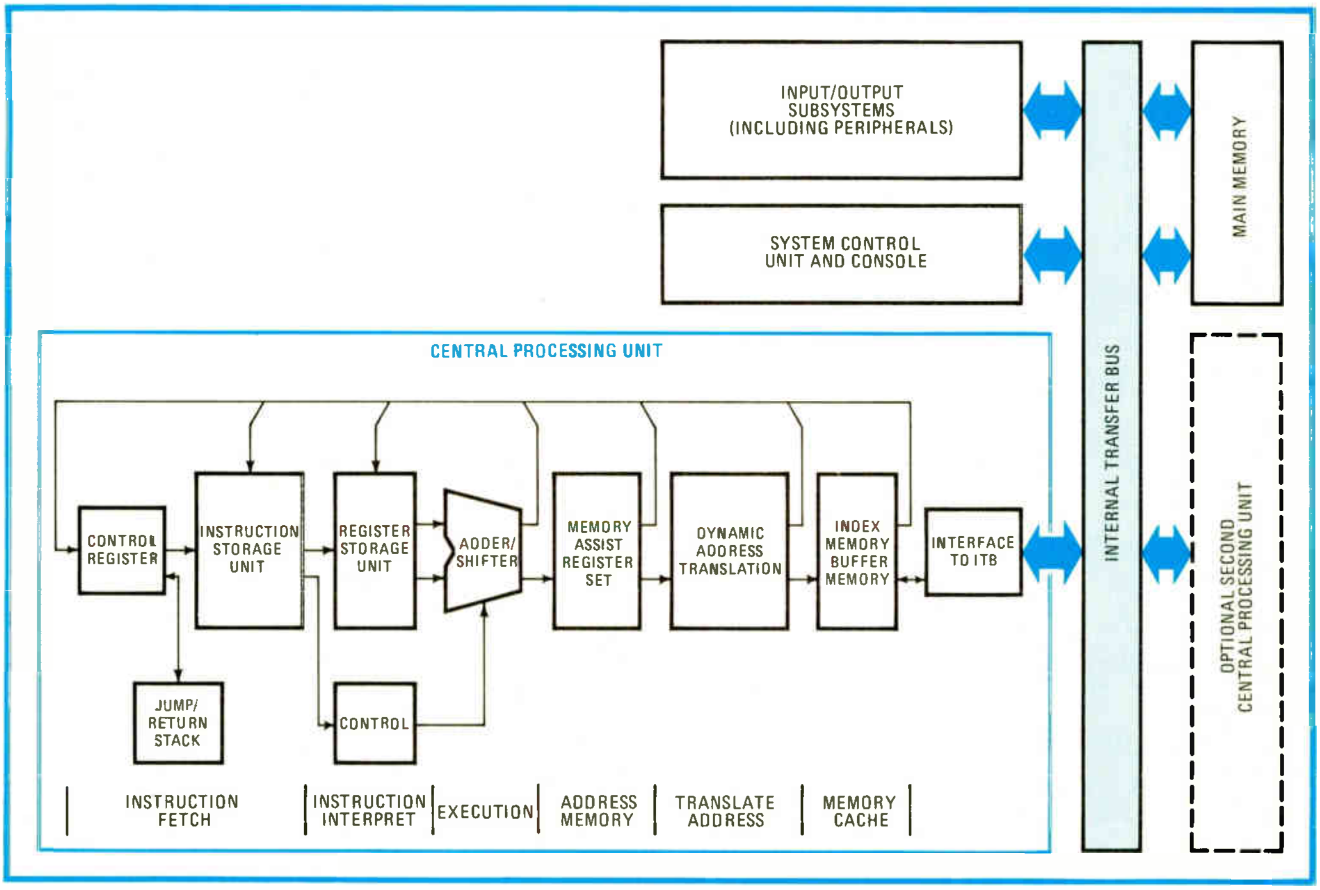
A bus in a mainframe

Using a single bus to transmit both control signals and data between the various portions of a computer is a common micro-architectural technique among minicomputer designers. It is unusual in larger—and faster—machines, however, because the shared bus can seldom operate at a high enough speed to keep up with the CPU. But the bus has its advantages in that each element of the computer operates independently, making the configuration flexible and later upgrading easier.

So NCR designed a high-speed bus. Called the Internal Transfer Bus, it is 32 bits wide and operates at 72 megabytes per second. As Thomas Mitter, program manager for large EDP programs, says, "The bus had to have a fast cycle time in order to distribute information," and the availability of fast emitter-coupled logic circuits to drive the bus lines "gave us the confidence to go to a bus design." Apparently it has worked. When the firm introduced its new top-of-the-line 8600 processor last year [*Electronics*, Dec. 7, 1978, p. 44], it was able to double the processor speed (from 56 ns to a cycle time of 26 ns) and still use the same bus design.

As can be seen in Fig. 9, the NCR 8600 also makes use of a number of the other micro-architectural devices mentioned so far, besides adding some special twists of its own. Microprogramming is heavily used to interpret the instruction set of the macro-architecture, enabling NCR to provide 8600 users with as many as three different operating schemes in what it calls "virtual machines." These three modes of operation each run with a separate set of microcode, which in turn is dedicated to efficiently running programs written in Cobol, Fortran, or NCR's own VRX language. Although most machines these days can understand more than one programming language, they do not contain separate microcode to optimize the performance of these programs the way the NCR machine does.

Cache memory is also included in the 8600 design to speed up memory access. An unusual aspect of the 8600's memory management hardware is the addition of an address translation buffer to hold the most recently



9. Bus-oriented. Unusual among mainframe micro-architectures is NCR's bus-oriented 8600, based on the 32-bit wide, internal transfer bus that operates at 72 megabytes per second. Extra registers aid in address translation and cache memory improves performance.

used virtual address. Once again, the use of an extra memory element improves performance by shortening the time it takes to access memory repetitively.

Compared to the changing micro-architecture of the hardware, the macro-architecture of the uppermost layer seems almost static. And computer engineers intend to keep it that way—especially for big mainframes.

"We don't see the macro-architecture changing much, except in an evolutionary way," says Tom Mitter of NCR, echoing the sentiments of many in the industry. "Particularly from the point of the view of the user, to migrate to a new architecture would be traumatic."

Room at the top

But this not to say that the macro-architectures are stagnant. "Certainly we will add more and more features," Mitter says. "It's like having a house—if you want other things, you add rooms." NCR's 8600 computers are excellent examples of that. Where the older 8500 machines have 71 instructions and operate in NCR's VRX or Cobol programming languages, the 8600 has 105 instructions and can operate in Fortran as well.

IBM took the same evolutionary approach with its 4300. Compatibility with the existing System/370 instruction set is provided by the Extended Control Program Support in System/370 mode. But extra features, including a new virtual memory system, have been added and are available under the new Disk Operating System/Virtual Storage Extended mode of operation. IBM will not specify how different the instruction set is, however.

"The higher up you get in the performance level, the harder it is to change the macro-architecture," says Univac's Barry Borgerson. "Several large computer companies started programs to develop sophisticated new architectures and canceled them because they discovered the conversion costs would be too high." Although he did not specify, two companies come to mind. IBM canceled its so-called "Future Systems" in March 1975, and Univac canned its project Roanoke in the spring of 1977.

But as already mentioned, the past several months have brought several macro-architectural surprises from smaller computers. "There comes a time when you have to break with the past and get a fresh start," says HP's David Crockett (see "Time to rethink," p. 122).

Fresh starts

A primary reason for making such a fresh start is to produce a computer that is easier to program and use. So although HP based the architectural design of its HP-300 on the current HP-3000 series of computers, much of the older 3000 software cannot be used on the new machine because several fundamental macro-architectural features are different. Crockett says that at least half of the 3000's instruction set was replaced with new instructions. What the architects did was remove infrequently used instructions and substitute new ones that simplified

Computers designing computers

As more and more of the computer architecture is placed on the semiconductor chip, more sophisticated design techniques are needed. To most computer companies that has meant computer-aided design. Almost all companies today have some sort of program to automate and therefore shorten the design process. Perhaps even more significant is the error reduction that design automation provides, because once a design is on a chip it is difficult to change.

Many in the industry agree that IBM appears to have the most sophisticated design automation system. The elaborate system is used to design the metal interconnect layers for its gate-array master-slice chips. The packaging scheme places up to nine of these logic chips on a single 23-layer ceramic carrier, which are then placed on 8-layer cards that plug into 16-layer boards. The automated design system is also used to lay out the metal interconnections on these elements.

Installed at some 25 IBM facilities worldwide, the approach enables designs from one location be transferred to another location where they can be integrated into a larger system. Once the design is complete, the plans are communicated to the manufacturing facility where a computer-driven electron-beam tool is used to write the patterns on the chips.

The first step in this process is the entry of the logic design into the computer either in list form through an alphanumeric terminal or as a logic diagram through a graphics terminal.

The designers then partition the functions between chips. The computer, using a set of software tools, simulates the logic to check if it does in fact perform its intended functions as it should. Then it automatically maps the logical design into a physical chip layout. As soon as it reaches this point, the computer checks to make sure that the circuit complies with applications rules such as fan-in and fan-out limits.

Another program determines the exact placement of each circuit on the chip with the goal of minimizing interconnection lengths and maximizing the probability of finding paths for all the interconnections. A separate wiring program then lays out the actual interconnections, as shown in the photograph on the left. This program also makes electrical checks to assure that voltage drops are within limits, as shown in second photograph. Should this program be unable to route an interconnection, the designer can manually intervene.

Now, additional checks are performed to make sure the resulting chip layout conforms to the fabrication technology's geometric parameters. As the physical layout of the chip becomes final, the computer begins generating test patterns. It determines the pattern of input stimuli and the expected outputs. Should the chip incorporate the internal registers of IBM's Level Sensitive Scan Design [*Electronics*, March 15, 1978, p. 108], it will also prescribe the data patterns to be put in and the expected output.

Finally, after the design is validated once again, it is transmitted to the manufacturing facility.

programming, such as instructions that can operate on strings of characters.

The HP-300 also uses a split stack, instead of the single stack the HP-3000 offered, making management of the stack easier. The earlier 3000 architecture permits only data to be stored in virtual memory, thus limiting the size of the programs themselves. To give programmers more flexibility, the HP-300 lets them store both programs and data in the variable-size virtual memory.

Whereas the older unit was basically a 16-bit machine, the 300 has a 32-bit architecture. Crockett notes that provides room for future growth. "Currently the HP-300 has 16-bit data paths, so there's room to slide in new hardware without affecting the user."

Although in the design of its 4300 IBM's Data Processing division felt constrained to stay compatible with the System/370, the General Systems division had more freedom. It produced an entirely new architecture that is intended to insulate the users from future changes in the hardware's micro-architecture. IBM describes the resulting System/38 as having a "high-level object-oriented architecture." This means all data and programs are stored as "objects" whose internal format stops being apparent to the user once the object's characteristics and initial values are defined. This is a departure from most architectures, which require a programmer to keep track of the type of data—decimal or integer, fixed or floating point—being stored in a particular location.

Object advantages

It also simplifies the instruction set the programmers must use. Instead of different add instructions for each of the different data types, one numeric add instruction is used in the System/38. It operates on whatever type of data is in an object, with the machine handling the necessary conversions and scaling between data types, lengths, and decimal positioning that are normally handled by the programmer.

Also breaking with the past to provide a more flexible and easier-to-program computer was Digital Equipment Corp. As already mentioned, its VAX 11/780 was a radical departure for the leader in 16-bit minicomputers. To begin with, the 32-bit addressing discussed earlier gave programmers the ability to directly address up to 4 billion bytes—some 62,000 times the previous limit.

There were also major modifications to the instruction set, to take advantage of the flexibility and increased precision 32 bits provides. Operations in the PDP-11 are primarily performed in a stack, but the VAX provides multiple-register, memory-to-memory data manipulation methods, and a number of indexed addressing modes as well. Floating-point arithmetic hardware was added to the micro-architecture, giving programmers the precision of 64-bit numbers. As data is now 32 bits wide, all the machine's data types could be extended and new ones such as packed decimal strings, character strings, and variable bit fields were added for programming ease.

It seems the architectural activity at the low end will continue. For example, Sperry Univac is planning a clean sweeping away of the past at its newly acquired minicomputer operation in Irvine, Calif. According to Ken Lamb, manager of processor developing, a machine due out next year will have "a brand-new innovative architecture," although he won't reveal details.

Debating room

There is debate in the industry over whether there is room for any more macro-architectures.

Promising improved reliability, Tandem introduced a new architecture with its Non-Stop system in 1975. Today, architect Katzman says there's still "absolutely room for new architectures. The question is are you providing a capability that's not available." The basic market for Tandem's multiple-processor redundant backup systems, Katzman observes, "is for new applications that were never automated before, not as replacements for existing computers." Thus the software compatibility pressure is not as great, he says.

Data General's Carl Carmen says there are actually two different types of machines on the market: general-purpose computers and integrated "hardware-software systems where all the user sees is a high-level language interface such as Cobol or Basic." Since such high-level languages are almost by definition consistent across various macro-architectures, this second type of machine could be varied architecturally. But with a general-purpose computer the user sees the instruction set, so any macro-architectural change will show up immediately as a change in the instruction set.

Carmen admits that to change such a general-purpose computer, "customers would have to see many benefits and positive attributes to justify the disruption such a change would cause."

Gene Amdahl, renowned as the architect of the IBM System/360 and later as the architect of the Amdahl Corp. plug-compatible machines, agrees that any future macro-architectures "must be perceived by the users as the architecture of the future. They must look worthwhile enough for the customer to make the enormous investment in the costs of conversion" (see "No free lunch," p. 123).

But he doubts such a dramatic change will take place. Instead, he proposes standardizing on the most widely used architecture around—IBM's System/370. He concedes the "System/360, /370 architecture is clearly not optimal by any stretch of the imagination." But still it is used by some 85% of computer users today, Amdahl estimates, and he says the world should "wake up and recognize that there ought to be a world standard and not an IBM standard. They should take steps to ensure that the standard is set by some organization, and not subject to change by one company whose interest is to dominate the market. Until then, one company, practically speaking, will have the whole cake."

Theoretically speaking

With the debate over the need for new architectures, the research work goes on. This often results in confusion between the universities and the industry, however, since the work being done at the universities is not immediately applicable to industrial problems.

"The question the industry must examine is how to use the technology in the best way to move forward and remain compatible with the existing software base," Borgerson notes. "If you look at the situation with those constraints, it's less interesting than the question people at the universities examine, which is how to use new technology in general." But he sees such pure research as necessary. "The universities come up with some good ideas. And some of these we can apply as we evolve our compatible architectures."

Much of the work today is being done on managing multiprocessor systems. Although several attached processors and multiple-processor computer systems are commercially available from companies such as IBM, NCR, and Burroughs, they cannot share jobs or functions between themselves. And they are not prevalent because they cost twice as much as uni-processors yet do not double the performance.

Still, the future of "functional multiprocessing is exciting," says DEC's Gordon Bell. Current examples are front-end communications processors and peripheral controllers that by taking over these functions unburden the CPU and increase its performance.

A multiprocessing example

Illustrative of this multiprocessing work is G. J. (Jack) Lipovski's research at the University of Texas at Austin. The 34-year-old associate professor of electrical engineering is working with a team to build the Texas Reconfigurable Array Computer (TRAC). Funded by the National Science Foundation, this machine will demonstrate the use of a Banyan switch as an economical method of interconnecting multiple computers.

Functionally similar to the cross-point switch used in telephone exchanges and in some computers today, Lipovsky says the Banyan switch should be cheaper than the crosspoint switch for interconnecting multicomputer multimemory systems.

Another function that might be delegated to a special-

Learning from software

"Many of the architectural ideas come out of the top layers of architecture, the instruction set, the operating systems software, and languages," says Gordon Bell. "The notion is to make anything you need to do [in software] migrate into the hardware."

Celebrated as the architect of the PDP-11 minicomputer, Bell has been involved closely in computer architecture and engineering since he joined Digital Equipment Corp. in 1960 as manager of computer design. After a six-year stint as a professor of electrical engineering and computer science at Carnegie Mellon University in Pittsburgh, he returned to DEC to the position of vice president of engineering in 1972.

Although he considers himself more an administrator than an architect these days, many in the field respect his perspective on the industry. And the integration of software into the hardware design—primarily as microcode or firmware—is a trend he definitely thinks will accelerate in future designs. "Operating system functions are now migrating into the hardware, and language functions will follow," he says.

At the same time, Bell thinks the process of hardware design is changing because "we've gone out of the era of handbook engineering." To work in this new environment, he thinks hardware designers should study the techniques used by the sophisticated software that equip today's computers with capabilities such as multiprogramming and virtual memory. "We should learn from the way software systems manage complexity," Bell says, "because once we put these concepts and functions into physical structures, they will be a lot harder to change."

Hardware designers have to be more careful as they place more and more of their architecture onto silicon chips, Bell concludes, because "our screw-ups tend to be much more permanent."

ized processor in a multiprocessor system is the management of the data base. As the use of computers grows, the amount of information stored in them also increases. Sophisticated software to control the access and organization of this data needs a lot of processing power. And with the price of hardware dropping more and more computer engineers are saying it now pays to devote an entire processor to the job.

At the University of Florida, for example, Stanley Y. W. Su, professor of computer and information sciences and of electrical engineering, heads up the Database Systems Research and Development Center. The center is developing special micro-architectures called Cellular Logic devices that associate a small processing unit with each memory track of disk or tape drive. In combination with these processing units, the memory unit can look at its own contents and match them with the requested item. Such a technique, when perfected, will allow data to be accessed by referring to its contents, not to an arbitrary address location. A primary advantage of such a "content-addressable memory" is that several users can access the same data file in a variety of ways. Thus a single payroll file could be accessed according to names, social security numbers, or departments. Otherwise three duplicate files—each arranged a different way—would have to be maintained.

This cellular data-base logic approach for data-base management hardware is being released commercially by ICL in its Content Addressable File Store System. What the company describes as primitive Boolean logic on each disk drive channel is programmed to perform an associative search operation on a number of data fields specified by the controlling search program. The associative search operation checks each file's contents for the sought-after information. The high search speed stems from the fact that the search electronics is replicated to scan many disk channels simultaneously.

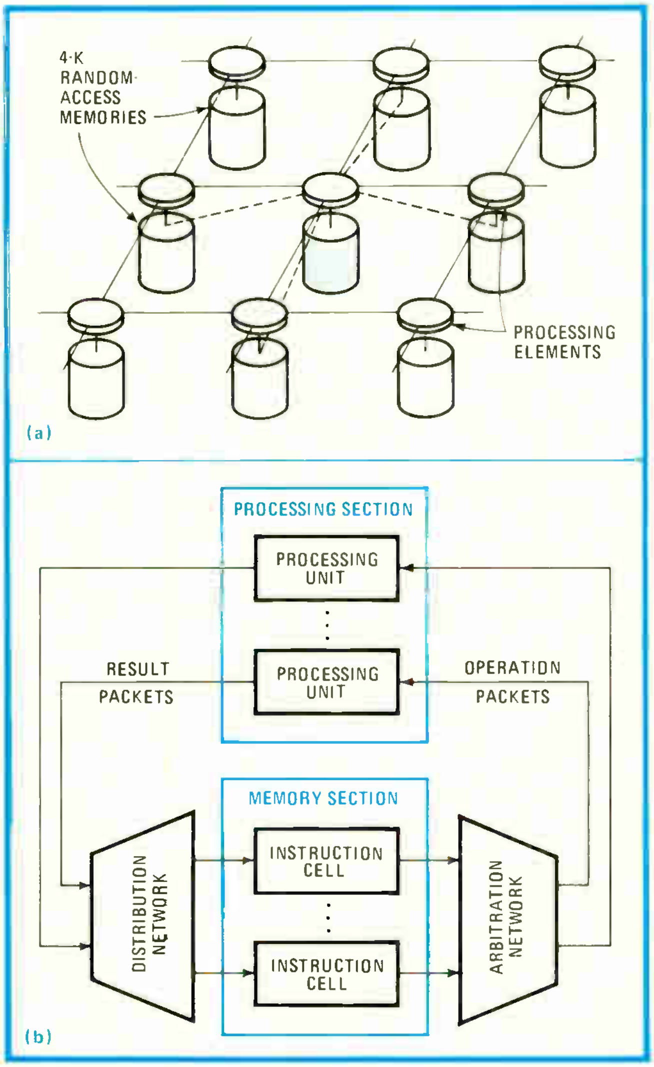
The fact that such innovative architectures are being applied to special tasks allows computer users to take advantage of them without reprogramming the applications. Systems operating software takes existing application-program requests for input/output to disk drives and routes them to the specialized data base machines where they will be carried out.

Big memory consequences

And Gordon Scarrott, who heads International Computer Ltd.'s Advanced Development Centre in Stevenage, England, says the new memory management capability offered by such schemes will open up a whole new realm of applications. For example, he says, "one reason why voice-interacting computer systems have been slow to develop is that computers have not been worth talking to until now." The reduced response time achieved by the Contents Addressable File makes real-time response "entirely practical," he claims.

Frederic G. Withington, for long a computer analyst with the research firm of A. D. Little, foresees such multiprocessor arrangements as the principal computer architecture by 1985. In a recently released report for the Department of Defense, Withington predicts these multiprocessor systems will become primarily bus-oriented by the late 1980s or 1990. In this way computer architects can best take advantage of the declining hardware costs, he says.

One of the most fundamental pieces of architectural



10. Departures. Two recent non–von Neumann architectures are International Computers Ltd.'s Distributed Array Processor, which uses a square array of processor/memory elements (a) and Massachusetts Institute of Technology's data-flow machine (b).

research being undertaken is that on data-flow computers. A data-flow machine is a total departure from the von Neumann architecture that has been basic to all computers till now (see "In the beginning," p. 113).

As envisioned at Massachusetts Institute of Technology Laboratory for Computer Science, the data-flow machine would have no single central processor. Instead it would have a processing section with tens, hundreds, or even thousands of processor units in it, each perhaps the equivalent of a simple arithmetic and logic unit. Instead of a shared random-access memory, there would be a memory section with a large number of "instruction cells," each holding an operation code, the data operand, and a destination address (Fig. 10). And in place of data paths and storage registers, a packet-switching system called an arbitration network would direct the output of an instruction cell to a processor unit.

Jack B. Dennis, the 47-year-old professor of computer science and engineering and the head of the data flow group, says the coming large-scale integrated logic devices will make implementing such an architecture both easier and cheaper. "In our early machines we might use only one or two types of processing units," he says. But with the economies of LSI, he projects units with 512 to 2,048 processing units.

But thanks to the software inertia, such an architecture would not replace the conventional general-purpose von Neumann machine, at least not yet. "For data flow to be most useful, existing programs in Fortran, PL-1, and Cobol would have to be rewritten in something like a new programming language that can take advantage of the parallelism of the machine," Dennis says.

Data-flow machines are also the subject of research at Britain's Manchester University, one of the bastions of computer research since the beginning of the technology (see "The Manchester group," p. 119). According to David G. B. Edwards, the project will also help solve the software problems associated with sharing the load between all the processors in such an architecture. This is important, Edwards says, because "all future performance increases will come from parallel processing."

Another non–von Neumann approach is under investigation at ICL's Advanced Development Centre in Stevenage, England. Called the Distributed Array Processor, the unit pairs a processing element with each block of memory rather than separating processors and memory as in the data-flow machines. These memory/processor pairs are then arranged into a square array (see also Fig. 10). Conceived by Stewart Reddaway, ICL has already built a 32-by-32-element DAP and is now building a 64-by-64-element unit [*Electronics*, April 27, 1978, p. 69] (Fig. 11).

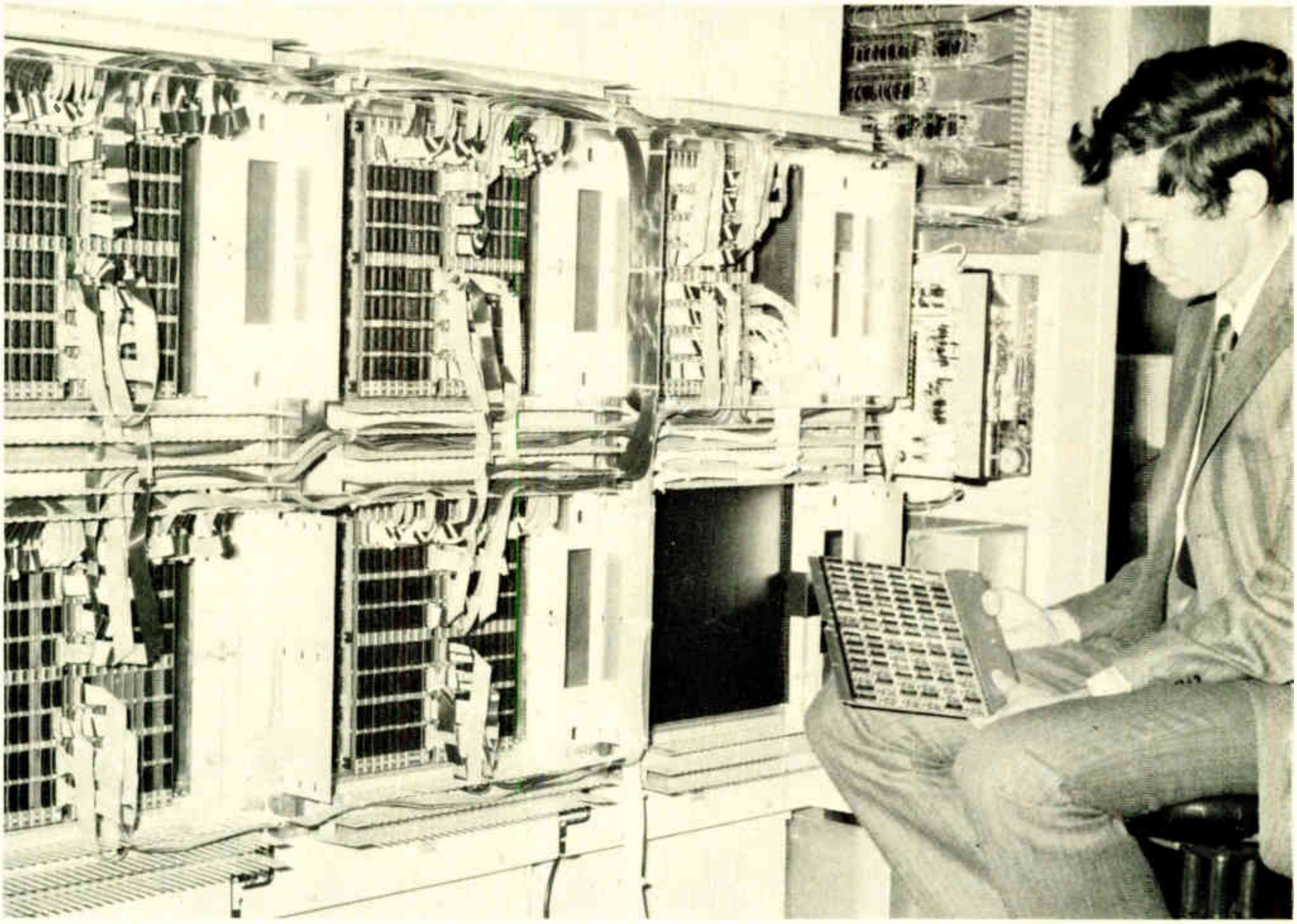
In addition to operating on the contents of its own store, each processing element can access information from its immediate neighbors or elsewhere in the array via row and column interconnections of the matrix elements. All processing elements obey a common program, but each can be instructed to ignore any commands, thus providing a great amount of flexibility. Programs to carry out complex tasks can be built from a sequence of simple processor operations, and ICL has developed a high-level language called DAP-Fortran for the machine. This gives a straightforward way of programming parallel operations, says Reddaway.

The challenges . . .

"I've never seen so many challenges," says Gordon Bell, summing up the feelings of most computer architects and engineers today. "And these challenges exist for one big reason—the price/performance range of the components is opening up," Bell says (see "Learning from software," p. 131).

From circuit components to completed computers, all hardware has decreased in price, opening up new ways of building computers and ultimately systems. The multiprocessor and parallel processor arrangements being implemented and planned are possible only because the price of the processing elements have dropped.

But the rapid shift in semiconductor price and performance makes it hard for computer engineers to plan for the next generation of machines. In fact, the rate of change is so great that some are finding it difficult to cope—a reaction that in a larger context



11. Future reality. Stewart Reddaway, developer of ICL's Distributed Array Processor, is shown here with a pilot model consisting of a 32-by-32 array of microprocessors and memory that have been configured onto a set of 64 printed-circuit boards.

Alvin Toffler has dubbed "Future Shock."

"We're coping with the problem of future shock during the development phase so that we won't be caught off guard when a product is finished," explains Peter Muller-Stoy, a department head at Siemens AG's Data Processing division in West Germany. This indicates closer cooperation between the semiconductor and computer houses because, Muller-Stoy says, this requires products to be designed with not-yet-available components in mind. A case in point is the 7700 series of mainframes his company announced last year. These units were designed for 64-K memory chips, although such devices are not yet available in quantity. But Siemens expects these chips to be available by the time the computers are shipped later this year. Similarly, the current development effort is planned around a master-slice array of LSI logic devices with gate delays as short as 0.5 ns. Yet these Siemens-made semiconductors will not be ready in volume until 1980.

Moreover, design tools are also changing, says Arlin Lee, processor performance analysis manager for IBM's Data Systems division in Poughkeepsie, which manufactures large mainframes like the 3033.

"There are a lot more options one has to deal with in higher levels of integration. The circuits are more complex and there is greater concern over the semiconductor's reliability and testability as integration increases." As a result, he says, the design process lengthens, and "the management of this technology becomes horrendous." A solution IBM is leaning heavily on now is computer-aided design (see "Computers designing computers," p. 129). "We're doing more and more with computers to aid the design and assembly process and the trend will continue. More and more time is spent today modeling a new system using computers. Engineers are doing less breadboarding."

. . . of greater freedom

While the design environment is changing, the rapid pace of price declines among the components has removed one of the fundamental engineering design factors—cost. "Constraints are good things in that you end up with only a few ways of doing something," says Bell. "Now there are fundamentally no cost restraints on what we'd like to do."

As IBM's Cordero warns, "It's harder to make choices when there are more degrees of freedom because then there are more strategies and it's harder to predict what will happen. The best thing to do is to assume the most aggressive projection of capability and cost of the most advanced technologies you can dream up—and then plan a product that will be competitive with it." □

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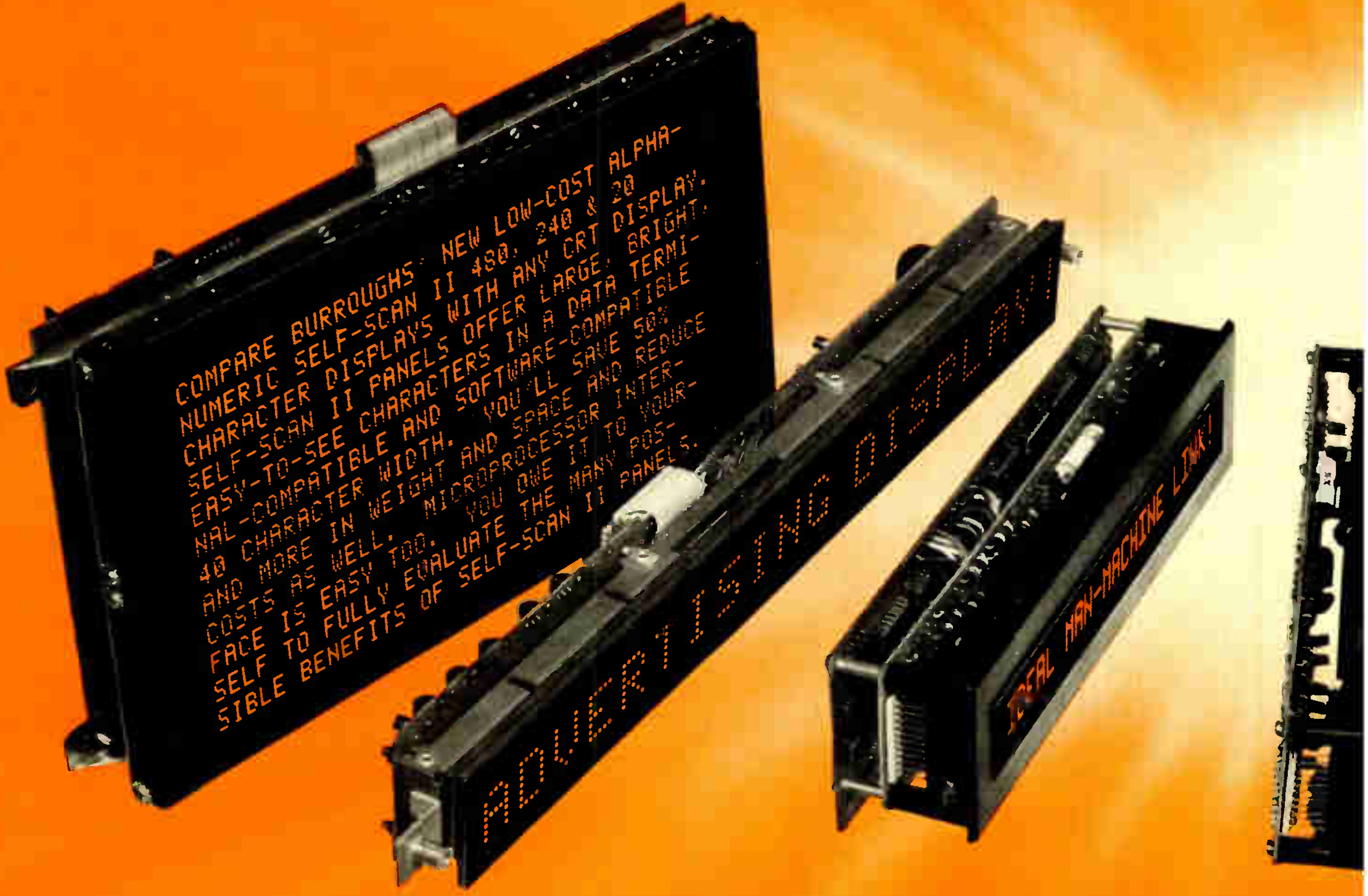

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V-MOS packs 16 kilobits into static random-access memory

Setting the stage for denser, scaled parts, the new RAM sports an access time of 150 to 300 nanoseconds with 3.5- to 5-micrometer-wide lines

by Gideon Amir, *American Microsystems Inc., Santa Clara, Calif.*

☐ Static random-access memories with access times below 55 nanoseconds are grabbing lots of semiconductor headlines lately. But while some of today's most sophisticated processing is used in pioneering impressive speeds, equally significant advances are being made on density frontiers in statics as well.

A case in point: the S2048, a new 2,048-by-8-bit fully static RAM from American Microsystems Inc. The part's byte-wide organization makes it ideal for storage of microprocessor data, and its 150-to-300-ns range of access times is more than adequate for today's microprocessors—and for future 16-bit parts, too.

What makes the S2048 significant for reasons beyond its 16-K capacity is V-MOS—the V-groove metal-oxide-semiconductor technology developed by AMI and now showing up in a variety of RAMs and read-only memories (ROMs). V-MOS is building denser memories than any other n-channel technology—and that without so far putting the squeeze on geometries, as other manufacturers have been forced to do.

V-MOS lives up to its promise of high density by packing the S2048's more than 100,000 transistors and resistors on a die occupying only 32,000 square mils. And this is using unscaled, fairly conservative line widths of 3.5 to 5.0 micrometers, assuming interlevel misalignment of 2 μm during contact printing. Future parts, using scaled V-MOS (see "The big shrink"), will be even denser.

For today's microprocessor applications, the S4028 has other impressive credentials: a power consumption of only 370 milliwatts from a 5-volt supply; pin compatibility with byte-wide ROMs and erasable programmable ROMs; and TTL-compatible outputs with a fanout of five gates. Those specs are largely a result of its design.

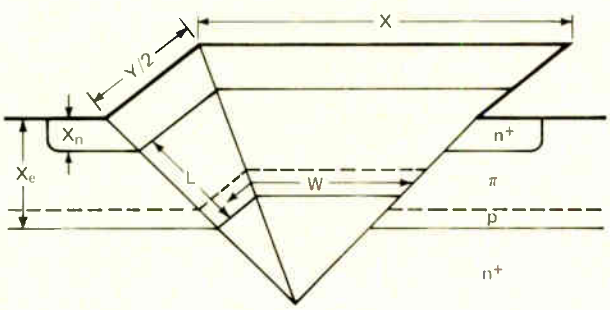
Compact

Figure 1 shows the layout of the S4028 die. Although only four core-cell banks appear in the photograph, each

The big shrink

A proven way to make a second-generation semiconductor device faster and less power-hungry is to shrink its dimensions. Scaling an n-channel MOS circuit by the factor α does two things: it boosts its speed by α; and it cuts its speed-power product by α^3, which includes the α reduction in power-supply voltage needed to prevent punchthrough of the shorter gate lengths. The use of a lower-voltage supply is disadvantageous here, since it lowers noise margins and is a nonstandard unit.

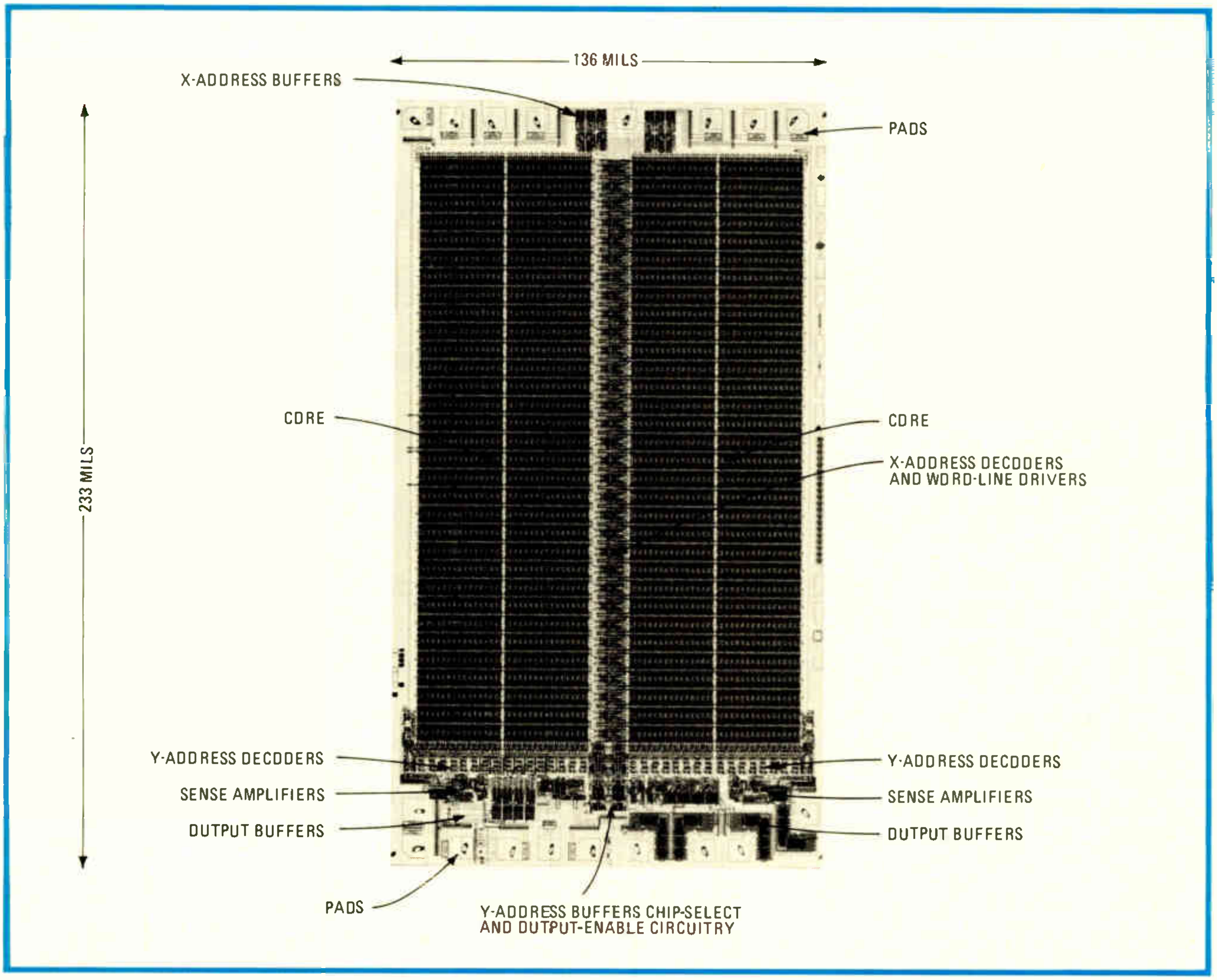
In V-MOS circuits, scaling by α improves both the speed-power product and the speed by α^2, with no need to scale the power supply.



$$W = 2(X + Y) - 4\sqrt{2}\,X_e$$
$$L = (\sqrt{3}/\sqrt{2})(X_e - X_n)$$

$X \to \alpha X$, $Y \to \alpha Y$, $X_e \to \alpha X_e$, $X_n \to \alpha X_n$ } $W/L \to \alpha W/\alpha L$

Parameter	V-MOS scaling	n-MOS scaling
Device dimensions	$\alpha X, \alpha Y, \alpha X_e, \alpha X_n$	$\alpha W, \alpha l, \alpha X_n$
Gate thickness	t_{ox}	αt_{ox}
Channel doping	N_A	N_A/α
Supply voltage	V_{DD}	αV_{DD}
Threshold voltage	V_T	αV_T
Current	$I = V_{DD}/R$	$\alpha I = \alpha V_{DD}/R$
Power	$P = IV_{DD}$	$\alpha^2 P = (\alpha I)(\alpha V_{DD})$
Delay	$\alpha^2 \Delta t = (\Delta V)(\alpha^2 C)/I$	$\alpha \Delta t = (\alpha \Delta V)(\alpha C)/\alpha I$
Power delay	$\alpha^2 P \cdot \Delta t$	$\alpha^3 P \cdot \Delta t$



1. Interleaved. Layout of the S4028—pads at the end and controls between the core sections—squeezes 16,384 memory cells into a die that measures 136 by 233 mils. Interleaving of cell-block pairs improves the efficiency of the Y-address decoders shown at bottom.

represents two interleaved blocks of 128 by 16 bits apiece. The interleaving improves the efficiency of the Y-address decoders shown below the core. All eight blocks share the X-address decoders and word-line drivers between the core sections. Pads are located at the ends of the die to conserve silicon real estate at the sides where the core abuts the scribe line. The Y-address buffers and chip-select and output-enable circuitry all fit between the two halves of the core. Even with its byte-wide structure, the die measures only 136 by 233 mils.

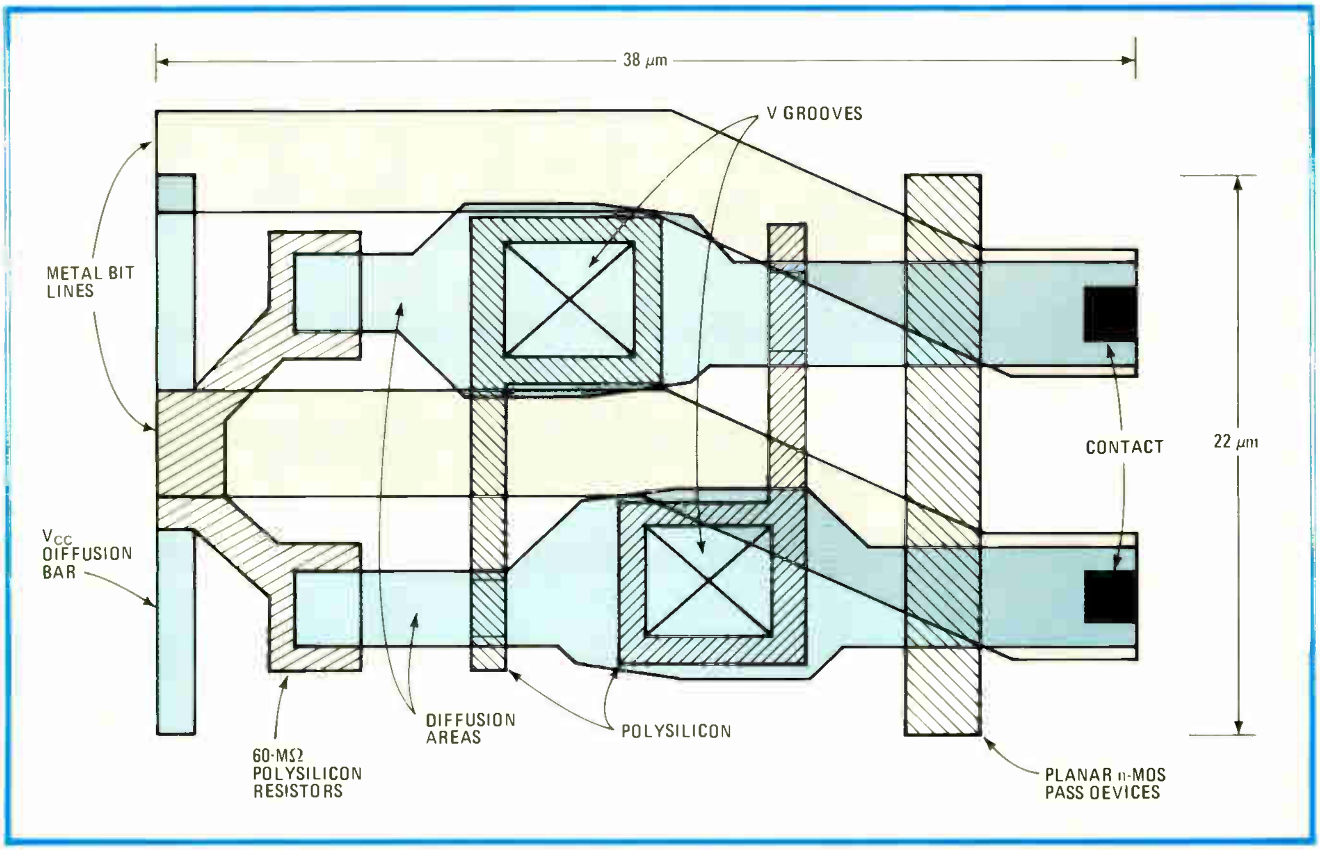
The core cell layout is shown in Fig. 2. The six-element design includes three types of devices: two V-groove MOS transistors, used for flip-flop pulldowns; two planar n-channel MOS transistors, used as pass devices; and two high-resistance (60-megohm) polysilicon load resistors. With only one layer of polysilicon, the cell measures 22 by 38 μm, or an area of 1.3 square mils.

Alpha-resistant

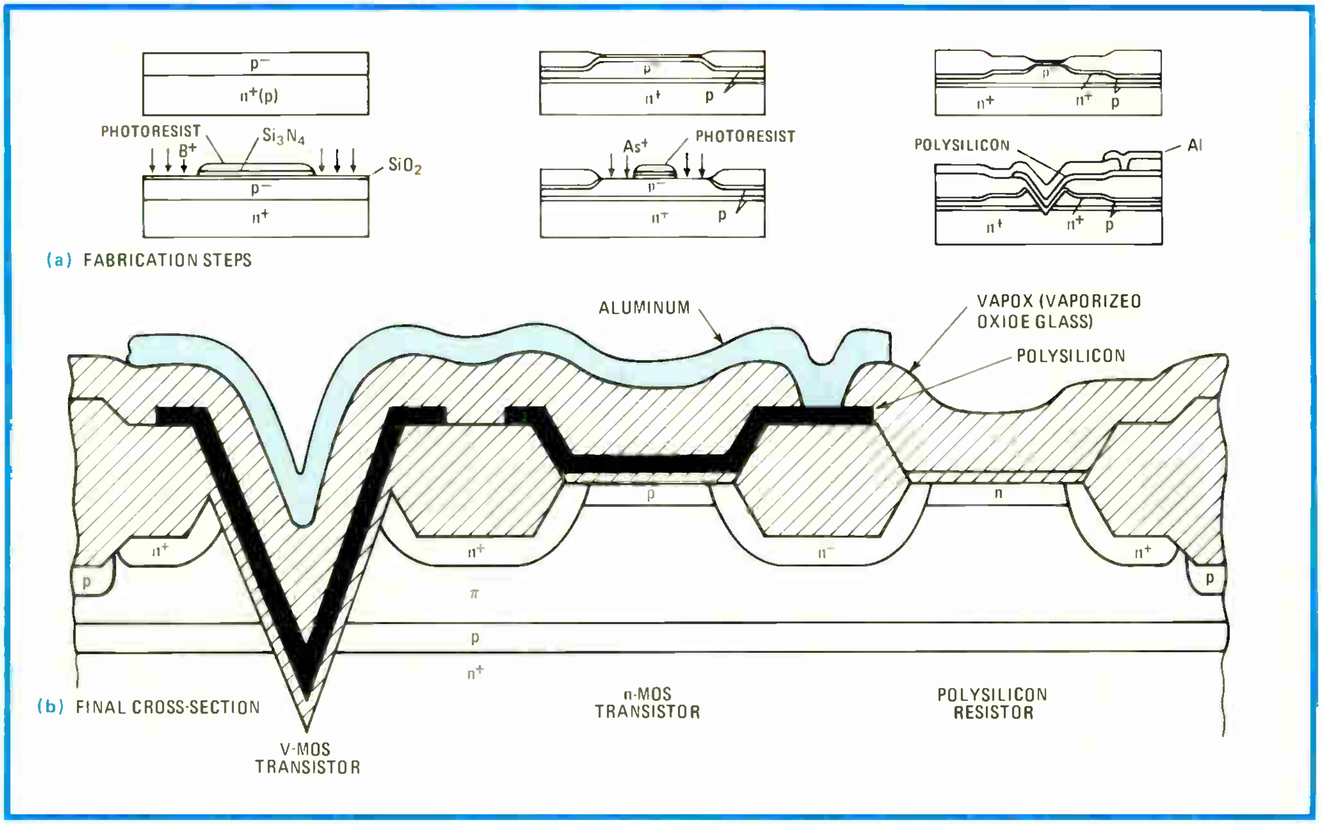
Despite the small cell size, there is more than 0.07 picofarad of capacitance on the flip-flop nodes—the diffusion areas in Fig. 2—to help dissipate charges generated by alpha-particle radiation. This eliminates the need to drive high compensating currents through the loads. The proximity of the diffused V_{cc} bus, a good collector of electrons, to the cell's storage nodes is another safeguard against alpha-generated noise. And the V-MOS structure itself helps prevent alpha errors, since it features a narrow epitaxial region between the chip's surface and the ground-plate substrate (3 μm). Mean penetration depths of alpha particles are in the 25-μm range, so that only a few alpha charges reach the core.

Figure 3 shows the construction of the V-MOS cell. The process offers two advantages to static-RAM design: the availability of a ground plate beneath the circuitry, which eliminates the need for a ground bus through the core; and a high current-gain-to-device-size ratio, typically 100 $\mu A/V^2$ for a 5-by-5-μm device.

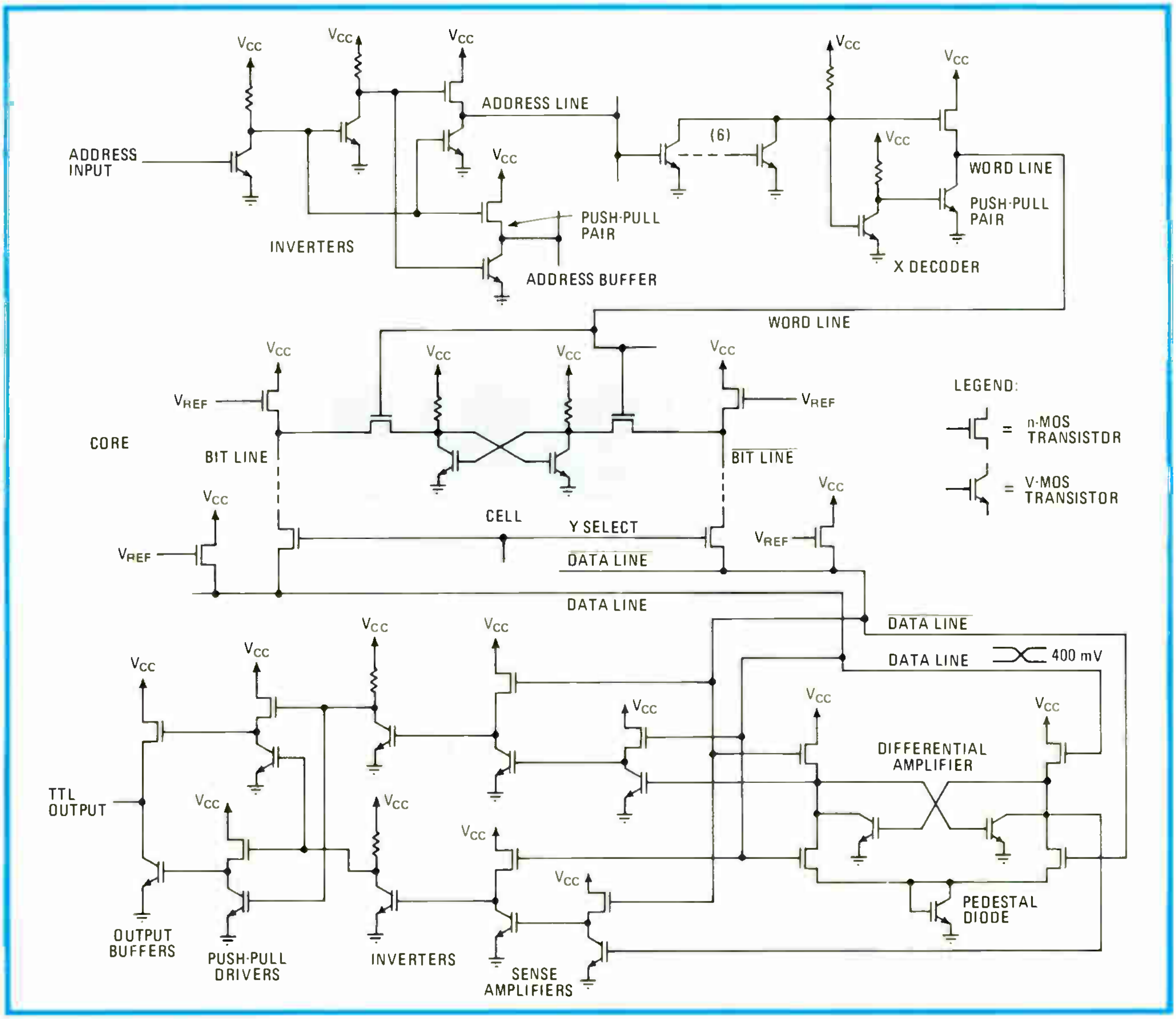
Figure 4 shows the S4028's internal circuitry. The address input buffer comprises two inverters, each driving a push-pull, n-channel MOS and V-MOS transistor pair. The X and Y decoders are NOR-type. N-MOS and V-MOS push-pull pairs also buffer the decoder node. This minimizes power dissipation in the X decoder because the load resistor, rather than the high-capacitance word line, drives the push-pull pair.



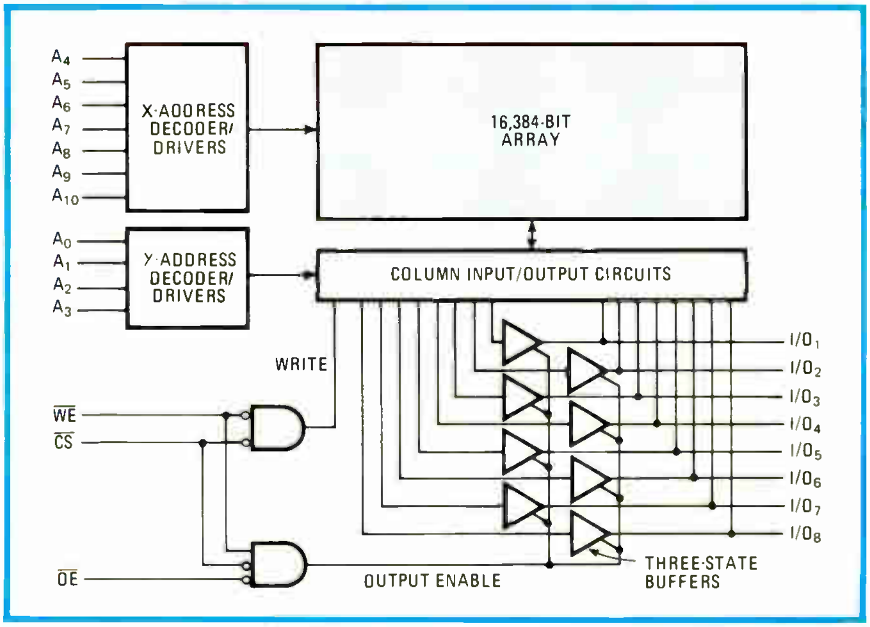
2. Groovy. Cells comprise six elements: two V-groove MOS transistors, two planar n-channel MOS pass devices, and two polysilicon pull-up resistors. Proximity of the diffusion bar at left to storage nodes helps minimize errors caused by alpha-particle radiation.



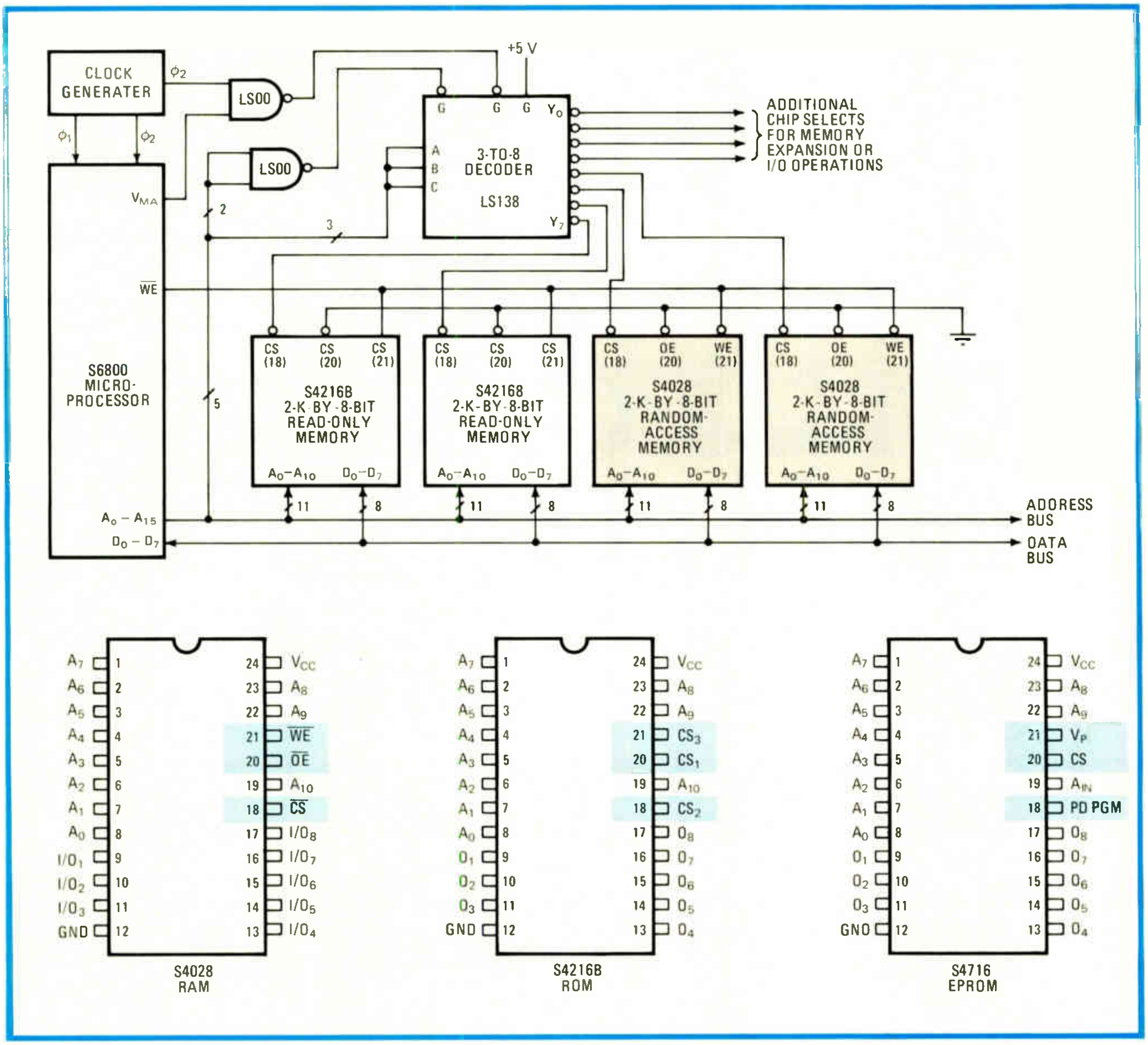
3. Construction. Multistep fabrication process at top produces the V-MOS cell whose final cross-section is shown at bottom. Thinness of epitaxial layer — 3 micrometers — helps keep alpha-particle-induced charges from affecting the core.



4. Circuitry. N-MOS and V-MOS push-pull pairs in the S4028 help lower chip's power consumption to 370 mW. Other design highlights are reference-clamped lines in the core that boost speed, plus a high-gain feedback differential stage in the sense amplifier.



5. Static. Three-state output control makes it easy to wire-OR the S4028 to memories in a data bank. This feature also facilitates connection to microprocessors with multiplexed address and data buses.



6. Compatible. This simplified block diagram of a 6800-based microprocessor memory system, shown at the top, highlights the flexibility of the chip. It can be interchanged with the 16K ROMs and E-PROMs, shown at bottom, without any external hardware changes.

To compensate for the lower voltage on the word lines, reference-clamped bit and data lines are used. The clamps restrict the voltage swings on the data lines to 400 mV and reduce the levels on the bit lines to match the most efficient operating point of the Y-select transistors. The restriction of voltage swings on the high-capacitance bit and data lines considerably reduces delays.

The sense amplifiers in Fig. 4 transfer the 400 mV data-line signals to 5-V TTL levels. The first stage is a pair of n-MOS transistors wired as a differential amplifier with positive feedback for high gain and a pedestal diode to provide threshold tracking with the following push-pull stages. Each stage consists of an n-MOS and a V-MOS transistor. This portion of the sense amp shifts the 400-mV signal down from 3 V to just over 1 V, the V-MOS threshold. This conversion occurs in less than 40 ns and requires only 1.5 mA of current. The outputs of the sense amplifiers then are buffered by resistive inverters whose 5-V outputs feed the push-pull drivers of the output buffer pair. Each of the eight outputs of the S4028 can drive five TTL gates or 20 low-power Schottky TTL devices.

Figure 5 shows the functional configuration of the chip. As a fully static RAM, it needs no clocks or refresh circuitry. The chip-select ($\overline{CS}$) and output-enable ($\overline{OE}$) pins facilitate expansion by wired-OR connections of the input/output pins to other memories. The output enable function is also useful for interfacing to microprocessors with multiplexed address and data buses since it allows the three-state buffers to be turned off until the address leaves the address-data bus.

Typical application of the S4028 in a microprocessor memory bank is shown in Fig. 6. In this system, the chip is interchangeable with the 2K-by-8-bit ROMs with no need to change other hardware. □

"One micron device technology will have greater impact on yield and productivity than all gains achieved in the past decade."

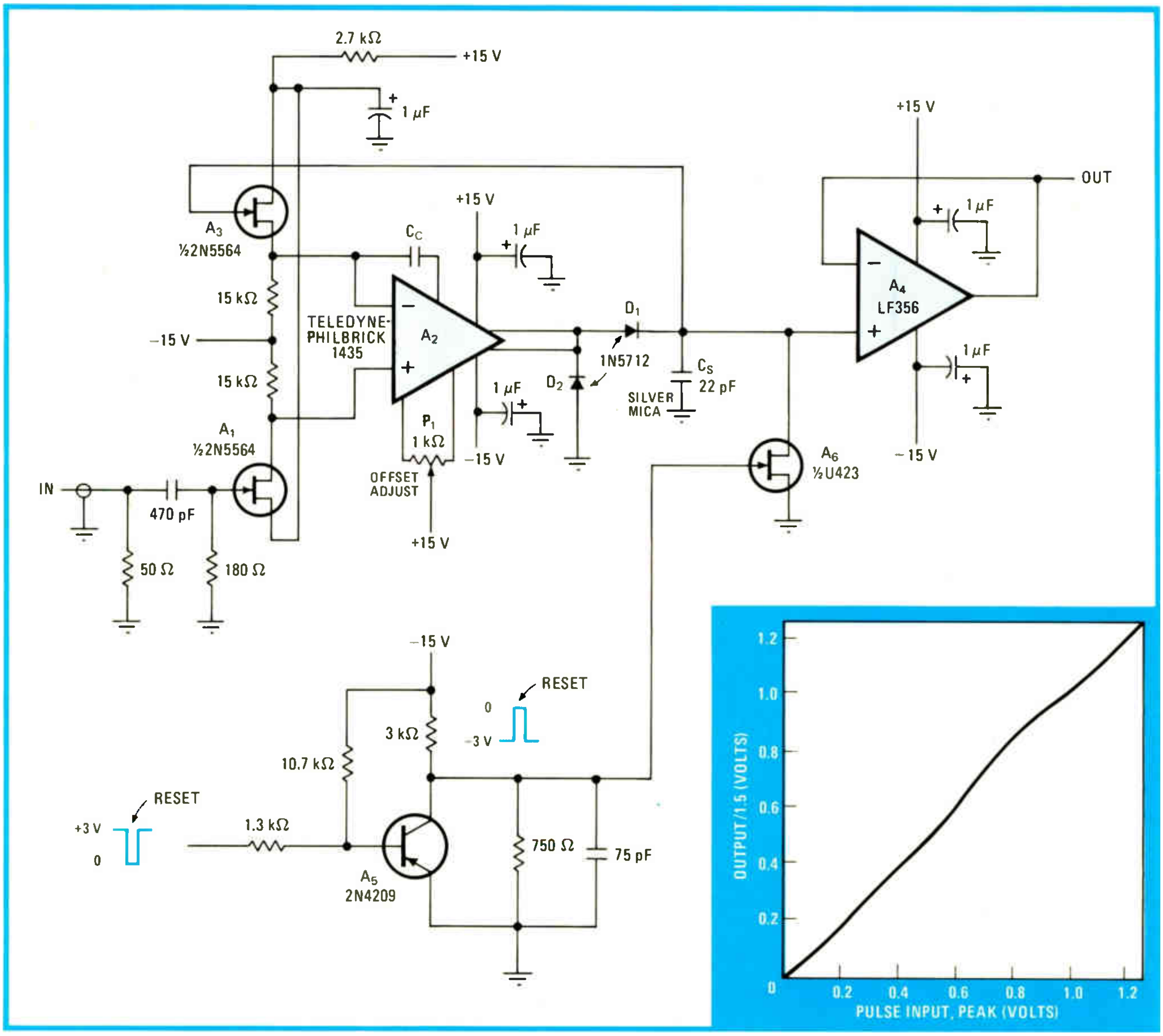
Wideband peak detector recovers short pulses

by Saul Malkiel
Advanced Technology Systems, Roselle, N. J.

Using a Schottky-barrier diode for detection and a wideband operational amplifier, this peak detector recovers data pulses as narrow as 10 nanoseconds in the range of 0.1 to 1.3 volts. The circuit's linearity as a percentage of the full scale output is 4%.

The input signal, whose rise time is assumed to be a minimum of 10 ns, is applied to one side of the differential source follower, A_1-A_3, via a 50-ohm coaxial cable. A blocking capacitor removes any baseline shifts. The output of this JFET follower is then applied to the wideband amplifier, A_2. The amplifier has a gain-bandwidth product of 1 gigahertz.

The output of the amplifier switches on diode detector D_1 so that a charging current can be delivered to storage capacitor C_s. When there is overshoot, source follower A_3 is turned on more heavily than A_1 so that A_2 may be driven negative. D_2 then comes into play, acting to limit the amplifier's negative excursion. The excursion, coupled through D_1's shunt capacitance, reduces the



Narrow capture. Wideband amplifier and fast diode detect pulses having widths as small as 10 ns. Output-to-input voltage linearity of circuit is 4%, and linearity is virtually independent of pulse width. Response is illustrated in curve at bottom right.

output voltage by 30 millivolts. This pullback effect is one cause of error in small-signal detection.

The storage capacitor is a silver-mica type, chosen for its low loss and its high stability. Its value is 22 picofarads, a tradeoff between A_2's hold-drift (100 microvolts per microsecond) and pullback characteristics.

The detected voltage is now applied to A_4, which serves as a buffer and provides a low-output impedance for driving the external circuitry. The LF356 operational amplifier used has wideband characteristics, notably a settling time of approximately 200 ns, after which its output becomes valid.

A pulsed command can then be applied to the 2N4209 transistor, A_5, to reset the circuit. The reset command is then transferred to A_6, the U423, and the stored voltage on C_s discharges exponentially toward zero. In order to minimize the discharge time, the output of A_2 is biased at 10 mv dc under no-signal conditions. Potentiometer P_1 is used to adjust the required offset. A total time of about 2 microseconds is required to reset the circuit. ☐

Serrodyne amplifier generates wideband linear ramp

by Roy Viducic
Loral Electronic Systems, Yonkers, N. Y.

Producing an extremely linear 200-V ramp or peak-to-peak sine wave over a frequency range of 50 kilohertz, this circuit is ideally suited for modulating the helix of a traveling-wave tube (serrodyning) or generating large voltages for circuit synchronizers. Because of the inherent symmetry of the circuit design, it can produce both positive-going and negative-going ramp waveforms.

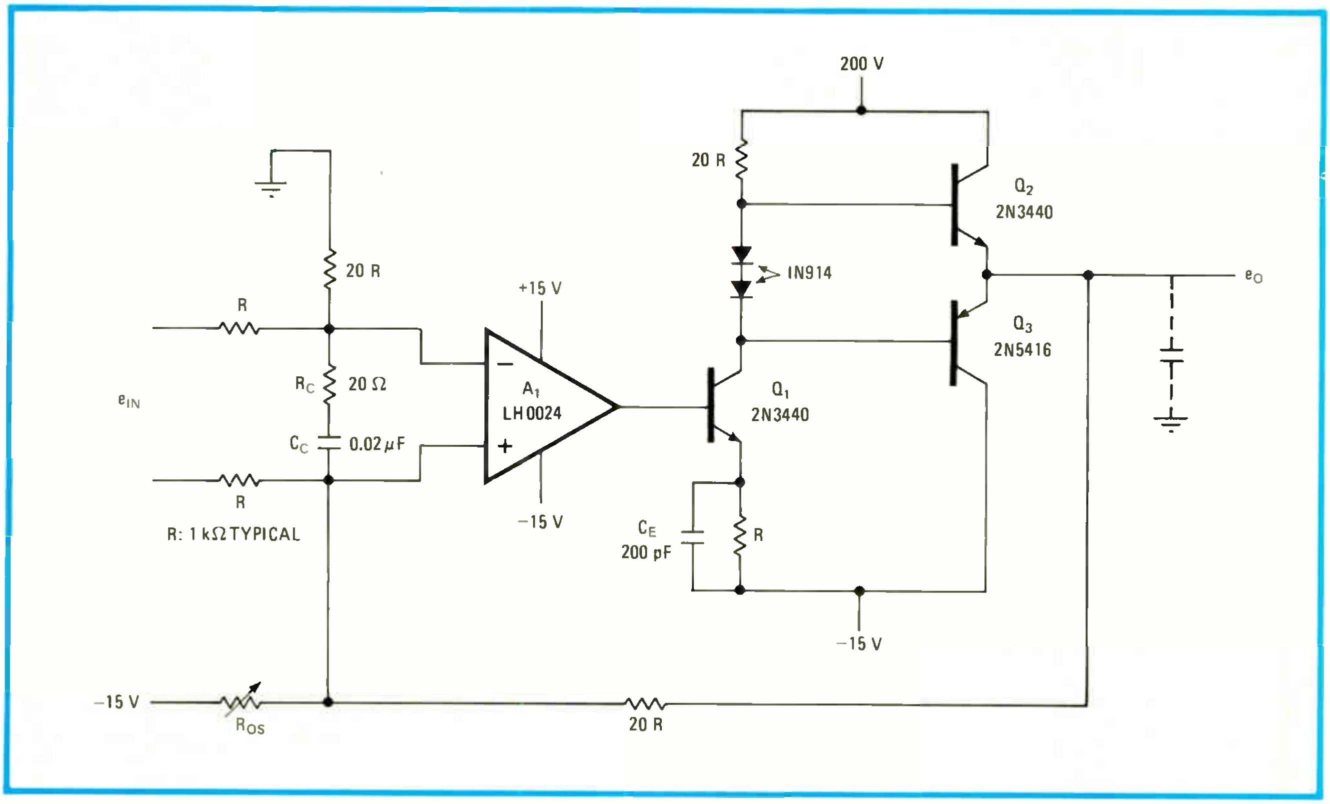
In addition to the advantages previously mentioned, the circuit offers:

- Low gain error through either input.
- Fast response for both ramp polarities—the output's flyback-settling time is 1 microsecond.
- Wide dc-offset capabilities.

To achieve this performance, an operational amplifier with a high slew rate and broadband response is used in a simple feedback arrangement.

The low-level ramp or sine wave signal is applied to either input of A_1. Note that the polarity of the ramp at the output is reversed if the input signal is applied to the opposite port of A_1. The broadband characteristics of A_1 provide sufficient output, even at a closed-loop gain of 20. This is the minimum loop gain required to obtain the linearity, precision, and dynamic range that were initially specified for this application.

After inversion and further amplification by Q_1, the signal passes through complementary-transistor pair Q_2–Q_3 to the output. Because Q_1 is designed for a closed-loop gain of 20, it is only necessary to swing 10 volts at the output of A_1, well within the operational



Well-behaved. Feedback circuit provides high-voltage ramp or sinewave to capacitive loads exceeding 200 picofarads. Broadband op amp having high slew rate contributes to excellent linearity of waveforms over 50 kilohertz range. Flyback settling time is 1 μs.

amplifier's capabilities in its linear region.

Capacitor C_E compensates for the total base-to-emitter capacitance at Q_2 and Q_3, which act to reduce circuit speed. Network R_cC_c stabilizes the entire loop. Potentiometer R_{os} is used to adjust the output offset.

Considerable heat will be generated in Q_1–Q_3 because of high collector voltage. In spite of this, the power dissipated by them is well within the ratings of their TO-5 cases. Therefore, the transistors do not require external heat sinks. □

Digital peak detector finds 4-bit highs and lows

by N. Bhaskara Rao
U. V. C. E., Department of Electrical Engineering, Bangalore, India

This circuit finds the maximum and minimum value of a 4-bit data signal over any given time interval. Here, a latch-comparator feedback scheme using standard TTL operates as a real-time memory bank to determine the peaks and valleys of the input signal.

A negative-going start pulse latches the incoming data, D, in A_1 and A_2 at the beginning of the sample period. Thus initially, $D_o = N_o = M_o$, where N and M are the stored maximum and minimum data values, respectively.

When the system clock first moves high, gate G_3 is enabled and N_o appears at the output of the data selector, A_3. N_o is then compared to the present value of the input data at A_4. If D should exceed N_o, pin 5 of A_4 will go high and A_1 will therefore latch the input data.

Similarly, when the system clock first moves low, gate G_4 is enabled and A_4 compares M_o to the present data value. If D is less than M_o, A_2 will latch the input data. This process is repeated during each system clock until the end of the sample period, which may be terminated by the user in any of several ways, depending on the application. The maximum and minimum values of D appear at the output of A_1 and A_2, respectively.

No difficulties have been encountered with the generation of signal spikes or transients from pins 5 and 7 of A_4 during A_3's switching periods, and no problems will occur as long as the data-input lines are settled during those times. □

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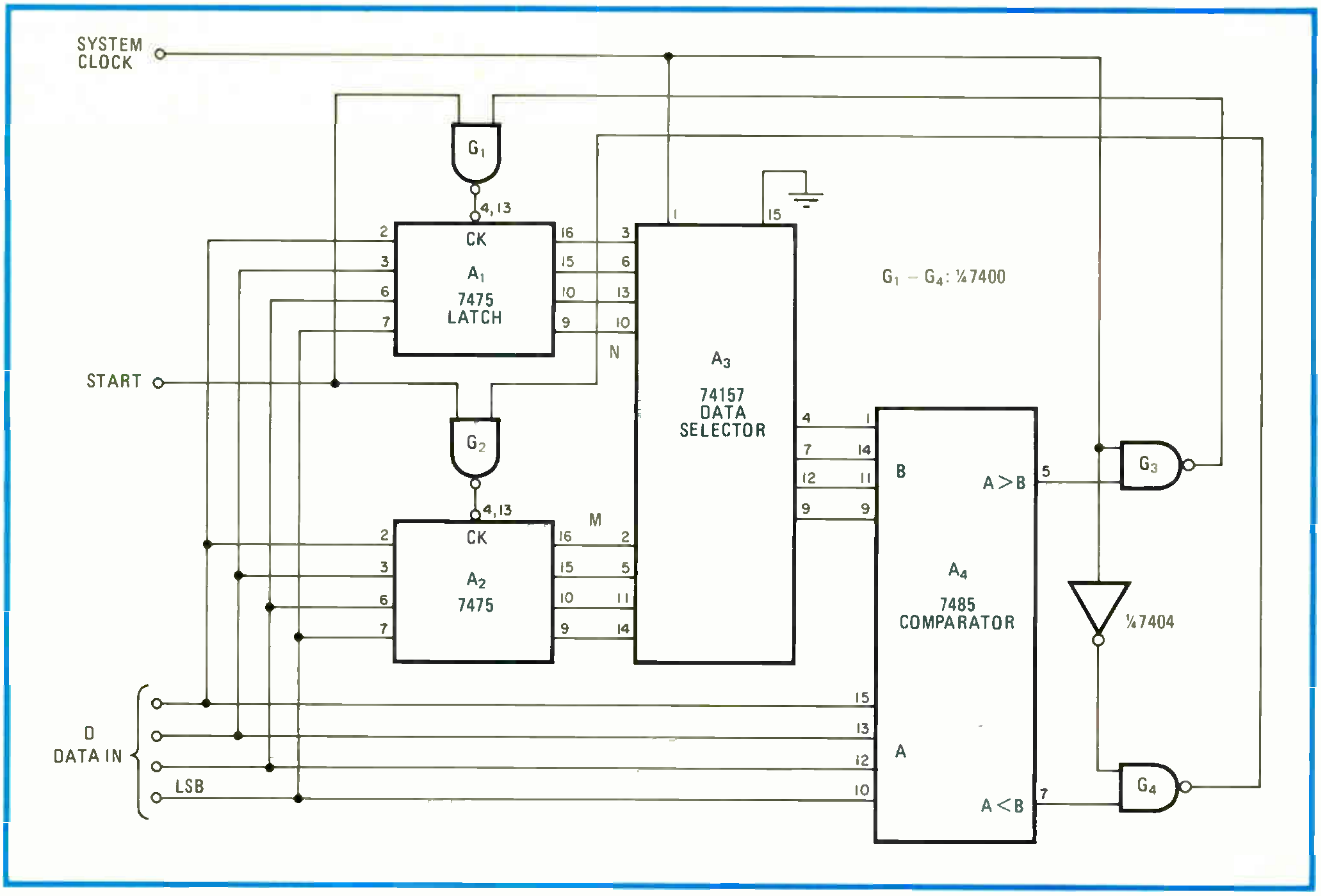

Peaks and valleys. Maximum/minimum detector for 4-bit digital data uses standard TTL elements in latch-comparator feedback arrangement. Circuit performs continual comparison of previously stored maximum and minimum data versus present value of input data, and relatches latter when necessary. Updated high and low values appear at output of A_1 and A_2, respectively.

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Part #	16	IH6116	IH6216	DG506	DG507	HI-506	HI-507
	8	IH6108	IH6208	DG508	DG509	HI-508A	HI-509A
$I_{D(on)}$ Leakage Current	16	100nA	100nA	300nA	200nA	500nA	250nA
x	8	100nA	50nA	200nA	100nA	250nA	N.A.
$R_{DS(on)}$ Resistance	16	700Ω	700Ω	500Ω	500Ω	400Ω	400Ω
=	8	400Ω	400Ω	500Ω	500Ω	1800Ω	1800Ω
Error Voltage Error	16	70μV	70μV	150μV	100μV	200μV	100μV
	8	40μV	20μV	100μV	50μV	450μV	N.A.
Power Dissipation @+25°C	16	4.5mW	4.5mW	300mW	300mW	60mW	60mW
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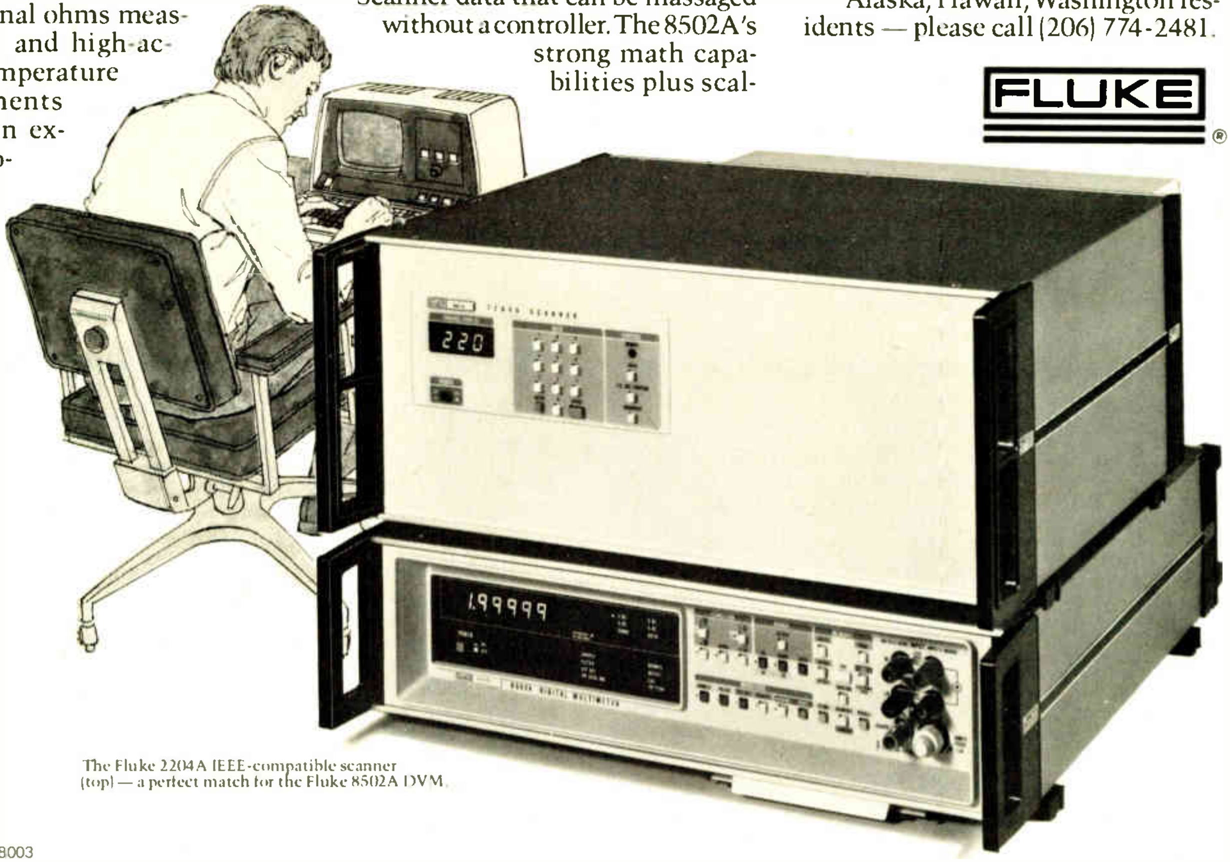

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In-circuit tester using signature analysis adds digital LSI to its range

by Craig Pynn, *Plantronics/Zehntel Inc., Walnut Creek, Calif.*

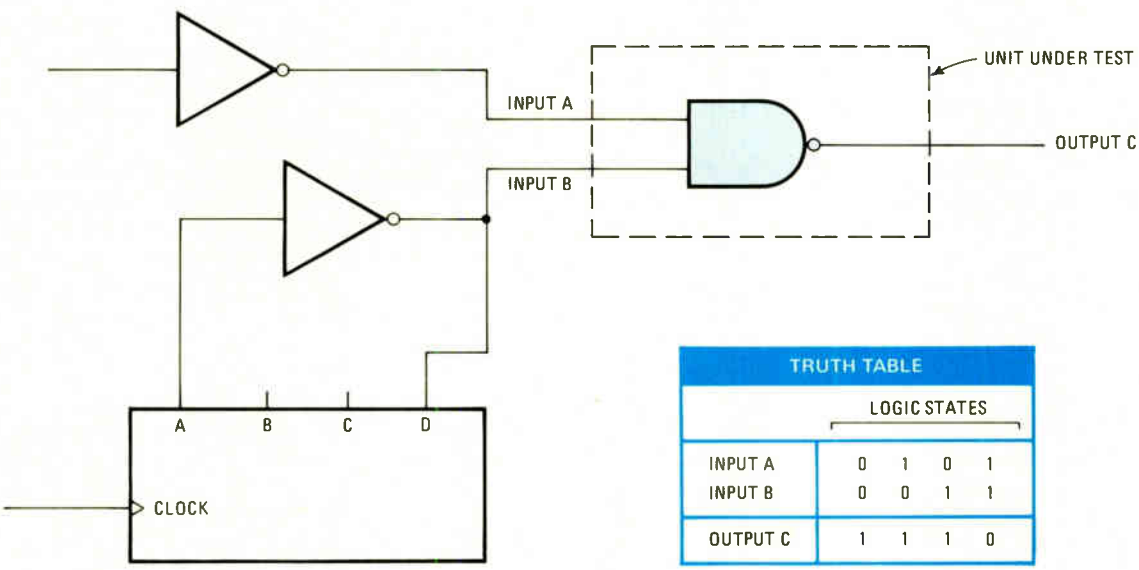
☐ One of the most cost-effective ways of testing analog printed-circuit boards is in-circuit testing. But boards that include large-scale digital integrated circuits like memories and microprocessors are beyond the capabilities of present-day in-circuit testers, which can at best do limited isolated testing of medium-scale digital ICs.

One solution is to adapt signature analysis, a technique originally developed for functional testing of arrays of LSI devices, to use with individual LSI devices. In combination with some of the older analog techniques, this approach yields a new in-circuit tester capable of checking out everything on a board from LSI devices through discrete components to the printed wiring. Yet programming is much simpler than for the alternative, functional board testing. Moreover, program execution time is short, making the instrument suitable for high-volume testing.

Like all other in-circuit test systems, the new instrument tests components, not circuits, treating a loaded board as a set of discrete unrelated devices. It gains access to them through a bed of nails, a fixture that forces an array of spring-loaded pins directly against the plated conductors and lands of the pc board. Also, because most components are interconnected, it isolates each component from its neighbors during measurement.

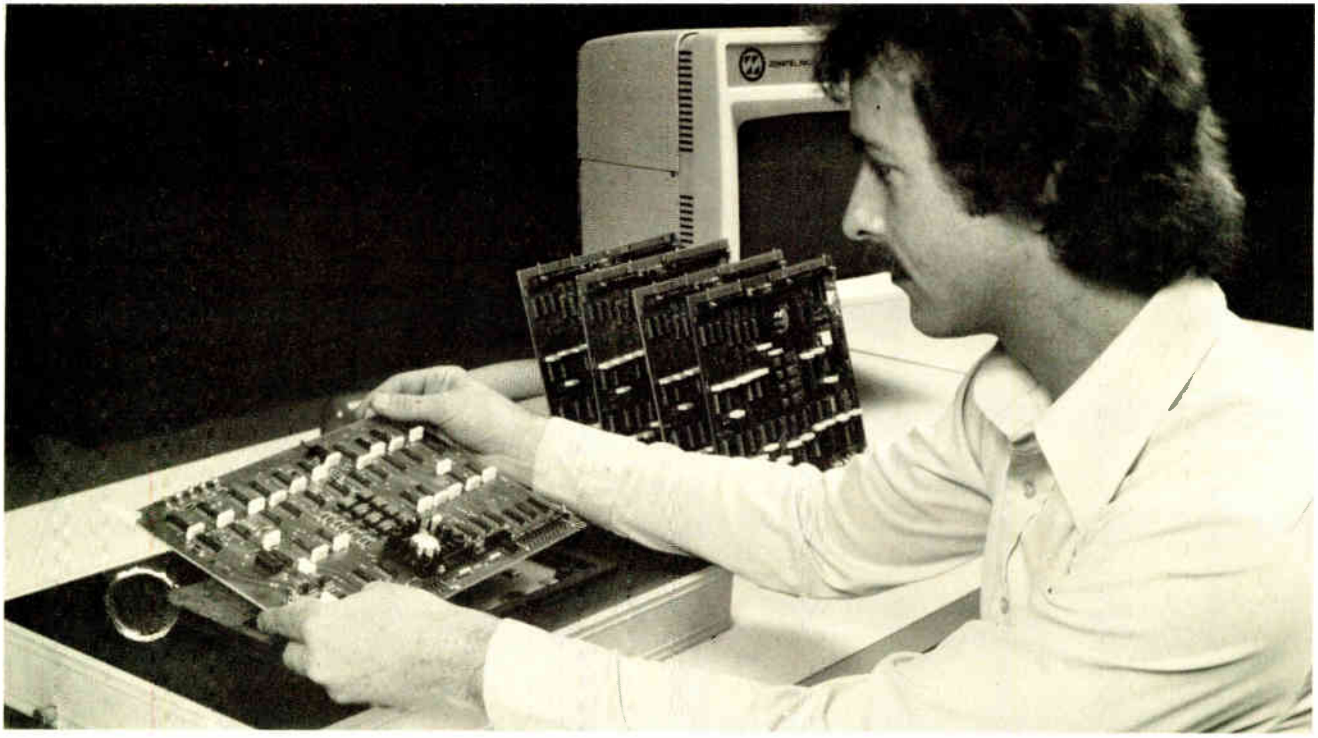
For this purpose, the early digital in-circuit testers used a brief, low-impedance logic stimulus to the IC under test, to keep upstream logic states from affecting it. They then tested the IC by driving its inputs high or low and checking its output for compliance with the pertinent truth table. Such a state-by-state analysis is shown for a NAND gate in Fig. 1. The circuitry for measuring the output was designed to synchronize with the input stimuli, so that it sampled the output state during a short stimulus and measurement interval (typically less than 1 millisecond).

However, the number of states in a truth table soon climbs above 10 with LSI devices, and once that happens, test programs become so unwieldy that test coverage has to be compromised. Moreover, a short, single-state input stimulus cannot easily test sequential LSI circuits with their complex synchronous and asynchronous input state



TRUTH TABLE	LOGIC STATES			
INPUT A	0	1	0	1
INPUT B	0	0	1	1
OUTPUT C	1	1	1	0

1. Digital isolation. In early digital in-circuit testing, each digital device was electrically isolated and then checked state by state. On this NAND gate, for example, inputs A and B would be driven to various logic states to check compliance of output with NAND truth table.



2. Coping with LSI. The Zehntel TS800 employs low-impedance drive for device isolation, coherent stimuli to excite device inputs, and signature analysis to detect faulty LSI devices. The system is also capable of conventional analog in-circuit testing.

requirements. Some more comprehensive but simpler-to-apply method of LSI inspection was called for, and time-domain stimulus and measurement—the compression of input and output information—provides the answer that is needed.

Comprehensive in-circuit testing

The instrument in Fig. 2 checks everything from shorts to chips. It begins by testing for faulty interconnections, proceeds to the analog components, and finally attacks the digital buses and chips (Fig. 3). For this last step it combines three techniques, first isolating each device by applying a low-impedance drive to it, then applying a set of coherent, time-varying stimuli to its inputs, and finally checking the output bit stream for agreement with the expected response (signature analysis). Truth table testing is complete yet, being done in the time domain, requires far fewer programming statements and hence much shorter programs than when done in the logic-state domain.

How coherent, parallel input stimuli interact with signature analysis is explained by Fig. 4a, which shows the same NAND gate as Fig. 1. Once again, all possible combinations of inputs are applied in sequence to the gate. But each output is not checked individually against the truth table. Instead, the entire set of outputs emerges in the form of a logic waveform that is a strict function of the input sequence.

In Fig. 4a, signal F_2 operates input B at half the frequency of signal F_1 operating input A. Both F_1 and F_2 derive from low-impedance sources, so that the input states normally created by upstream devices will be overridden. The phase and frequency relationship of the stimuli create a parallel input pattern that transmits all possible combinatorial states. (It is of no consequence if some patterns occur more than once.) To ensure that all the states in the truth table of the device are executed, the test interval must extend over at least one full cycle of the lowest-frequency stimulus signal. The resulting data bit stream is sampled at the output of the device under test and fed back to a signature-generating circuit in the test system for transformation into a four-digit signature unique to the device.

(The technique is sometimes called a cyclic redundancy check (CRC). It has been used extensively for detecting data errors in magnetic-tape and disk equipment and more recently in field service test instruments intended for digital systems.)

Since the measurement interval and stimulus pattern are exactly the same from board to board, a defective IC does not yield the same signature as a good device. Because just one IC is tested at a time, fault diagnosis is certain and immediate.

The program statement required to execute the complete test discussed above is shown in Fig. 4b. First the reference designation, the device type, and the output pin are named. Then the pin numbers at which the input stimuli were applied and the frequencies of these stimuli are listed. The last line is the signature expected at the output node and obtained earlier from a known good IC. In the event of a mismatch, the system identifies the defective IC by printing out its reference designation.

Thus, the programming effort involved in signature analysis is minimal. What is most significant is that a valid and rigorous test can be programmed without the need either to manually program each input state or to analyze each output state of a complex circuit.

The technique can also identify precisely which line of a multiple-line bus is stuck. However, to determine which IC is "hanging up" the node requires use of a manually operated current probe. In the case of a sequential circuit, the test programmer must understand the timing relationships of the device—its functional specification—so that he can decide if and when certain inputs should be defeated and which outputs should be monitored for proper response.

A vital issue is the thoroughness of a test, a particularly challenging consideration in relation to LSI testing. Here in-circuit digital inspection resembles the more traditional card-edge functional test techniques since in both cases, the correlation of test coverage with the detection of failure modes is generally performed empirically. Results to date indicate that a programmer using this technique of LSI inspection needs very few instructions to construct a test program that will yield a test confidence level exceeding 90%.

Applying in-circuit digital testing

The in-circuit digital technique just described can be applied to both combinatorial and sequential types of logic circuits, including decoders, counters, shift registers, universal asynchronous receiver/transmitters, random-access and read-only memories, and direct memory access chips, as well as microprocessors.

As an example, Fig. 5 pictures an inspection test for a 256-by-4-bit programmable read-only memory (PROM). Coherent stimuli, labeled F_1 through F_8, are applied as inputs to the address lines. Since each frequency is half the frequency of the previous one, all the PROM addresses will be exercised if the test duration equals or exceeds the periods (1/F) of the lowest frequency (in this case, F_8).

Static logic levels are applied to the chip-enable inputs CE_1 and CE_2, respectively. All other logic devices with outputs connected in common to the outputs of the device under test (the bus) have been previously disabled. Outputs O_1, O_2, O_3, and O_4 are monitored for consistent signatures.

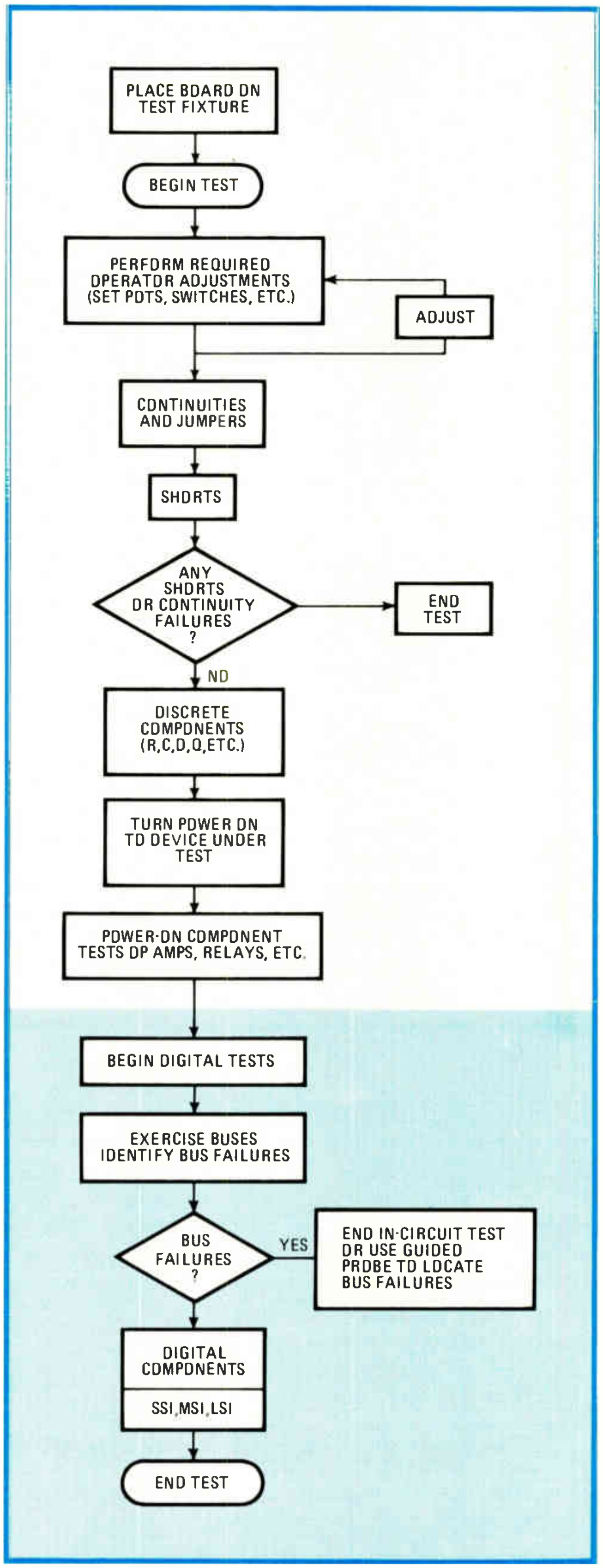
In practice, the in-circuit test system would apply the stimulus bit stream to the PROM on a known good board, sample the output bit stream, generate a signature, and store it in memory as a characterization of a good PROM. The output bit pattern and consequently the signature, of a good PROM is determined by the program stored within the IC. If because of an engineering change or for some other reason the PROM program is modified, it is a simple task for the in-circuit test system to generate and store the new signature.

Dealing sequentially

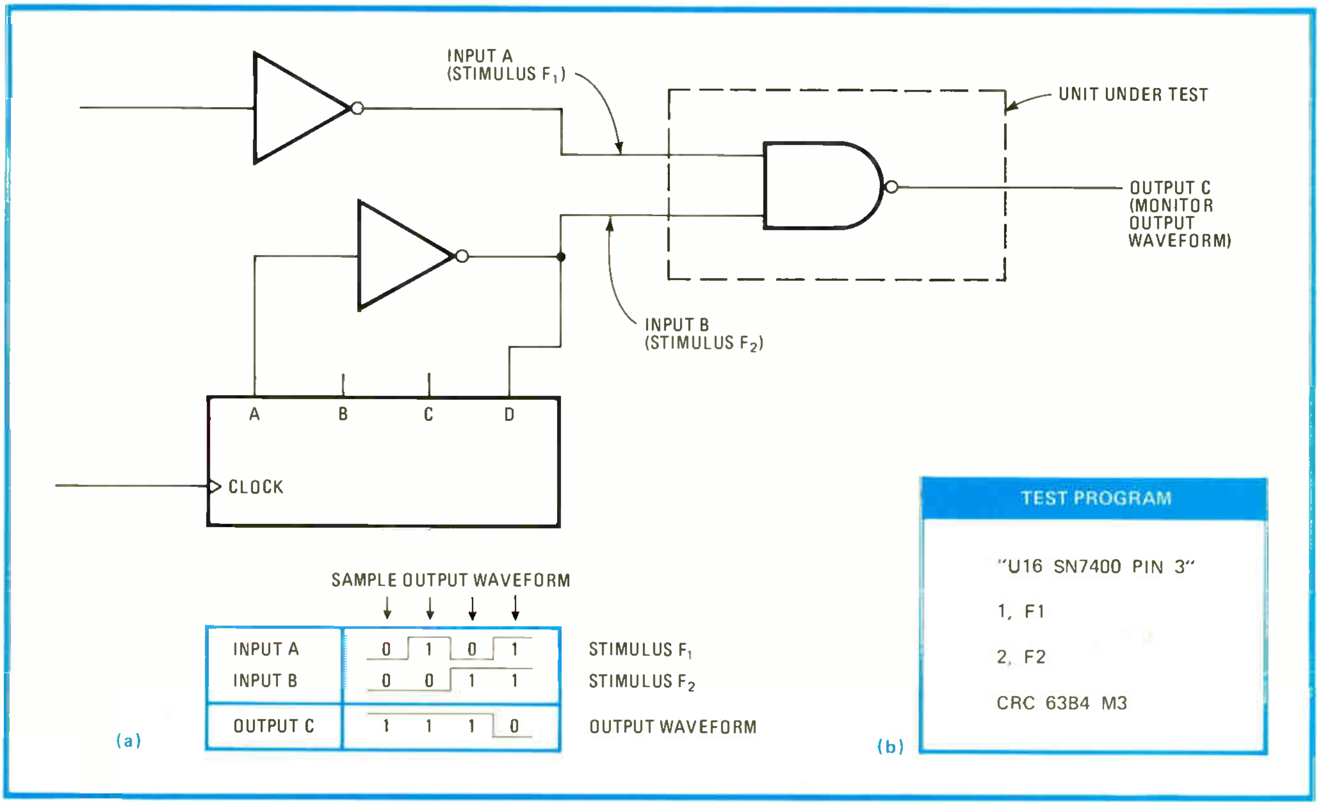
Though the technique of signature analysis does away with the need for a state-by-state analysis of combinatorial devices like PROMs, the programmer does need an understanding of the functional characteristics of complex sequential circuits like microprocessors.

An LSI device such as a microprocessor requires a defined sequence of stimuli at appropriate inputs in order to be tested properly. An in-circuit test system cannot totally exercise all the states of such a device, but it should be able to interface with the inputs and outputs and exercise the IC through enough logical states to yield a high level of confidence that the device is operating in the way it should be.

Since tests must be performed that cause a change at the output pins of the device, altering internal combinatorial states such as occur in incrementing a microprocessor accumulator is not productive. It is better to execute two instructions in its instruction set that will



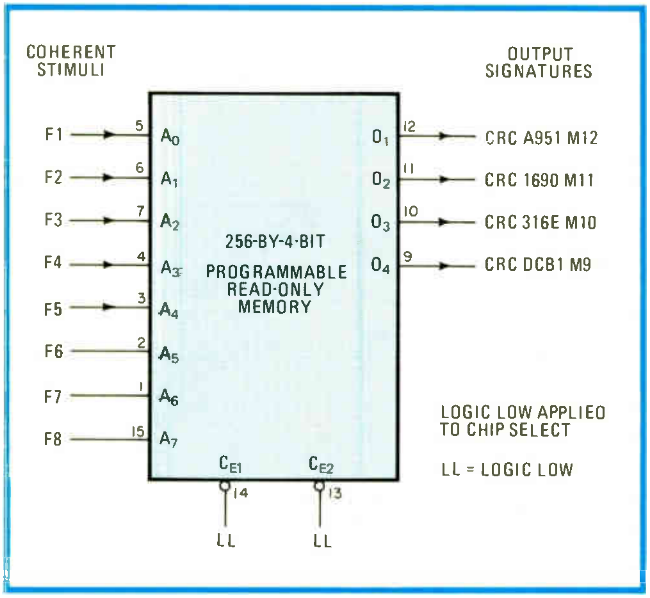
3. Test flow. In testing a typical board carrying both analog and digital circuitry, the in-circuit system first checks for shorts and opens in the wiring, then inspects nondigital components for proper placement and operation, and lastly begins exercising the digital elements.



4. NAND test. Waveforms representing all combinations of logic states are fed into pins 1 and 2 of NAND gate by middle two lines of program, which then checks output at pin 3 against correct signature in fourth line. If gate is faulty, first line of program prints out, identifying culprit.

enable the in-circuit test system to monitor the data, address, and status lines for valid responses.

Clock, reset, and other control inputs are applied to synchronize the IC under test to the test system. Then the instruction NO-OP is applied to the data bus, and the address bus and various status outputs are monitored for the expected signatures. This single operation exercises the microprocessor's instruction decoder, program counter, address register, refresh counter, and various status control logic lines. Next, the HALT, or HALT-INTERRUPT, instruction is used to check the basic input/output registers and controls and also to exercise the jump and halt logic. In this test, the data bus first receives the instruction input and then provides the program counter contents (0001) so the bus can be read as data output.



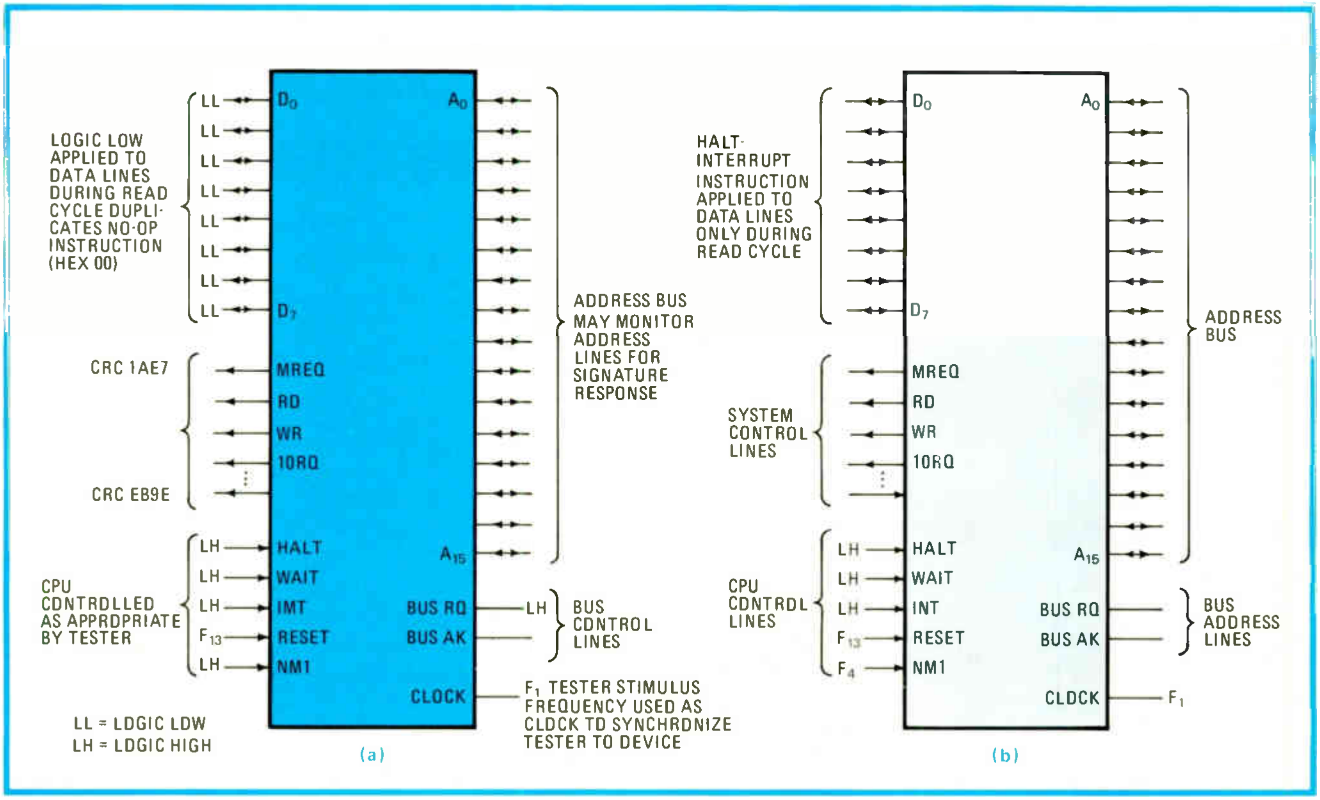
5. PROM test. Because the coherent stimuli, F_1 through F_8, of this 256-by-4-bit programmable read-only memory have powers-of-two relationship, all memory addresses are accessed so long as the test interval is at least equal to the period of the lowest stimulus, (F_8).

The NO-OP test for a typical microprocessor is illustrated in Fig. 6a. Note the simplicity of the programming steps. F_1, the highest frequency, is the clock input. F_{13}, a lower frequency, initializes the microprocessor. The NO-OP instruction is produced by writing static logic lows (LL) onto the data bus. The microprocessor executes its entire NO-OP cycle once reset has duly been accomplished.

Figure 6b illustrates a typical HALT/INTERRUPT TEST. It resembles the NO-OP test except that a hexadecimal instruction is placed on the data bus to initiate the half cycle. The test system makes it possible to disconnect the stimuli at any time except during the read cycle. Here, multiplexing allows stimulation and measurement of bidirectional lines.

A DMA example

The Intel 8257 programmable direct memory access (DMA) controller is typical of the class of smart peripheral chips now appearing on printed-wiring boards. Designed to simplify and speed the transfer of data between memory and peripherals in microcomputer systems, it supervises the transfer of data between peripheral chips and memory, controls system buses



6. Testing one, two . . . Signature analysis can be applied to sequential circuits like microprocessors, on which it can carry out both a NO-OP test (a) and a HALT/INTERRUPT test (b). Output lines are monitored for conformity of test results with expected signatures.

when needed, and resolves the priority requests of external peripherals.

Before the operation of the DMA controller can be observed, it must be preconditioned. (The 8257 is a four-port device; each port undergoes identical tests.) To precondition port 0, it is necessary to:

- Reset the DMA chip.
- Ensure the chip to be in the slave (not selected) mode.
- Program the terminal count of port 0 (this takes 2 bytes, the memory block size).
- Program the beginning memory address of port 0 (also 2 bytes).
- Program the mode register to enable port 0 (1 byte).

When preconditioning is complete, the controller is given control of the address bus by being placed in master mode ($\overline{CS}$). It is then sent a DMA request (DRQ_0) so as to begin the transfer operation. During actual DMA operation its various outputs are monitored for a characteristic signature.

Test setup and execution

In the case of the 8257, terminal count, block size, and beginning memory address data are determined by the byte present on the data bus (D_0 to D_7). The port and corresponding functional information are specified by the current address present at A_0 to A_3. Data is latched by clock transitions at input/output write ($\overline{I/OW}$).

For the test of port 0, 2 bytes must be loaded for the terminal count, 2 bytes for the starting address, and 1 byte for the mode set. By choosing appropriate coherent stimuli from the tester and applying them to A_1, A_2, and A_3, all the programming addresses required for port 0 are produced. A higher-frequency stimulus is chosen for $\overline{I/OW}$ to produce strobes to latch the required number of bytes at each address. A data word is presented synchronously by the tester at D_0 to D_7 to load the desired information at each program state.

Once programming is complete, a low-frequency stimulus places the controller in the master state ($\overline{CS}$ high). Following this, the DMA request line (DMARQ) is taken high and DMA operation begins.

Any output may be monitored for transitions and a characteristic signature acquired for comparison with a signature obtained from a known good chip. The outputs of interest include: address bus (A_7); memory read ($\overline{MEMR}$); memory write ($\overline{MEMW}$); hold request (HRQ); and address strobe ($\overline{ADSTB}$).

In-circuit versus functional testing

An in-circuit test system with the digital capability described above is quite new, while digital card-edge functional test systems that interface at the card edge are well entrenched today. Is there room for both in the automated test equipment market?

The ability of in-circuit testing to test at the throw-away component level and the relative ease with which it can be programmed are undoubted advantages, particularly for high-voltage applications. Moreover, as LSI devices increase in complexity, modeling their functions will become a more formidable and hence more costly task. Simple programming, plus its simple one-device-at-a-time test strategy, would suggest in-circuit digital testing holds promise for years to come as a highly cost-effective production test technique. □

Cellular system expands number of mobile-phone channels

Dividing an area into hexagonal units allows simultaneous multiple use of frequencies; LSI and stored-program control make the system practical

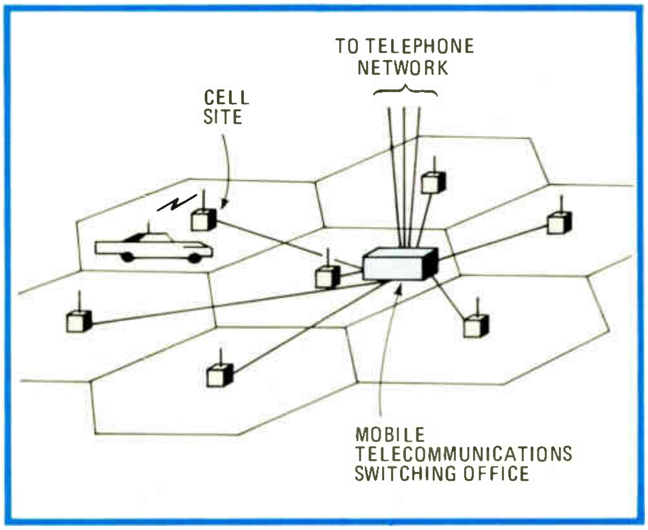
by Harvey J. Hindin, *Communications & Microwave Editor*

☐ Most people take telephone calls for granted, and it is reasonable for them to do so, given the quality of the system as it now exists. Yet there is an exception: anyone trying to make even a local call from a phone in an automobile will soon discover that it is very difficult to get a clear channel.

There are too many users on any one channel because there is not enough spectrum space to accommodate all the people who are currently using the service. Add to that the many thousands who are on the waiting lists and it is obvious why a new aproach to the problem is needed. Bell Laboratories' answer is the Advanced Mobile Phone Service, called AMPS.

The old way

Today's mobile systems use a single, high-powered base station to serve an entire city—much like television stations. Only one telephone call can be handled on each mobile channel at a time, and the channels cannot be used in nearby cities because the powerful signals would interfere with each other. The minimum distance for multiple simultaneous use of a channel is on the order of 75 miles, and therefore a maximum of only 25 channels is available in some 5,000 square miles.



1. Cells. Through frequency reuse, a cellular mobile-telephone system in one coverage area can handle many more calls simultaneously than the number of allocated frequency channels. A hexagonal cell is the most efficient, requiring the fewest transmitter sites.

This very limited number of channels makes large-scale service impractical. For example, in New York City only about 700 customers can be handled, and they experience relatively poor service because of the difficulty in obtaining an idle channel. In fact, the chance of completing a call on the first attempt is well under 50%.

Dividing it up

To overcome this problem, Bell Laboratories engineers decided on the so-called cellular approach. Instead of using only one high-powered transmitter near the center of a city to serve all mobile units in the area, they divided an area into units, called cells, each with its own low-power transmitter.

In the Advanced Mobile Phone Service, each cell is served by a receiver and a control system, located at a "cell site," or base station, as well as by a transmitter (Fig. 1). Every cell is allocated a set of frequencies, with neighboring cells assigned different frequencies to avoid interference. Cells sufficiently far apart, however, can use the same frequencies simultaneously—allowing reuse of each channel for different conversations many times in a given service area.

The cellular approach eliminates the need for high-powered radio transmission by carrying the conversation over regular telephone lines to a cell site near the mobile customer. The cell site then completes the call by means of radio transmission that covers only a small area in which the vehicle is traveling.

Each cell serves mobile customers when their vehicles are within that cell. As a vehicle moves to another cell, the call is transferred, or "handed off," to another cell site. This automatic transfer maintains service quality throughout the conversation and in most cases is not noticeable to customers.

Because radio transmissions coming from cell sites closer to the mobile unit override weaker signals originating in more distant cells, a channel that carries a conversation in one cell can be used several cells away to carry another conversation. As a result, radio channels can be used simultaneously 20 or more times in a large urban area.

Also, as the demand for service increases, the capacity of the system can be increased through "cell splitting"—adding new cell sites by subdividing existing cells to form

AMPS: What happened, when

1930s, early 1940s	Early development work begins on mobile service, proceeds through testing and trial stages
1946	First commercial mobile service introduced in St. Louis
1950s, 1960s	Mobile service expands nationwide, becomes comparable operationally to regular service but does not compare favorably with quality of regular service; Bell Laboratories begins effort to develop new and better mobile systems
1968	Federal Communications Commission opens Docket No. 18262, focuses attention on mobile service, seeks more efficient systems
1970	FCC conducts extensive investigation of mobile service, finds need to expand and improve service, invites proposals from telecommunications industry on new mobile system
1971	In response to FCC invitation, Bell System files proposal for development of cellular mobile systems
1974–75	FCC allocates frequencies for cellular systems, opens field to all those interested in developing cellular systems
1975	Illinois Bell Telephone Co. files application with FCC to begin developmental test of high-capacity cellular system in Chicago area
1977	FCC grants Illinois Bell's application for Chicago test; Bell System announces it will proceed with Chicago trial; AT&T announces that Bell Labs has selected three companies to supply mobile sets for Chicago trial
1978	Installation completed at the Chicago cell sites, and hand-offs between cell sites are successfully demonstrated
1979	Tests go into final stage with favorable results expected; data to be studied and plans for future to be evaluated

a grid of smaller cells. By increasing the number of cells and hence reducing the power of the transmitters, this process provides even more channels for mobile users. Through cell splitting, several hundred thousand customers can be served in an urban area.

Although a high-capacity cellular system could theoretically have been built many years ago (see "AMPS: what happened, when"), it has taken the technology of the 1970s to make such a system economically feasible. With the significant strides in the development and use of computer-controlled call switching, plus the introduction of microelectronics, mobile cellular communication has become a reality.

System design

The cellular concept in mobile telephony involves interference-limited operation of both the mobile unit and the fixed radio equipment, in contrast to the noise-limited operation that characterizes the existing mobile service. In cellular systems, small cells using the same frequencies are situated as close to one another as is permitted by a probabilistically tolerable level of cochannel interference.

Channel reassignment, which is invoked, as noted, when a car with a mobile telephone moves from one cell to another, is initiated under program control in the fixed equipment—the mobile telecommunications switching office (MTSO), and the cell sites. The switching office is the AMPS controller. The cell sites contain the fixed radio equipment and logic equipment that interface the mobile telephones with the MTSO.

Channel reassignment is implemented by a command originating at the MTSO and transmitted by the appropriate cell sites. This produces a response from the mobile equipment resulting in a reconfiguration of the mobile unit for operation on a new radio channel. Reswitching in the MTSO is also required to connect the land party to the fixed equipment in the new cell.

Preceding, during, and following the actual voice conversation, analysis and signaling are required to set up the call, hand off the channel, and terminate the call, respectively. Continuous call supervision is necessary to ensure high voice quality and to determine when hand-off is needed. Also, the fixed equipment is continuously monitored to detect problems. When failures are detected, the equipment is reconfigured to bypass the fault. The mobile and land parties are unaware of all these processes.

The AMPS concept, which has been subjected to testing in a coverage area of about 2,000 square miles in greater Chicago (see "AMPS: what's happening now"), is made possible by the Federal Communications Commission's assignment in 1971 of a 40-megahertz band at about 850 MHz for common carrier use.

Making it work

With the 40-MHz band, several hundred channels are available, and the reuse concept multiplies by many times the effective number of channels. In fact, the number of channels in each cell is large enough so that the per-cell trunking efficiency—the ratio of the number of messages carried to the number of channels available—is also high. The result is a large potential number of customers—anticipated to be as much as several hundred thousand in the large cities.

But perhaps more important, the revolution in integrated circuits has made possible low-cost parts to execute complicated logical processes under software control. In particular, the stored-program electronic switching system and the microprocessors in the cell site and mobile-radio equipment have not only enabled the construction of low-cost hardware, but also provided the computing power and flexibility needed to meet the service's complex control and maintenance requirements.

There are five stored-program controllers in the AMPS system (Fig. 2). These are the large processor in the

AMPS: What's happening now

The Chicago trial of the Bell System's Advanced Mobile Phone Service, or AMPS, was designed primarily to demonstrate and evaluate the technical quality of a cellular system when operating with a relatively large number of mobile-telephone sets and to assess the marketability of the new system under actual operating conditions.

It has two phases. The first, or technical, phase began last July. It involves about 100 mobile units operated by Bell System employees and is intended to confirm the technical capability of the equipment.

The second phase, or service test, began early this year. During this phase, AMPS is being marketed as if it were a regular service—with two major exceptions. First, in order to ensure that the results are truly representative, the marketing effort is addressing a randomly selected sample from all segments of the business community. Second, in compliance with restrictions set by the Federal Communications Commission, no more than 2,500 mobile units will be installed.

The Chicago AMPS system has 10 cells, each served by a separate cell site. They provide coverage of about 2,100 square miles of the metropolitan Chicago area.

The mobile telephones used in the service test have been designed to Bell Labs specifications but are supplied by three non-Bell companies. They have several unique features. For example, a user can dial the last number called at the touch of a button. The phones also have the capability of storing information, so that a call can be started at one traffic light and completed at the next. Phones are being installed in a variety of vehicles to identify any potential problems of compatibility.

A separate but related evaluation of AMPS is also under way in Newark, N. J. That evaluation uses equipment and procedures that essentially provide a laboratory environment in the field to test all the basic cellular radio plans and to provide most of the data to verify the technical feasibility of small-cell systems. However, it involves no actual customer service.

Once both the Chicago and Newark tests are complete, the data obtained will permit a comprehensive evaluation of cellular operation. If the tests are successful, a high-capacity cellular system could be introduced in the marketplace by 1980. Five years later, AMPS could be provided in some 25 major urban areas.

MTSO and four control microprocessors—one in the data link that provides the signaling path between the cell sites and the MTSO, two in the cell site, and one in the mobile telephone.

Implementing AMPS requires a step forward in software technology. Not only must the MTSO perform many of the functions that a telephone office does for land lines, but it also must provide a number of functions that are unique to AMPS.

Switching office functions

The first unique function concerns the location and hand-off process. Once established, calls are periodically supervised by a coordinated effort between programs in both the MTSO and the cell site. Under control of these programs, the former determines when a hand-off between two cells is appropriate.

The location and hand-off process is one of the key differences between the MTSO software dealing with land-line phones and that dealing with the mobile units. Typically, in a land-telephone connection, once the call has been established, it is left undisturbed unless a change is initiated by the subscriber—for example, by hanging up or flashing the switch hook. In the case of AMPS, however, the program itself may initiate changes in network configurations.

Another significant difference in the AMPS software is apparent in the process of establishing a connection between a mobile unit and another party, either fixed (land) or mobile. In the case of land-line phones, a relationship between the telephone directory number and the physical state of that line in the central office is contained in the central office's data base. Though this data base may be changed for administrative reasons or under customer control for certain custom-calling services, the relationship between the directory number and the physical location is fixed.

In the case of AMPS, however, there is obviously no physical relationship between the directory number and the physical location. Thus, the MTSO must first find the mobile phone. In many cases of land-to-mobile calls, the MTSO will not be able to locate the mobile phone because it is turned off.

Finally, a larger than usual portion of the program in the MTSO is devoted to system maintenance. Some of the maintenance programs conduct routine tests on the standby equipment in the cell site to ensure that it will function properly when needed. Others check on the progress of calls in order to detect any failures that might occur on the active equipment. Still another set of maintenance programs reconfigures the redundant, or duplicated, pieces of equipment in the cell site to isolate faulty equipment and remove it from service.

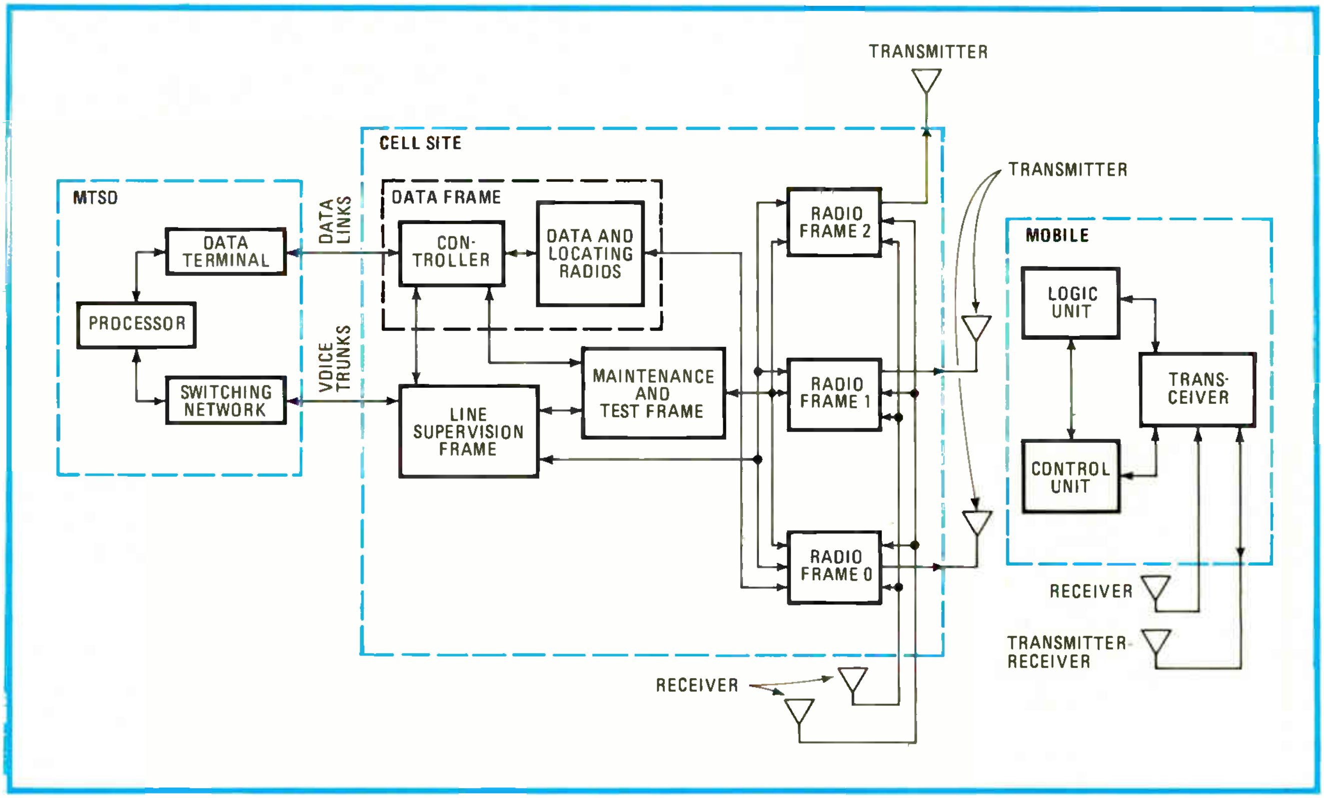
Switching

The AMPS system exploits two communications disciplines: radio transmission and switching. The radio system is based on 850-MHz frequency modulation. The switching system is based on the standard AT&T No. 1/1A electronic switching system (ESS).

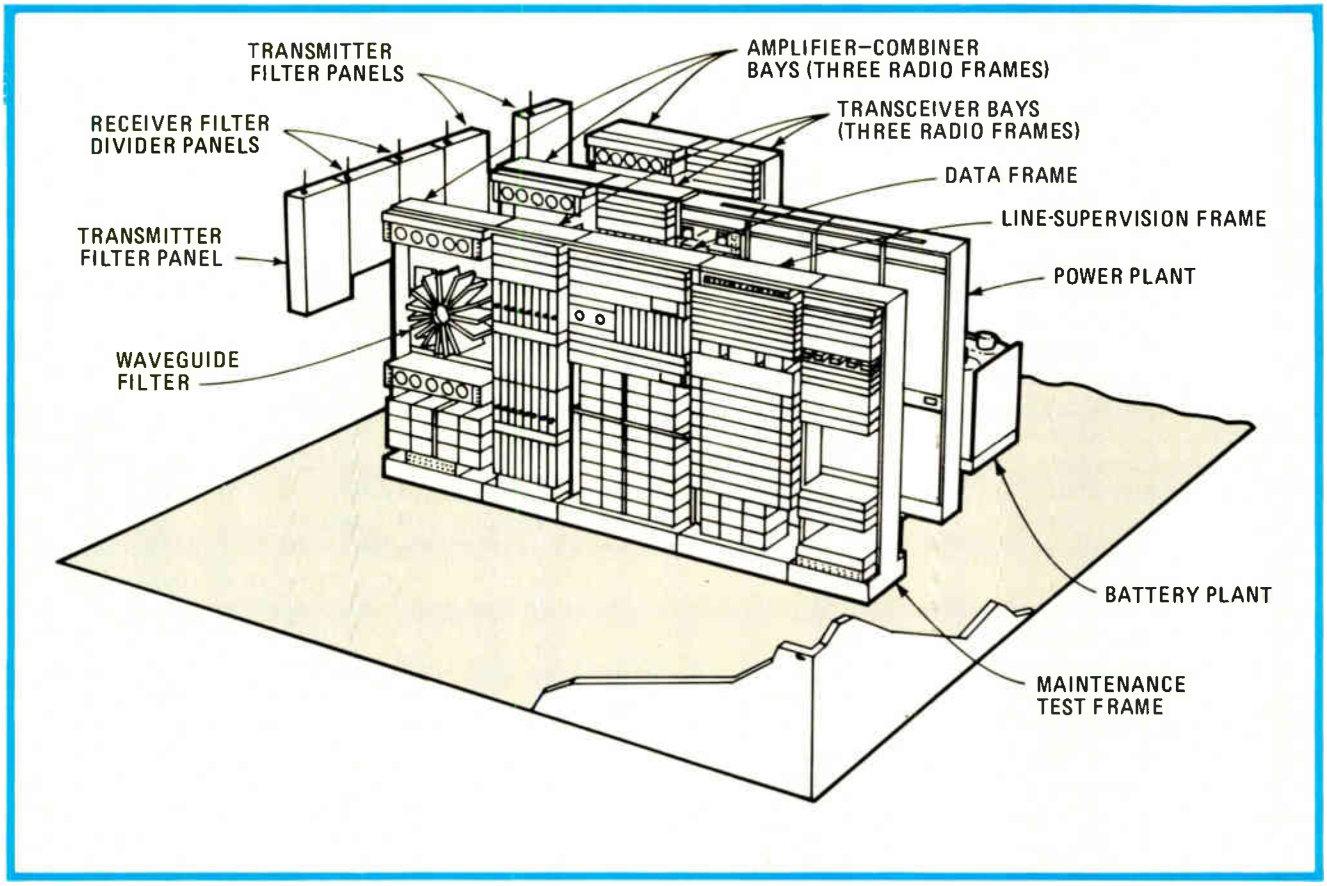
AMPS coordination is provided by the MTSO, which controls the system and interfaces it with the land-telephone network. In the Chicago test, the MTSO occupies a position in the switching hierarchy below that of a local office, to which it is connected with standard trunk facilities. The MTSO interconnection arrangement is similar to that used with a private branch exchange and it employs existing capabilities in ESS local offices.

To ensure compatibility, an MTSO is built with standard ESS hardware. For example, all logic to control mobile-telephone calls and maintain the cell-site hardware is implemented as additions to the electronic switching system's stored program.

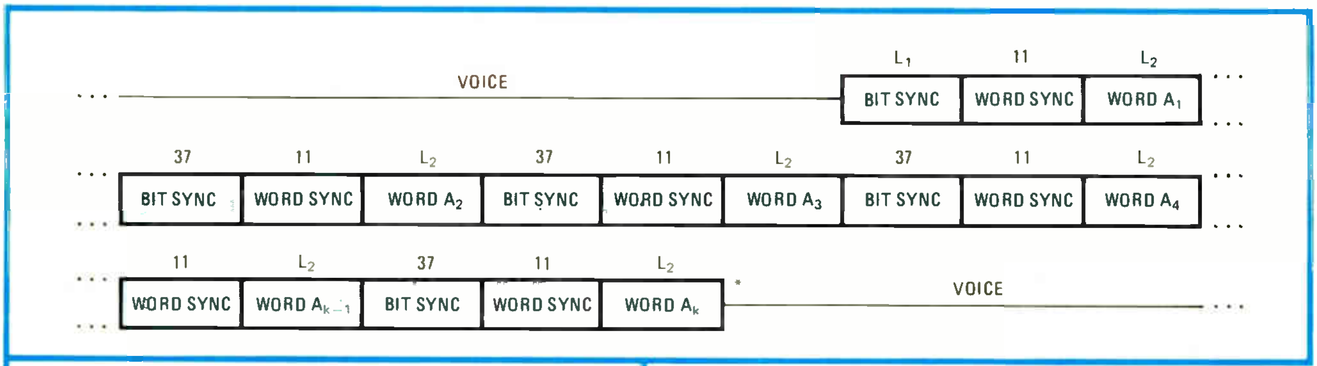
The No. 1/1A ESS itself consists of processors, memo-



2. Connections. There are three major AMPS subsystems: the mobile telephone switching office (MTSO), the cell site, and the mobile unit itself. The mobile unit is connected to the cell site by an fm radio link, and the cell site is connected to the switching office by land lines.



3. How many? The number of separate frames at each cell site is a function of the site's voice-channel requirements. Operational control of the frames is maintained by the use of both hardwired logic and programmable controllers. Many of the control functions are redundant.



Symbol	Forward direction	Reverse direction
K	11 repeats	5 repeats
L_1	100 bits	101 bits
L_2	40 bits	48 bits

* In reverse direction a second message (b) may follow word A_K.
Forward direction is from the cell site to the mobile unit.
Reverse direction is from the mobile unit to the cell site.

4. Format. Mobile-telephone control is maintained by using data streams generated during momentary voice muting. Repetition of the data message ensures that sufficient data words will be received to permit accurate decoding by the mobile unit's logic circuitry.

ry, switching network, trunk circuits, and miscellaneous service circuits organized as a common control system. It is fundamentally a dedicated computer operating under the control of its stored program.

Three types of programs are available: call processing, hardware maintenance, and administration. Call-processing programs provide the logic that controls call setup and disconnection for the wide variety of call types. The maintenance programs provide the means of recognizing hardware failures, reconfiguring the active and standby units to achieve a working system, and diagnosing suspected failures to aid in repair. Administrative programs provide a mechanism for changing the system data base, which includes customer records and billing data.

Interface

In the AMPS system, the interface between the land-telephone network and the radio paths to the mobile telephones occurs at the cell sites. As well as transmitting and receiving, the sites perform other system functions under the direction of the MTSO.

For example, cell sites search for mobile units and communicate data between the MTSO and the mobile units. They also locate the mobile units; test, control, and reconfigure equipment upon remote orders; and supervise calls. These operations are controlled by both hard-wired logic and programmable controllers.

A typical cell has a maximum of 48 voice channels. The cell site (Fig. 3) contains 16 radios in each radio rack, or frame, and each line-supervision frame can handle 48 voice channels. Only one data frame and one maintenance test frame are necessary, regardless of the number of voice radios at the site. The maximum size of a cell site is 144 voice radios, which require a total of 14 frames: 9 radio frames, 3 line-supervision frames, 1 data frame, and 1 maintenance and test frame.

Frame structure

The radial structure in the power-amplifier–combiner frame shown in Fig. 3 is a waveguide filter that combines the output of 16 transmitters onto a single coaxial cable for connection to the transmitting antenna. The adjacent radio frequency frames each have arrays of 16 transmitters and 16 receivers arranged in four rows of 8. The transmitters are connected to the filter-combiner through power amplifiers.

Most of the logic and control is concentrated in the data frame. This frame houses two microprocessors—one on line, the other redundant. Both are Western Electric Procon programmable controllers, each with a random-access memory of 4,096 24-bit words, a read-only memory of the same size, and a data memory of 2,096 18-bit words. The microprocessor buffers, reformats, and executes the requests, commands, and responses that flow by radio between the cell site and the mobile unit and between the cell site and MTSO. The programmable controllers also direct the cell-site functions, such as the exercise of cell-site diagnostic features when that is requested by the MTSO.

The line-supervision frame has the audio and data-processing circuits associated with such functions as audio companding, signaling, and supervision. It also handles injection and recovery of data bursts interpolated by brief voice interruptions. In addition, it allows the mobile unit (through data bursts on the talking path) to tune to a new channel when there is a hand-off.

The maintenance and test frame also contains a Procon programmable control microprocessor. This one has 6,144 24-bit words of program memory and 2,048 16-bit words of data memory. Commanded by the microprocessors in the data frame, it does diagnostic testing and provides the data for troubleshooting.

When a call is in progress, it must be monitored to determine when various data orders must be sent to the mobile units. These might be an order to turn off the transmitter at the termination of the call or an order following a user's request for one of the optional services

5. Who's calling? Except for some extra digits that are necessary because the customer is calling from a mobile unit, the car telephone works much the same way as an office phone. Incoming calls are perceived as beeps on a built-in loudspeaker.

like third-party connection or person-to-person calls.

Orders and service requests must be transmitted without interfering with voice conversations. Therefore they are sent in the form of binary data messages over the voice channel by momentarily muting the voice and inserting a binary data sequence. The data sequence requires approximately 0.1 second.

Data messages

The data messages over the voice channel from the cell site to the mobile unit are referred to as forward blank-and-burst; those from the mobile unit to the cell site are called reverse blank-and-burst. The forward blank-and-burst order is initiated by the MTSO, which sends an appropriate message over the data link to the controller in the cell site. The controller then sends the required message to the voice transmitter data interface. This is done with a single 40-bit serial word that is sent at 10 kilobits per second to the voice radio transmitter by way of an electronically switched connection in the line-supervision frame.

The data word (Fig. 4) is preceded with the bit and word synchronization coding signal. This grouping of bit sync, word sync, and 40-bit data word is repeated 11 times before the channel is restored to the voice mode. This repetition ensures a sufficient number of properly received words to permit accurate decoding by the mobile unit's logic circuitry.

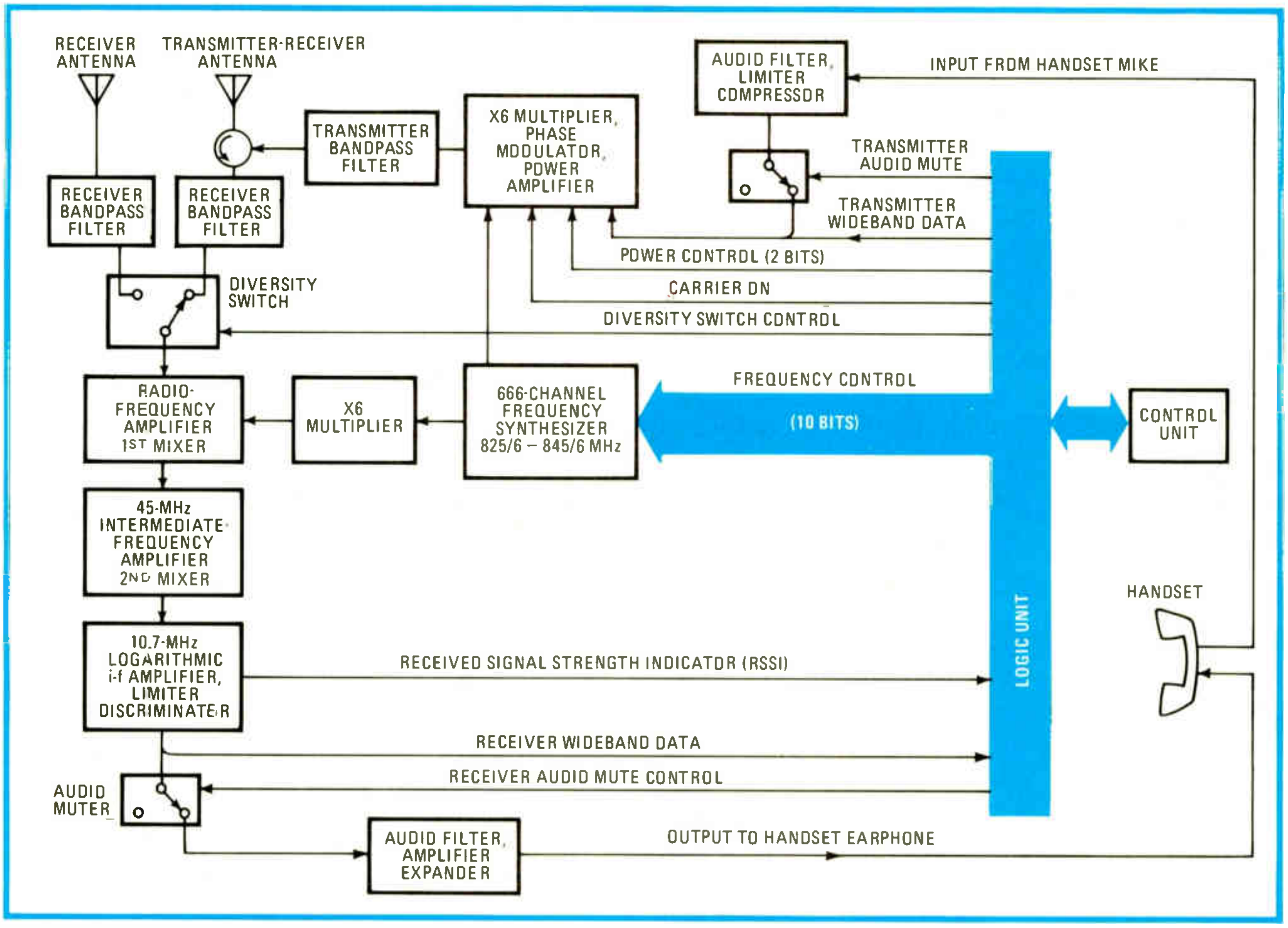
The reverse blank-and-burst message format consists of 101 bits of bit sync, 11 bits of word sync, and 48 bits of message data, of which 36 are information bits and 12 are error-detecting and -correcting bits. This grouping is repeated five times.

The subscriber's mobile-telephone equipment consists of three basic elements: a control unit, a transceiver, and a logic unit. The control unit is the subscriber's primary contact with the AMPS system and is mounted in the car's passenger compartment. It serves as the required physical interface between the customer and the telephone network, by means of a handset for conversation, a push-button keypad for entering commands into the telephone network, and signal lamps and/or acoustic tones for alerting the customer.

Making the call

When the subscriber presses a numbered push button on the control unit (Fig. 5) during dialing, the decimal digit is converted to a 4-bit binary number stored in a 64-bit recirculating shift register in the handset. Then the "dialed" digits, circulating through the shift register, drive a time-multiplexed, seven-segment, seven-digit fluorescent display. When the user presses the send key to originate a call, the logic unit reads the recirculating shift register serially and stores the digits in the microprocessor's RAM.

The transceiver unit (Fig. 6) is generally mounted in



6. Synthesizer. The key to mobile-telephone transceiver operation in the AMPS system is the use of a frequency synthesizer to generate any of 666 stabile radio-frequency carriers on digital command of the logic unit. Thus the probability of getting a clear channel is very high.

the car's trunk. Basically, it is a solid-state fm full-duplex, 850-MHz radio. It operates over 666 channels over the 825-to-845-MHz transmission band and the 870-to-890-MHz reception band, with 45-MHz duplex-channel spacing. The transmitter provides 12 watts of output power at the antenna port, sending either phase-modulated audio signals or frequency-modulated data. The receiver amplifies and demodulates selected signals from the diversity antennas and supplies the voice output to the control unit and the data output to the logic unit for decoding.

On command from the cell site, the AMPS transceiver must generate any one of 666 stable radio-frequency channels. To do so requires a frequency synthesizer, which generates the carriers as commanded by the logic unit. Each carrier is located in the 140-MHz region. (They are later multiplied by six to operate in the 850-MHz region). A portion of the synthesizer power output is phase-modulated with the audio signal from the telephone handset or frequency-modulated with wideband data from the logic unit. As noted, it is then multiplied in frequency six times and amplified in power to 12 W by a transistorized modulator-multiplier-amplifier chain. After being filtered for harmonic and spurious signals by a seven-stage 825-to-845-MHz transmission bandpass filter, the signal is sent by way of a vertically polarized antenna.

The logic unit functions as a master control for the mobile telephone. It also encodes and decodes the wideband digital information transmitted between the cell site and the mobile unit. The digital section of the logic performs all necessary operations required to actually process a call. A stored-program controller based on a 8-bit microprocessor is used because of the complexity of these operations.

Controller

The microprocessor is an Intel 8080. This is an 8-bit parallel central processing unit driven by a 2-MHz, two-phase clock. It has a 16-bit address bus (only 13 bits used) and an 8-bit bidirectional data bus, which it uses on a time-shared basis to communicate with memories and input/output circuits. The microprocessor also periodically provides an 8-bit status word employed by the CPU to develop signals for all the peripheral circuits.

The CPU has an interrupt control line that is held at logic 0 for normal program flow. A peripheral device may at any time request service from the CPU by simply applying a logic 1 on this line.

The total memory is contained within a 4-kilobyte programmable ROM (four 1-kilobyte ultraviolet-light–erasable Intel 2708s) for main program storage and a 256-byte RAM (two 256-by-4-bit Intel 5101s) for temporary storage. □

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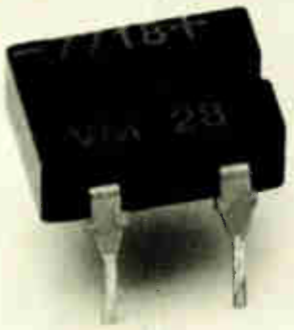

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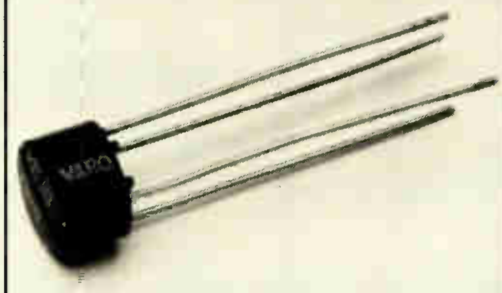

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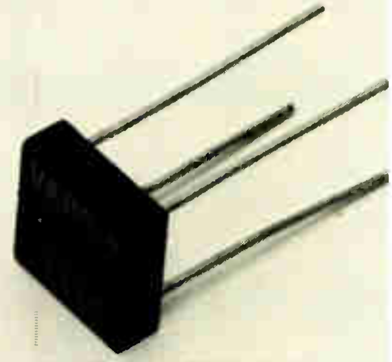

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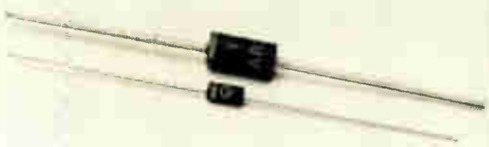

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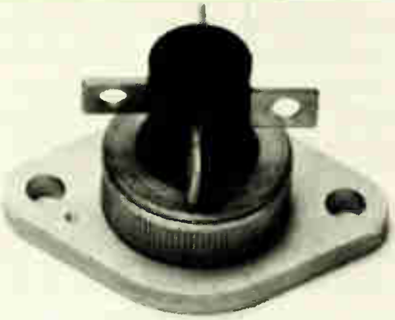

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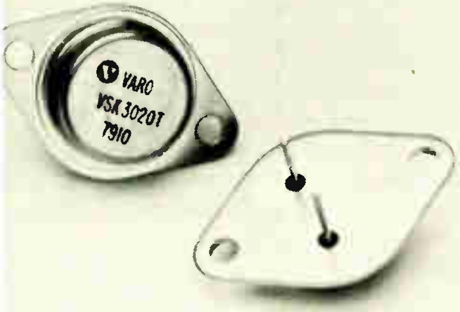

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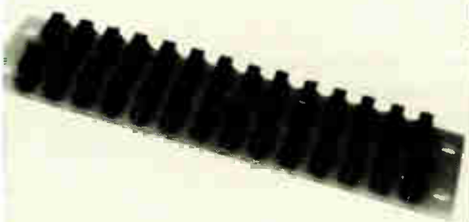

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Circle 167 on reader service card

Phase-locked loop aids in measuring capacitance

by Ronald E. Pyle
Tracor Inc., Austin, Texas

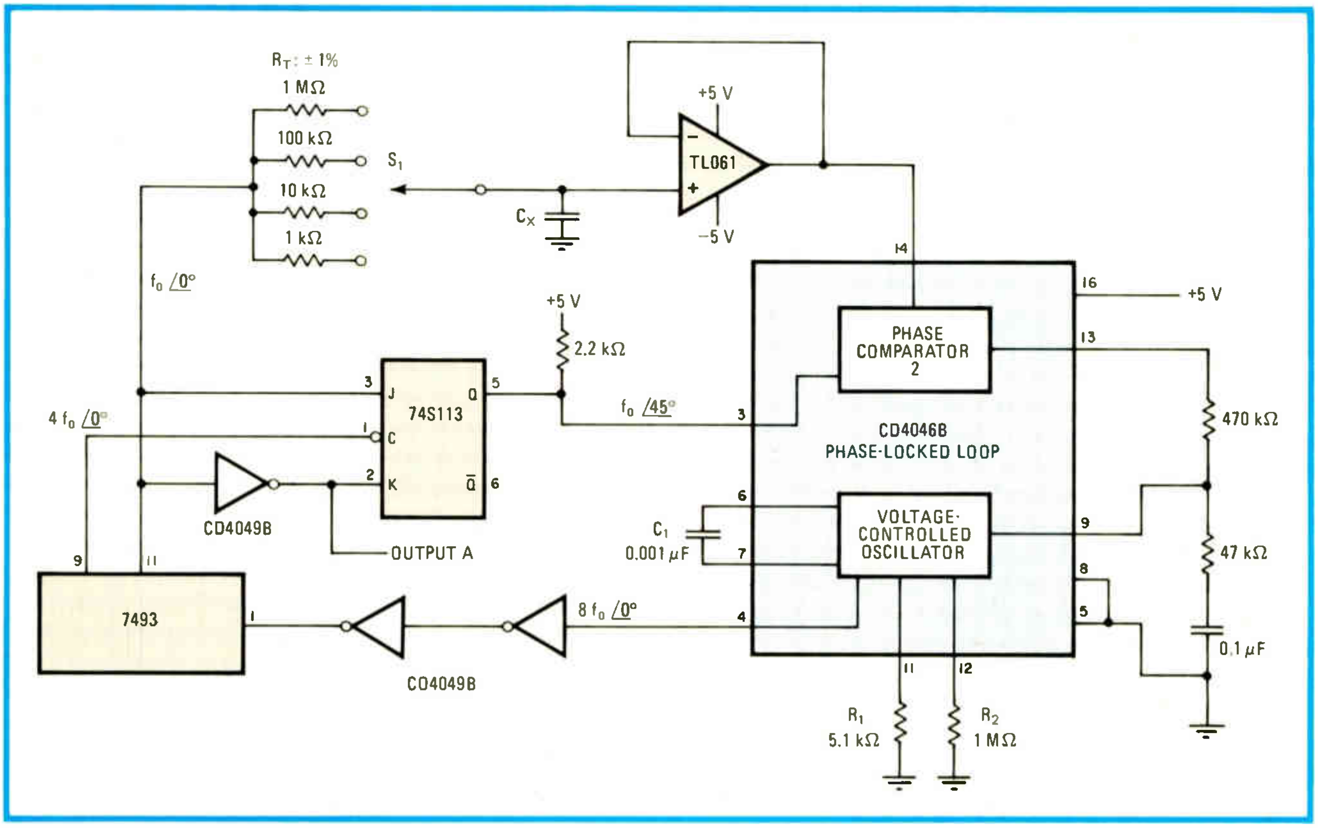
In this circuit, a phase-locked loop (PLL) aids in measuring an unknown capacitance to within 1% of its true value, over the range of approximately 10 picofarads to 1 microfarad.

As the figure shows, the unknown capacitance, C_x, is part of low-pass filter R_TC_x. The filter's output serves as one input to the PLL's phase comparator, the other input being derived from the loop's voltage-controlled oscillator (VCO). Circuit operation is based on the principle that the phase lag at the filter's output is 45° at f_o, the filter's center frequency. The PLL thus acts to generate a frequency having a 45° lag on the other port of its phase comparator, locking the loop. The output frequency of the oscillator at locking represents an index of the capacitance measured.

The output frequency of the VCO in the CD4046B PLL passes through a buffer and is divided by 2 and 8 by the 7493 4-bit counter. These signals are next routed to the 74S113 J-K flip-flop, which generates a wave shifted 45° with respect to the input signal on the J port.

The flip-flop's output is then compared with the filter's output signal at phase comparator 2 of the 4046B. This comparator is an edge-controlled network that indicates 0° phase difference between the input test signal and the VCO-derived signal, when locking is achieved. The 4046's locking and capture range is approximately two decades, which is what makes it possible to measure the wide range of capacitances mentioned above. Suitable selection of R_1 and C_1 extends the measurement range still further.

A frequency counter measures the output of the circuit in the locked condition as $f_o = 1/2\pi R_TC_X$. From this the unknown capacitance can readily be determined. Look-up capacitance tables plotted as a function of f_o and R_T can be readily constructed for rapid checking. Alternatively, extra hardware may be added to convert the frequency into a capacitance value directly, thus forming a self-contained digital capacitance meter. □



Filtering an answer. A phase-locked loop finds the center frequency, f_o, of low-pass filter R_TC_X, thus enabling determination of test capacitance C_X, from $f_o = \pi R_TC_X$. The VCO derives an output whose phase lag matches that of the lag at the filter output at the PLL's comparator, so that locked state is achieved. The VCO output, f_o, thus represents an index of the capacitance measured.

LED dot/bar driver simplifies solid-state scope

by Forrest M. Mims III
San Marcos, Texas

The design of this solid-state scope is simplified by use of a one-chip driver to address the rows of the light-emitting-diode matrix comprising the scope's display. The circuit is a viable alternative to a scope that has previously been described.[1]

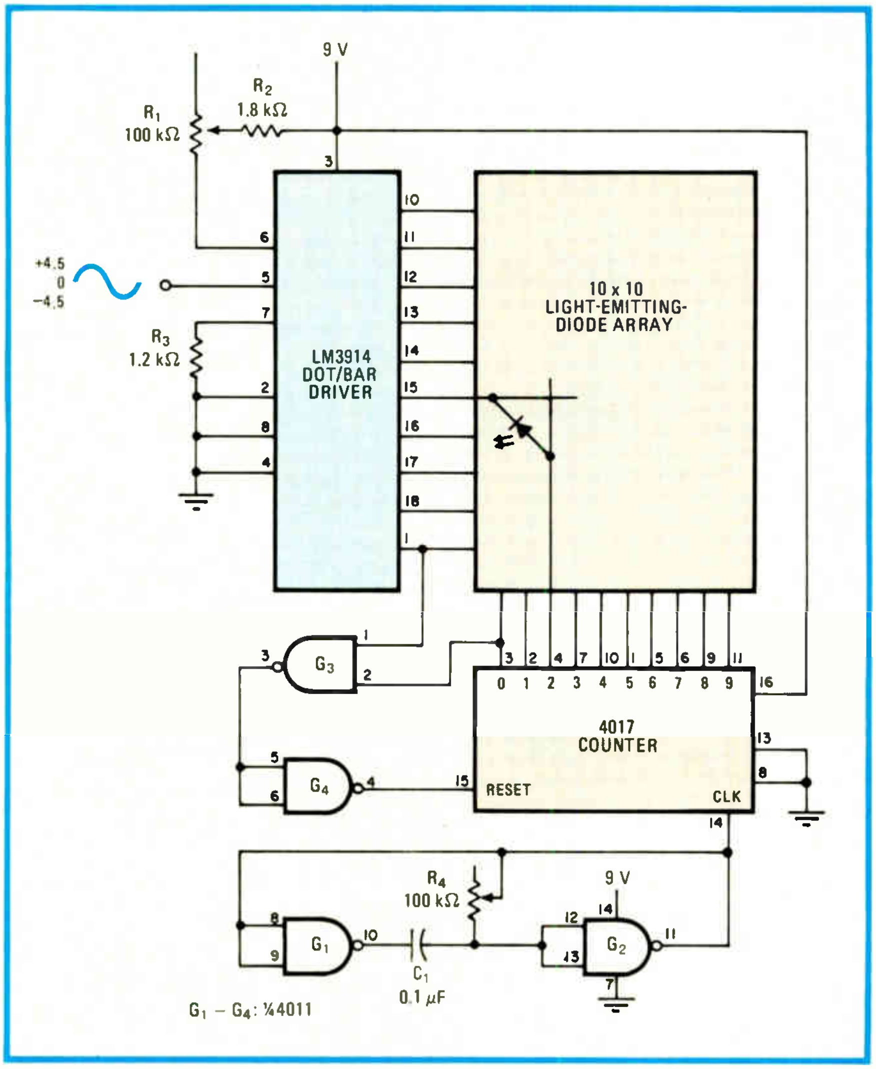
The unit will handle input signals in the audio-frequency range. Signals to be displayed are applied to pin 5 of the National LM3914 dot/bar driver and resolved to one of ten active-low output levels. Note that R_3 provides a programmable current control for all LEDs in the display. Thus, current-limiting resistors are not required at each output port of the driver. Pin 7 is connected to an internal 1.2-V reference so, as a result, current through R_3 is approximately equal to one tenth the LED current; thus, with R_3 = 1.2 kilohms, the LED current becomes equal to 10 milliamperes.

The 4017 Johnson counter and accompanying gates comprise the scope's horizontal-sweep circuit. The sweep oscillator driving the counter is made from half a 4011 quad-NAND gate, G_1 and G_2, its frequency controlled by resistor-capacitor combination C_1–R_4. In this way, the instantaneous input voltage is resolved to 1 LED in 100. G_3 and G_4 provide automatic triggering of the sweep.

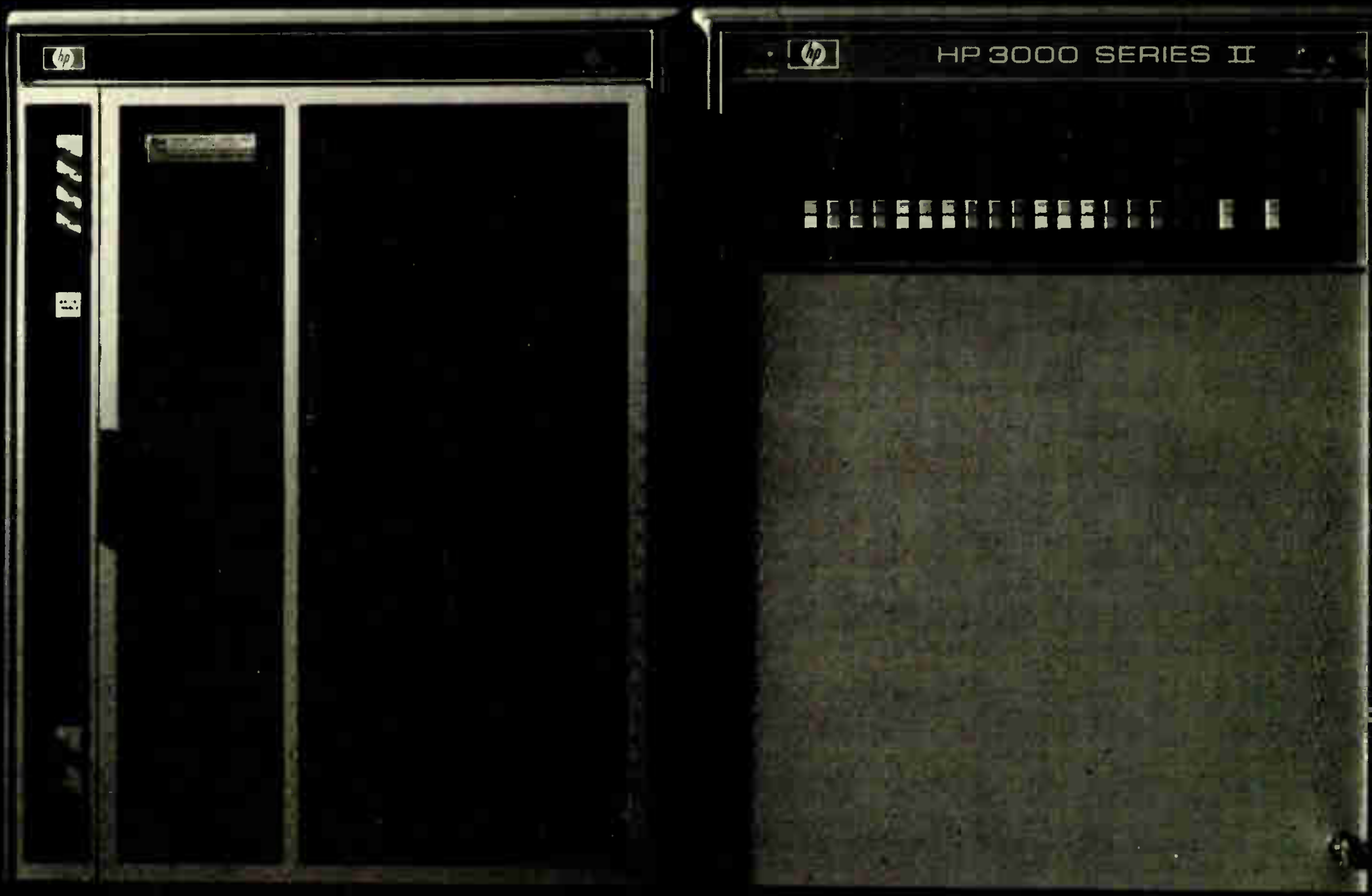
As for the LED display itself, bar arrays that contain 10 diodes each are easier to use and provide a more uniform display than discrete diodes, and are therefore recommended. Another option is to employ miniature matrix arrays of five by seven dots. At least one firm, IEE Inc. (7740 Lemona Ave., Van Nuys, Calif. 91405), offers such displays that can be mounted adjacent to each other without a gap in the LED columns.

Both the vertical and horizontal driving sections of the basic scope can be readily expanded. For instance, five cascaded counters and five cascaded dot/bar chips can drive a 50-by-50-diode matrix, forming a scope with a display resolution of 1 LED in 2,500. □

References
1. Vernon Boyd, "LED bar-segment array forms low-cost scope display," *Electronics*, Nov. 24, 1977, p. 128.



Drive center. One-chip dot/bar driver reduces complexity of vertical scanning portion of scope having light-emitting diode display. Horizontal scanning portion uses G_1 and G_2 for clock, wired as astable multivibrator, and 4017 counter. Display resolution is 1 LED in 100.



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Hardware breakpoints aid 8080 program debugging

by Guy Sundman
Espoo, Finland

If the instructions that place breakpoints in a program are generated by hardware instead of software, the user finds it easier to debug the program, regardless of the architecture or memory type used in a microprocessor-based system. Shown here is a method to enable the required program interrupts for an 8080 microprocessor, using a modest low-power interface.

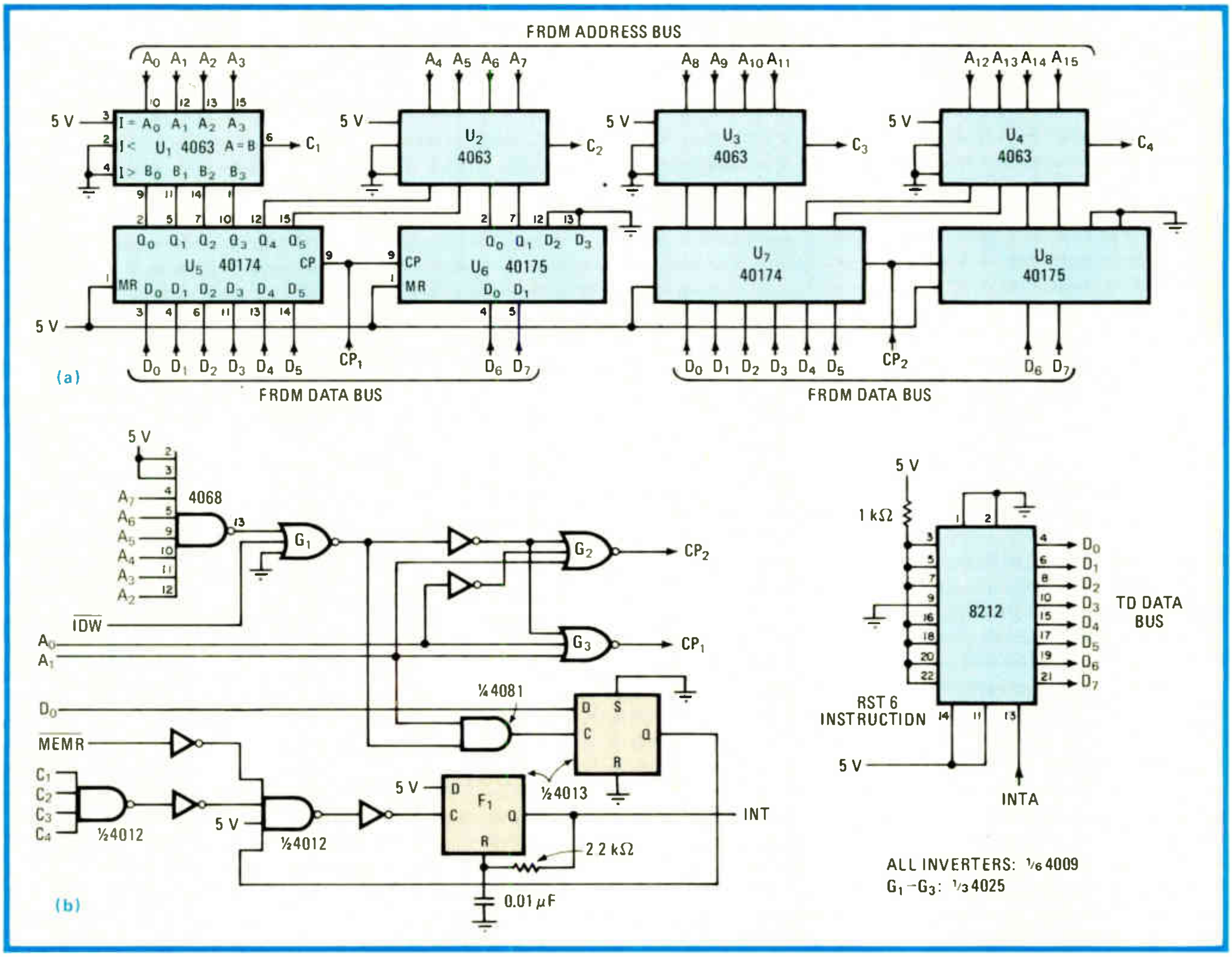
In the comparator and register logic (a), the desired breakpoint that is represented on lines D_0–D_7 is saved by placing an arbitrarily selected key logic word on lines A_2–A_7 of the 8080's 16-bit address bus and then generating two output instructions. In this particular instance, D_0–D_7 is latched by U_5–U_8 when logic word 111111 is placed on the bus.

Because the 8080 interfaces to an 8-bit data bus, the saved breakpoint must be entered in two steps. When lines A_0 and A_1 are both made equal to logic 0 and the first output instruction is executed, CP_1 in the decoding and interrupt-generation logic (b) moves low, so that U_5 and U_6 stores the lower part of the breakpoint. D_0–D_7 are then set to the upper half of the breakpoint address and the key logic word is again generated, with A_0 and A_1 made equal to 1 and 0, respectively. This action causes CP_2 to move low, and U_7–U_8 latches the upper half of the breakpoint.

During program execution, lines C_1–C_4 of U_1–U_4 move high when the program counter (lines A_0–A_{15}) reaches the breakpoint. If the breakpoint has previously been enabled (an output instruction at A_7–A_0 of 1111111X with D_0 = 1), and a memory-read ($\overline{MEMR}$) operation performed, flip-flop F_1 generates an interrupt, INT, to the microprocessor.

Assuming the interrupts are enabled, the microprocessor will generate the INTA signal to the 8212 8-bit I/O device. A hard-wired instruction (in this case, RST 6) is then placed onto the data lines D_0–D_7.

Program execution will thus resume from location 60. This location may represent the first instruction of a program jump to the debugging or utility routine. □



Picking points. C-MOS interface (a) enables hardware entry of any desired breakpoint. When microprocessor's address counter reaches breakpoint, program interrupt is generated by decoding logic (b), in turn permitting a jump to debugging routines.

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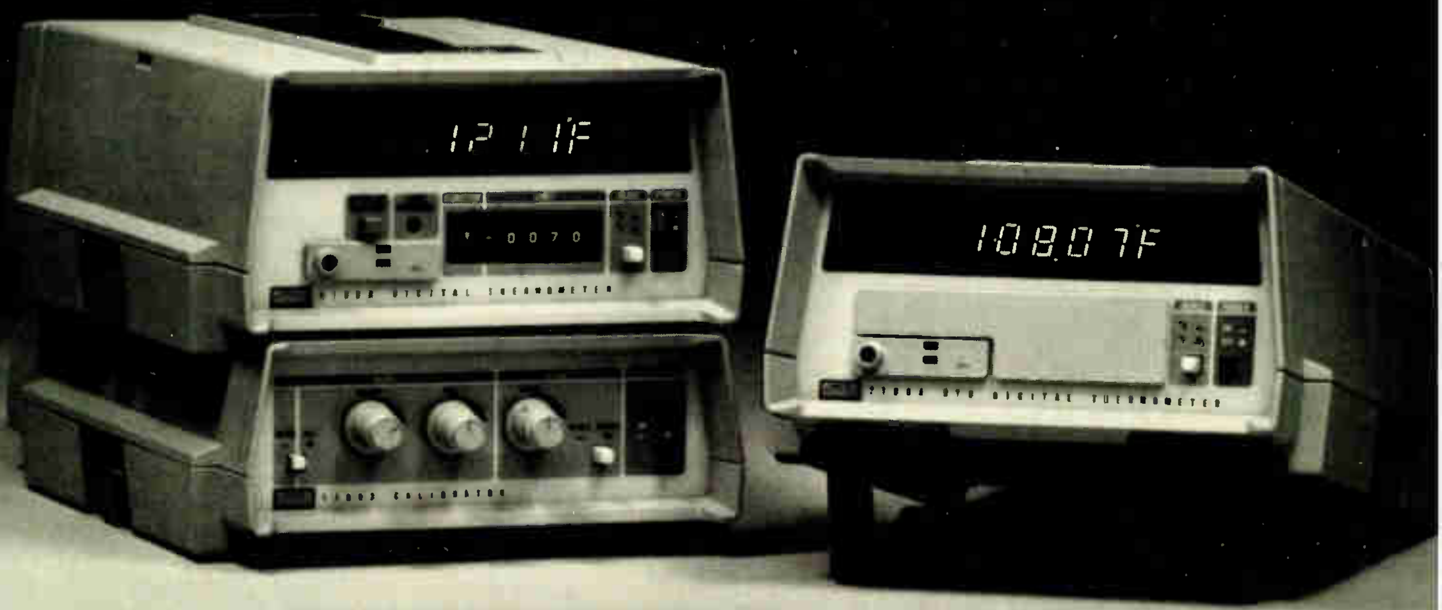

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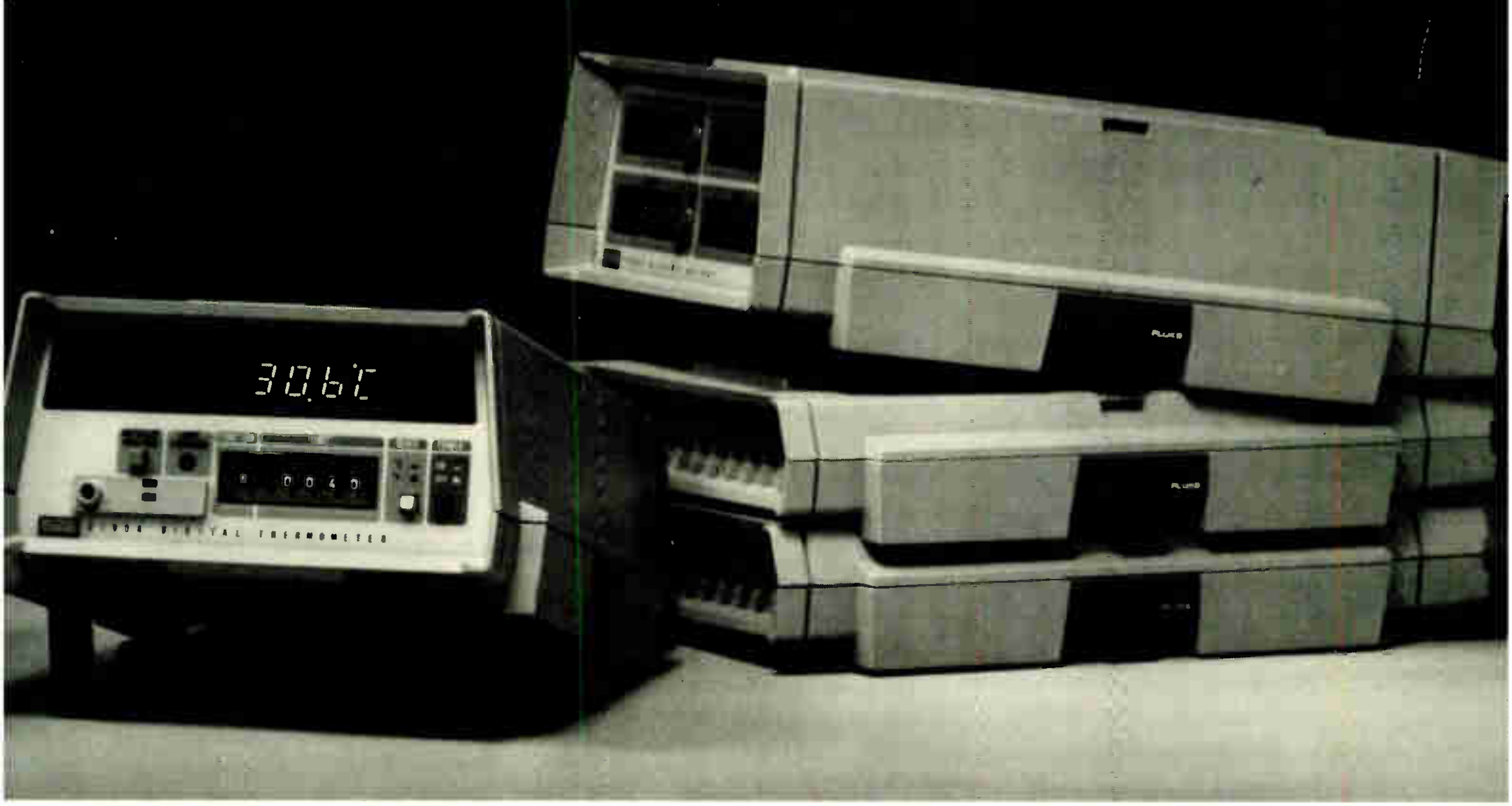

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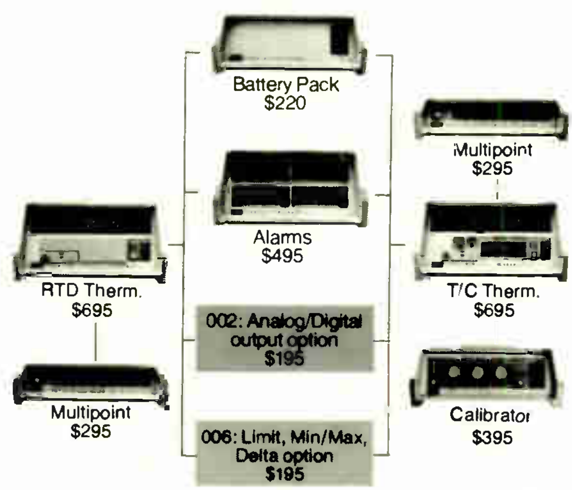

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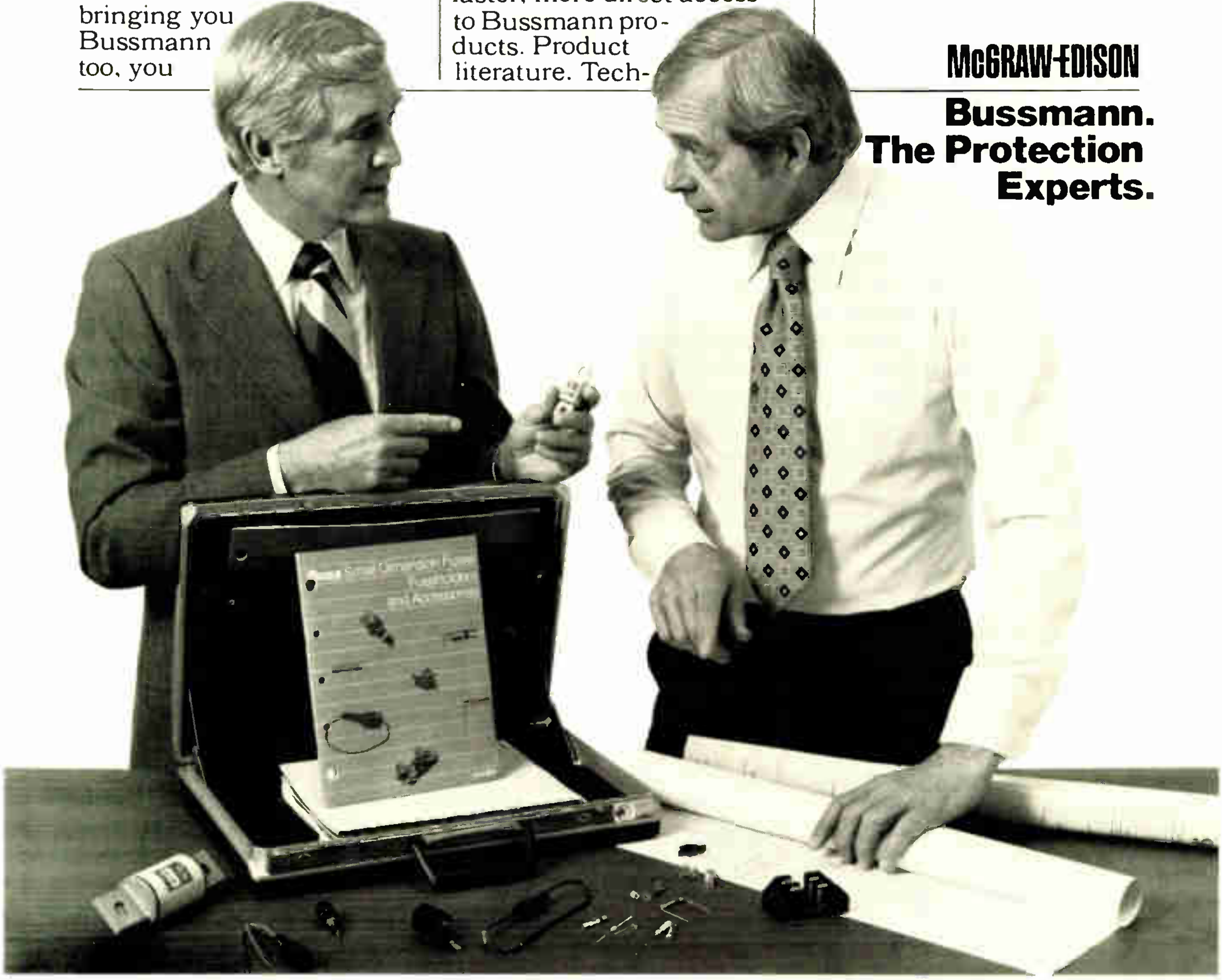

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NCC program studies impact on society

National Computer Conference also features miniconferences on banking, insurance, health

by Howard Wolff, *Assistant Managing Editor*

☐ Both June and the National Computer Conference will soon be bustin' out all over New York as the show returns to the Big Apple for the first time since 1976. Prepared to take a hard look at social and economic as well as technological facets of the art of computing, NCC '79 will hold its technical sessions at two hotels—the Sheraton Centre and the New York Hilton—and most of its exhibits at the New York Coliseum, June 4–7.

The invitation from show chairman Merlin G. Smith describes the NCC as not to be missed. "The program will highlight recent developments in computer science and technology and will provide individuals with a better understanding of the entire industry, including a greater consciousness of the social implications of the expanding use of computers," he says. Smith is a member of the research staff in the computer sciences department at International Business Machines Corp.'s Thomas J. Watson Research Center in Yorktown Heights, N. Y.

But the conference will not be anchored at that level. For the third year in a row, the people at Afips—the American Federation of Information Processing Societies, which organizes the NCC—are orchestrating their immensely popular Personal Computing Festival. To be held concurrently with the NCC, the festival will consist of some two dozen sessions exploring two major questions about personal computing: what do you do with it, and is it worth it? The sessions will cover a wide range of subjects, among them personal robotics, speech synthesis and recognition, computer crime, and computer ethics.

Under the banner of special events will be a first for the NCC: an exhibition of postage stamps about computers. Also featured will be a science film theater, contests, and application demonstrations in personal computing. One of the more interesting non-technical highlights will be Pioneer Day, this year commemorating the development 20 years ago of Cobol (Common Oriented Business Language), the most widely used language.

However, the brightest light in the conference's array is still the 120-plus technical sessions covering nine broad areas. In keeping with the theme of social awareness, there will be examinations of subjects such as government regulation, security restrictions on international trade in data processing, computing in developing countries, software patents and taxation proposals, and legal risks. There will also be discussions about the role of computers in specific industries: banking, insurance, and hospitals and health care.

For the strollers and literature collectors, the days of

New this year. Among systems introduced by IBM since the 1978 edition of the National Computer Conference is this 3033 Attached Processor Complex. It is aimed at large data networks, high-volume jobs, and expanded business or scientific applications.

the conference will be filled with action. The total of more than 350 organizations occupying more than 1,700 booths at the Coliseum and the New York Hilton add up to what the NCC's organizers are calling the largest computer show ever assembled.

Hot topics at the show

The biggest obstacle for the NCC-goer is the large number of concurrent sessions. Then there are the concurrent conferences-within-a-conference: one on personal computers and others on the use of computers in health care, for financial transactions, and computer law and public policy. However, sessions run in blocks on the same day organized by subject.

A broad guide is offered by program chairman Richard E. Merwin, a research professor at George Washington University in Washington, D. C., and a consultant on real-time computer systems and special-purpose languages. Merwin says, "We have three overriding objectives: increased coverage of important issues involving management, marketing, applications, and the social impact of computers; [assessment of] critical issues including implications of the expanding use of data bases, regulation of transborder data flow, and the merger of data processing and communications; and special attention to applications areas of key importance through 'miniconferences' " (see "Pushing the boundaries outward," p. 179).

Of the technology-oriented sessions, the group on data-base management and machines occupies the No. 1

NCC SESSION SCHEDULE

	MONDAY p.m. 2:30–4:00	MONDAY p.m. 4:15–5:45	TUESDAY a.m. 8:30–10:00	TUESDAY a.m. 10:15–11:45	TUESDAY p.m. 2:30–4:00	TUESDAY p.m. 4:15–5:45
HILTON (MERCURY)	Regulation or antitrust – competition in the computer/communication marketplace		Computers at work in the White House, the Senate and the Federal courts	Evolution of the computer communications market in a new technological era	Computer communications and the international data marketplace	Foreign policy and national security restrictions on international trade in data processing
HILTON (TRIANON)	Insurance industry automation	Trust and securities industry automation	Commercial banking automation	EFT and consumer banking automation	International banking automation	The automation of check processing
SHERATON CENTRE (IMPERIAL A)	Software performance modeling and analysis	Measurement of software reliability	Designing distributed systems	The interface between data-base management systems and operating systems	Computer systems analysis and evaluation	Modeling of program behavior
SHERATON CENTRE (IMPERIAL B)	Impact of future technologies on the computer industry	Mass-storage system technology	Data flow – Part I	Data flow – Part II	Dynamic and reconfigurable architectures	Dynamic and reconfigurable architectures: problems, evolution and applications
SHERATON CENTRE (GEORGIAN A)	An assessment of future computer system needs for large-scale computation	Array processing: an innovative approach to scientific computing	Power management in the computer facility	Computer facility support functions	Impact of security and protection on computer architecture	Distributed system control architecture
HILTON (GRAND BALLROOM E.)	Unions in data processing	Business and entrepreneurial opportunities in computers	End-user training – building the DP interface	Why managers fail	Factors for innovating DP professionals vs other jobs in the DP department	White House information systems. . .information for decision making in the Executive Office of the President
HILTON (GRAND BALLROOM W.)		Data-base machines	Distributed data-base systems	Relational data-base systems	Data-base evolution	Data-base management systems architecture
SHERATON CENTRE (ROYAL B)	State of art of minicomputer hardware/software and distributive processing	Computer page printing	Management's challenge: the office of the future	Benchmark selection of teleprocessing systems	Planning, acquisition and implementation of mini-computer-based business systems	The information officer: fact or fancy?
HILTON (REGENT)	User assistance in on-line systems	Computers in biological and medical simulation	Emulation laboratories and experience	Simulation development tools	Simulation of industrial processes	Simulation languages
SHERATON CENTRE (GEORGIAN B)	Networks and data: an interim report by the CODASYL systems committee	The ANSI reference model for network protocols	An overview of network technology	Measurement phases of computer selection	Economics of networking	Assuring data-base integrity in the networking environment
HILTON (SUTTON)	Developing professional standards	Technical aspects of privacy protection in transnational data systems	Privacy and security in the 80s	Data security	Computer security technology vis-à-vis audit	Managing the computer security problem
SHERATON CENTRE (ROYAL A)	Practical applications of data encryption	Determining the value of computer applications	Software psychology: exploring the human factor	Social effects of computerized conferences	The status of women and minorities in computing	Power, politics, and structure: computers and organizations

spot by virtue of multiplicity as well as importance. The reason is that, as computers become more powerful and more used, more data is being sorted, changed, and pushed through the machines. This leaves the entire industry searching for means of managing the growing mountains of information. At the same time, processors are becoming less expensive, so computers can devote some of their power to more sophisticated schemes for organizing and processing files and for establishing relationships between files and the records in each.

Perhaps the best place to start exploring the whys and wherefores of data-base management is a paper-cum-panel session called "Data-Base Machines." Chairman T. H. Bonn of the Sperry Research Center in Sudbury, Mass., will sum up user and manufacturer issues following a paper on each of the two approaches to such machines: associative processors and back-end processors using the standard Codasyl model. A quartet of panelists will then debate the two.

A second session, led by Shem Navathe of New York University, is called "Data-Base Design." Speakers will discuss the design and building of data bases in business, industry, and government, emphasizing the decisions, issues, and strategies involved. The third data-base session, led by P. Bruce Berra of Syracuse University (N. Y.), will deal with "Relational Data-Base Systems," and the fourth, headed by Dennis McLeod of the Society for Computer Simulation in La Jolla, Calif., will cover "Data-Base Evolution."

To examine some of the problems encountered in

8:30–10:00 WEDNESDAY a.m.	10:15–11:45	2:30–4:00 WEDNESDAY p.m.	4:15–5:45
Conducting the trial: evidence in computer crime and fraud cases	No patents for software? If so, what now?	Software tax: an idea whose time has come ...or gone?	Legal risks: technical decisions, computer experts and business sense
Issues and policy concerns in health computing – Part I	Issues and policy concerns in health computing – Part II	Data center issues – Part I	Data center issues – Part II
Quantitative measures of the quality of programs and systems		Case studies of software development techniques	
Employing handicapped computer professionals	The impact of new a-d LSI technology on systems	High-end microprocessor architecture	Data-base design
Fault-tolerant and maintainable systems	Testing and fault tolerance in digital systems	Advanced industrial robotics	Advances in computer graphics
Improving the performance of the data-processing professional	How to sell new technology to management	Computers for the Chief Executive Officer	Data processing's "Proposition 13"—a look at the state software and related taxation issue
Data-base models	Data-base applications	Cobol – its origin	Cobol retrospective
Design issues for word-processing systems	Computer-based systems in complex organizations	Special computer applications	Computer graphics in the building industries
Simulation for predicting computer system performance	Languages for computer system simulation	Simulation results	
Model-based management support for distributed data processing	Experiences in local area networking	Appropriate level of network security	Technological issues in supporting network access to data
Advances in secure operating systems technology in the Dept. of Defense – Part I	Advances in secure operating systems technology in the Dept. of Defense – Part II	Risk assessment techniques	Sexual barriers in business and how to overcome them
Computers and society research and education	Data bases in the humanities and social sciences	Women in computer management: where do we go from here?	More for less with computers in local government – a challenge to users and the industry

8:30–10:00 THURSDAY a.m.	10:15–11:45	2:30–4:00 THURSDAY p.m.	4:15–5:45
Information privacy: public policy and recordkeepers' responsibilities	The international privacy debate: laws, licenses and limitations	Data processing and the provision of legal services in the private law office	Data processing and litigation support
Implementation factors in hospital information systems		Computer-based consultation and ambulatory patient care – how should it be implemented? who should control it?	
Communications technologies: their impact on computing			
Performance modeling and evaluation of data-base management systems	Data dictionary systems	Associative processors—why are they needed? what can we expect in the future?	Associative languages
New directions in distributive architectures		High-level language and direct execution machines	Documentation: the first interface
The expanding world of service	People power: the key to effective management of data-processing projects	Time management for the DP professional	Finding value in used computers
Computer chess – the next decade	Computer technology and the movie industry		User microprogramming of minicomputers
What can pattern recognition and image processing do for society?	Computation problems in pattern recognition and image processing		Error-correcting codes: application to memory systems
Computing in developing countries	Making business models easy to use	Applications of computers in criminal justice systems	
Network performance modeling	AUTODIN II – data-communication system	The military message experiment	Current topics in information retrieval
Computer fraud	Microcomputers in technical professional development	Management of computer centers by contract	Personal career planning for the information systems professional
		Computerized control systems for automated production facilities	

adapting data-base systems to the actual operating computer system, Eduardo B. Fernandez will lead a panel session entitled "The Interface Between Data-Base Management Systems and Operating Systems." Fernandez, who works for IBM in Los Angeles, will have with him another IBMer, James N. Gray of San Jose, Calif. Ehud Gudes of Pennsylvania State University, H. Rex Hartson of Virginia Polytechnic Institute, and Larry Kerschberg of Bell Laboratories in Holmdel, N. J., will also participate.

Away from prying eyes

With the proliferation of data-processing and handling machinery has come an increase in problems associated with the need to safeguard data. Thus, the NCC will have no less than eight sessions on the various approaches to computer security.

A good place to start is the panel discussion called "Managing the Computer Security Problem." It will be led by Robert B. Campbell, who works at the headquarters of the Department of the Army at the Pentagon. Campbell's copanelists will be Peter S. Browne of Computer Resource Controls Inc., Rockville, Md.; Robert V. Jacobson of International Security Technology Inc., New York City; and Edward C. Springer of the U. S. Office of Management and Budget, Washington, D. C. They will look at current practices and trends in areas such as assessing the relative sensitivities of computer operations and establishing an organization to manage the security problem, as well as at corporate policy options and management techniques.

In two sessions devoted to "Advances in Secure Operating Systems Technology in the Department of Defense," Stephen T. Walker of the DOD will preside as seven papers are read. These range from Walker's own explanation of why the day of the trusted system is at hand—that after eight years of research, operating systems with enough integrity for Pentagon multilevel secure use will be available this year—to an explanation of UCLA's secure UNIX by a team of six researchers from the University of California at Los Angeles, led by Gerald J. Popek. The team used a tightly constrained base kernel, a second-level policy kernel, an interface essentially identical to Bell Labs' UNIX, Pascal language, and formal, semiautomatic program verification for the source code of both kernels.

Another paper describes the design of the Defense Department's KSOS—for kernelized secure operating system—also based largely on Bell Labs' UNIX. The paper, by Ford Aerospace and Communications Corp.'s E. J. McCauley and P. J. Drongowski, says that KSOS will be able to handle information at various military security levels (such as secret or top secret) with a security kernel at its heart to monitor access. And John P. L. Woodward of the Mitre Corp., Bedford, Mass., discusses applications for secure multilevel systems: for use when a secure system is communicating with one that is not secure, and in data-base management systems, message-processing systems, and front ends.

Putting them together

As the cost of data processing shrinks, more computers are being placed in remote locations. But it would still be too costly and impractical to have big central processors scattered about. The solution: distributed processing, or networking.

The importance of networking is reflected in the amount of time devoted to it on the NCC program. There will be 14 sessions covering a range of subjects from protocols to military uses, including one on the omnipresent matter of security.

On its most elementary level, networking serves limited geographical areas such as college campuses or office buildings. To discuss such setups and their use for intramural data communications as well as for local distribution of data from long-distance networks, Ira W. Cotton of the National Bureau of Standards, Washington, D. C., has put together a session called "Experiences in Local Area Networking." Richard Sherman of the Ford Motor Co. in Dearborn, Mich., and James W. White of the Xerox Corp. in Palo Alto, Calif., will describe their companies' operations, while Robert J. Carpenter, an associate of Cotton's at the NBS, will talk about the bureau's intelligent network.

The military has been a pioneer in data networks, so of particular interest is a session on "The Military Message Experiment," a program which sought to evaluate interactive message handling in the military. The experiment evolved into a study of the Sigma service supporting 24 on-line users in Hawaii. There will be two papers about Sigma followed by a panel of users, developers, and evaluators of the results.

What does networking cost, and how much does it save? Some answers come in a session called "Economics of Networking," led by Norman R. Nielsen of SRI

At the flickers

Want to see a movie at the National Computer Conference about computers in Hollywood and how they perform their feats of legerdemain? Then attend a panel called "Computer Technology and the Movie Industry." Session leader Suzanne Landa of the Rand Corp., Santa Ana, Calif., and two fellow panelists, William Dietrich of Mini-Micro Systems Inc. of Anaheim, Calif., and A. Jerumanis of MCA Inc., Universal City, Calif., will look at the growing impact of computers on the movie industry. They will examine their role in production, distribution, exhibition, preservation, and redistribution—and show some examples. The session should be popular, so get there early for a good seat: Thursday, June 7, 10:15 a.m. in the Grand Ballroom West at the New York Hilton. Bring your own popcorn.

Pushing the boundaries outward

A new wrinkle at NCC '79 is a series of miniconferences, three groupings of sessions on particular applications areas. They will cover financial transactions, law and public policy, and health care. The conferences-within-a-conference represent an effort on the part of the NCC's organizers "to bring in people making use of computers," says conference program chairman Richard E. Merwin. "It's an attempt to push the NCC farther out into interdisciplinary areas."

The financial area will consist of six sessions scheduled for Monday and Tuesday, June 4 and 5. They have been organized by Donald R. Hollis, vice president of Chase Manhattan Bank, New York City. Each session will have two formal papers before a third member joins the panel for a discussion of developments and trends.

The law and public policy coverage will be spread through all four days of the conference. Organized by Washington, D. C., attorney William Wewer, the 14 sessions will explore wide-ranging aspects of regulatory issues, law enforcement, international trade, and computer crime and fraud.

On Wednesday and Thursday, June 6 and 7, health care will be handled in sessions organized by Karen A. Duncan of the Mitre Corp., McLean, Va. The keynote session will feature Rep. James Scheuer (D., N. Y.), who conducted recent congressional hearings on computers in medicine, and Joyce Lashof, assistant director for human resources of the U. S. Office of Technology Assessment. For physicians who are attending the health-care miniconference, Mt. Sinai Hospital of New York will offer credits toward the total required by various specialty governing boards to attain board certification.

International, Menlo Park, Calif. Nielsen will deliver a paper on the economic impact on colleges, while the control of computing funds and resources will be covered by Beverly O'Neal and Ronald Segal of Educom at Princeton University. Educom is a consortium of more than 270 colleges and nonprofit organizations that helps its members make the best use of computer communications. There also will be a three-member panel.

Software: patented or taxed?

In two sessions bristling with attorneys, and including a tax expert and a government official, speakers will give an overview of the patent and tax status of software. Both are led by John W. Behringer, a Washington, D. C., attorney. His session on "No Patents for Software—If So, What Now?" will review the reasoning behind the U. S. Supreme Court's decision that certain computer programs are unpatentable. It will look at what software may be patented and at alternative forms of protection—such as by copyright or as trade secrets.

In "Software Tax: An Idea Whose Time Has Come . . . or Gone?" the spotlight will be on existing state and Federal taxation as well as on the latest development: imposition of personal property taxes on software. The speakers will represent government, the legal community, and an accounting firm: Thomas Lynch, commissioner of the Department of Taxation and Finance of the State of New York; Gordon O. Pehrson, an associate of Behringer's in the Washington law firm of Sutherland, Asbill & Brennan; and John E. Haner of Arthur Andersen & Co., Boston.

Let the computer do it

Simulation and computer-aided design are two more technologies that owe their growing importance to the ready availability and decreasing cost of computing equipment. Now, with systems becoming complex because more organizations can afford more components, simulation is a vital tool in keeping track of data. Computer-aided design not only helps design a mechanical, biological, or electronic system, but it can take the designer through the breadboarding stage and then determine tests and test procedures. Eight NCC sessions will explore the world of simulation and CAD.

In "Computers in Biological and Medical Simulation," Thomas G. Coleman of the University of Mississippi Medical Center, Jackson, will lead a panel summarizing the state of the biological simulation art and discussing hardware, software, numerical methods, and other factors required for further advancement. Ingrid A. Eldridge of the Army's Communications, Research, and Development Command, Fort Monmouth, N. J., will lead a session on "Emulation Laboratories and Experience" in which speakers will describe their own simulation work in research and development, testing, and teaching.

On the industrial front, Joseph Talavage of Purdue University, West Lafayette, Ind., leads a session on "Simulation of Industrial Processes" with papers on work in discrete manufacturing systems (by William Biles of Pennsylvania State University), computerized food processing (by Richard Schuman of the Staley Co., Decatur, Ill.), and automated distribution system analysis (by Burnett Moody of Deere & Co., Moline, Ill.).

"Languages for Computer System Simulation," a session headed by Brian W. Unger of the University of Calgary in Canada will discuss modeling of both system software and network architecture. Philip H. Enslow Jr. of Georgia Institute of Technology in Atlanta will cover languages for operating systems, Imrich Chlamtac and William R. Franta of the University of Minnesota in Minneapolis will discuss aids to the development of network simulators, and M. H. MacDougall will talk on the simulation language SIML/I. Unger also will head a session called "Simulation for Predicting Computer System Performance." □

Engineer's newsletter

Hole-and-fiber technique builds low-cost optical link

An interim, low-cost way of building a limited-bandwidth, optical-fiber link is to make a hole in a standard epoxy-encapsulated light-emitting diode,then cement a single fiber in place near the LED's chip with cyanoacrylate adhesive, says Forrest Mims III of San Marcos, Texas. While this method seems crude, none of six RL-50 LEDs so modified was damaged by the procedure, notes Mims, and **sufficient power was transferred to support a half-duplex voice channel over a 200-meter length of ITT T-323 fiber** when the LED was forward-biased at 20 mA.

Mims makes the hole with a blunt sewing needle that has been heated in a flame. With the diode's leads held fast in a small clamp or vise, the hot needle is guided through the epoxy to the surface of the chip. A bright pinpoint of light can be observed by peering into the hole if it is properly formed. A fiber with a cleaved end is then dipped in the adhesive (trade name Cyanolit, from Denis Leader Ltd.) and inserted into the hole.

Positive supply sinks current

Sometimes a positive supply is called upon to sink current rather than source it, and this is especially true if the supply is used as a reference. Al Kovalick of Hewlett-Packard Co., Palo Alto, Calif., noting the ease with which the pin-to-pin voltage requirements of a three-terminal regulator can be met, says that **two of them—one positive-voltage and one negative-voltage device—can be simply combined to accomplish the task.**

Kovalick's +5-V supply uses the LM7810 10-V regulator and the LM320K −5-V regulator. Grounding the input-voltage port (pin 3) of the LM320K, he drives the normally grounded pin 1 of the device with the stable output of the 10-V regulator. Thus the voltage at the output (pin 2) of the −5-V regulator becomes +5 V. When the free end of the output load resistor is connected to a voltage greater than 5 (12, typically, or that needed to drive the 10-V regulator), the circuit will sink current.

NBS calibrates ac devices down to 0.1 Hz

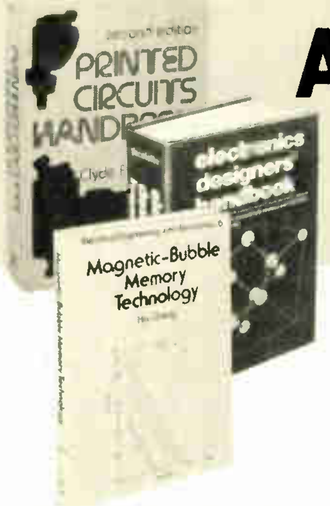
The National Bureau of Standards now provides calibration services for instruments measuring low frequencies over the 0.1-to-10-Hz range. The low-frequency limit of the calibration system is **about 20 times below that of existing thermal voltage-converter systems,** according to physicist Howard K. Schoenwetter. For further technical information, contact him at the Center for Electronics and Electrosystems, NBS, Washington, D. C. 20234, or call (301) 921-2727.

Seminar at Stanford for computer-aided IC design

Stanford, Calif., is the setting for a one-day program on July 9 that discusses process and device modeling for integrated-circuit technologies. Entitled "Computer Aids for IC Technology and Device Design," the program will emphasize **new aspects appropriate to the design of very large-scale integration,** such as thin oxides, laser and electron-beam annealing, oxidation-enhanced diffusion, bulk defect generation, and interface charge and annealing. The seminar is sponsored by the College of Engineering of the University of California, in cooperation with the electrical engineering department of Stanford University.

The program cost is $125 and advance enrollment is required. For further information, write Continuing Education in Engineering, University Extension, University of California, 2223 Fulton Street, Berkeley, Calif. 94720, or telephone (415) 642-4151. **-Vincent Biancomano**

An introductory Electronics



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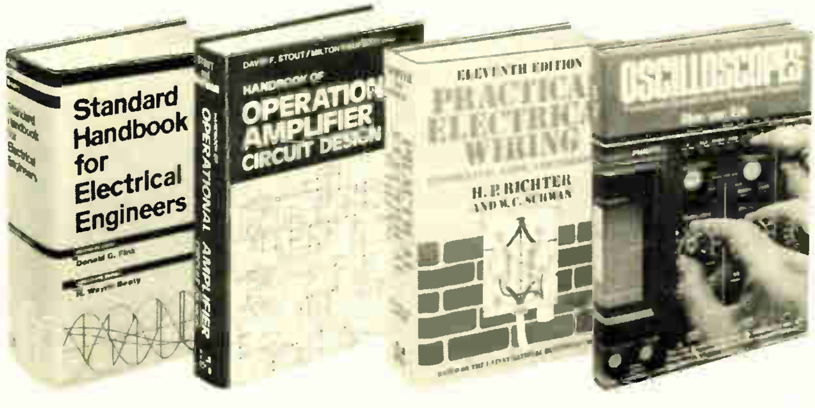

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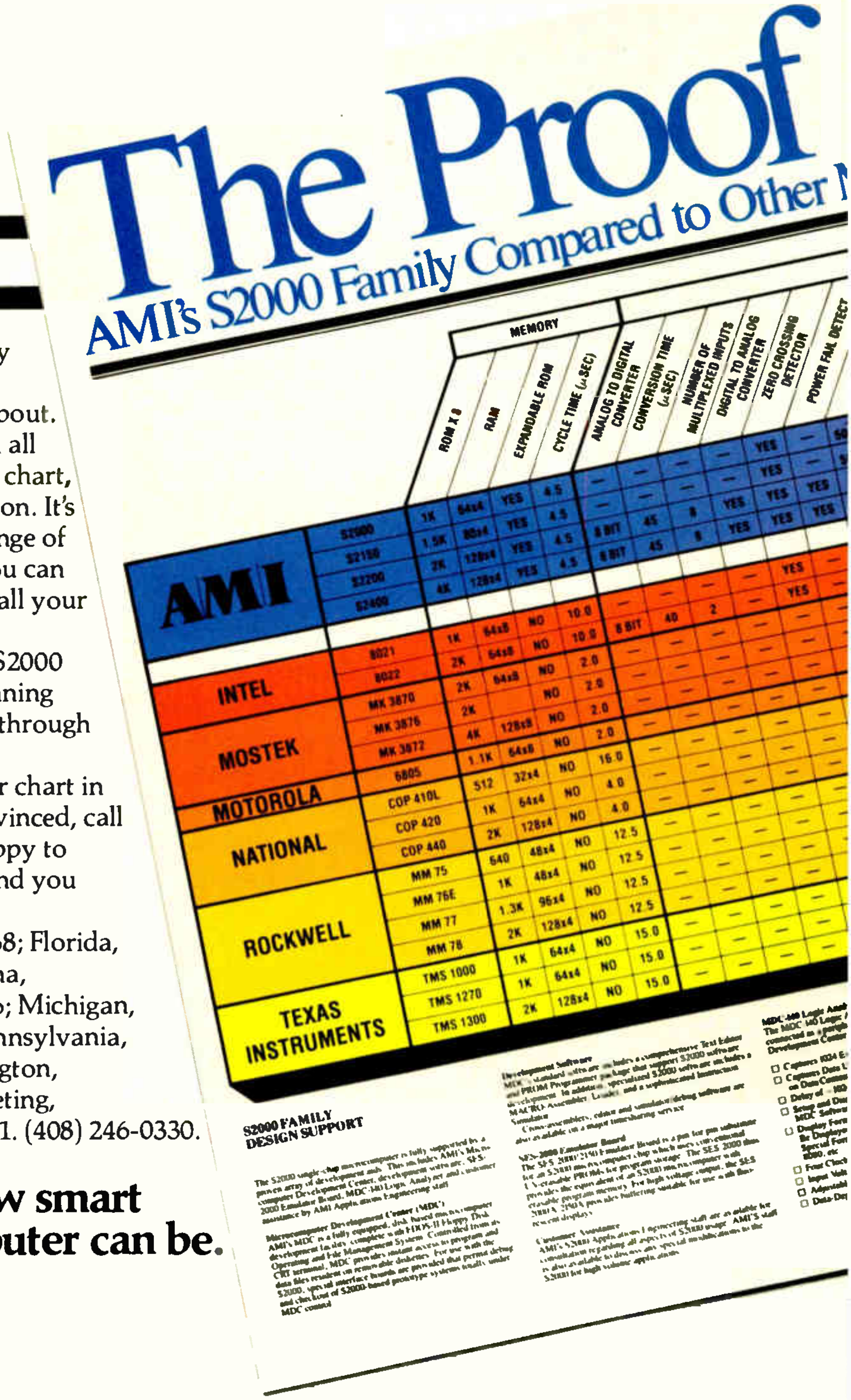

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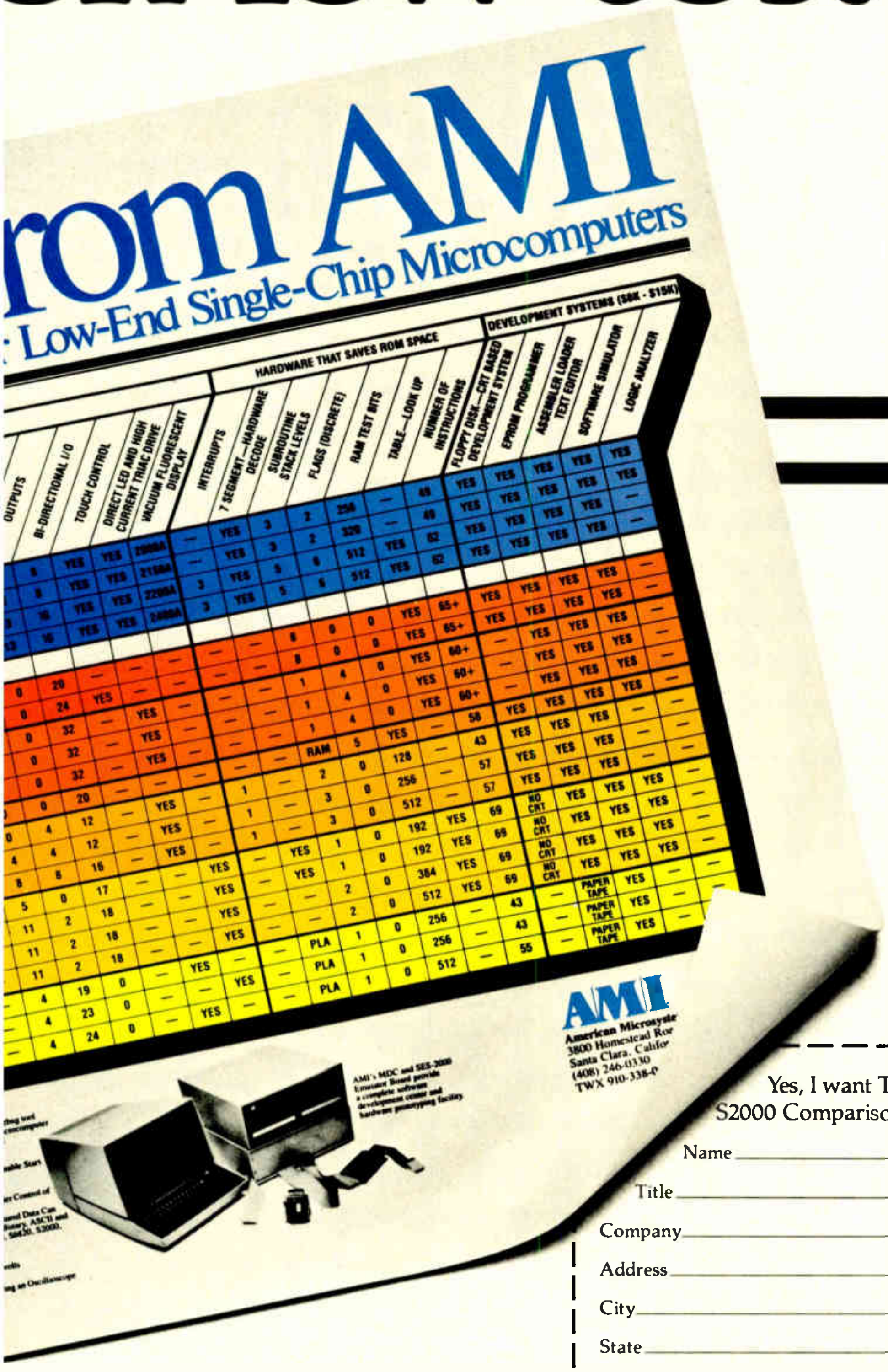

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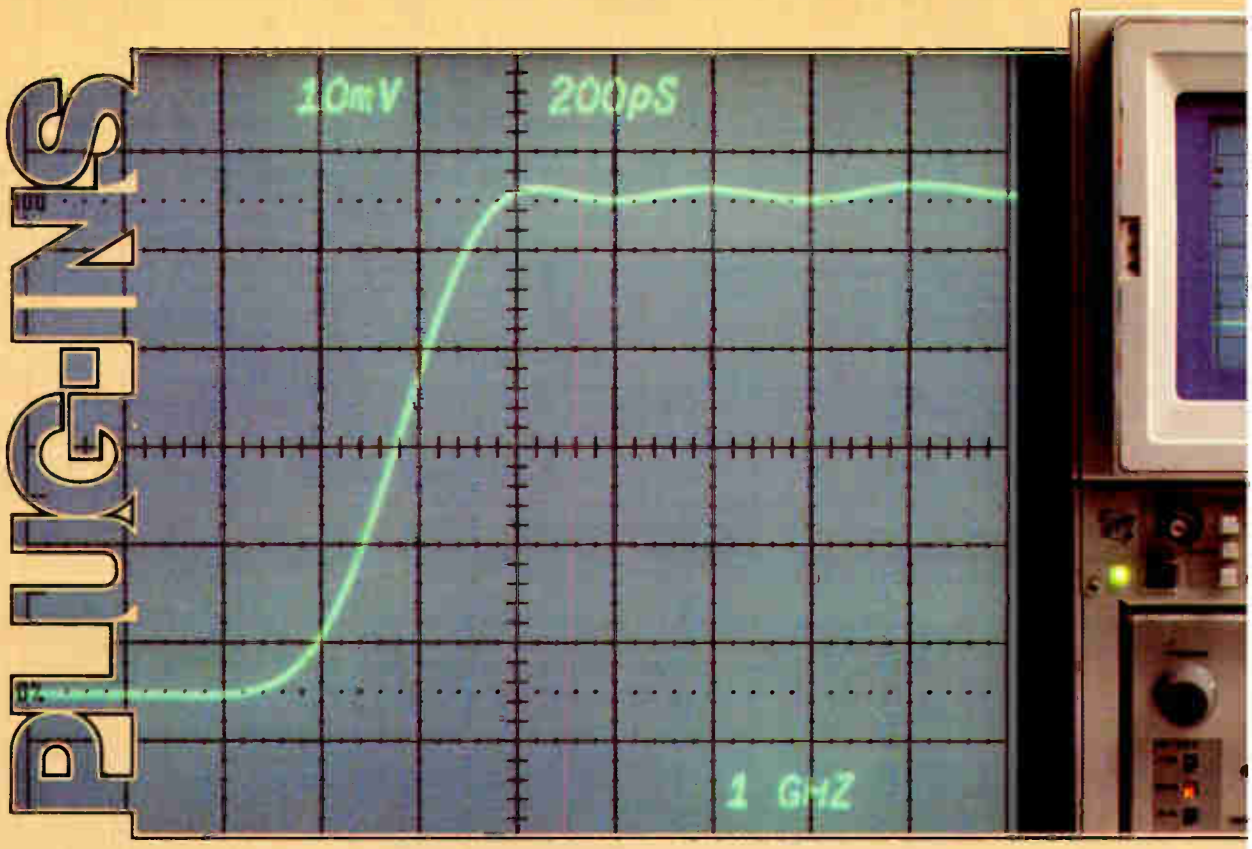

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For Technical Data circle #156 on Reader Service Card

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Development system supports 9440 and 9445

Chip sales typically go up when a microprocessor manufacturer supports its devices with a development system. Fairchild Camera and Instrument Corp. hopes this will hold true when it introduces its Focus-XVI–based development system at the National Computer Conference next month. The sales pace Fairchild hopes to quicken is that of its 16-bit 9440 and the forthcoming 9445, devices fabricated using its Isoplanar integrated injection logic technology, which the company refers to as I^3L.

The 9440 was introduced more than a year ago but has been available in production quantities for only the last six months. Interest in it "has been reasonable," says Thomas A. Longo, vice president and chief technical officer. However, Longo sees the development system as a necessary ingredient before the I^3L family can really take off. "Users are asking for a development system and now they'll have it," he says.

Fairchild's strategy is to offer a development system that can be used not only for the 9440 but for future, higher-performance family members and its lower-performance metal-oxide-semiconductor microprocessors as well. At the outset, though, the system will be aimed at the I^3L devices exclusively, Longo says.

To meet the high-end requirements, the system needs to be powerful and fast. Fairchild turned to the Focus XVI minicomputer, a boxed

version of its two-board 16-bit central processing unit, the Blaze-16. Bipolar and microprogrammable in design, Focus XVI is flexible enough to accommodate the MOS devices later and fast enough for the I^3L chips now, according to Longo.

What's more, like the 9440 chip, the Focus XVI emulates the instruction set of Data General's NOVA 3 minicomputer. Its 10-MHz clock rate ensures it will work quickly even with the 9445, which is expected to execute the instructions four times as fast as the 9440.

Combined with a cathode-ray-tube display and keyboard terminal, dual double-density flexible-disk drive, and 150-character-per-second dot-matrix thermal printer, the 16-bit central processing unit will be offered to end-users along with appropriate development system software, Longo says. Despite Focus XVI's general-purpose minicomputer design, it is not intended for that application. "The software that we supply is not suitable for on-line general-purpose computing," Longo explains.

Whereas the system is designed for both hardware and software development, in-circuit emulation hardware will not be immediately available. "We will have an ICE by the end of the year," Longo asserts. All the useful software development aids such as a relocatable linking loader, symbolic debugger, editor, and the like will be available with the system 60 days after receipt of the order. A complete system, including software, terminal, flexible-disk drive, and printer, will sell for $23,500.

Fairchild Camera and Instrument Corp., 464 Ellis St., Mountain View, Calif. 94042. Phone (415) 962-2394 [401]

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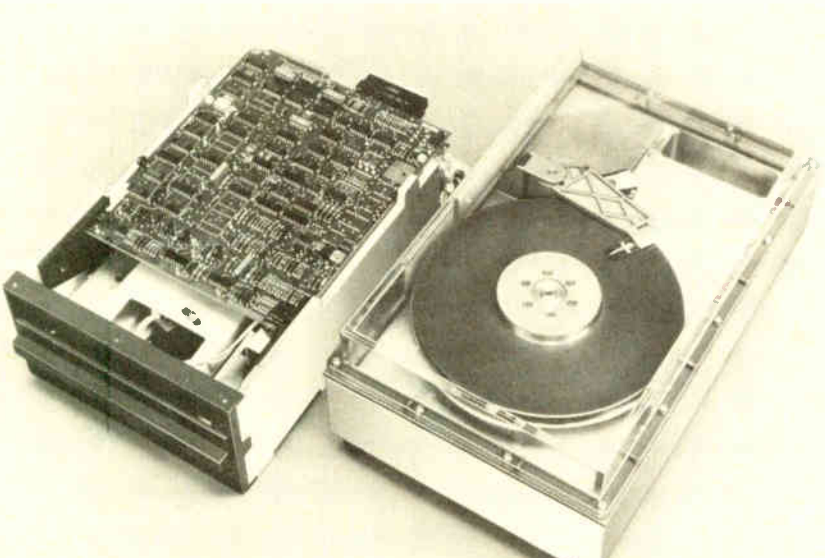
8-in. hard-disk drive fits floppy slot

At present, their combination of price, size, and simplicity gives flexible-disk drives a virtual lock on the market for on-line mass storage for low-end computers. But this edge figures to erode soon under the onslaught of new fixed-media drives that not only fit in the same space as the floppy-disk drives, but carry price tags half the size of current hard-disk units.

Making its debut at the National Computer Conference is an 8.25-in. fixed-media drive from Pertec Computer Corp. One of the first such drives to be offered by an independent supplier, the model D8000 is mechanically similar to an 8-in. floppy drive and has a capacity of 20 megabytes. Furthermore, its large-quantity price of $1,800 is well below the $3,000 or so commanded by full-size (14-in.) hard-disk units. Floppies, in contrast, sell for $300 to $500 a megabyte.

"There's no doubt the big feature is that it fits in a floppy-disk slot," says Lee Benedict, product marketing manager for Pertec's peripherals division in Chatsworth, Calif. The dimensions of the D8000—4.62 in. high by 8.55 in. wide by 14.25 in. long—provide interchangeability, so the manufacturer of a piece of computer equipment can increase the storage capacity of this product to 20 megabytes by replacing a 1.6-megabyte floppy-disk drive with a D8000. The hard-disk unit uses the same voltage levels as the floppy drives do, further reducing the impact on system design.

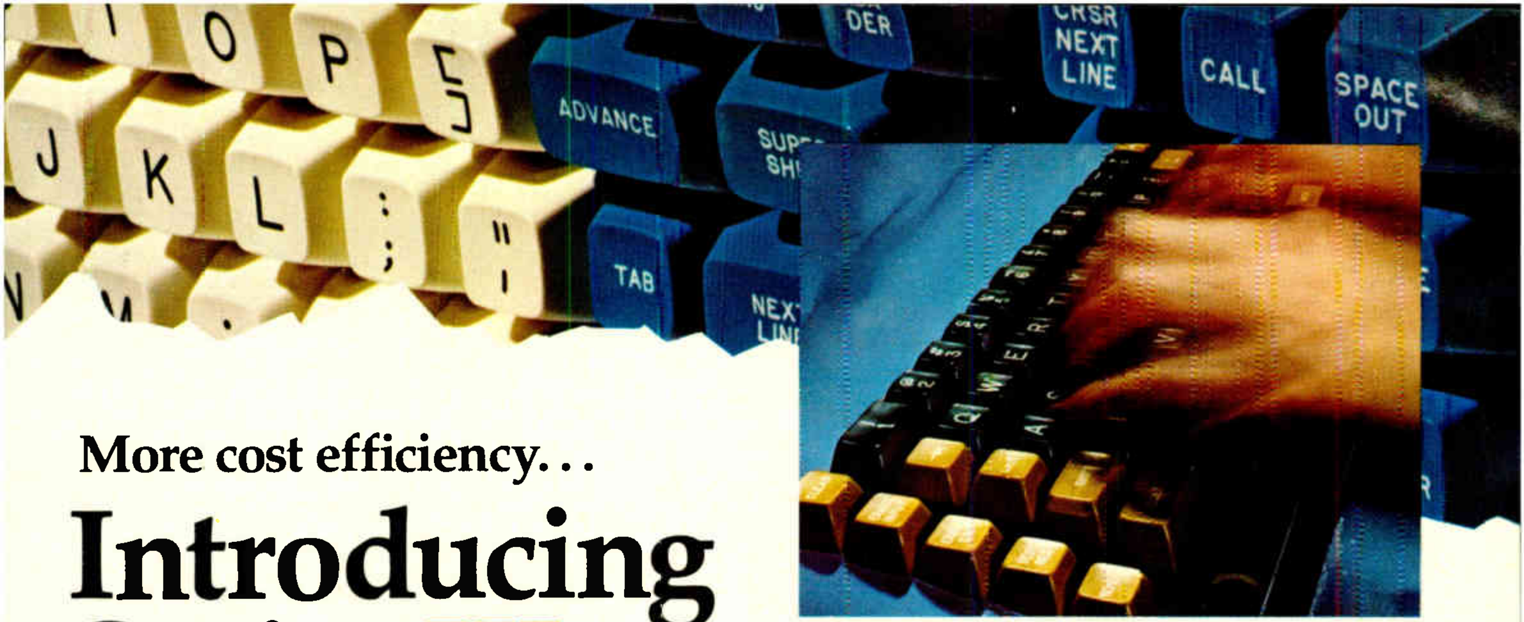


Not only does the Pertec drive provide more storage capacity than a floppy unit of comparable volume, it also offers faster access. Its rotary positioner helps keep its average access time down to 50 ms (80 ms maximum), which is useful in multi-terminal applications. Nominal data-transfer rate for the drive is 0.87 megabyte per second.

To simplify communication between the drive and its computer, the D8000 interface has a bidirectional command-and-status bus and byte-oriented data transfer. A single 50-pin connector makes it easy to hook up the interface; both radial and daisy-chain connections are available. The unit is compatible with the voltage levels of transistor-transistor logic.

As recording media, the drive uses a pair of aluminum alloy disks. Three of the four available surfaces are used for storing data; the fourth is pre-written with servo-control information for the drive. Recording density along the tracks is in excess of 6,000 bits per inch, with the tracks packed in at 476 to the inch.

Benediction. Although the opportunities presented by the replacement of the 8-in. floppy disk have been apparent since the microcomputer revolution started several years ago, translating the idea into hardware took longer than expected, in Benedict's view. Another delay stemmed from the disk medium itself, which is just now becoming available. In the meantime, the potential of the 8-in. hard disk was underscored by "the blessing of



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IBM," as Benedict puts it, since the computer giant introduced its own Piccolo Drive [*Electronics*, May 10, 1979, p. 40].

Evaluation samples of the D8000 will be available in August, with single-quantity pieces selling for about $3,000. Production runs will be ready in December. Pertec's line will be on display at NCC Booth 3300.

Peripherals Division, Pertec Computer Corp., P. O. Box 2198, Chatsworth, Calif. 91311. Phone (213) 999-2020 [402]

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Cartridge backs up smart disk drive

The use of sealed-enclosure, nonremovable-media (Winchester-type) technologies has greatly improved the reliability of magnetic-disk storage systems. But they are not likely to replace other types of storage completely.

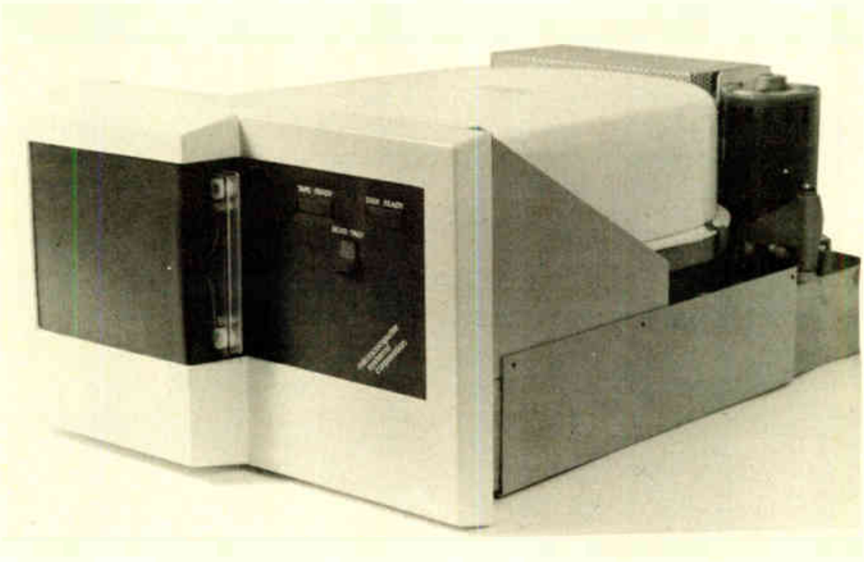
The reason is that other storage media are still required not only as a hedge against possible system failure or destruction, but also as an economical means of transporting large quantities of data and maintaining archives. IBM, originator of the Winchester technology, recognizes this and provides backup in the form of flexible-disk drives for its low-end computers and magnetic-tape drives for its larger mainframes.

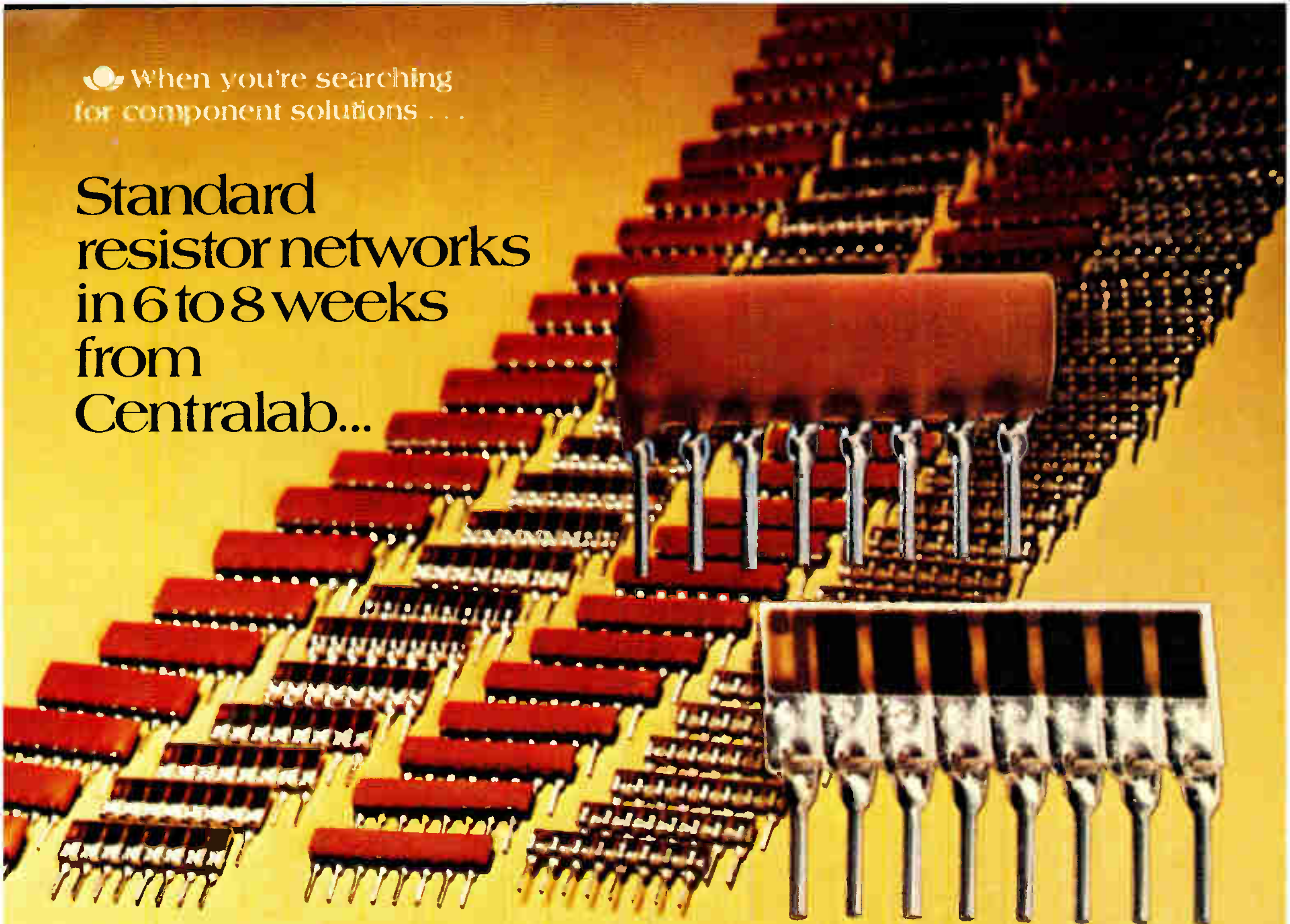
While no one has yet found a way around the back-up problem, James Toreson, president of Microcomputer Systems Corp., feels his company has found an effective means of dealing with it. That means is embodied in the MSC-5900, a Winchester-type, hard-disk drive with a built-in drive for magnetic-tape cartridges.

MSC, however, is tackling not only the back-up problem with its 5900 design. "We are really addressing the whole cost-of-ownership issue, which is a function of initial cost, reliability, and maintainability," Toreson says.

Traditionally, three subsystems were required for a computer-to-peripheral arrangement: a host computer input/output adapter, the peripheral controller, and the peripheral itself. MSC's system engineers chipped away at initial cost by taking one of the subsystems, the peripheral controller, and imbedding it in the peripheral. By taking advantage of large-scale integrated circuitry, they reduced the parts count, thus enhancing reliability and reducing costs.

To make the storage system easier to maintain, MSC uses self-diagnosis and even self-prognosis. Now, in addition to telling you why it stopped operating, it also tells you why it will





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stop operating, Toreson says. "All systems have scheduled down times. Knowing where a potential problem exists allows a technician to eliminate it before it causes an unscheduled system stoppage," he explains. Prognosis is a key part of MSC's strategy to stretch the 5900's mean time between failures (MTBF), which is a minimum of 8,000 hours.

An Intel 8085 controls both disk and cartridge drives, provides host interface communications, and oversees self-diagnosis and prognosis. A user can set up diagnostic routines using the dual-in-line-packaged switch at the control board's periphery and see the results on the light-emitting-diode array nearby. Prognosis is accomplished by monitoring any increases in the seek time and the amount of error correction.

Field-programmable logic arrays offer high-speed data formatting ability, and emitter-coupled logic sets up the very precise and rapid sampling-time windows used for decoding the modified frequency modulation (MFM) flux transitions. Error correction coding (ECC), which permits the 5900 to do on-the-fly correction, is a key element in future failure prediction. Whereas ECC requires some redundancy of functions and capacities, it helps to stretch the MTBF even further, according to Toreson.

The MSC-5900 comes in four models that differ in capacity: 12.5, 37.6, 62.7 and 87.8 megabytes. The smallest model contains 1 disk and 2 data heads and the largest contains 4 disks (seven data surfaces) and 14 data heads. The system transfers data at 7,080 kilobits/second (885 kilobytes/second); maximum latency time is 20.24 ms and maximum access time is 70 ms.

The cartridge drive section holds 17.1 megabytes of data and transfers it at a 1.1-megabyte-per-minute rate into a 3M-type cartridge containing 450 feet of magnetic tape. Adapter boards are in stock for interfacing the 5900 to Digital Equipment Corp.'s PDP-11, IBM's Series One, Data General's Eclipse and Nova and Hewlett-Packard's 21-XX minicomputers. In quantities of 100 and more, an 87.8-megabyte version of the storage system sells for $8,500 and is available 90 days after receipt of order.

Microcomputer Systems Corp., 432 Lakeside Dr., Sunnyvale, Calif. 94086. Phone (408) 733-4200 [403]

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Tape terminal challenges floppies

If nothing else, this year's NCC should demonstrate that tape technologies are far from being outmoded by the encroaching floppies. A good example of this premise will be seen in the form of the series 1000, a group of four dual-port communications tape terminals that

use 3M DC100 tape cartridges. Each tape cartridge can store up to 336,000 bytes of unformatted data—about three times the capacity of a minifloppy.

All four models use the model 200 minidrive tape transport, which reads and writes tapes at speeds up to 30 in./s. Since the recording density of the tape in this system is 800 bits/in. (well below the tape's maximum), the maximum data transfer rate is 24,000. The series 1000 units are at present equipped for interfacing to 9,600-baud links, this being the highest communications rate commonly encountered.

Two configurational possibilities differentiate the models of the series 1000: single or dual tape drives and remote-only or remote/local control. All models, built around a 6802 processor, have dual RS-232-C interfaces for hooking up to terminal, printer, telephone line, or other communications links. With their high-speed data-handling capabilities, the units can store data until, say, a slow terminal is ready to accept it. Dual-cartridge models can in addition allow information to be edited and updated while in the process of being transferred from one tape to another.

Although the storage capacity of the tape is greater than that of a minifloppy, Leon Malmed, sales manager for Qantex, points out that the main event between floppies and tape drives will be held in the arena of reliability. "The cartridge's tape is totally enclosed and protected, providing inherent invulnerability to damage," he says. In contrast, he characterizes the floppy as "a relatively delicate storage medium, harmed by careless handling and requiring care in storage and insertion."

He further notes that the series 1000 provides a read-after-write tape head; this permits error detection at the source so that important data need not be lost, a feature no floppy system offers at present. It further uses cyclic-redundancy-character coding to ensure data integrity in system use.

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ries 1000 models varies from $1,625 for a single-cartridge, remote-only unit to $2,175 for a dual-cartridge, remote/local terminal. Delivery time for any of these units is approximately eight weeks.

Qantex Div., North Atlantic Industries Inc., 60 Plant Ave., Hauppauge, N. Y. 11787. Phone (516) 582-6060 [404]

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Slave improves old master

A new wrinkle on the old parallel processing idea is Computer Automation Inc.'s answer to extending the life and performance of its widely installed board minicomputers, some of which have been in service for five years. Ready for National Computer Conference showing, its new "slave" computer requires only a minimal software change to plug into any of its 16-bit "Naked Mini" line. The intent of the development, a response to users, says the company, is to push performance up into intermediate computing levels with a minimum of reprogramming.

While "the idea of putting more than one computer to work in parallel is not new," admits George O'Leary, vice president of marketing for the Naked Mini division, company designers have more precisely defined it for the 4/10S slave. "It is a technique for adding parallel autonomous computers with their own memory and I/O on the same bus as the system processor."

A single-board (half-card) computer, the 4/10S has the same custom MOS chip set used as a central processing unit by the CA 4/10 minicomputer. It also holds 32 kilobytes of dynamic random-access memory, four on-board input/output ports, and also associated logic.

Besides central processing similarity to the 4/10 computer, the "slave" is alike in physical size, architecture, and software compatibility. Where the 4/10S differs from the 4/10 (and what actually makes possible its development) is in the use of higher-density memories and logic

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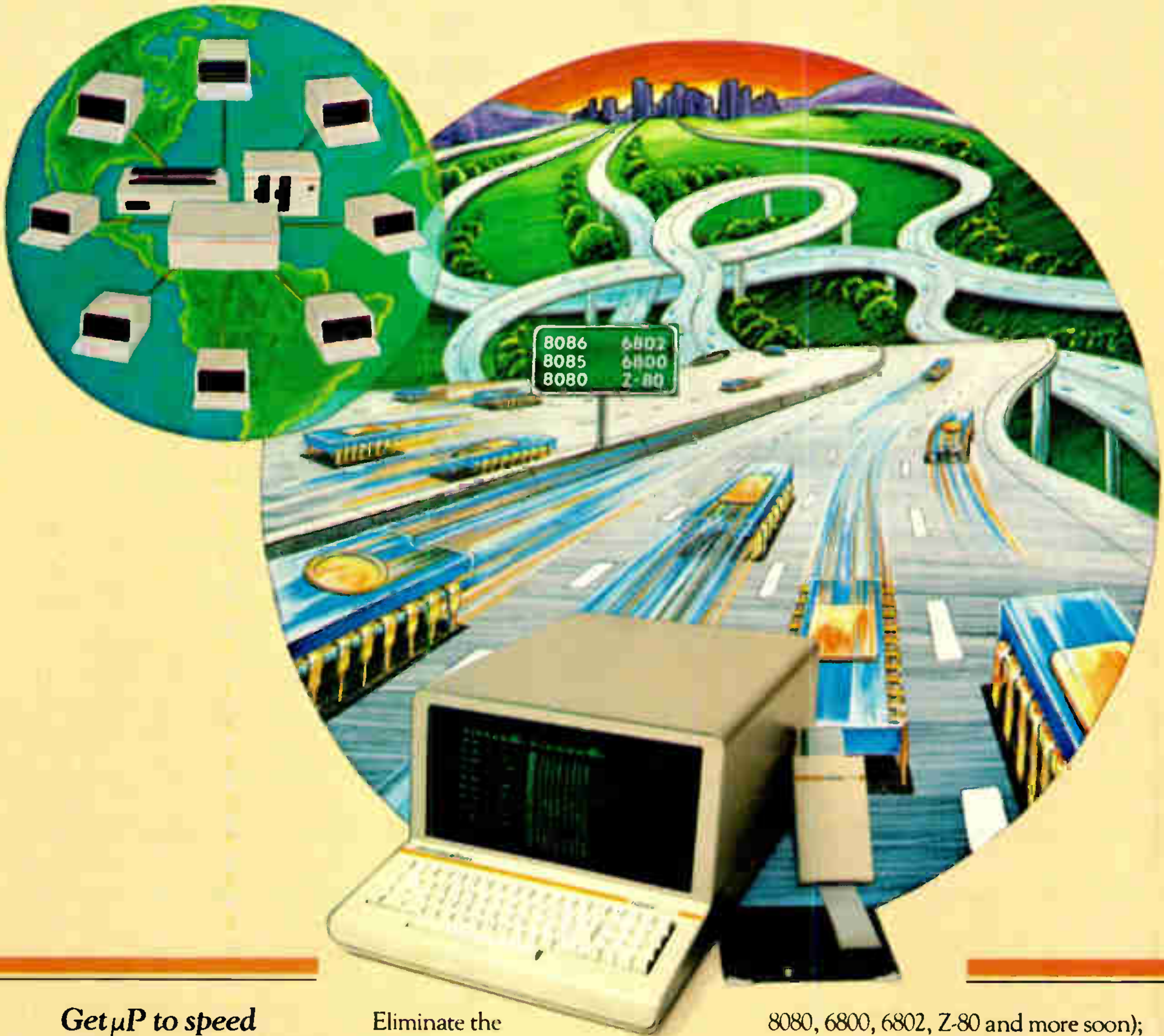

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futuredata

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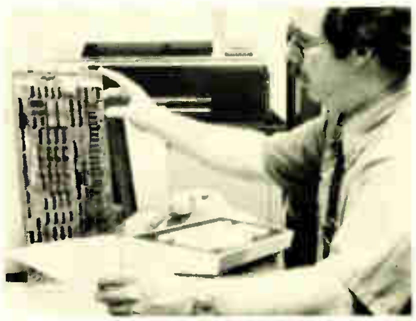
circuitry heretofore unavailable. Particularly important, notes O'Leary, are programmable logic array devices that have a space-saving advantage of approximately 4:1 over the 4/10 mini.

In the master/slave configuration the 4/10S operates as a peripheral direct-memory-access device for off-loading CPU functions that can run both concurrently with and independently of the host processor, says O'Leary. This degree of independence is an important feature that distinguishes the 4/10S from current multiprocessing architectures that usually share host memory and input/outputs. With "private" memory and I/O, the 4/10S directly addresses its on-board 32 kilobytes and half the host ("public") memory and executes instructions out of either sector. Data or instructions can be moved as a block from public to private memory, according to the marketing executive.

The 4/10S is not intended to function as a stand-alone host computer, he points out. Up to four 4/10S slave computers may be linked with a single host, thereby increasing total system memory in 32-kilobyte increments. It may be reset and interrupted and have slave control service functions performed from the host machine through I/O instructions. An on-board real-time clock can be used for loading and debugging, he says.

CA officials believe the new computer is ideal for such applications as process control and communications, where computer-to-computer interface and parallel processing are important.

Evaluation units of the 4/10S are available immediately, priced at



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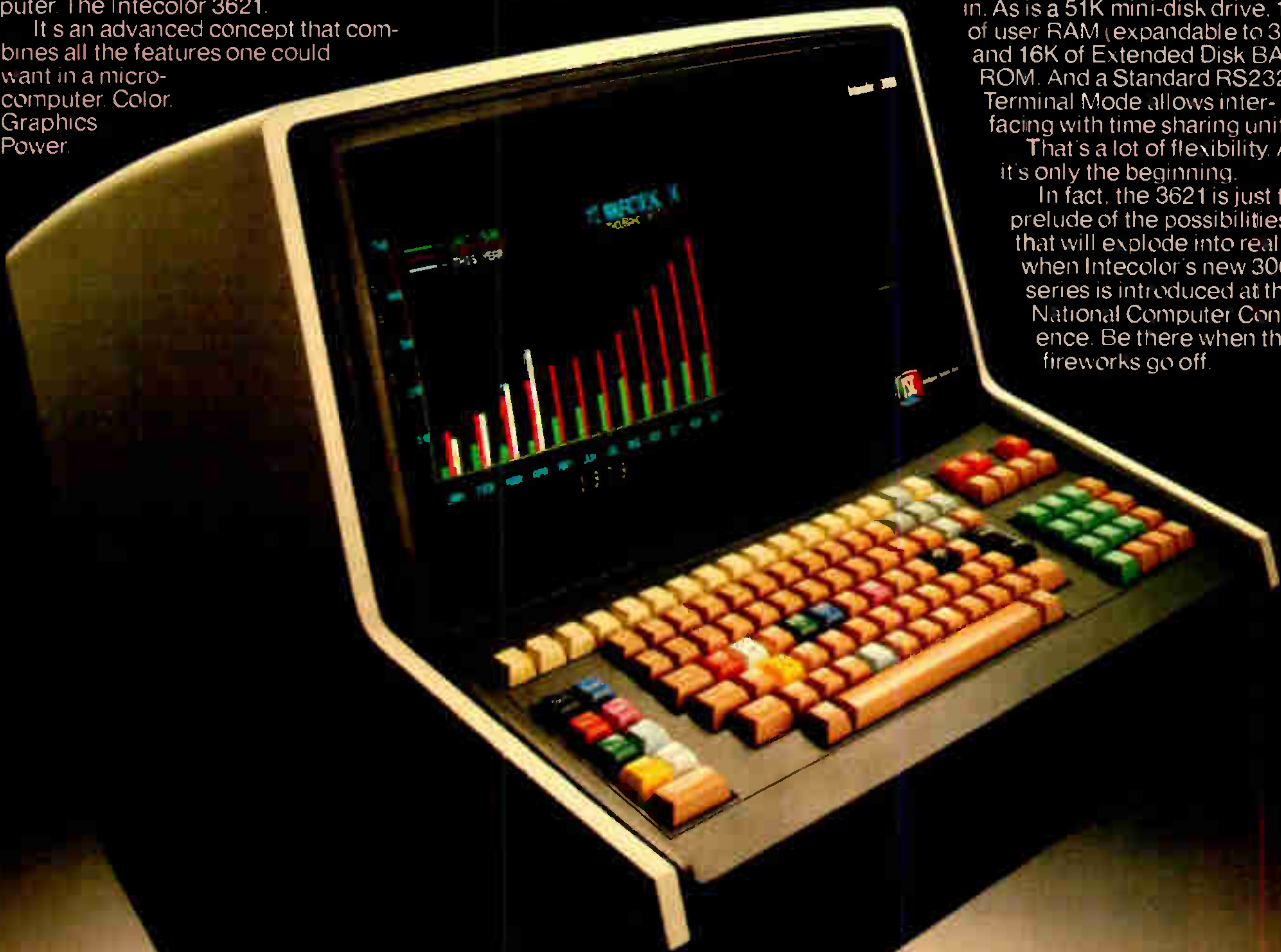

See us at Booth 4806 at the NCC Show in June.

Unretouched photo of screen

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For sales and service in other countries contact ISC headquarters in Norcross, GA., U.S.A.

Intelligent Systems Corp. ☐ 5965 Peachtree Corners East ☐ Norcross, GA 30071 ☐ Telephone 404-449-5961 ☐ TWX 810-766-1581

Circle 205 on reader service card

Store Recorders have made

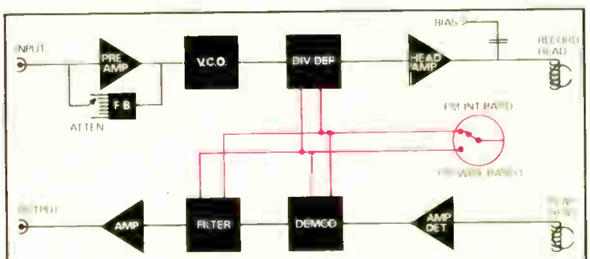
Flick a single switch on a dual standard recorder in the new Racal Store DS range, and you've changed instantly from Intermediate Band to Wideband operation on FM. A single switch that selects either recording standard – without the need to interchange plug-in modules. A single switch changes all the signal channels (four to fourteen) on all seven speeds.

FM Capability

The Store range of instrumentation recorders, well-renowned for research in the scientific, automobile, aerospace and medical fields, now offers an FM capability over the entire band DC to 40 kHz, and up to 300 kHz on Direct Recording.

Greater Flexibility

And even greater flexibility. Switch any channel to unipolar, and the full dynamic range becomes available to either positive or negative going signals. Switch any channel to offset, and you can record a 100 mV peak-to-peak signal on a 20 V step – without losing any dynamic range.



DUAL STANDARD FM SIGNAL CIRCUITS

We've just built a brand new case for color graphics.

The new Intecolor 3621.

Desk top computing will never be the same.

From Intelligent Systems Corporation, the company that developed color graphics at black and white prices, comes a sophisticated new design that will put dynamic, efficient color at the fingertips of everyone who uses a desk top computer. The Intecolor 3621.

It's an advanced concept that combines all the features one could want in a microcomputer. Color. Graphics. Power.

Reliability. Performance. Style. All in a sleek, compact package. At a price that's irresistible.

Eight brilliant colors speed comprehension and communication on an ample 13" screen. The unit has the capability of displaying 32 lines of 64 ASCII characters, as well as plotting graphics on a 128 x 128 grid. Vector software is built in. As is a 51K mini-disk drive, 16K of user RAM (expandable to 32K) and 16K of Extended Disk BASIC ROM. And a Standard RS232C Terminal Mode allows interfacing with time sharing units.

That's a lot of flexibility. And it's only the beginning.

In fact, the 3621 is just the prelude of the possibilities that will explode into reality when Intecolor's new 3000 series is introduced at the National Computer Conference. Be there when the fireworks go off.

See us at Booth 4806 at the NCC Show in June.

Unretouched photo of screen

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Circle 205 on reader service card

$1,990 in single quantity. Volume deliveries of the computer will require 90 days.

Computer Automation Inc., Naked Mini division, 18651 Von Karman, Irvine, Calif. 92714. Phone (714) 883-8830 [405]

NCC NCC NCC NCC NCC NCC NCC

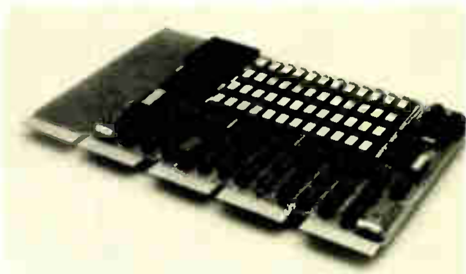
New memories for an old machine

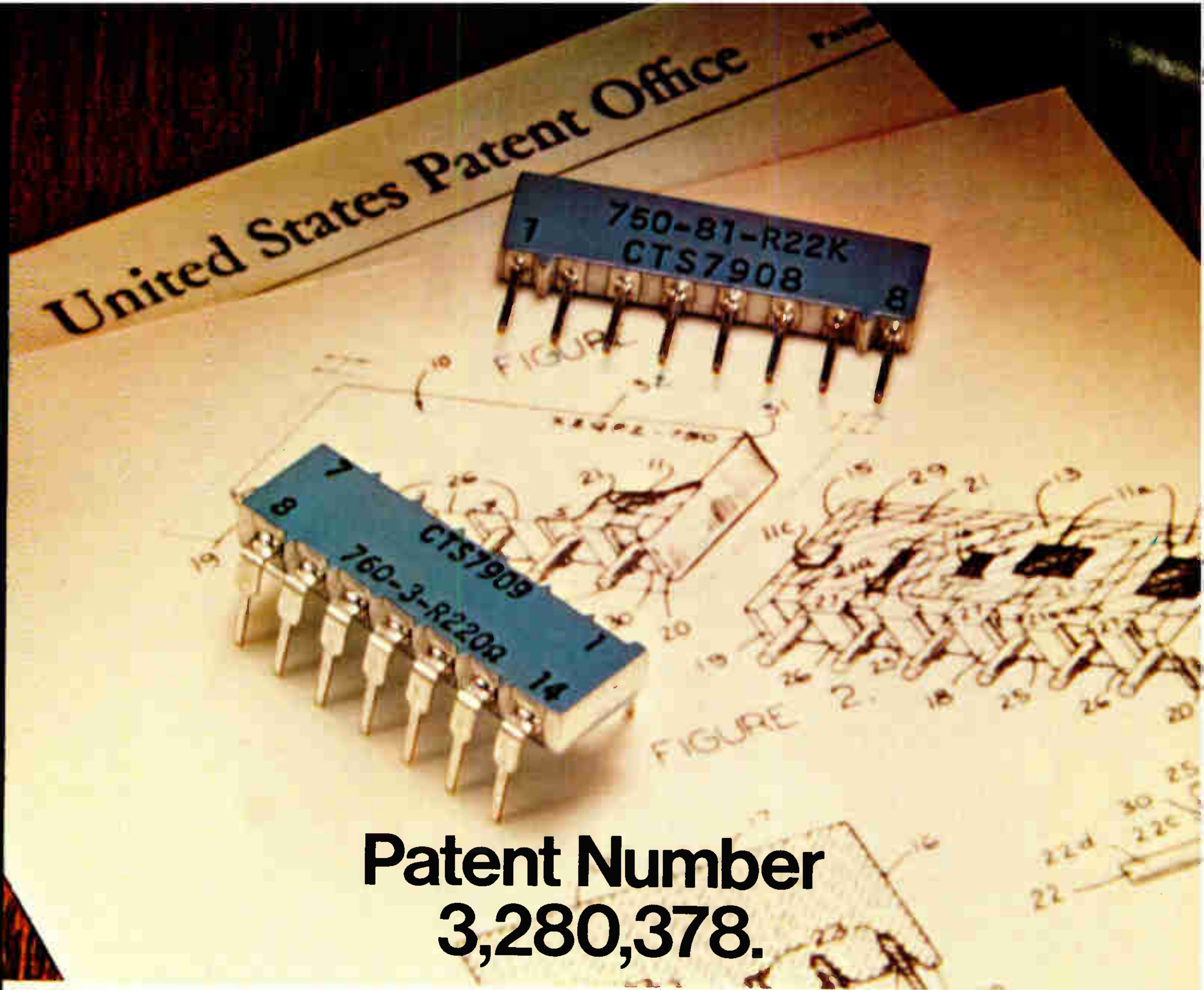
Filling out the lower end of its line of memory systems designed to be used with minicomputers made by Digital Equipment Corp., Mostek Corp. has come up with an add-in memory board for DEC's venerable PDP-8 machines.

The MK8009 will be available in a "quad-wide" version measuring 8.44 by 10.45 in. and a "five-wide" version with dimensions of 8.44 by 13.2 in. Both plug into a standard Omnibus slot. The five-wide version works in conjunction with DEC's KT8A memory management system to reach a maximum capacity of 131,072 12-bit words using two 8009 cards with DEC's PDP-8/A machine, which was brought out in 1974. The quad version works with earlier-generation PDP-8 models E, F, and M to reach the maximum 32,768-word capacity possible with those machines.

Making use of Mostek's MK4116 16,384-bit random-access read/write memory chips, the MK8009 requires only a single 5-V power supply; it generates the other required voltages on-board. The 8009 refreshes itself in synchronism with the PDP-8 memory cycle. Thus, according to Mostek, the memory can run at machine speeds with no degradation due to the need for refreshing.

The primary market for the 8009 boards is expected to be original-





Patent Number 3,280,378.

Termination strength is the key to network reliability—patented CTS Anchor Lock™ Terminations are the key to strength.

The secret? Our patented process forcefully drives the leads into tapered holes in the substrate, cold forming the lead to the substrate and wedging it tightly in place prior to soldering. Try pulling out a CTS lead; you'll see how much assurance our 5 lb. pull strength gives you. Then try it with a competitive product! You'll see what we mean.

Why risk a loose termination that can alter the resistance value of your network? CTS, and only CTS, can deliver the superior mechanical and electrical reliability qualities of Anchor Lock™ terminations. The same exclusive insertion process applies to both CTS Series 750 SIP and Series 760 DIP style cermet resistor networks.

Reliability has been our key to success. With more than one billion element hours of extended load life testing, CTS resistors have exhibited a failure rate of only 0.00041%/1,000 hours @ a 95% confidence level. Each SIP and DIP network is 100% value and tolerance tested before shipment.

Ask us about customizing your special network requirements; or choose from 400 standard part numbers available off-the-shelf from authorized CTS distributors.

See for yourself how superior Anchor Lock terminations earned that patent—plus a lot of respect over more than fifteen years of production experience. Ask for your free samples and network catalog. Write CTS of Berne, Inc., 406 Parr Road, Berne, Indiana 46711. Telephone (219) 589-8220.

CTS CORPORATION
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A world leader in cermet and variable resistor technology.

Circle 207 on reader service card

equipment manufacturers who are still buying PDP-8 machines, says Dan Ray, standard products marketing manager in Mostek's memory systems operation. With first deliveries scheduled for July, the quad-wide 8009 in its maximum 32-K configuration is priced at $1,500 for single units. The largest five-wide unit has a capacity of 64-K words and sells for $2,100 in singles.

Mostek Corp., 1215 West Crosby Rd., Carrollton, Texas 75006. Phone (214) 242-0444 [408]

NCC NCC NCC NCC NCC NCC NCC

Tape drive has low cost, high speed

Priced below $1,800 in large quantities, a low-profile streaming tape drive is intended for use as a disk backup in small business systems. Its low price is expected to allow it to compete effectively with cartridge, flexible-disk, and removable-hard-disk drives in these applications.

In its high-speed "streaming" mode, the unit's half-inch tape races along at 100 in./s, taking data on the fly in large blocks of up to a full disk at a time. As it does so, the drive automatically inserts industry-standard inter-record gaps onto the tape. In its conventional stop/start mode, it runs at 12.5 in./s.

Compatible with IBM and ANSI standards, the drive writes data in a phase-encoded format at a density of 1,600 bits/in. It has a nominal capacity of 30 megabytes on a single 10.5-in. reel. Thus many disk files may be dumped into the tape drive in a single continuous operation.

Unlike expensive high-speed drives, which are designed for fast stop/start operation, the streaming drive has no need for vacuum columns or conventional tension arms to provide tape buffering. It therefore can handle reels up to 10.5 in. in diameter (inserted horizontally) while occupying only 8.75 in. of vertical rack space. Deliveries are scheduled for early 1980.

Cipher Data Products, 5630 Kearny Mesa Rd., San Diego, Calif. 92111. Phone (714) 279-6550 [409]

Store Recorders have made

Flick a single switch on a dual standard recorder in the new Racal Store DS range, and you've changed instantly from Intermediate Band to Wideband operation on FM. A single switch that selects either recording standard – without the need to interchange plug-in modules. A single switch changes all the signal channels (four to fourteen) on all seven speeds.

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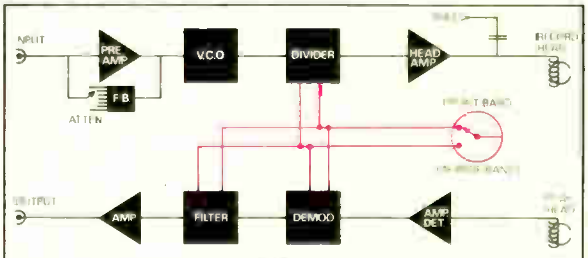
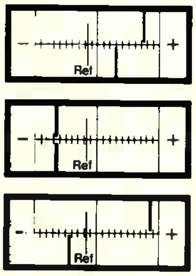
Greater Flexibility

And even greater flexibility. Switch any channel to unipolar, and the full dynamic range becomes available to either positive or negative going signals. Switch any channel to offset, and you can record a 100 mV peak-to-peak signal on a 20 V step–without losing any dynamic range.



DUAL STANDARD FM SIGNAL CIRCUITS

a quick switch to wideband.



Proven Success

All these outstanding new advantages have been added to the host of features which have made the existing range such a success–like single switch seven-speed selection, full servo operation, dual peak-indicating meters, full remote control of all functions, portability, and operation from AC or battery power sources.

That's why, by switching to the Racal Recorders' new Store DS range, you can make a quick switch to a whole new wideband world.

Racal Recorders Limited Hardley Industrial Estate, Hythe Southampton Hampshire SO4 6ZH England. Telephone: 0703-843265 Telex: 47600.

Racal Recorders Inc 5 Research Place, Rockville Maryland 20850. Telephone: (301) 948 3085.

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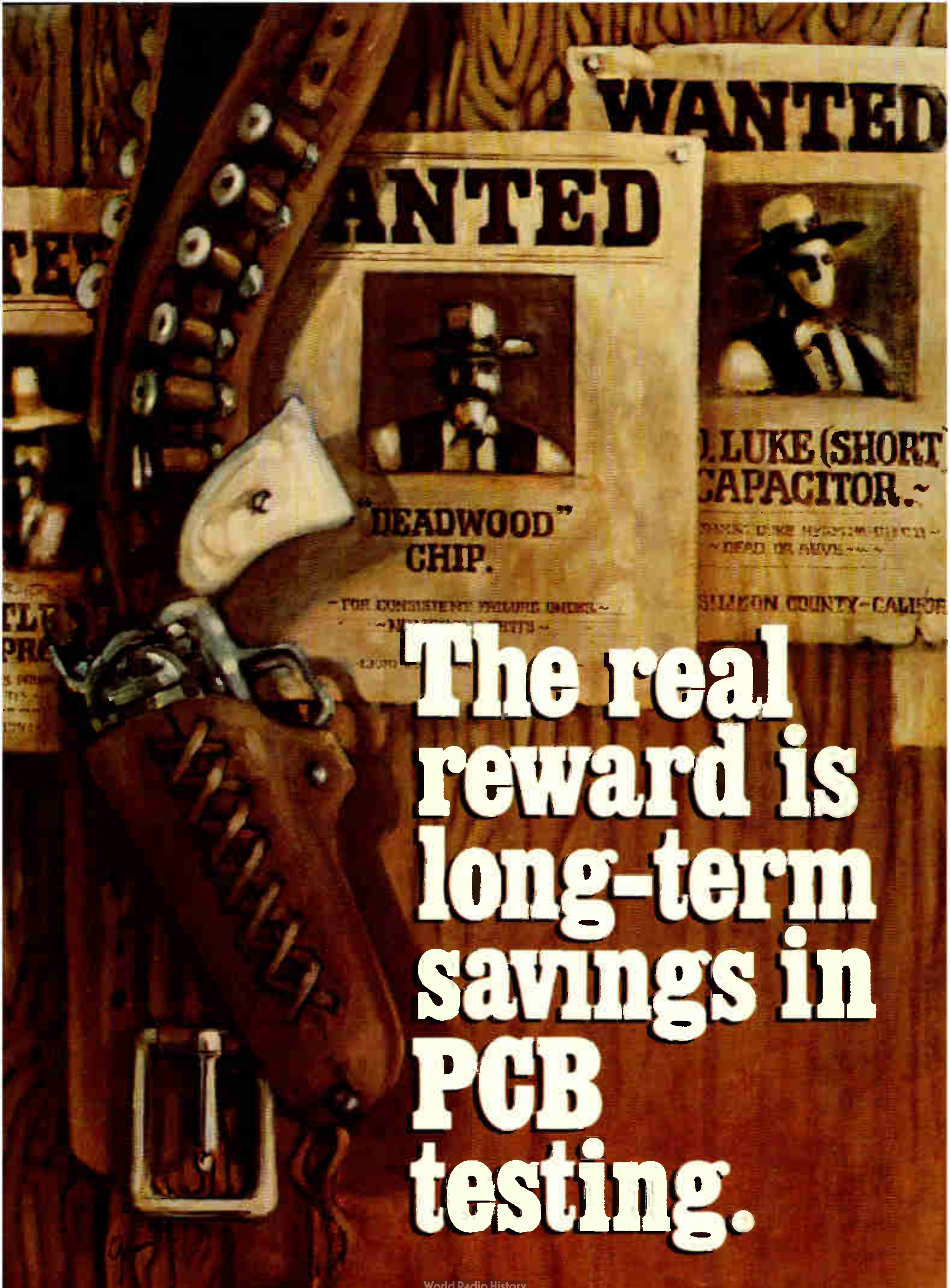
Racal Recorders *Always on the right track*

RACAL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Fairchild component test systems have paid big rewards in the world of LSI testing. Now Fairchild gives you the same rewards in production testing and field testing of printed circuit boards.

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Test Systems Group

The First Family of ATE

Circle 213 on reader service card

NEC gets serious about CMOS RAMs.

Introducing the μPD444/6514

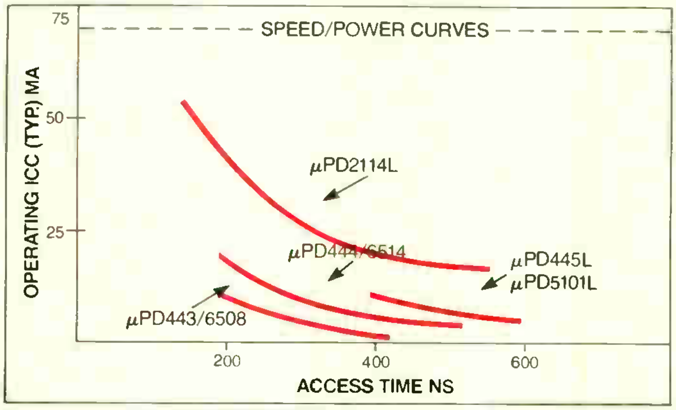
Our new 1K x 4 CMOS RAM, the μPD 444/6514, offers pin for pin compatibility with our industry-standard NMOS μPD2114L. So whether your memory requirements call for low standby power down to 0.065 μW, or high speed applications down to 150 ns, or a combination of both, NEC has exactly the part you need.

With our unique short channel length CMOS technology, we've designed the μPD444/6514 to provide access and cycle times as low as 200 ns in the industry standard 300 mil wide 18-pin package. Like the μPD2114L, it's manufactured on four-inch wafers—for low cost and high volume production. And the μPD444/6514 will operate in a fully static or asynchronous mode.

The μPD444/6514 is the latest

addition to our growing line of CMOS RAMs— a line that includes a 20-pin 4K RAM (μPD 445L), a 22-pin 1K RAM (μPD5101L), and an 18-pin 1K RAM (μPD443/6508). And besides depth in products, we offer depth in support—including engineers available to help with specific application problems, plus complete documentation, testing, and special selection.

Our 1979 product catalog contains full details on our complete line of memories, plus our 8-bit and 4-bit microprocessors and peripherals.



PART NUMBER	ACCESS TIME	OP. POWER (TYP.)	NO. PINS	STANDBY POWER (TYP.)	LOW Vcc POWER (TYP.)
μPD444/6514C	450 ns	45 mW	18	.065 μW	.022 μW
μPD444/6514C-1	300 ns	60 mW	18	.065 μW	.022 μW
μPD444/6514C-2	250 ns	75 mW	18	.065 μW	.022 μW
μPD444/6514C-3	200 ns	95 mW	18	.065 μW	.022 μW
μPD445LC	650 ns	45 mW	20	100 μW	1 μW
μPD445LC-1	450 ns	75 mW	20	100 μW	1 μW
μPD5101LC	650 ns	45 mW	22	1 μW	.016 μW
μPD5101LC-1	450 ns	75 mW	22	1 μW	.016 μW
μPD443/6508C/D	450 ns	25 mW	16	5 μW	.3 μW
μPD443/6508C/D-1	300 ns	45 mW	16	5 μW	.3 μW

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Logic analyzer has 48 channels

50-MHz state and timing unit with independent 16-channel blocks can handle three clock rates and two mnemonic sets at one time

by John Gosch, Frankfurt bureau manager

As microprocessor-based equipment becomes more complex, logic analyzers need larger numbers of channels to cope with its increasing numbers of ports, peripherals, and interface circuits. This need is becoming all the more pressing now that 16-bit processors are being widely accepted and applied.

A small West German firm, Dolch Logic Instruments GmbH (DLI), has therefore built a logic analyzer with 48 input channels, enabling it to handle "all popular 16-bit central processing units with up to 23 address lines, 16 data lines, and a number of control and status lines," says Volker Dolch, head of the instrument's design team and president of the 25-man company in Heusenstamm, near Frankfurt.

Billed as the most flexible logic analyzer available today, the LAM4850 succeeds DLI's 8-, 16-, and 32-channel analyzers—an equipment program that has helped the company capture some 20% of Europe's logic analyzer market. Characterizing the 50-MHz machine as a third-generation instrument, Dolch points out that it is a stand-alone system with a built-in microprocessor-controlled display device—specifically, a raster-scanned cathode-ray tube.

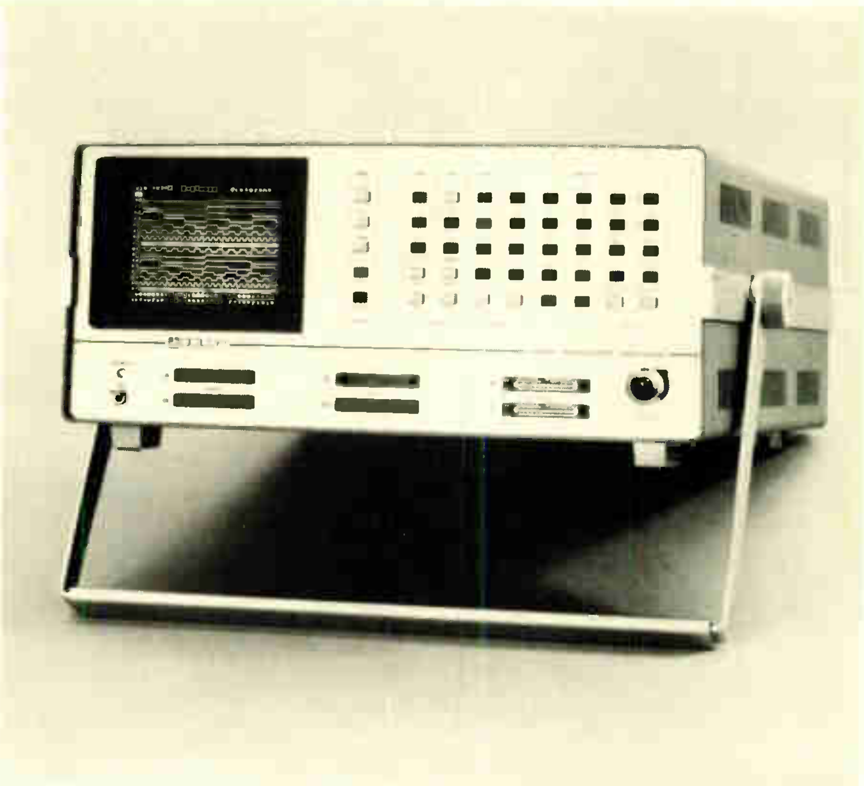
Three in one. Built around a Z80 microprocessor, which controls trace specifications and display formats, the LAM4850 consists of three independent 16-channel analyzer blocks. These may be configured to provide as many as seven different parallel and serial recording modes.

Using three memory blocks, each consisting of 16 channels with a depth of 1,024 bits per channel, the instrument can sample at three different clock rates simultaneously. This capability, which Dolch believes to be unique to the LAM4850, makes the instrument particularly well suited for analyzing distributed multiprocessor systems.

The instrument can simultaneously record synchronous logic-state information as well as asynchronous logic-timing signals. This, Dolch declares, should come in handy in complex digital system analysis. The unit's ability to sample asynchronous timing signals with clock rates up to 50 MHz and to catch glitches as short as 5 nanoseconds in duration makes it "a powerful tool in the logic-timing domain," he adds.

When used as a logic-state analyzer, the LAM4850 can display data in standard codes, such as binary, octal, hexadecimal, and ASCII, as well as in two optional firmware codes. Disassembler software options can provide mnemonic displays of most popular microprocessor op codes. Since there are two independent firmware options, the instrument can display two different mnemonic listings at the same time.

Sophisticated triggering. A key feature of the LAM4850 is four-level sequential triggering. Specified in a trigger menu displayed on the CRT screen, a sequence of four trig-



ger words, each containing 48 bits, may be set up in a "then" or "then not" algorithm to define complex nested loops. Another feature is window triggering, which allows the definition of limits within a 48-bit data stream and the specification of any section in which a trigger sequence of two successive events may occur.

Still another feature, one that Dolch calls a "trigger space monitor," makes complex sequential triggering more transparent to the user. It uses a dynamic counter display, which is part of the trigger menu, whenever a trigger search is in progress. The monitor keeps track of the sequential trigger conditions at all times and can thus be used to maintain a check on complex programs without resorting to the instrument's data-recording facility.

The LAM4850 is simple to operate, Dolch says. Extensive use of comment and range lines displayed on the screen makes the set-up procedure a self-teaching process. Expandable by factors of 10 and 20, the display provides a timing diagram of 16 channels and presents software notations and menus for trace specifications and formats as well as address and sequence information.

The instrument uses active-probe input pods, each with eight lines. Since they present a capacitive load of less than 5 pF at their tips, the probes have virtually no effect on the circuit under test. Four different threshold voltages, programmable from −10 V to +10 V, are simultaneously available.

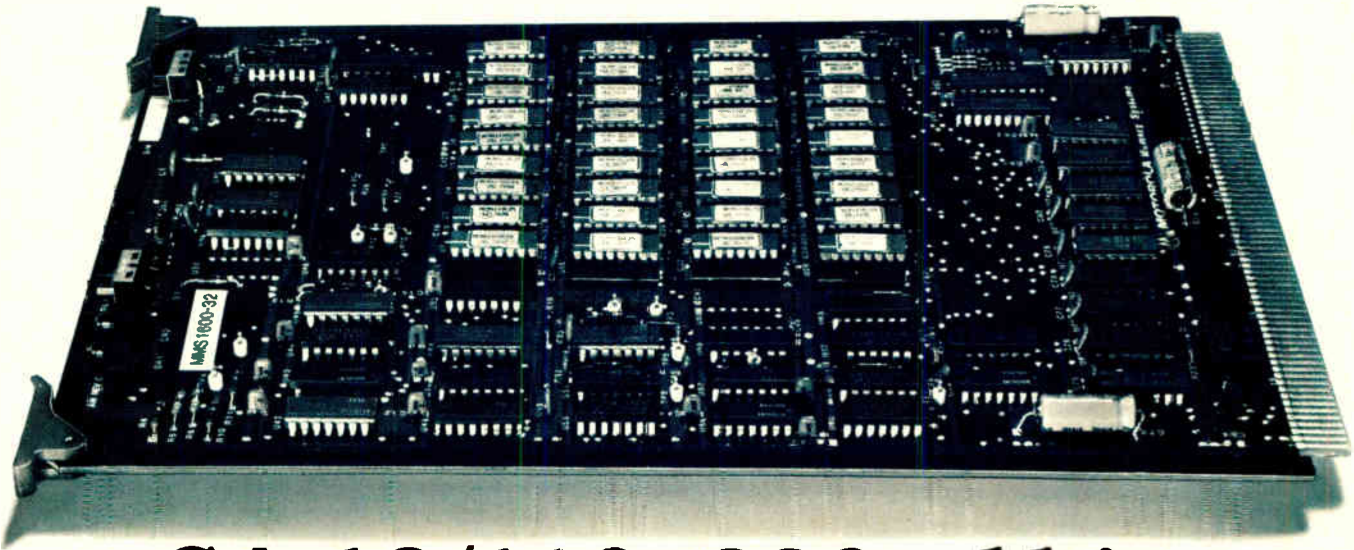
Interfacing the LAM4850 with peripherals is by means of an optional IEEE-488 bus interface. A standard RS-232-C interface allows direct access to the internal memories for hard-copy printout or remote reference memory loading.

The LAM4850 will be available in both Europe and the U.S. next month. Its $9,850 price includes seven active probes.

Kontron Electronic Inc., 700 South Claremont St., San Mateo, Calif. 94402. Phone (415) 348-7291.

Dolch Logic Instruments GmbH, 6056 Heusenstamm, Ottostr. 25, West Germany [338]

Technological leadership.



GA 16/110, 220 add-in. Another fully-compatible memory from Motorola. Now.

The MMS1600. It's Motorola's hardware- and software-compatible add-in for users of General Automation's 16/110 and 220.

So good it's warranteed for a full year. You get that rare combination of high performance and low cost with the assurance of quality. It's the add-in GA system users have been wanting but probably couldn't get.

The MMS1600 has the speed you look for, with a fast 400 ns maximum read access time and a minimum cycle time of just 450 ns. The low typical power consumption of 0.9 A and a worst-case drain of only 1.6 A @ +5 V make it a great system power saver. And, there's nothing like the extra 5° in the wide 0°C to 55°C operating temperature range for providing a cushion of reliability.

Four board configurations provide excellent design flexibility. Choose between the basic 32K-word × 16 and 16K-word × 16 sizes, or use either of the 32K-word × 18 and 16K-word × 18 parity option versions.

Small (1-9) quantity prices are low at $1350 for the 16K-word × 16 and just $1800 for the 32K-word × 16 memory. Yes, OEM discounts are available. Get the MMS1600 off-the-factory-shelf, now.

LSI-11*, PDP-11* add-ins for DEC* users.

The MMS1102 provides 32K of LSI-11 series-compatible high-performance memory, with on-board parity generation and internally distributed refresh. It decodes a full 18-bit address, making it ideal for the new LSI-11/23.

The high-speed MMS1117 supplies up to 64K of fully-compatible memory for most PDP-11 models, including the 11/60, 11/34, and 11/04.

Call (512) 928-6776.

For immediate Motorola memory system price and delivery information, call (512) 928-6776 or your Motorola sales office. For an MMS1600 data sheet, write to Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036, or circle the reader service number.

Motorola memories are available now for systems everywhere. Leading edge storage is but one of the many technologies in which Motorola is serving the designers of

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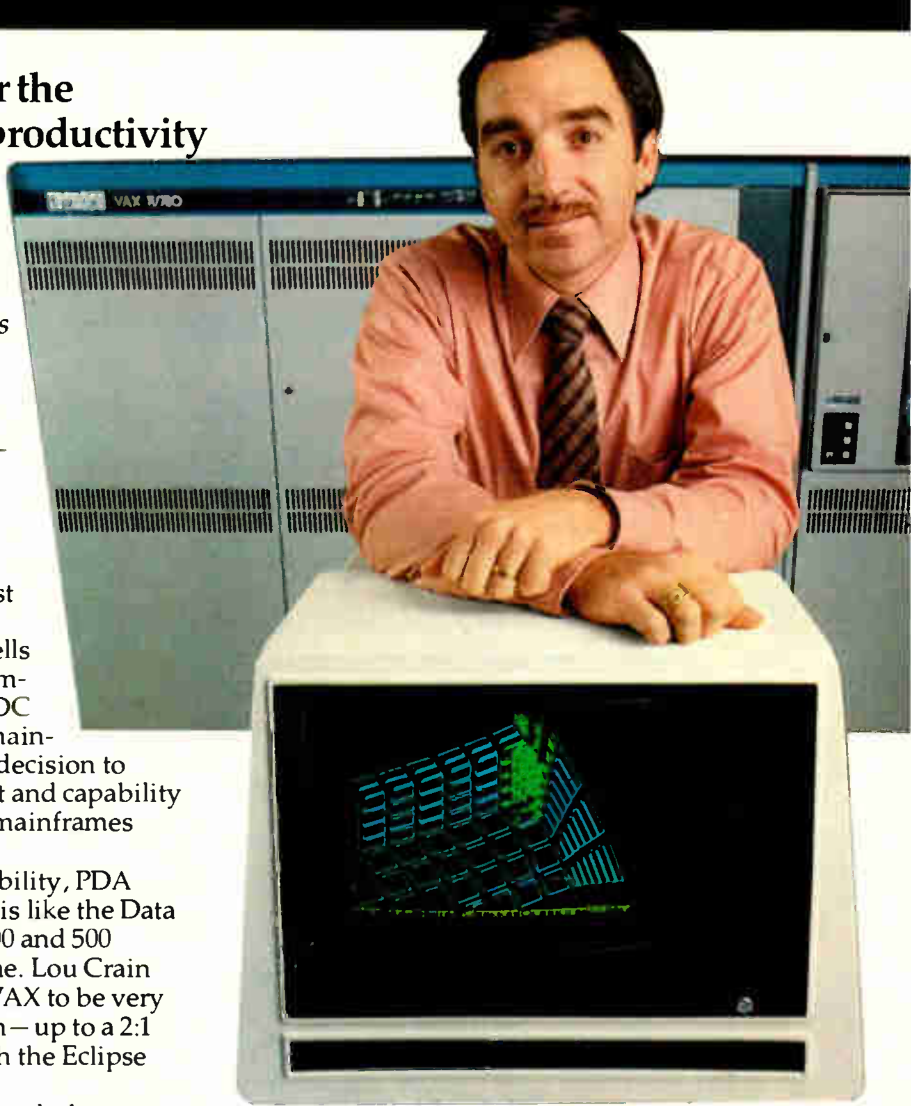

"VAX simply ran over the competition. In cost/productivity ratios, nothing even came close."

Lou Crain, Mgr. of Software Products
Prototype Development Associates
Santa Ana, California

PDA is an employee-owned engineering concern whose business ranges from fundamental research in structural analysis to the manufacture of critical aerospace components.

The VAX-11/780 is PDA's first in-house computer. Lou Crain, Manager of Software Products, tells us, "We've been doing all our computing through utilities using CDC 6600, Cyber 74 and Univac 1108 mainframes. The key elements in our decision to acquire the VAX-11/780 were cost and capability — compared to service bureaus, mainframes and competitive minis."

From the standpoint of capability, PDA considered traditional superminis like the Data General Eclipse and the Prime 400 and 500 series, plus a used 1108 mainframe. Lou Crain says, "Our benchmark showed VAX to be very powerful against the competition — up to a 2:1 performance advantage over both the Eclipse and the 1108."

"After installation," Crain concludes, "VAX has lived up to our expectations and has performed impressively. It's resulted in better products for our customers, as well as improved cost-effectiveness. Having our own interactive capability in-house has meant an increase in engineering productivity of up to 300%."

"VAX turns out to be twice the machine for the same amount of money."

Roger Vossler,
Section Manager and Systems Engineer
TRW Defense and Space Systems Group
Redondo Beach, California

Sensor data processing and distributed processing systems in support of real-time embedded applications are among the specialties of TRW's Defense and Space Systems Group.

To find the right computer, TRW continues to evaluate numerous machines—including Digital's VAX-11/780. They've also conducted numerous FORTRAN and PASCAL benchmarks.

In every test, VAX stands out as a clear winner.

Roger Vossler, Section Manager and Systems Engineer, says, "VAX is one of the best implementations we've seen of a successful integrated hardware and software system."

Since TRW's sensor data processing applications require enormous memories—over a million bytes to store a single image, for example—VAX's true 32-bit address space is vitally important. In addition, says Vossler, "VAX's I/O bandwidth capabilities are extremely important for effectively moving large quantities of real-time data at very high data rates."

Because TRW already had an investment in Digital technology, Vossler is particularly impressed with the relative ease of moving PDP-11 series programs onto VAX.

"But," says Vossler, "Even if I were starting all over again—without our Digital experience—I would still pick VAX, on the basis of its architecture, both hardware and software, and its impressive performance."

"Implementation was faster on VAX than on 25 other machines."

Brian Ford, Director
Numerical Algorithms Group
Oxford, England/
Downers Grove, Illinois

The Numerical Algorithms Group develops and maintains mathematical and statistical software libraries for customers in industry, science and academia.

Before VAX, NAG had implemented their complex Mark 6 Library on 25 major machines, including the Burroughs 6700, CDC 7600, Univac 1100, and the IBM 370. The average implementation time was 13 man-weeks.

VAX took five.

In Dr. Ford's words, "A successful implementation requires the correct functioning of the 345 library routines to a prescribed accuracy and efficiency in execution of NAG's suite of 620 test programs. Whilst the activity is a significant examination of a machine's conformity to the ANSI standard of the FORTRAN compiler, its main technical features are file creation, file comparison, file manipulation and file maintenance."

And implementation performance was just the start. Dr. Ford comments on VAX's impressive record of reliability after the program was up and running: "No problems were encountered in the VAX/VMS software even though approximately 3000 files were being handled. The operational availability time for the machine was close to 100%, an outstanding statistic for new hardware and a new operating system.

"VAX," Dr. Ford concludes, "is an implementor's dream."

Digital's VAX-11/780 has re-defined the level of performance you can expect from computers in its price range.

If your application requires large number crunching capability, high floating point accuracy, or lots of high-speed real-time calculations, there is simply no better system.

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☐ Please send me the new "VAX—Ask Any User" brochure and detailed Technical Summary.
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Digital Equipment Corporation International, 12 av. des Morgines, 1213 Petit-Lancy, Geneva, Switzerland

In Canada: Digital Equipment of Canada, Ltd.

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Industrial

Angle encoder sells for $200

Absolute potentiometer unit with external a-d converter covers full 360° rotation

The increasing use of microprocessors in control systems is generating an ever bigger demand for shaft-angle encoders, particularly for absolute types that are less prone to error than are incremental versions. Their major drawback, however, is a fairly high price, which hardly complements the declining price trend for microprocessors.

Now, however, a West German electronics firm has broken through the price barrier with an absolute encoder that will sell for up to 80% less than competitive devices with comparable resolution and accuracy. For example, one unit with 12-bit resolution and 10-bit absolute accuracy will sell for about $200. That, the firm says, compares with roughly $1,000 for similarly rated optical encoders now on the market.

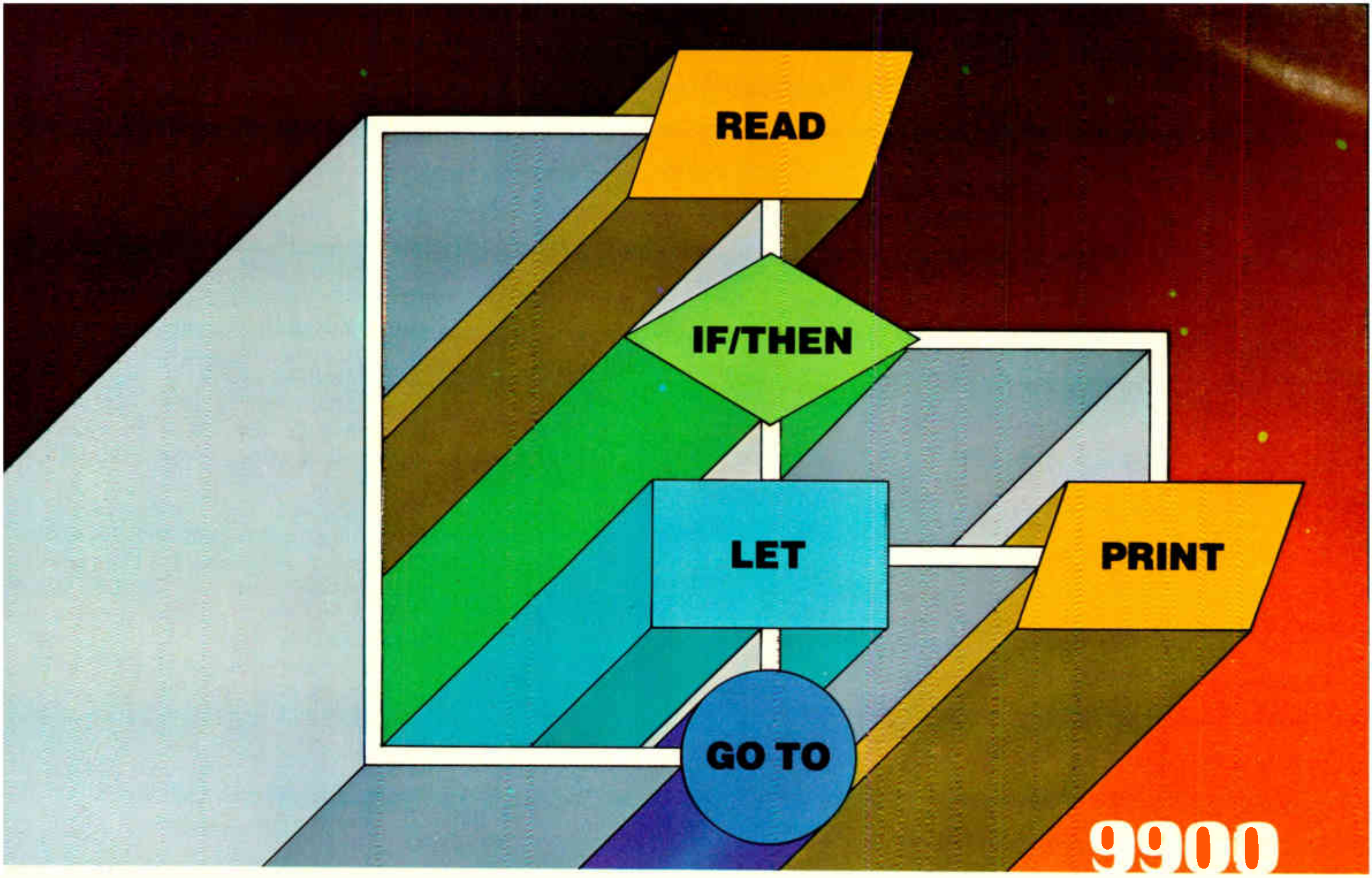
Developed at Novotechnik KG, an 80-person company in Ostfildern, near Stuttgart, the new encoder will be on the market in the U. S. and elsewhere early this summer. Besides being inexpensive, the device is microprocessor-compatible and is highly reliable. Typical applications are in rotary antenna systems, machine-tool coarse/fine controls, and analog and digital angular-position displays.

Full circle. "The key to the low price is the encoder's novel design," says Ernst Gass, Novotechnik's president. The device uses a comolded conductive-plastic potentiometer that operates continuously over 360°. Its output is processed into an uninterrupted sawtooth voltage, which is applied to a separate analog-to-digital converter. For ease in interfacing with microcomputer systems, the digital output is binary, rather than the more common binary-coded decimal or Gray code. The new device is claimed to be the first potentiometer-based absolute digital full-360° shaft encoder. It does without the conventional encoders' expensive coding disk as well as the slide contacts, light source assembly, or magnetic reading head found on brush-type, optical, or magnetic encoders used today.

Novotechnik will initially come out with two basic versions of the encoder: one for operation over 360° and the other over 2,880°, the latter corresponding to eight revolutions. Their potentiometer and hybrid sawtooth-voltage processing circuitry, both in a common housing (see photo), connect directly to the external a-d converter. Early next year the firm will offer encoders with the converter built in, Gass says.

The 360° versions have a resolution of 12 bits and come with an absolute-accuracy rating of either 10 bits or 11 bits. Designated the AW360ZE/10 and AW360ZE/11, they will sell for about $200 and $250, respectively. The 2,880° versions sport a 15-bit resolution and come with absolute-accuracy ratings of either 13 or 14 bits. Designated the AW8-360ZE/13 and AW8-360ZE/14, these will sell for about $350 and $400, respectively.

(The 2,880° types have two pots. When pot 1 has made a complete revolution, pot 2 has covered 45°. With each additional revolution of



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Three POWER BASIC versions let you select the capability and cost best suited to your application. All versions make TI's 990/9900 Family even easier to use. Choose from:

- **Evaluation POWER BASIC**– 8K bytes of memory in four Solid-State Software™ ROMs. For single microcomputer module evaluation of POWER BASIC language.
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For an easy-to-understand Reference Guide on the language you can write after an hour's instruction, call your nearest TI field sales office or authorized distributor. Or write Texas Instruments Incorporated, P.O. Box 1443, M/S 6404, Houston, Texas 77001.

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pot 1, pot 2 advances another 45°. This continues until pot 2 has made one complete revolution. Then pot 1 has covered 2,880°.)

The Novotechnik-designed potentiometer exhibits a remarkable set of performance characteristics. Its operating life, said to be five times longer than that of other pots, is guaranteed at about 50 million revolutions at a wiper speed of 1,500 revolutions/min. The maximum wiper speed and acceleration values check in at 6,000 rpm and 50,000 radians/s^2, respectively. The pot nonlinearity ratings are as low as 0.025% and those for resolution as low as 0.007%.

The encoder uses the AD574 from Analog Devices Inc. as its a-d converter. This hybrid 25-μs 12-bit successive-approximation converter is microprocessor-compatible, and its high accuracy and stability mesh well with the pot's high linearity and resolution.

Making up the encoder's hybrid sawtooth-voltage processing circuitry are essentially a complementary-MOS analog switch and a bi-FET operational amplifier. These devices—from various U. S. suppliers such as Motorola, RCA, Texas Instruments, Fairchild, and others—have enabled Novotechnik to develop a pot operating over a full 360° range and providing an uninterrupted sawtooth output at high speed and accuracy.

The encoder operates off a supply of ±15 V and over a temperature range from −25°C to +85°C. The analog output from the sawtooth-voltage processing circuitry goes from 0 to 10 V.

Novotechnik KG, 7302 Ostfildern 1, P. O. Box 4220, West Germany

Waters Manufacturing Inc., Longfellow Center, Wayland, Mass. 01778. Phone (617) 358-2777 [371]

Amplifier drives synchros with up to 50 W

Designers who want to use a computer to drive large synchros can design an interface using the PA-13.

New products

This power amplifier can deliver up to 50 W and is also offered on a board with a digital-to-synchro converter.

The amplifier, whose closed-loop gain is 3.6 at 50 W, has a frequency response that is within ±0.2 dB from 50 kHz. Third-order harmonic distortion is less than 0.1%.

The PA-13 accepts inputs of 3.0 ±0.6 V rms. It has an output quadrature voltage rating of better than 1 mV/V when used with a transformer. Response time for a 0 to 90% change is at most 50 ns.

The DRPA-13 is a combination of amplifier and on-board d-s converter with a standard resolution of 14 bits; other resolutions are available on special order. Commercial or industrial temperature versions are priced at $395 (PA-13) and $595 (DRPA-13). Delivery is in 60 to 90 days.

Natel Engineering Inc., 8954 Mason Ave., Canoga Park, Calif. 91306 [372]

Digital time-delay relay owes versatility to microprocessor

Although they look much like other industrial relays, Agastat series DSA digital time-delay relays actually contain a microprocessor that controls all timing functions. By using the semiconductor device, the designers claim to have eliminated errors caused by temperature changes and line disturbances, which affect other RC-threshold timers.

Six timing modes are field-select-

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Super Bright .5" LEDs ● 20mA Drive Per Segment ● Hi-Rel Design for Long MTF ● Accuracy ± (.05% reading + 1 digit) ● Sample Hold Feature ● Ideal Replacement for Low Drive capability single chip DPMs

The PM-35D is a full feature 3½ Digit Instrumentation DPM • Full Differential Inputs • Bipolar • Auto Zero • Ratiometric • 4/20 mA • Ohmmeter/Ammeter • Programmable Decimals • Scaling in Engineering Units with offsets • Low TC Lamp • Test • Sample Hold • ±12v DC @ 5mA Power Output from Internal DC to DC Convertor • 5v DC Pwr Circle 49

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The PM-45D Represents the ultimate in miniature Hi Rel DPM Design featuring very bright .3" LEDs • 4/20mA Inputs • Ohmmeter/Ammeter Ratiometric • Programmable Decimals • Scaling in Engineering units with Offset • +7 to -3v Common Mode Voltage • Sample and Hold • Usable at 0 to 100mv to DISPLAY 0 to 20,000 Counts • Internal Attenuator for 2v, 20v, 200v, 2,000v, Rdgs (Max 1200v Input) • Lamp Test • Overrange Output • Busy Output • Clock Output • 5v DC Pwr Circle 50

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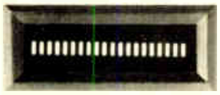
AM-20 $32* (1-9) $26 (100's)



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Solid State Dual or Single Set Point Controller • Set Point Accuracy ±1% • Full Scale Accuracy ±2% • Minimum Full Scale Voltage Span 0.5v DC • 4/20 mA Inputs • Offsets • Scaling • User Programmable for Bar or Dot Display Mode • Unipolar Full Scale or Bipolar Center Zero Null Meter • 20 Selectable Set Points • Two Opto-Isolated Relay or Alarm Drivers • Max Off Voltage 30v • Max on current 200 mA • 5v DC Pwr Bar Mode • 5v to 15v DC Pwr Dot Mode Circle 52

NOTE. Both the AM-20 and AM-20S can be ordered in Center Mount or End Mount cases for multiple arrays or twin mounting with a Digital Panel Meter

TM-150 $49* (1-9) $41 (100's)

Designed for direct Temperature Measurement with most Popular IC Temperature Transducers such as the NSC LM135H, Motorola MTS102 or Analog Devices AD590 • Accuracies of 1°C from -55°C to 150°C are possible • The TM-150 is user programmable to read °C or °F • A proportional Voltage Output is available to operate the AM-20S controller • Input Pwr is 5v DC Circle 55

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Incorporating TEXMATE's propriety Hi-Rel Hi-Contrast LCD Displays

PM-35XDC $59* (1-9) $51 (100's)

All the Features of the PM-35A, but with Low-Low Power and a wide Operating Voltage Range • 3.5v to 50v DC @ .4/15 mA • Full Multimeter capability with 8 selectable Function Descriptors Circle 53

PM-35XAuto $75* (1-9) $65 (100's)

Autoranging DPM • Has all the Features of the PM-35 Auto but with the Added Advantage of the Low Power LCD multimeter display and the wide operating Voltage specs of the PM-35XDC Circle 53

PM-35XAC $59* (1-9) $51 (100's)

The World's smallest 115/230v AC Line Operated DPM. Fully isolated with internal transformer

PM-35X AC has all the Features of the PM-35X DC but with AC Pwr • Can alternatively be also operated from DC Voltages of 8.5v DC to 50v DC Circle 53

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NEW PRODUCTS!!

RV-C8 $39* (1-9) $33 (100's)

Accuracies of ±.1°C between -50°C and +125°C with inexpensive interchangeable Curve-8 NTC Thermistors are possible with the RV-C8 Convertor Standard Output is 100mV/°C (1mV/.01°C) Power Supply is 5v DC The RV-C8 is designed for panel mounting usually in association with a DPM and/or AM-20S controller Thermistor Inputs are available through a front Terminal Jack or Rear Edge Connector Accurate calibration of the RV Requires only two Precision resistors • Many types of inexpensive Curve-8 Thermistors are available from Western Thermistor Corp , Oceanside, CA 92054 TEL (714) 433-4484 Circle 54

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THE REPLACER SERIES OF AC POWERED DPM's DESIGNED TO FIT MOST OTHER MANUFACTURERS' CUT-OUTS AND MEET DIN/NEMA STANDARDS.

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World's lowest priced 115/230V AC line operated DPM • 3½ Digits • .5" LEDs • True Differential inputs • 2v to 1200v FS • Ratiometric • Bipolar • Auto Zero Circle 54

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Full feature 3½ digit 115/230v AC line operated DPM • Differential Inputs • Customer Programmable Current and Ohmmeter Capability • Ratiometric • 4/20MA • Scaling in Engineering Units with Offset • DC Outputs Available • Display Test • Low TC 30 ppm Typ • Auto Zero • Bipolar • Programmable Decimals Circle 54

RP-35Auto $75* (1-9) $65 (100's)

World's lowest cost autoranging AC PWR DPM • All the Features of the RP-35A plus Autoranging • Auto Ranges between any two Ranges from 200mV - 2V to 200V - 1200V • Auto Switching Selectable Decimals Circle 55

RP-3500 $69* (1-9) $59 (100's)

RP-4500 $85* (1-9) $74 (100's)

RP-3500-3½ digit and RP-4500-4½ digit are low cost 115/230V line operated DPMS • Single ended Inputs • MUX BCD • Remote Control Sample/hold feature • Display blanking • Leading zero blanking • Autorange outputs • Display Test • Auto Zero • Bipolar • Flashing overload • 2V FS to 1200V

BCD Option $30* (1-9) $23 (100's)

Optional factory installed Board with buffered parallel BCD outputs to suit RP3500/4500 DPMs. Circle 54

RP-3500D $97* (1-9) $87 (100's)

RP-4500D $125* (1-9) $108 (100's)

RP-3500D-3½ digit and RP-4500D-4½ digit are top of the line 115/230V AC PWR Instrumentation DPMs High normal mode Noise Rejection at 50/60HZ of -120db with internal 200K HZ quartz crystal clock Scaling in engineering units with offsets • 4/20MA • Ratiometric • Ideal for load cell measurements • 2ohm to 20Mohm Ohmmeter capability • 10 micro volt resolution on RP-4500D • Provision for plug in signal conditioning modules

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Factory-installed Board with Buffered Tri-State Parallel BCD outputs. Up to 32 RP3500D/4500D's may be bussed together and individually print out on command. Circle 54

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USA WEST COAST DISTRIBUTORS: BASIC SYSTEMS: LOS ANGELES 213-673-4300; ORANGE COUNTY: 714-991-5390; SAN DIEGO: 714-268-8000; SANTA CLARA: 408-727-1800; WESTCON INC.: PORTLAND 503-283-0132; AMERICAN ANALOG COMPANY, INC. HOUSTON TEXAS 713-941-7265 able: on-delay, off-delay, interval, latched interval, latched on-delay, and accumulated on-delay. A counting mode of up to 9,999 counts is also provided

Delay times are selected using front-panel thumbwheel switches and an internal DIP switch that sets the overall timing period to any of three ranges, the longest being 1 to 9,999 seconds. Absolute timing accuracy for the delay relay is within ±(½ clock period + 10 ms + maximum operate or release time of the relay). Maximum operating time is 28 ms and the maximum release time is 25 ms.

Available in a choice of four operating voltages, the units are priced at $155 with a four-digit light-emitting-diode timing display and $135 without.

Amerace Corp., Control Products Div., 2330 Vauxhall Rd., Union, N. J. 07083. Phone William Witt at (201) 964-4400 [374]

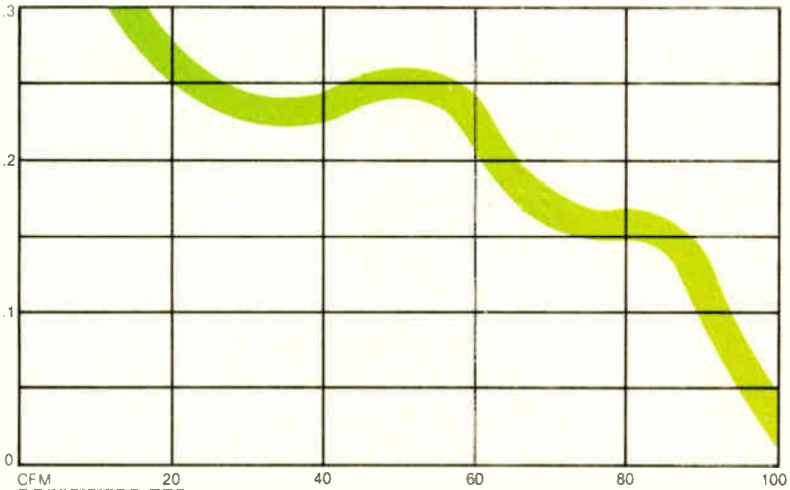
Line-voltage monitor memorizes spikes

The LSM-110 monitors line-voltage spikes using a random-access memory, magnitude-comparator circuitry, and a light-emitting-diode display. With its internal d-a converter, it can also drive a chart recorder.

A 1-kHz-to-10-MHz voltage spike is quantized as one of eight discrete values between 100 V and 2 kV. The monitor operates in either a manual mode, holding the largest reading taken in the LED display until a front-panel button is pressed, or in a recording mode, retaining the value for 1 minute so that it can be noted even by a slow recorder. The monitor is priced at $285.

Power-Science Inc., 7667 Vickers St., San Diego, Calif. 92111 [375]

ROTRON PROUDLY INTRODUCES ITS NEW IMPROVED LINE.



MUFFIN XL

The new improved line is the new improved pressure-flow curve produced by our new Muffin® XL fan.

As the curve shows, our 60 Hz Muffin XL moves 115 cfm or 54.3 L/Sec. at free delivery.

That's approximately 10% more cooling air than comparable models. Including our regular Muffin.

And the Muffin XL works against about 50% more static air.

At greatly reduced noise levels. As low as NC-45.

What's just as impressive as the Muffin XL's new improved line are some of the other changes we've made in our line.

We have a new Wafer® fan that delivers 37 cfm. And it's only 1″ deep.

Our new Scout® line, for installation in customer designed air passages, is available with three different impeller options.

And we have two new high performance fans, the Major® and the Patriot®. Both produce 240 cfm at very comfortable noise levels.

As good as all these fans are, we realize that they often have to be modified to fit your specifications.

So we do that, too.

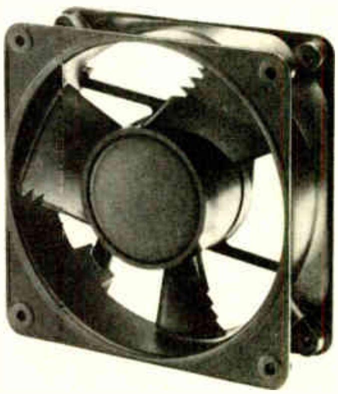
We can add finger guards. Change terminals. Lengthen the leads. Or even paint daisies on them.

And we can do it at a total installed cost that will leave you smelling like a rose.

If you want improved cooling performance with low power levels and proven reliability, ask us to send you more information on our new fan's line.

And our new fan lines.

Write to: Commercial Products Div., Rotron Inc., Woodstock, N.Y. 12498, (914) 679-2401.



Rotron B.V., Oosterhout, Netherlands. Tel 01620-32920.

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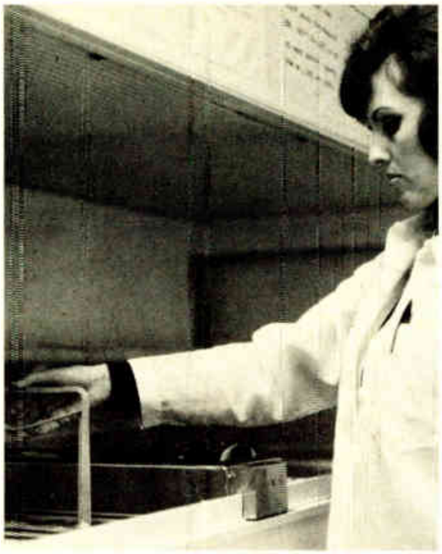


Ultratech counts on Culligan ultrapure R/O water for precision manufacturing

Water purity is an absolute must for Ultratech of Santa Clara, California. Their only business is the manufacturing of photo masks for integrated circuit production. Even the smallest impurity in the emulsion can cause rejection of the end product.

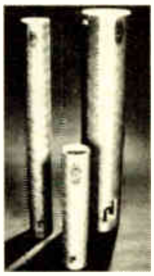
So Ultratech relies on a Culligan-designed system to prevent any impurities from endangering this precise manufacturing process. Included is filtration, softening, deionization, reverse osmosis, ultraviolet light sterilization and submicron filtration.

The importance of this system is pointed out by Ultratech's emulsion production manager, David Lee. "Any serious problem with the quality of our water could possibly cause us to lose a valuable customer, not just a few rejects."

Culligan even installed conductivity monitors to make sure quality water standards are maintained. And a Culligan dealer is always nearby to handle emergencies at once.

Culligan Offers 2 Types of "State of the Art" Reverse Osmosis Membranes—cellulose acetate and hollow fiber.

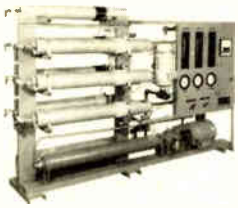
Culligan's patented COR-FLO™ module solves previous size limitations for spiral wound cellulose acetate membranes—produces more high quality water in the available space. Removes up to 95% of total dissolved solids, organics, even most bacteria.



The DuPont PERMASEP® hollow fiber modules, for large applications produce quality water with up to 95% of the total dissolved solids, and most organics and bacteria removed. Proven design simplicity.

Culligan Aqua-Cleer® S Series. Low cost, fully automatic ultra-filtration at 20, 50, 100, 200 and 300 gallons per day.

Aqua-Cleer® M, MC, MD Series. Quality water—high bacteria and organic rejection, at 500 to 6000 gallons daily.



Aqua-Cleer® KD Series. For high volume applications requiring ultra-filtration at 8000 to 140,000 gallons a day.

Your Inquiry is Welcome—To find out how Culligan can add precision to your manufacturing process, call your local authorized Culligan dealer. Or contact Greg Montgomery at Culligan USA. Phone 312/498-2000. Or mail the coupon.

Greg Montgomery, Culligan USA 9A21
Northbrook, Illinois 60062

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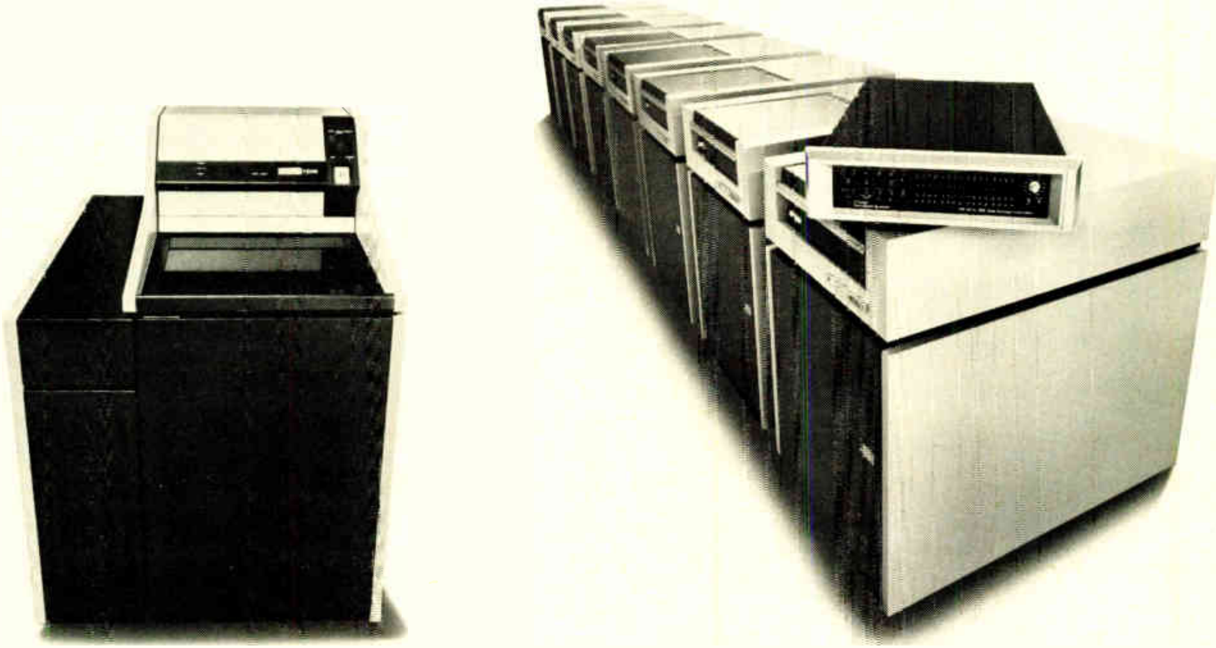

With every RP04/5/6,® you get a controller:

To get mass storage for your PDP-11,® you can use DEC's RJP04 or 05 with their 88 megabyte drives, or the RJP06 with its 176 megabyte drive. After installing DEC's four-board RH11® interface, drives can be added up to a maximum system capacity of 1408 megabytes.

But each drive you add comes with its own controller, the large box on the side of the drive. This adds hundreds of IC's to your system, and thousands of dollars to your system costs.

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Plessey controls your costs:

Our PM-DS11/300C mass storage systems are direct replacements for DEC's RJP04/5/6 systems, but store up to 45% more and cost 30% less.

Fully compatible with standard DEC diagnostics and operating systems, Plessey mass storage systems use a single microprocessor-based controller to handle up to eight of our 254 megabyte drives for a total system capacity of 2000 megabytes. The PM-DC11/300C controller includes power-on and off-line diagnostics, software error detection and correction, adjustable DMA control and dual Unibus® ports. System expansion requires no special device drivers, and *no* additional controllers.

The PM-DC11/300C controller is available in a 5¼" expansion chassis with a diagnostic panel, or may be embedded in only two system units of your PDP-11 cpu.

Providing more reliable yet less expensive products has made us the largest independent supplier of DEC-compatible peripherals Our product line presently includes add-in/add-on core and semiconductor memories, cartridge disc systems, floppy disc systems, mag tape systems, complete computer-based systems, and a wide variety of backplanes, expansion chassis and other accessories.

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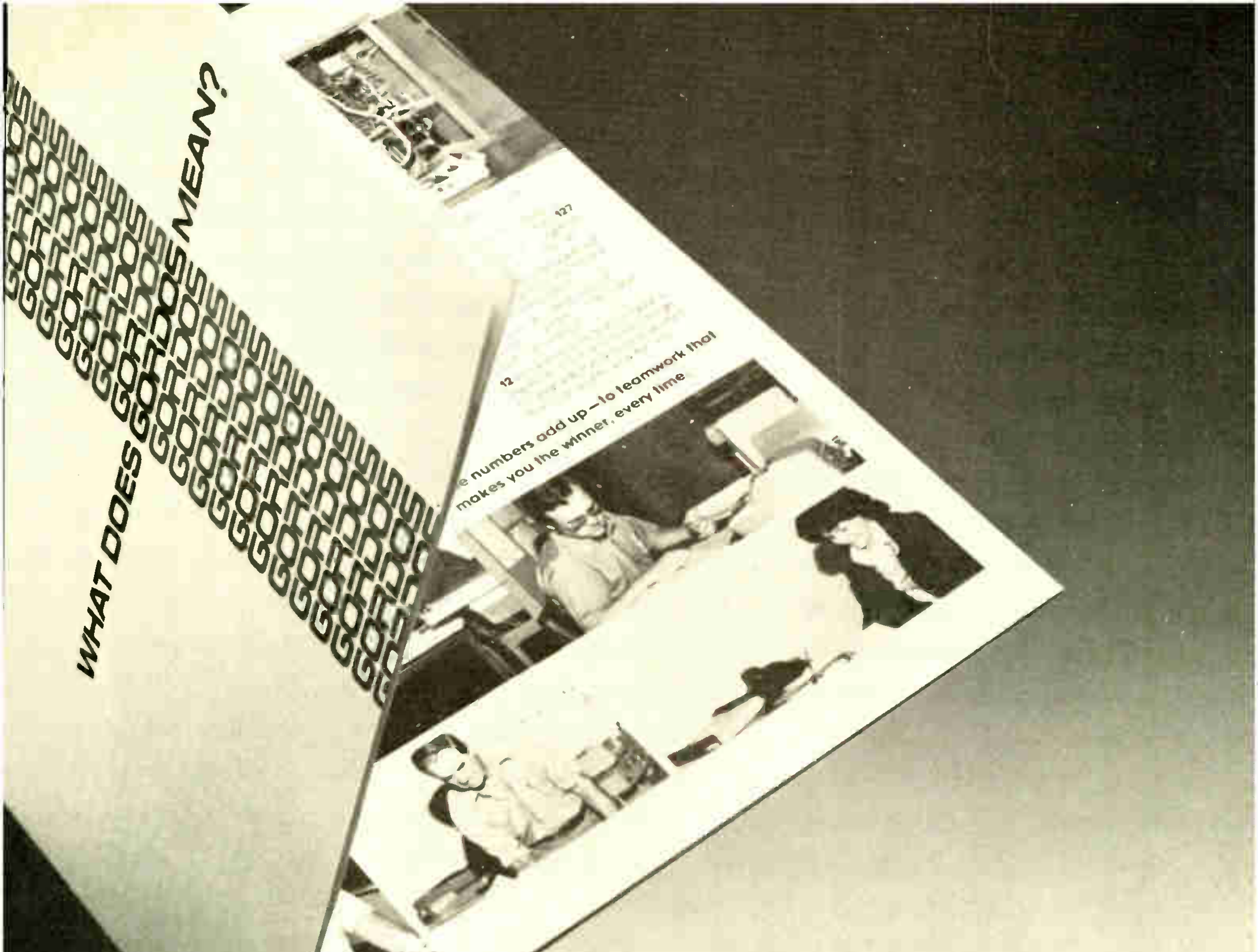

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You'll use Rockwell's SAW devices to enhance signal processing in satellite and other communications systems, in radar and countermeasures, in navigation, and similar instrumentation equipment.

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For more information, contact Jim Campbell, Filter Products Sales Manager, D-F6, Microelectronic Devices, Rockwell International, 4311 Jamboree Road, Newport Beach, CA 92660. Phone: 714/833-4632.

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Instruments

DMM fits design to application

3½-digit multimeter aimed at bench-top measurements sells for just $149

Before buying a low-cost digital multimeter, engineers would do well to consider carefully where the instrument will actually see the most service. While the increasingly popular hand-held meters are easily toted into the field, Keithley Instruments' Marv Nevins, DMM product manager, notes that, as often as not, "the 3½-digit DMM winds up on the lab bench." And it is here, he feels, that the model 169 will outshine its smaller brethren.

The unit provides those features commonly found in handheld meters, and more, at a lower price than most: $149. For instance, it offers the full five ranges that they provide: dc ranges with maximums from 200 mV to 1,000 V and 200 μA to 2 A, ac ranges with the same maximums, and resistance ranges with full-scale maximums of 200 Ω to 20 MΩ. It also has a liquid-crystal display, whose low power consumption allows the meter to operate from six 1.5-V alkaline C cells for 2,000 hr and an indicator that shows when the battery runs low.

However, the unit weighs 3 lb, about four times what the handhelds weigh, and measures 3.5 by 9.25 by 10.75 in.—eight times their volume. While this means that the 169 is a bit more cumbersome to carry around, it also means it will be more stable on the bench, not toppling over when a test lead is pulled too far, Nevins points out. "Nor is it as likely to get lost," he adds.

Another advantage he points to is the displaying of range along with the measurement, so that the user does not have to review the position of the various push buttons to determine what is being indicated. The 16-position handle also permits the meter to be positioned at the best angle for viewing the 0.6-in.-high display while working.

Accuracy of the 169 is slightly less than that of the more expensive handheld instruments: for example, dc voltage measurements are accurate to within ±(0.25% + 1 digit) with the 169 and typically ±(0.1% + 1 digit) for the smaller meters. Nevins explains that, in talking to users, he found that the higher accuracy was not required in most bench applications. When greater accuracy is needed, a more sophisticated instrument is used.

The 169 maintains specified accuracy for a full year and has a one-year warranty. Options include a variety of probes, hard-shell carrying case, and a spare-parts kit to maintain 10 DMMs for one year. Deliveries are slated for mid-July.

Keithley Instruments Inc., 28775 Aurora Rd., Cleveland, Ohio 44139. Phone (216) 248-0400 [351]

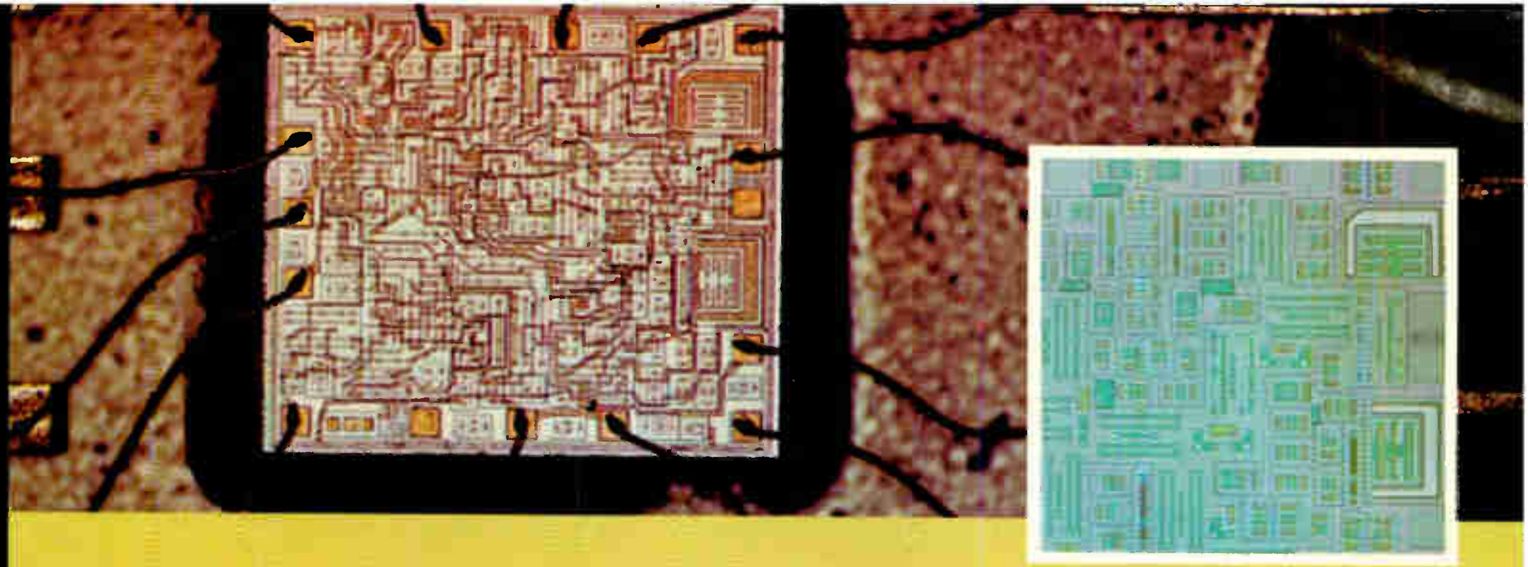
Logic analyzers meet field and lab needs

Philips is a name that has been conspicuous by its absence from the list of logic analyzer manufacturers. Electro79 saw the end of that state of affairs with the company's introduction of not one but two such instruments—one aimed at the system designer, the other at the field engineer.

The lab-quality, 16-channel analyzer is called the PM 3500 and offers users a chance to study hardware and software operation with both time-domain and state displays. The latter can be tables of binary, hexadecimal, or octal data or an eight-by-eight-element matrix (or map) with row-column locations determined by the first and last 8 bits of the 0 to 15 channels. Because collected data is stored in a 505-by-16-bit memory and controlled by a Signetics 8X300 microprocessor, users can easily switch from one display format to another at the push of a button. TTL or C-MOS input levels can be selected by a push button for each set of eight channels, and logic with other operating levels can be handled as well.

The 3500's minimum sample time of 10 ns makes it a 100-MHz analyzer—a device fast enough to deal meaningfully not only with today's popular 4-MHz systems but with faster systems as well. To achieve that sample rate, an 8-bit, serial-to-parallel converter is used to transfer input data to memory.

Selecting the trigger word that defines memory content is a simple matter of setting a three-position switch at 0, 1, or X (for "don't care") above each channel's front-panel BNC input connector. The triggering delay is adjustable over 0 to 9,999 sample periods; qualifiers for



Section of an Exar Master Chip before customizing. Note the individual circuit components already on-chip, but still unconnected. After the customer has designed circuit connections according to his system needs, Exar prepares a final mask and fabricates the custom chip, as shown in large photograph above.

This integrated circuit was manufactured to a custom design and delivered in a matter of weeks.

YOU CAN CUT DEVELOPMENT TIME UP TO NINE MONTHS ON BIPOLAR AND I²L CUSTOM CHIPS . . . WHILE YOU SLICE COSTS TO THE BONE . . . THROUGH THE UNIQUE "SEMI-CUSTOM DESIGN PROGRAM" FROM EXAR INTEGRATED SYSTEMS. Compared to traditional development times for custom ICs, which frequently exceed one year, and tooling costs which can be five to ten times greater, this new concept allows custom chips to be justified economically at far smaller quantities than previously thought practical.

How the semi-custom idea works.
Exar's standardized circuits contain undedicated active and passive components such as transistors, resistors, logic gates, etc., fabricated onto the chip, but left unconnected. You choose how to interconnect these components to create your own custom circuit. The actual interconnection process is simple, requiring only one to three layers of tooling. As a result, development time compresses drastically, becomes far less expensive and virtually risk free.

Choose from eight different chips.
Five of the standard semicustom chips are bipolar, and are best suited for linear designs. Some (XR-A100, XR-C100, XR-F100) feature high current NPN output transistors, making them suitable for drive circuits. The others (XR-B100, XR-D100), more appropriate for signal amplification or control circuits, contain only small signal, low current transistors. All, however, present the designer a wide variety of NPN and PNP transistors, Schottky diodes, various resistors and ample bonding pads.

Exar's three I²L digital chips (XR-300, XR-400, XR-500) contain high density I²L logic arrays and bipolar interface circuitry. Outwardly they look and perform like a bipolar LSI chip, readily interfacing with TTL or MOS level signals. This feature, incidentally, makes it very convenient to retrofit I²L LSI designs into existing MOS or TTL logic systems.

And Exar has in development additional semi-custom chips offering even greater applications flexibility.

If you decide to modify your design.
Even after evaluation of initial design prototypes, if you see a need to modify the custom chip, a new design iteration usually takes less time than the original development cycle. And typical costs of additional design cycles are proportionately less than the original prototype development cost.

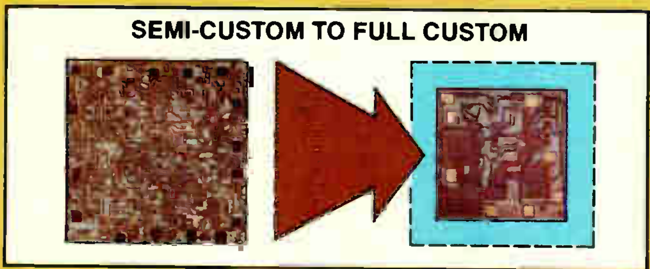
What about second sources?
This is one of our most asked questions. In response, Exar has made alternate-source agreements with other IC manufacturers, so you can specify and order custom circuits with confidence.

Testing, testing.
After prototype acceptance of semi-custom devices, Exar will develop software and fixtures for fully testing all production ICs. Production devices receive 100% electrical testing, and are screened to agreed-upon Acceptable Quality Level (AQL) standards. Charges for this test engineering are nominal, and vary depending on the complexity of the tests.

Semi-custom to full custom. For when the numbers get big.
Because Exar manufactures its own wafers, it can grow with your needs. As your product matures we can convert your semi-custom chip into a customized IC. Consider the advantages: You get the quick, inexpensive turnaround of semi-custom chips, providing prototypes and intial production units; then when your design has proven itself and your market has developed, the subsequent full custom product provides further cost savings at high volume production . . . often with a significant improvement in product performance!

Design kits make it simple.
Exar provides linear and digital design kits, including circuit components for breadboarding, comprehensive design manuals and layout worksheets corresponding to Exar's master chips. These, as well as technical assistance when you need it, will speed and simplify your preliminary steps toward custom IC design.

Learn the economics and advantages of semi-custom.
Exar's entire semi-custom story is detailed in a 40-page data book, "Semi-Custom IC Design Programs." For your copy, write on company letterhead to your nearest Exar representative or to Exar, 750 Palomar Ave., Sunnyvale, CA 94086.



Exar can convert your semi-custom chip to a custom IC, reducing chip size, saving money, and often providing added performance benefits.

EXAR CUSTOM

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sample interval and trigger delay further enhance the engineer's ability to collect data from desired locations in the data stream. The capture mode indicates glitches as small as 3 ns, and a comparison mode divides the memory into two 249-by-16-bit segments. In this way a reference pattern can be stored and compared with fresh data in any format. Differences are highlighted by increased intensity, with a legend indicating the display's overall status. Complete with a set of probes that can be grounded individually or in groups, the PM 3540 logic analyzer sells for $8,295.

For field use, the PM 3540 is a combination of a 10-MHz logic analyzer and a 25-MHz dual-trace oscilloscope. The unit will store 64 by 16 bits of data and display it in binary, octal, or hexadecimal modes, paging through the entire block. Analysis of real-time data can be made with the scope and, as with the 3500, memory can be divided for side-by-side comparison of captured data. With probes, the PM 3540 is priced at $3,975.

Philips Test and Measuring Instruments Inc., 85 McKee Dr., Mahwah, N. J. 07430. Phone (201) 529-3800 [353]

Low-cost capacitance meter covers wide range

Priced at only $149, the 3½-digit model 938 capacitance meter offers eight measurement ranges, from 200 pF full-scale to 2,000 mF. Resolution on the 200-pF scale is 0.1 pF. Measurement uncertainty for the hand-held instrument is ±(0.1% of reading + 0.5 pF + 1 count) on the bottom seven ranges. But on the 2,000-mF range, it increases to ±(1% of reading + 1 count).

Housed in a case similar to that used for the model 935 digital multimeter [*Electronics*, Feb. 1, 1979, p. 150], the 938 features a 0.5-in. liquid-crystal display. A fuse protects the meter against burnout by charged capacitors or inadvertent connection to a power source. A 9-V alkaline battery, supplied with the meter, will keep it running for up to 200 hours. Also supplied, in addition to the instruction manual, are a certificate of conformance to NBS standards and a final quality-control test report. Available from stock, the 938 has a one-year warranty.

Data Precision Corp., Electronics Avenue, Danvers, Mass. 01923. Phone (617) 246-1600 [356]

100-kHz plug-in FFT analyzer shows full and partial spectra

Plugged into a Tektronix series 7000 oscilloscope mainframe, the Rockland Systems model 7530A general-purpose spectrum analyzer generates a background display of the entire frequency range it can measure—dc to 100 kHz—and a foreground display of the particular segment of that range selected for close analysis. The minimum resolution of 1 Hz can be achieved by selecting a 200-Hz span starting at any selected frequency up to 99.8 kHz.

The unit divides its operating chores between two microprocessors, one to handle the fast Fourier trans-

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Circle #238 for information
Circle #239 for contact by FPS

formation of the input signal and another to control the oscilloscope display. Thus the instrument provides the front-panel feel of a swept analyzer and the calibration accuracy of an FFT unit.

The instrument measures frequency to an accuracy of within ±0.001% of full scale and has an average noise floor of 90 dB below full scale. It has a calibrated, full-scale sensitivity of 0.32 V rms to 10 V rms that is accurate to within 10 dB/step ±0.2 dB. Without calibration, the sensitivity range increases to 32 V rms full scale.

The 7530A is priced at $7,900 and has a delivery time of 10 weeks.

Rockland Systems Corp., Rockleigh Industrial Park, Rockleigh, N. J. 07647. Phone (201) 767-7900 [355]

Automatic counter stretches frequency readings to 40 GHz

With a bit of catalog searching, engineers have been able to find automatic frequency counters that would work up to approximately 24 GHz. Moving into what it calls "the next generation of frequency counters," EIP Microwaves has developed a counter that can now be equipped to read frequencies as high as 40 GHz automatically.

Beginning with the model 548, the company is introducing a series of units, the 54X family, that it plans will eventually provide 90-to-100-GHz measurements. The model 548 by itself reads from 10 Hz to 26.5 GHz, using heterodyne conversion techniques, by dividing the range into three parts: 10 Hz to 100 MHz, 10 MHz to 1 GHz, and 1 to 26.5 GHz. Each of these bands has its own input connector.

In the factory or the field, the instrument can be fitted with option 06, which adds on a 26.5-to-40-GHz band with a separate connector to accept inputs from a remote sensor, model 591. Higher-frequency options will also be field-installable.

The 548's time base is generated by a 10-MHz temperature-compensated crystal oscillator. Its tempera-

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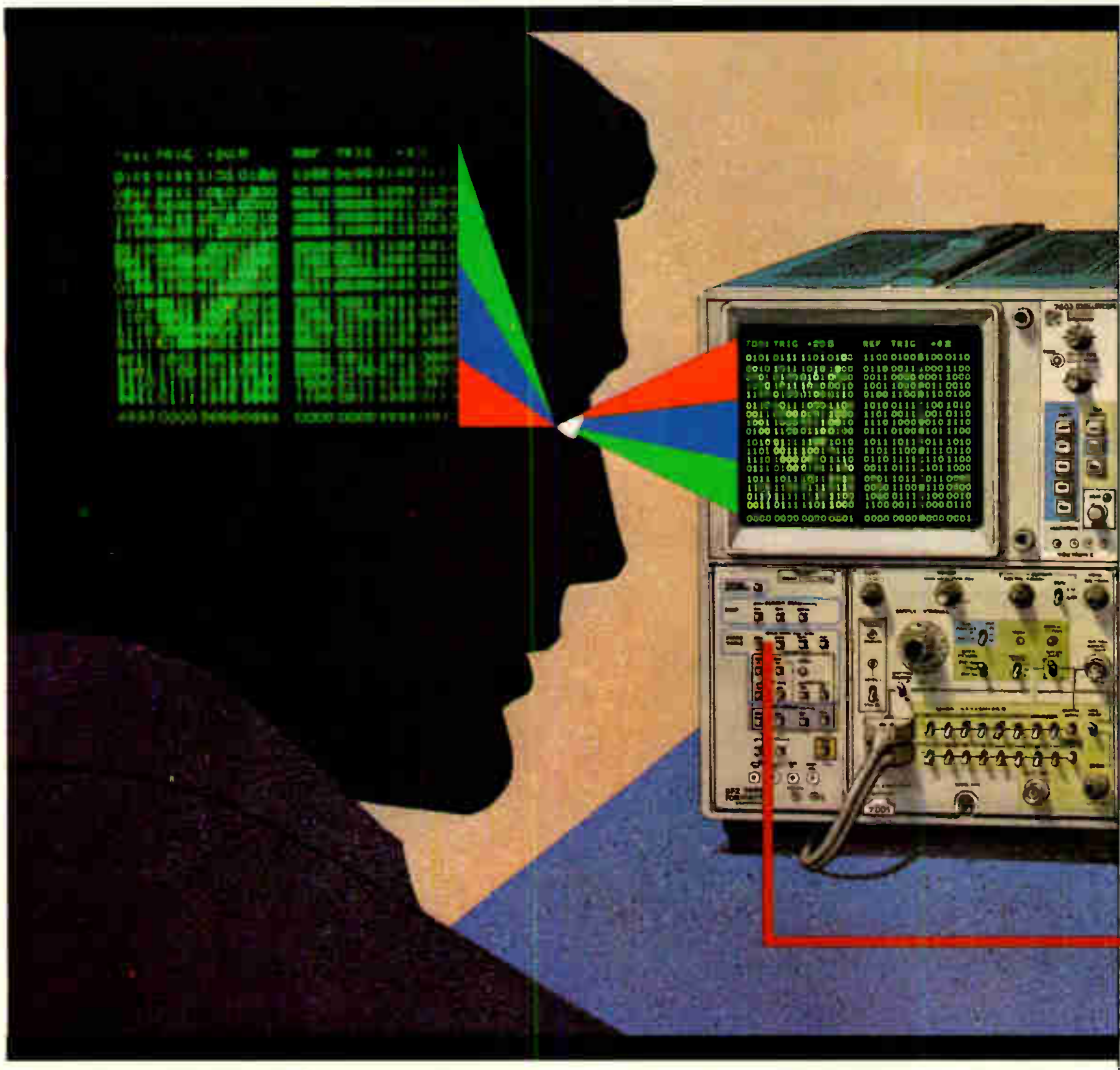

Touch a button for any of seven display formats: mapping, timing, binary, octal, hexadecimal, GPIB, ASCII

You need to be versatile enough to tackle a variety of digital design problems every day. To turn from hardware to software analysis. Or from microprocessor to non-microprocessor design. And so you need a logic analyzer as versatile as you are.

And that means a logic analyzer that lets you *see* logic the way you *think* logic; that lets you look at logic in the most *convenient* language; that gives you a *variety* of logic displays... to solve a variety of problems.

Tektronix Logic Analyzers/ Display Formatters provide this essential versatility. So you — not the logic analyzer — decide how you'll look at logic: in mapping for an overview of program flow; in timing to view timing relationships between signals; in state tables (binary, octal, hexadecimal, GPIB mnemonics, or ASCII) to view system language.

Go from one logic display to another — *without going from one logic analyzer to another.* To make your job easier, faster, and more convenient.

Display Formatters: they help make our Logic Analyzers versatile. So you can do today's job and tomorrow's. So you can change applications without changing your logic analyzer.

Contact Tektronix Inc., P.O. Box 500, Beaverton, OR 97077. In Europe, Tektronix Ltd., P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

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TEKTRONIX LOGIC ANALYZERS THE VERSATILE ONES

For immediate action dial our toll free automatic answering service, 1-800-547-1512 ture stability is within 2 ppm from 0° to 50°C and short-term stability is within than 10^{-9} rms/s average.

The counter can resolve 1 Hz with a measurement time of 1 second. Resolutions ranging from 1 Hz to 1 MHz can be selected using the front-panel keyboard, which will also set high and low frequency limits, offset frequency, and the measurement band. Sensitivity varies according to measurement band (ranging from 25 mV rms to −20 dBm), as does maximum input level (120 V rms to +5 dBm).

The model 548 alone is priced at $5,700, option 06 costs an additional $2,550. An interface for the IEEE-488 bus is also offered as an option. Delivery takes from 10 to 12 weeks.

EPI Microwave, 3230 Scott Blvd., Santa Clara, Calif. 95051. Phone (408) 244-7975 [354]

Digital phase meter has wide dynamic range

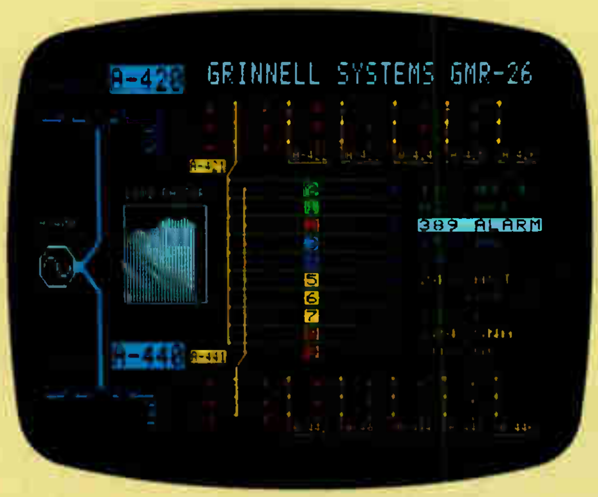
The phase difference between two signals of greatly differing amplitude may be measured using the wide-range model 355B digital phase meter. The four-digit instrument will handle input voltages from 1 mV to 400 V in only two ranges—1 mV to 2 V and 200 mV to 400 V. Test signals are applied to two identical processing channels, which will accept differential (balanced) or single-ended (unbalanced) inputs, or one of each. Frequencies from 10 Hz to 2 MHz can be handled.

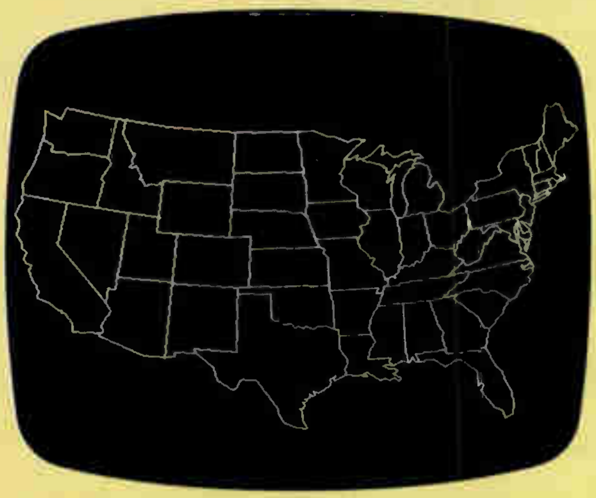
To avoid problems that arise near the edge of a phase range, two display ranges are provided—0° to 360° and −180° to +180°. An error-sector indicator lamp lights up when the practical limits of the range in use are reached.

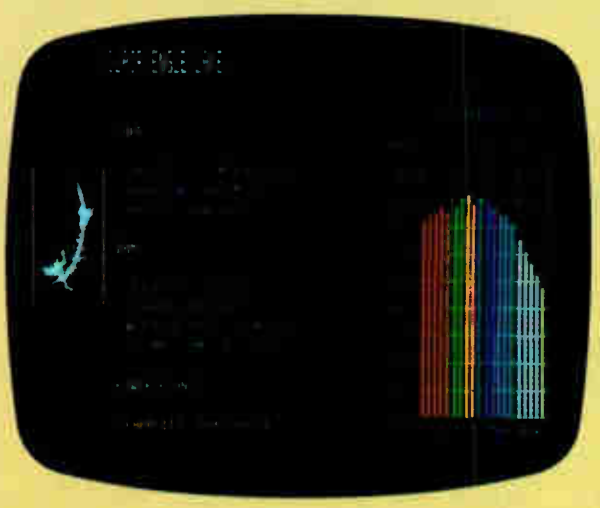
An analog output voltage proportional to the measured phase angle is a standard feature; a binary-coded-decimal output is optional. The model 355B sells for $1,990 and has a delivery time of six weeks.

Wiltron Co., 825 East Middlefield Rd., Mountain View, Calif. 94043. Phone (415) 969-6500 [357]

Vector graphics. OEM prices.







Now, with Grinnell's GMR-
systems, you can have the
advantages of dot matrix te
the same price as more limit
based systems.

And, every GMR-37 display i
operating system: display gene
refresh memory, vector and rect
ics, alphanumerics in 4 sizes, bi-
RS-232 computer interface and R
interface. Systems, including powe
are housed in a 7", rack-mountable
and drive standard closed circuit monito

Four basic GMR-37 models can be tailored to fit into almost any computer-based system. Here are just a few examples. (Prices are F.O.B. San Jose, and quantity discounts are available. TV monitors are extra.):

GMR 37-10: $3300
256 x 256 resolution, one channel RGB color plus blink. (Two channels: $3700)

GMR 37-20: $3700
256 x 512 resolution, one channel RGB color plus blink. (Two channels: $4500)

GMR 37-30: $4500
512 x 512 resolution, one channel RGB color plus blink.

GMR 37-60: $4700
1024 x 1024 resolution, one channel B/W.

In addition, you can also have several economical options: independent cursors, joysticks, keyboards, special character sets and 16 bit, plug-compatible parallel minicomputer interfaces.

Further, if you ever want to move up, Grinnell has a complete line of larger systems—all software compatible with the GMR-37—to do things like animation, image processing and real-time frame grabbing.

So, if quality graphic displays are important to your product, look at the GMR-37 line. For a quotation on the system that meets your specific requirements, call or write.

GRINNELL SYSTEMS

2159 Bering Drive, San Jose, California 95131 (408) 263-9920

Circle 243 on reader service card

THINK BAUSC? & LOMB Q?ALITY

...depends on precision, convenience, ...oZoom® microscope quality.
...OMB introduced the first zooming micro- ...people all over the world have put ...oscopes to work for them than any other ...r kind.
...all relate to BAUSCH & LOMB quality. ...nce of resolution and depth of field, ...tics, highly reliable mechanical compo- ...cise photomicrographic exposure capabili- ...a wide variety of illuminators, stands, and ...ories are just a few of those reasons.

From industrial research to routine failure analyses and wafer inspections, there is a BAUSCH & LOMB StereoZoom microscope precisely right for your application. Write or call for a detailed catalog or demonstration. THINK BAUSCH & LOMB ... Quality since 1874.

...CH & LOMB ...reoZoom ...roscopes 20 ANNIVERSARY

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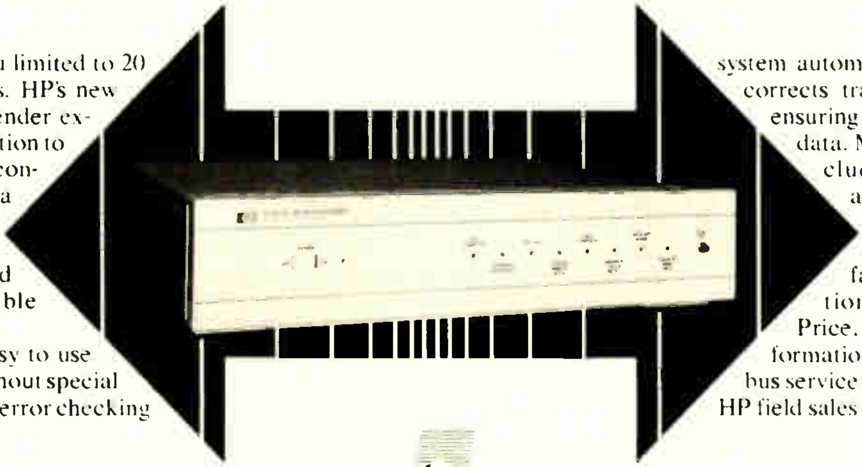
TELEX 97-8231, CABLE: Bausch & Lomb
In CANADA: Bausch & Lomb Canada Ltd. 2001 Leslie Street Don Mills, M3B2M3, Ontario, Canada (416) 447-9101

Consult Yellow Pages under "Microscopes"

Circle 244 on reader service card

HP announces extended Bus service!

The New HP 37201A HP-IB Extender lets HP-IB instruments and systems operate over almost unlimited distances.



No longer are you limited to 20 meter cable lengths. HP's new "transparent" extender expands HP-IB† operation to 1000 meters when connected directly via twin pair cable — and, with modems, the range is limited only by the available telephone network.

The 37201A is easy to use and will operate without special software. Its built-in error checking system automatically detects and corrects transmission errors — ensuring a high integrity of data. Modem operation includes Point-to-Point and Multi-Point configurations and an RS366/V25 interface permits connection to an autodialler. Price, $1840.* For more information on HP's extended bus service contact your nearby HP field sales office or write.

HEWLETT hp PACKARD

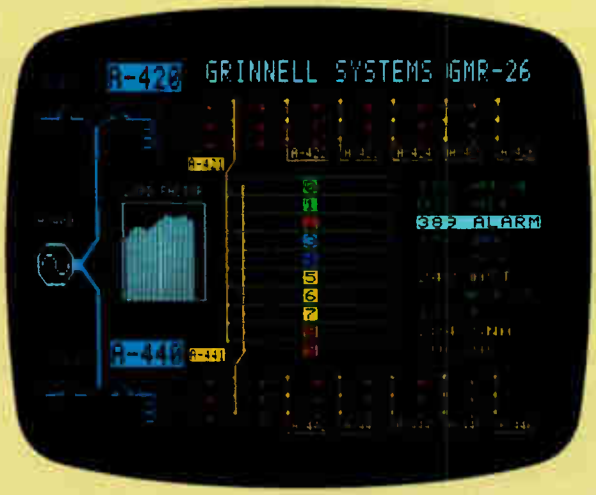
1507 Page Mill Road, Palo Alto, California 94304

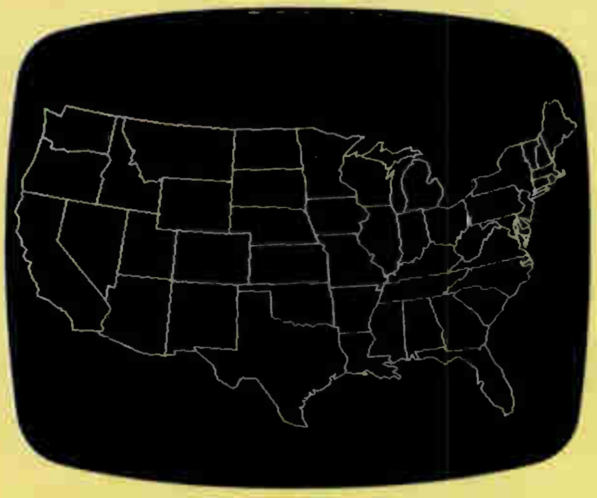
*Domestic US price only.

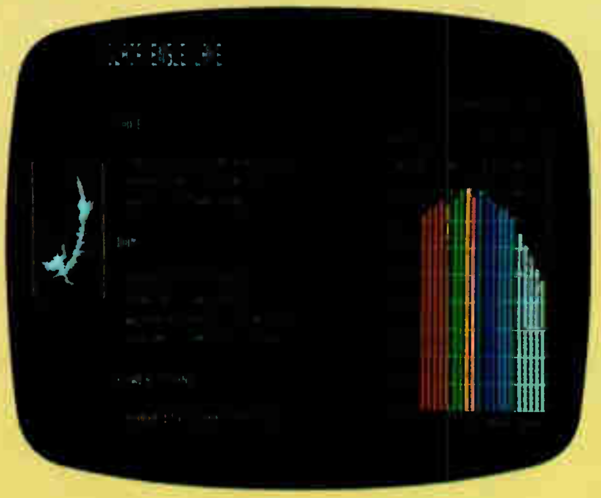
†HP's implementation of IEEE Standard 488 and the identical ANSI Standard MC1.1.

14902

Vector graphics. OEM prices.







Now, with Grinnell's GMR-37 graphic display systems, you can have the resolution and input advantages of dot matrix television for about the same price as more limited character-based systems.

And, every GMR-37 display is a complete operating system: display generator, MOS refresh memory, vector and rectilinear graphics, alphanumerics in 4 sizes, bi-directional RS-232 computer interface and RS-170 video interface. Systems, including power supplies, are housed in a 7″, rack-mountable chassis and drive standard closed circuit monitors.

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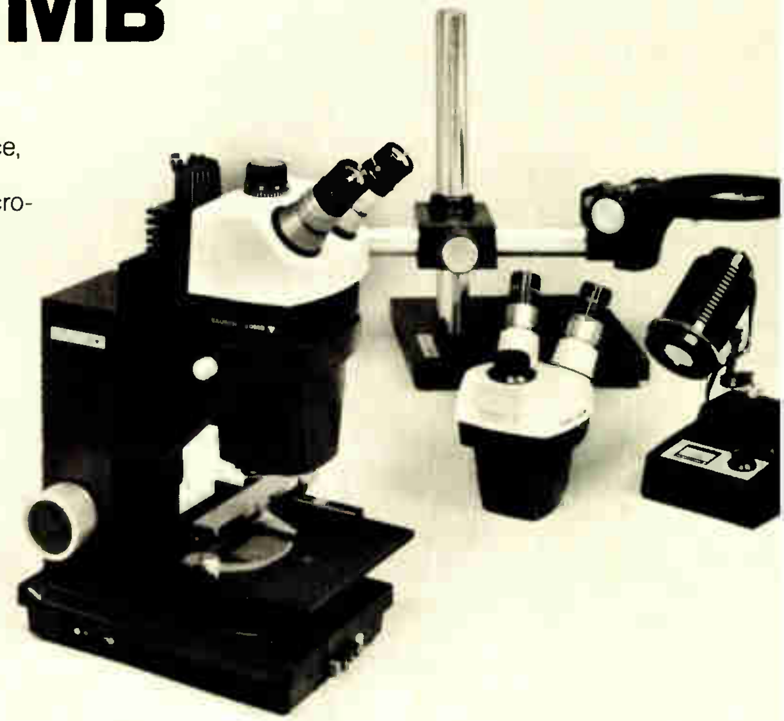
GRINNELL SYSTEMS

2159 Bering Drive, San Jose, California 95131 (408) 263-9920

Circle 243 on reader service card

THINK BAUSCH & LOMB QUALITY



When your quality control depends on precision, convenience, or reliability—think StereoZoom® microscope quality.

Since BAUSCH & LOMB introduced the first zooming microscopes in 1959, more people all over the world have put StereoZoom® microscopes to work for them than any other instruments of their kind.

The reasons all relate to BAUSCH & LOMB quality. Optimum balance of resolution and depth of field, precision optics, highly reliable mechanical components, precise photomicrographic exposure capabilities and a wide variety of illuminators, stands, and accessories are just a few of those reasons.

BAUSCH & LOMB StereoZoom microscopes 20 ANNIVERSARY

From industrial research to routine failure analyses and wafer inspections, there is a BAUSCH & LOMB StereoZoom microscope precisely right for your application. Write or call for a detailed catalog or demonstration. THINK BAUSCH & LOMB . . . Quality since 1874.

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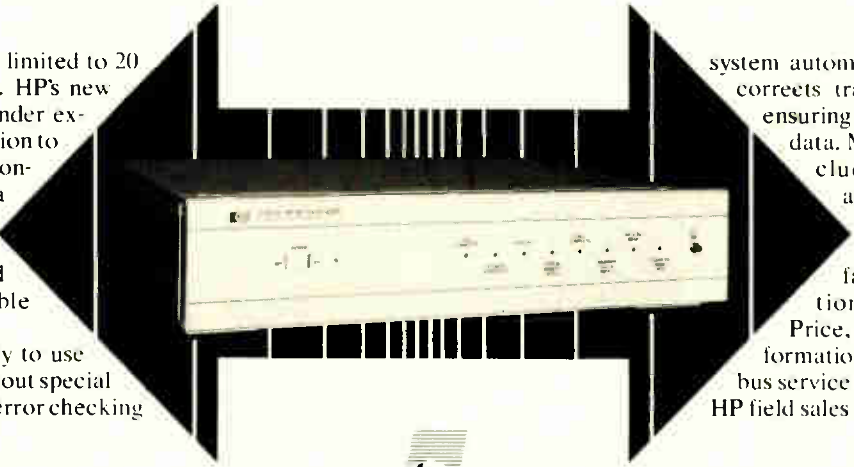

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1507 Page Mill Road, Palo Alto, California 94304

*Domestic US price only.

†HP's implementation of IEEE Standard 488 and the identical ANSI Standard MC1.1.

14902

abbott POWER SUPPLIES

Our standard products meet MIL specs

Why order "specials" and pay for "options" when you can get an Abbott militarized power module virtually off-the-shelf for fewer dollars per watt? Take our Model C's and W's, for example. They're hermetically sealed, feature superior tracking accuracy for *all* rated conditions, and come in package sizes as small as 2⅛" x 3¼" x 3¼". (The units we put on SKYLAB, except for some special components and testing, were "standard".)

28 VDC to DC Power Modules (Model "C") — feature smaller volume, lower weight, and higher performance. Low peak-to-peak ripple and close regulation meet even the most demanding specs. The standard Model "C" line converts 24-30 volts DC to any output between 5 and 100 volts DC.

For Catalog Circle Card Number 100

400 Hz to DC Power Modules (Model "W") — feature close line and load regulation, low output ripple, and are built to meet the EMI requirements of MIL-STD-461. The Model "W" family provides output voltages from 5 to 100 VDC with current levels from 0.3 to 20 amps. Why waste time and money designing a "special" power supply?

For Catalog Circle Card Number 101

Dual Output Versions — both the C and the W series are available in hermetically sealed, dual output models that feature 1% tracking accuracy, 0.2% regulation, low peak to peak ripple, +100°C operation . . . and we offer CC's and WW's as standards, not "specials."

For Catalog Circle Card Number 102

See Power Supply Section 4000, and Transformer Section 5600, Vol. 2, of your EEM catalog; or Power Supply Section 4500, and Transformer Section 0400, Vol. 2, of your GOLD BOOK for complete information on Abbott products.

abbott transistor LABORATORIES, INCORPORATED

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1224 Anderson Ave., Fort Lee, N.J. 07024
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Microcomputers & systems

Printer sells for only $995

Unit aimed at microcomputer market handles three types of paper, prints 50 c/s

Many customers balk at paying more than about $1,000 for a printer to go with a microcomputer system that itself costs them less than $2,000. Centronics Data Computer Corp. agrees with these customers, and is now offering a lightweight, low-cost, dot-matrix printer suitable for most professional and small business computer applications. "Substantial numbers of [micro]computers are installed today without printers," notes W. Patrick Decker, marketing product manager. "Only one in five computers is purchased with a printer." Centronics believes that it will change that picture with its model 730, priced at $995 and scheduled for showing at the National Computer Conference in New York next month.

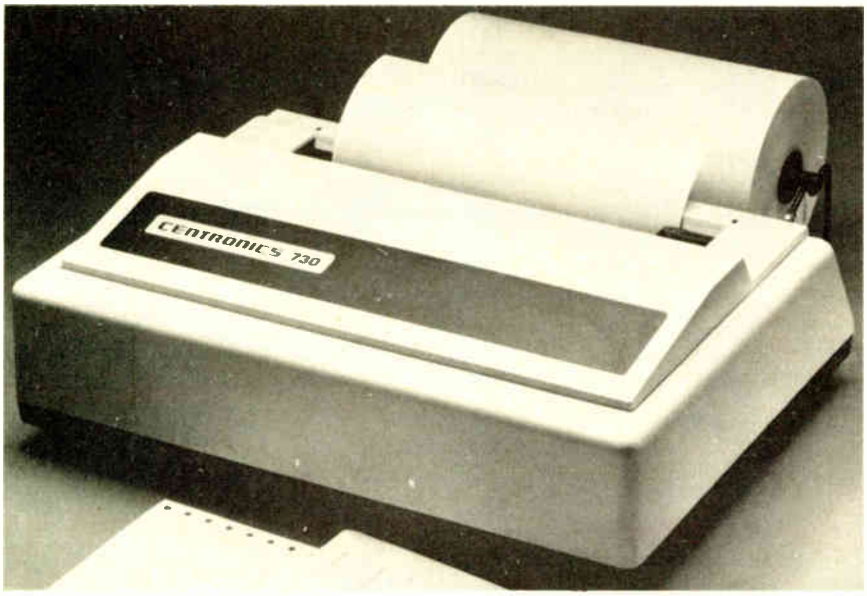
An important feature of the unit is that it will take three different kinds of paper: cut sheets, fan-folded paper, and paper rolls. "A wide variety of needs can be met with this paper selection," says Decker, pointing out that fan-folded paper can be used for billing purposes, the teletypewriter rolls for logging and printouts, and the cut sheets for memos and direct-mail letters. The distance from print head to carriage is adjustable, so that up to three carbon copies may be made at once.

The 730 employs a seven-by-seven dot-matrix print head and can print elongated characters. The printer uses the 96-character ASCII set, with other fonts under development for foreign-language applications.

Two interfaces are offered with the 730: parallel, accepting up to 15,000 characters per second, and serial. Separate motors are used for the ribbon drive and the print head. The latter moves unidirectionally across a maximum line length of 80 columns. A front-panel reset switch allows the printer to be disabled without dropping the interface line. A regular on/off switch is also provided.

The unit prints 10 characters per inch at a rate of 50 per second. With the serial interface unit, a density of 16.7 characters per inch is software-selectable.

The printer is small—14.5 by 11 by 4.89 in.—and weighs only 10 lb. Its portability is important because Centronics wants customers to be able to bring the printers to service centers for maintenance. "We'll have walk-in maintenance," notes Decker. "With some printers, the cost of maintenance can be more than the system itself after a few service calls."



Shipments of the 730 are scheduled to begin next month. The $995 price is for singles; large-quantity discounts will be offered. Centronics plans to market the printer through the OEM network, its own distributors, and possibly also retail stores. Delivery time is 60 days.

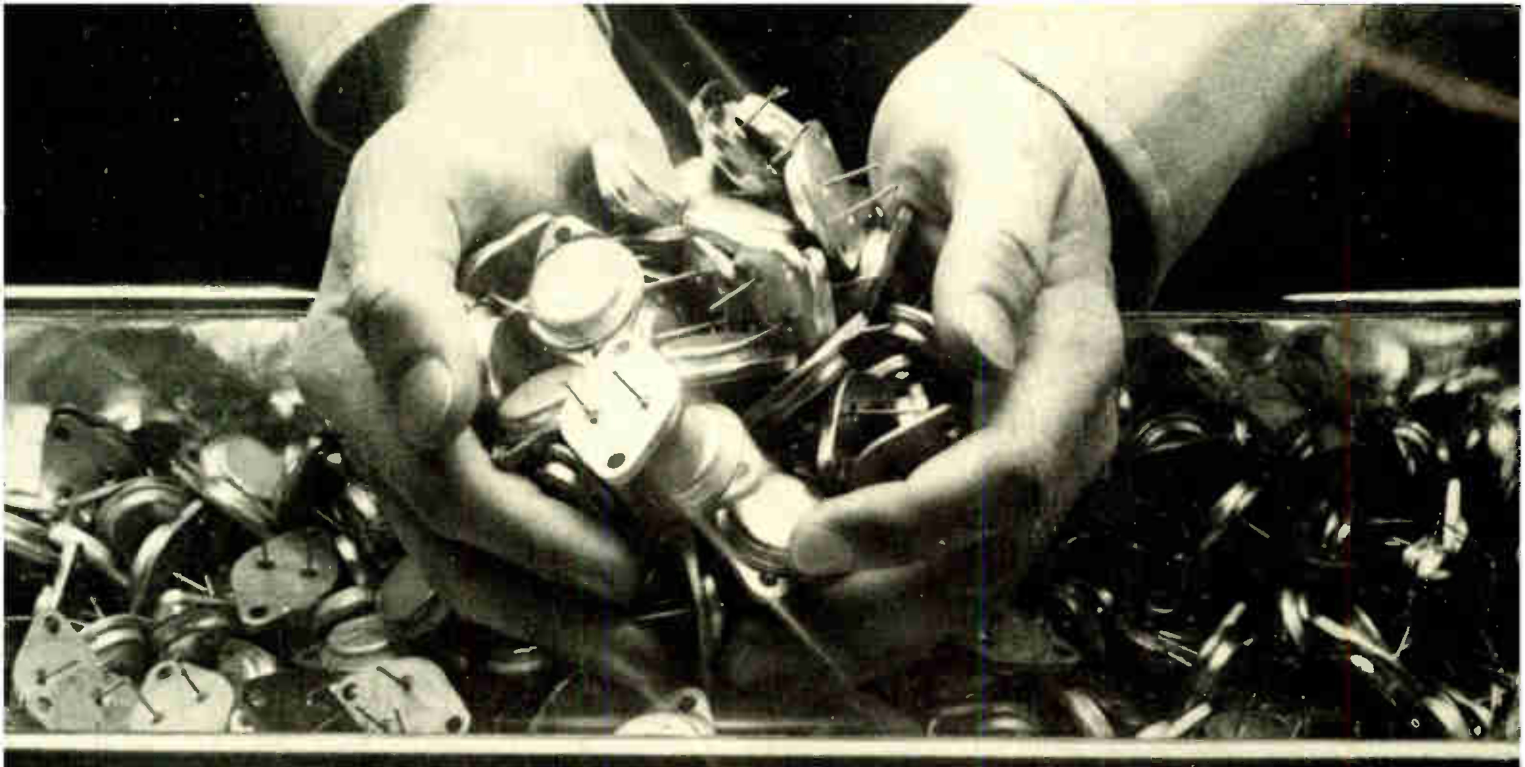
Centronics Data Computer Corp., Hudson, N. H. 03051. Phone Pat Decker at (603) 883-0111 [341]

Multibus-compatible board controls up to 40 megabytes

The iSBC 206 hard-disk-controller board gives designers and users of Multibus compatible systems access to very large amounts of storage: up to 40 megabytes. Developed for the more sophisticated original-equipment manufacturer, the 206 supports from one to four 10-megabyte drives. These include the Diablo 44B, Pertec D3422, Wangco (Perkin-Elmer) ST2222, Caelus 306 R, CDC 9427 "Hawk," as well as other drives that conform to the same interface standards.

The controller can accommodate 8- or 16-bit data transfers and can handle 16- or 20-bit address-bus structures. Thus it can be used in system architectures employing the 8080A, 8085A, or 8086 microprocessors. Existing software developed in conjunction with the RMX/80 Real-Time Multitasking Executive can be upgraded readily from floppy- to hard-disk storage by configuring an iSBC 206-controller driver into RMX/80 software (in place of iSBC 201, 202, or 204 drivers). This software driver is available with the iSBC 206 board at no added cost.

Overcoming one of the major problems of rotating-memory systems—fault location—the iSBC 206 is supplied with its own diagnostic routines in on-board read-only memory. Thus the system designer or



HERE'S WHERE FASTER TESTING PAYS OFF.

At the end of the line, throughput is what you're looking for. More devices for each capital dollar.

And higher throughput is what Teradyne's T347C delivers. By testing discrete semiconductors faster than any competitive system.

Here's how it's done.

FASTER TEST TIMES.

Cut test time and you increase throughput.

In the case of leakage current testing (the most time-consuming), the T347C is exceptionally quick. Up to twice as fast as other automatic testers.

Datalogging is also faster. Using the system's A/D converter, you can take high-speed voltage measurements at least five times faster than with successive approximations. The job is done in the time it would normally take to perform one pass/fail test.

LESS SETUP TIME.

Teradyne went to some lengths to simplify the T347C. Error messages quickly locate programming faults. "On-demand" job plan formatting speeds up programming considerably.

Any series of commands and dialogs can be combined by an operator into a single keystroke using the "command key."

"Bin-oriented testing" permits rapid assembly of test programs by allowing the operator to group test specifications by device type. This eliminates the need to store and retrieve each test individually.

All the above reduce your overall test time. The bottom line is throughput.

MORE UPTIME.

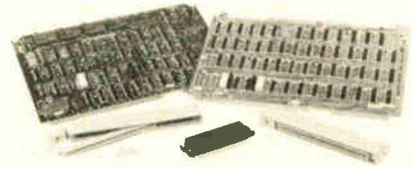
No matter how fast a system can test, it can't test if it's down. Uptime is critical. And Teradyne has designed the T347C to stay up.

What's more, with worldwide stocking, service, and applications centers, Teradyne offers the industry's most comprehensive support system.

It all adds up to higher throughput. And if you're testing discrete semiconductors, it's high time you learned more. Write: Teradyne, 183 Essex Street, Boston, MA 02111. Or call (617) 482-2700.

TERADYNE

Circle 247 on reader service card



user can run a diagnostic routine on the controller itself to ascertain whether a failure occurred in the disk-drive unit or the controller. And in most cases, the fault is pinpointed. Also, data transfers are fully buffered with on-board random-access memory. This guarantees that there will be no data overrun and further, this 1-kilobyte buffer allows the iSBC 206 controller to be placed lower in an interrupt sequence.

The iSBC 206 controller, supplied as a two-board set, operates from a single 5-V supply, drawing an average current of 5.5 or a maximum 6.5 A. The module conforms to the Multibus-standard layout dimensions of 6.75 by 12 in. The price of each iSBC 206 disk controller in single quantities is $2,500, and it is available immediately from the manufacturer's stock.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif., 95051. Phone (408) 987-8080 [342]

Package lets users design with MC6801

The MEX6801 support package permits the design of microcomputer systems that employ Motorola's latest single-chip microcomputer: the MC6801. The package consists of an EXORciser/EXORterm-compatible control module, a buffer board, an interceptor module, and control software that allows evaluation and debugging of programs under development.

The support package allows development of MC6801 software and hardware of any of the Motorola microcomputer development systems; that is, on the EXORciser I or II, or the EXORterm 200 or 220. Additionally, the support package provides the User System Evaluator (USE) capability. With the USE capability, the user can extend the EXORciser or EXORterm debugging features to his target system.

The MEX6801 is completely compatible with all current EXORciser options such as the System Analyzer, programmable read-only memory Programmer, EXORdisk, etc. It is also compatible with Motorola's present static and dynamic memory and input/output modules. The MEX6801 features real-time emulation in the 6801's three modes of operation: single-chip, multiplexed, and nonmultiplexed. The MEX6801 requires 24 kilobits of memory.

The unit price (in quantities of one to five) for the MEX6801 EXORciser support module (including USE capability) with Macro Assembler is $2,500.

Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, Ariz. 85036. Phone (602) 244-6900 [346]

Cross assembler generates 6800 code on Intel MDS

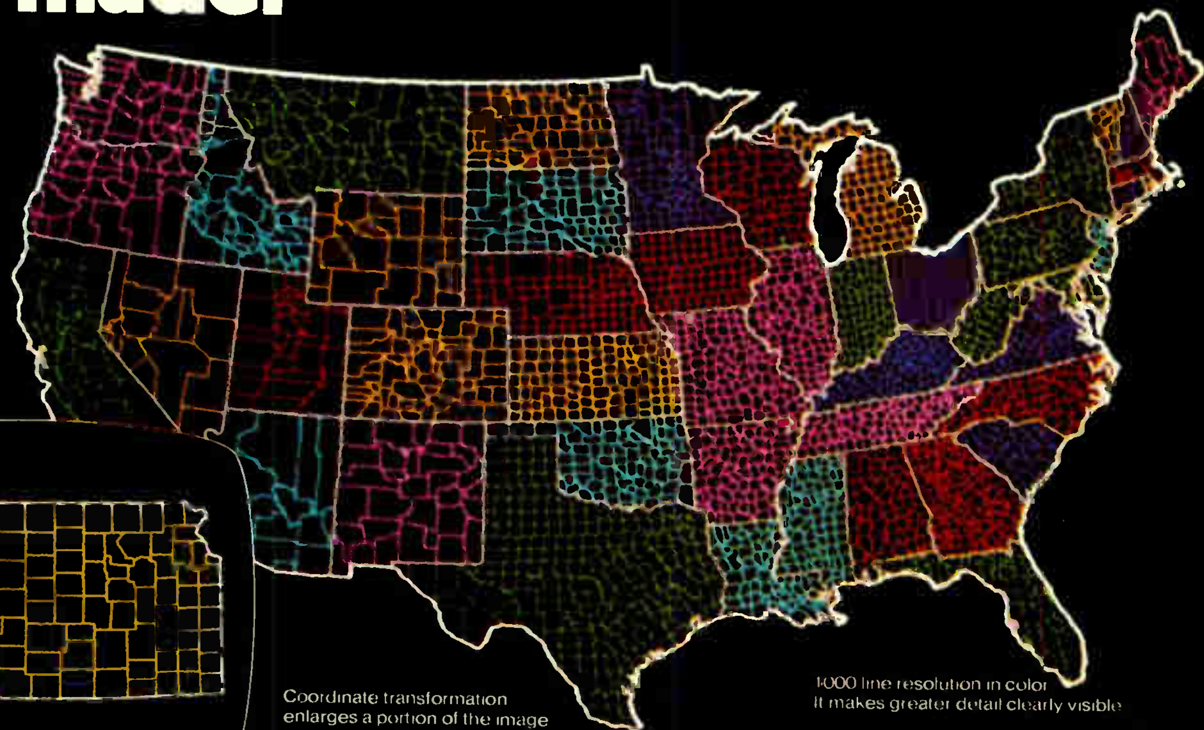
With the 6800/6801 cross assembler from Xener Corp., designers who have access to an Intel MDS Microcomputer Development System can now use 6800 and 6801 microprocessors in their products. The cross assembler runs under the ISIS-II operating system.

The cross assembler uses standard Motorola mnemonics to symbolize 6800 and 6801 instructions. It also supports conditional-assembly instructions, cross referencing, page-width and -length controls, as well as form feed and spacing for a new page. Source-statement format is identical to that of the assembler provided with a Motorola EXORciser development system, and there are only a few differences in assembler-control statements.

The price of the 6800/6801 cross assembler is $550.00, and it is available from stock on a single- or double density ISIS-II diskette.

Xener Corp., 6641 Backlick Rd., Springfield, Va., 22150. Phone Ray Gwinn (703) 569-5050 [343]

Ramtek introduces the most powerful raster graphics and imaging display system ever made.



Coordinate transformation enlarges a portion of the image in memory without increasing line thickness. You can see more, selectively display more.

1000 line resolution in color. It makes greater detail clearly visible.

Here's the Ramtek 9400. Finally, a display that combines raster color, 1000 line resolution, coordinate transformation, high-speed graphics and more—all in one package.

It's colorful. More than 16 million color possibilities thanks to raster scan technology. Or, choose black and white or gray scale.

It's fast. Vector writing speeds are greater than 16,000 vectors a second with 50 pixel average vector lengths.

It's sharp. At the top of the line you can display—in color—1024 scan lines of 1280 elements.

It's powerful. Local spatial transformations include translate, rotate, scale, pan and zoom. You can store and deal with pictures that are much larger or more detailed than can be displayed at one time. De-cluttering allows greater detail to be displayed as the picture is enlarged or less as it's reduced.

It's convenient. Subpictures and special symbols may be down loaded and stored in user memory. Pictures from display lists can be clipped to arbitrary viewports on the display surface.

It's interactive. Subpictures can be called by keyboard function keys. The entity detection feature identifies graphic procedures and instructions that draw objects pointed out by the operator. Interactive controls include a general purpose keyboard, trackball, joystick, light pen and tablet.

It's more than one. The 9400 system is seven different models offering resolution from 256 x 640 to 1024 x 1280. All with the same powerful range of capabilities for command and control, process control, mapping, computer aided design, remote sensing—or any application requiring the ultimate in graphics and imaging potential.

It's more than ever. The sophisticated graphics user no longer has to settle for monochrome or limited color. Now, you can have high density, flicker-free *color* and high speed performance. Ramtek put it all together in the 9400.

It's available now. For more information call your nearest Ramtek office. Or, write: Ramtek, 585 N. Mary Avenue, Sunnyvale, CA 94086.

Ramtek

Our experience shows.

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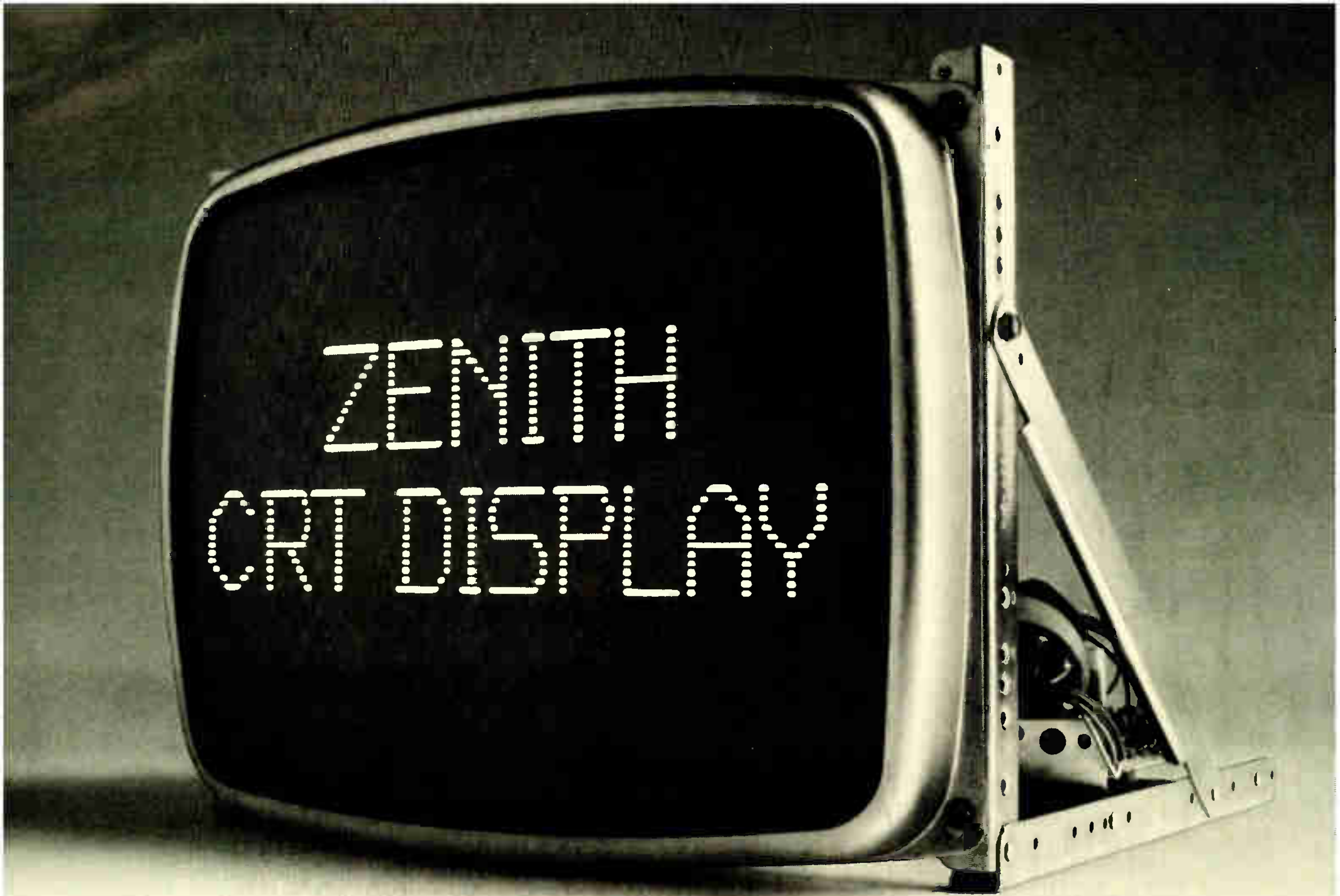
Circle 249 on reader service card



The read-out is quality.

Quality is what has made Zenith famous for over sixty years and number one in the television industry. It's that quality, that commitment to excellence – that insures the reliability of every product we make.

Our manufacturing facilities, laboratories, equipment, procedures, experience and know-how give you the quality and reliability that you look for in a CRT Display. A CRT Display that will hold up under really tough operating conditions.

And to all this, our people add the personal service and special attention you want from your CRT Display source.

Exhaustive testing

Our testing insures that every component operates to exacting Zenith standards. Exhaustive computer analysis, electron microscope and thermograph scan tests are only a sample of what we do.

Our environmental lab tests Zenith CRT Displays for thousands of hours under extreme humidity, vibration, altitude and temperature conditions.

Zenith CRT Displays are designed not only to meet our exhaustive testing requirements, but your demanding specifications as well.

Application engineering

Every CRT Display we design has our customers in mind. Before our engineers even begin new circuit layouts, we'll meet with you and find out what your exact needs and specifications are.

Advanced componentry

Components in the CRT Display are designed with reserve capacity for low maintenance and continued reliability.

The Zenith CRT Display is equipped with a Zenith designed and built deflection transformer. It not only gives a consistent scan, but it is also embedded in epoxy for long-term reliability and the elimination of high frequency squeal.

Important Zenith Features

The Zenith CRT Display is precision engineered. No linearity controls are required and the CRT Display's vertical and horizontal synchronization is automatic.

The Zenith CRT Display frame can be adjusted to virtually any angle you want. This will satisfy many customer requirements without having a frame custom designed.

But we do welcome the opportunity to meet all your special requirements.

Zenith tradition

At Zenith we'll make sure you get the same service, quality and reliability in your CRT Display that we've been giving our customers for over sixty years.

For further information and specifications, write CRT Display Engineering Division, Zenith Radio Corporation, 1000 Milwaukee Avenue, Glenview, Illinois 60025, or call 312-773-0074.

ZENITH®

The quality goes in before the name goes on.

National Computer Conference, June 4-7, Booth 314.

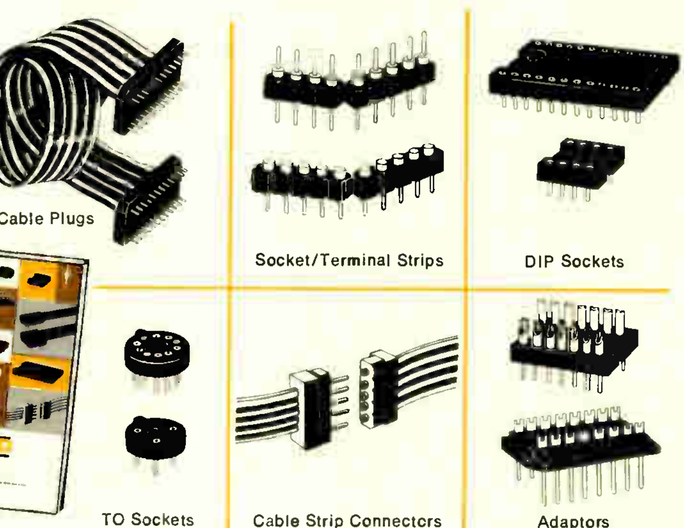
Circle 77 on reader service card

"We'll give you old-fashioned personalized service."

The customer comes first at Samtec . . . and our growing OEM and distributor accounts really appreciate it. We believe that service follow-up, delivery and pricing promises are meant to be kept — and we work hard to see that they are.

Why not give us a try and see how trouble-free *personalized* service can be?

Get our New 32-page catalog today—complete with all specs and ordering data. See what a difference personalized service can make!



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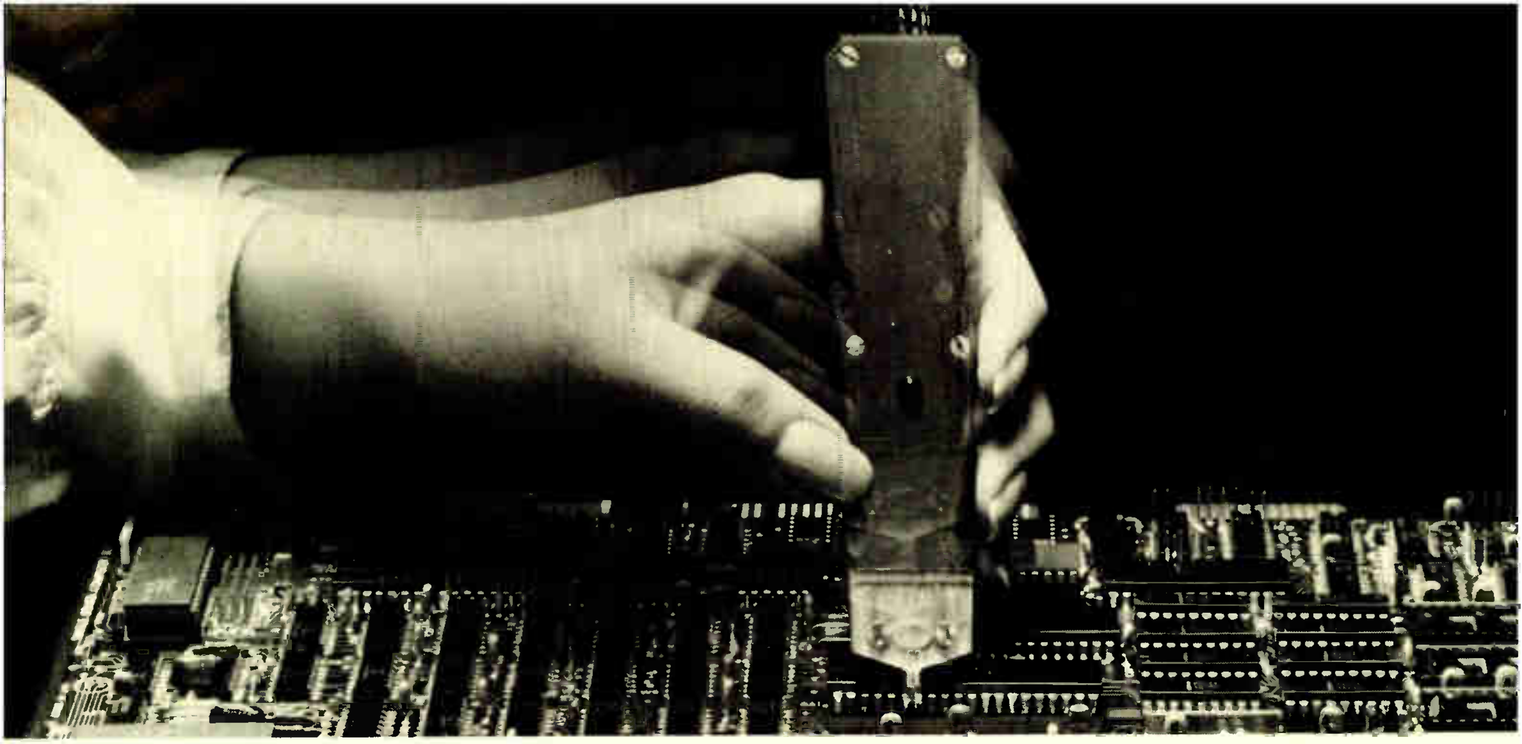

NO SYSTEM DIAGNOSES LSI FASTER THAN THIS SYSTEM.

No doubt about it.

In board testing, you have to have fast diagnosis before you can have high throughput. And Teradyne's L135 LSI Board Test System delivers the fastest diagnosis in the industry.

What's more, the L135 is the only practical means for production testing LSI. Because only the L135 is engineered to handle the long bidirectional buses and multi-pin devices that stop other test systems cold.

THE ELECTRONIC KNIFE CUTS THROUGH TO BAD DEVICES.

Regular guided probing can only take you so far. Specifically, to the failing bus or node.

That's where Teradyne's Electronic Knife takes over. With a few additional probes, the Electronic Knife precisely identifies the faulty IC.

Costly trial and error replacement of LSI chips is eliminated. Skilled technicians need not spend hours searching out problems.

The L135 even handles multi-layer boards and low-power driver families. Finding faults that can only be detected with the board powered and active.

So the Knife cuts two ways. It cuts diagnosis time for higher throughput, and it cuts operating costs for higher profitability.

PROBES ARE FEWER AND FASTER.

LSI chips are simply too complex for regular probing. Back-tracing the failing signal path may require hundreds of successive, time-consuming probes.

To solve this problem, Teradyne developed a software routine called State Sensitive Trace. It analyzes the circuit and directs the probe first to those inputs most likely to contain the failing signal.

Total probes are reduced from hundreds to, say, 20 or 30.

Also, the L135's On-Line Circuit Model cuts probing time still further. By displaying successive probe commands without the delays other systems may require.

If you're testing conventional boards, the L135 will give you the fastest diagnosis available. If your boards are LSI, only the L135 has the capability to test them on the production line.

Remember that. Because productivity is the bottom line.

For more information on these and other L135 features, contact your local Teradyne Sales Office. Or call Teradyne Boston, (617) 482-2700.

PRODUCTIVITY IS THE BOTTOM LINE.

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Circle 252 on reader service card

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- ☐ Burr-Brown
- ☐ Computer Automation
- ☐ Control Logic
- ☐ Data General
- ☐ Digital Equipment Corporation
- ☐ General Automation
- ☐ Iasis
- ☐ Mostek
- ☐ National
- ☐ Texas Instrument
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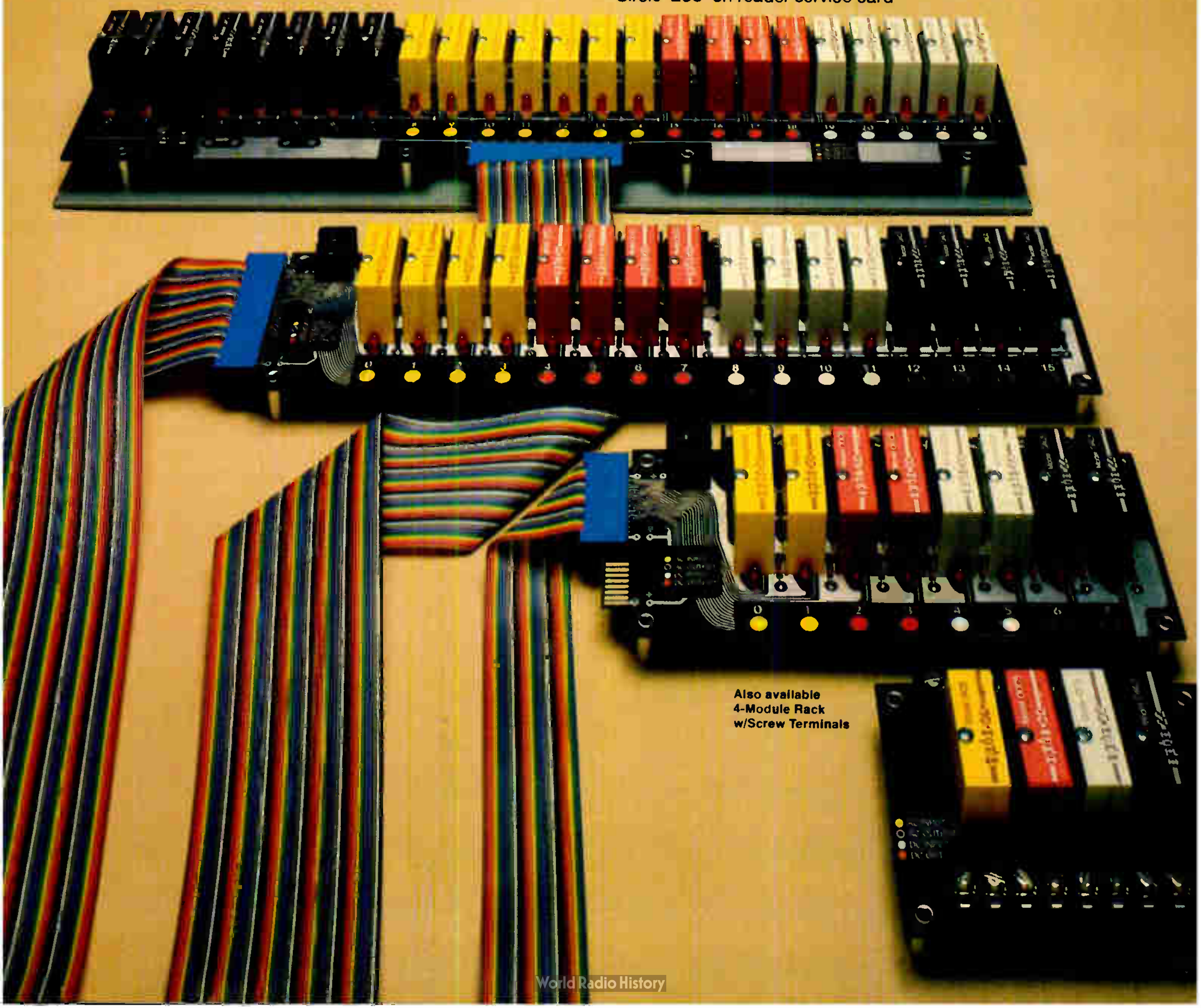
opto 22

5842 Research Drive, Huntington Beach, CA 92649, (714) 892-3313

Circle 253 on reader service card



Packaging & production

Smart analyzer studies waves

Microprocessor-based unit with 1-GHz bandwidth is aimed at automatic testing

Like most computer systems, computer-based automated test equipment can be improved by the use of intelligent peripherals. Toward that end, E-H International Inc., Oakland, Calif., introduced a microprocessor-based waveform analyzer, its model 1060, at Electro79 that combines intelligent control with a choice of interface features. These ease testing of such parameters as rise time, fall time, time between events on channels A and B, plus measurement of from 1 to 16 cycles of a pulse train for more accurate period determination.

"We had to make several key decisions before undertaking this design," Dick Woods, director of marketing, says. "In our previous systems we had serial interface but were aware of the growing popularity of the 8-bit parallel general-purpose interface bus. In addition, we wanted to make the unit more flexible. As a result, we went to a microprocessor [8085] design and added IEEE-488 interface capability, too."

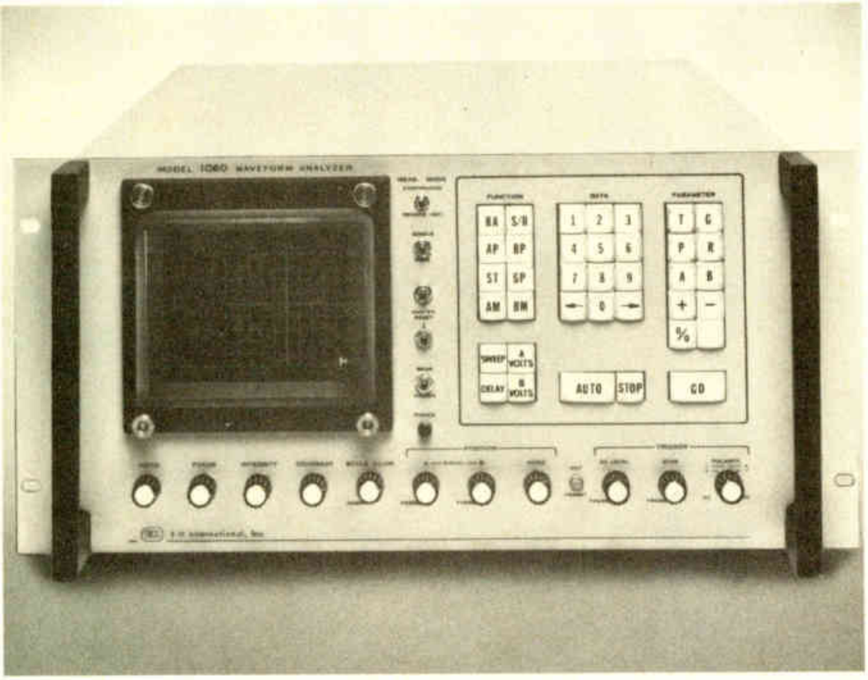
Primarily designed to work in conjunction with a host computer, the 1060 can be used in a local mode with functions controlled from its front-panel keypad. The cathode-ray-tube screen to the keypad's left (photo) displays both the signal or signals of interest and the operating program being run. Placed into the auto search mode, the 1060 will automatically adjust the range and delay-sweep values until the desired signal is found. This mode is addressable either via the host or from the front panel.

Each of the 1060's two channels has a 1,000-bit random-access buffer, which is written into by the input sampling circuitry. This data, once stored in RAM, is displayed on the screen and can also be retrieved by the host for further measurement or for comparison with other signals. The unit's 1-GHz input bandwidth allows it to measure signals down to 0.2 ns per division. Signal amplitudes that range from only a few millivolts to a maximum of 100 V may be measured and displayed, too. Digital values of the time and amplitude appear on the screen and are available to the host computer if requested.

Up to 10 programs of 56 characters maximum per program can be stored in internal RAM. This allows the host to jump from one test program to another via the control program, or the operator can switch programs using the front-panel keys. An input multiplexer is available, permitting users to increase the number of input lines from 2 to 40, all of which are selectable by the operating program, Woods says.

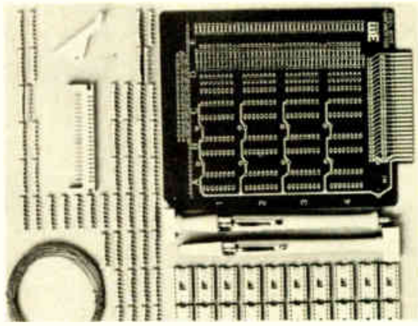
The model 1060 is self-contained except for the external high-frequency probes. It will interface to automatic test equipment with its serial RS-232-C interface (variable from 110 to 9,600 baud) or through its IEEE-488 interface (implemented using a Motorola 68488 single-chip interface circuit). The price of the 1060 is $18,750 and it will be available this July.

E-H International Inc., 515 Eleventh St., Oakland, Calif. 94604. Phone (415) 834-3030 [391]

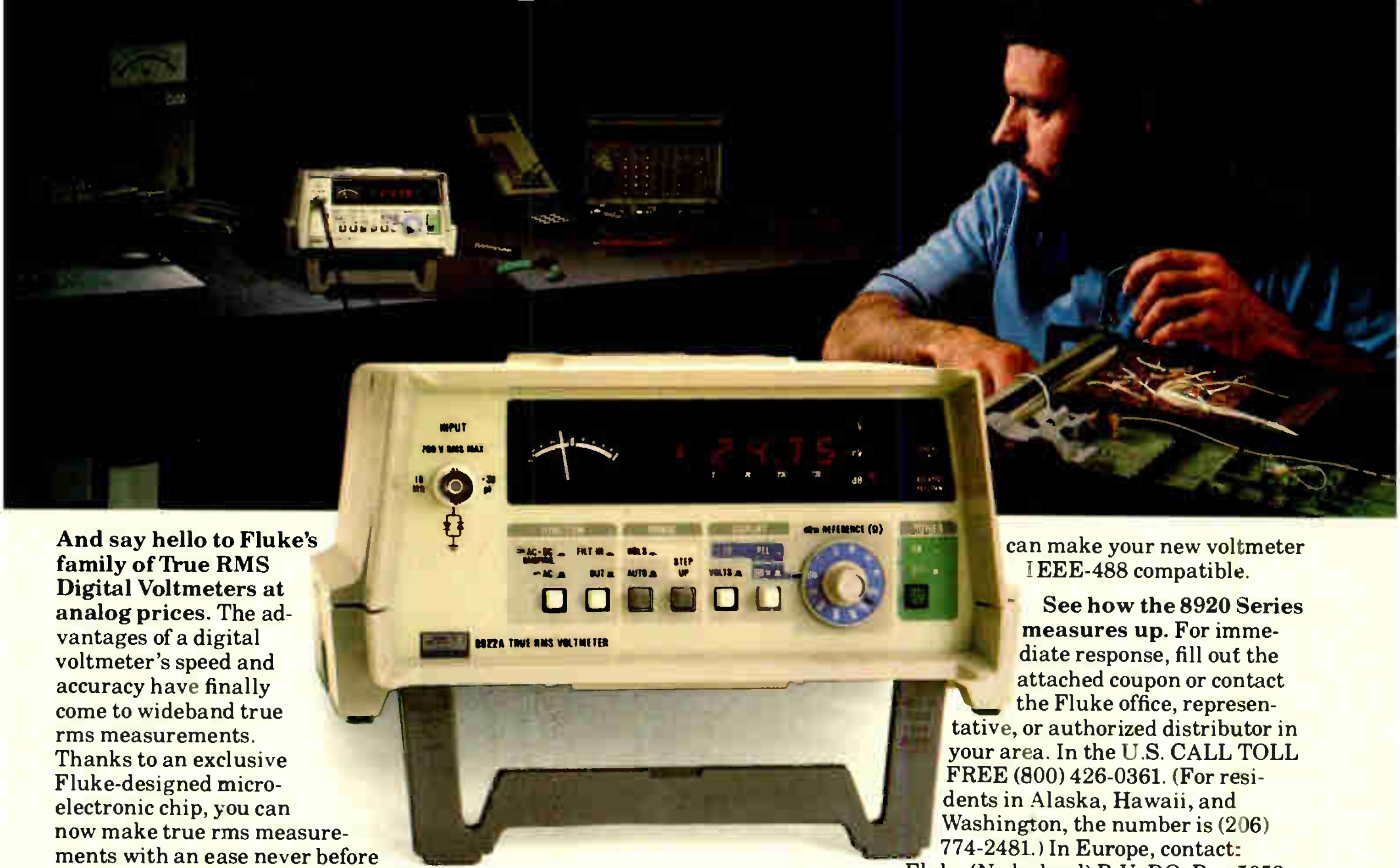


Breadboard system makes solderless connections

Designed for the prototyping of printed-circuit boards, the Scotchflex breadboard system consists of insulation-displacement connectors together with U-shaped contacts that permit solderless connection to boards with plated-through holes. The connectors include solder strips with eight contacts, plug strips, and 16-pin dual in-line sockets. To make



Say goodbye to your old Analog RMS Voltmeter.



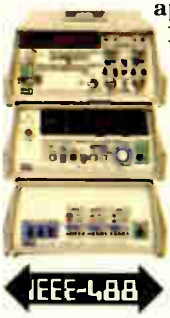
And say hello to Fluke's family of True RMS Digital Voltmeters at analog prices. The advantages of a digital voltmeter's speed and accuracy have finally come to wideband true rms measurements. Thanks to an exclusive Fluke-designed microelectronic chip, you can now make true rms measurements with an ease never before possible — and starting at just $995*.

Try this on your old analog meter. Each model boasts an autoranging LED display of volts (3½ digits) or dB (4½ digits) with 0.5% midband accuracy. An exclusive "dial-a-reference" feature lets you match the instrument's dBm reference to the impedance of the system you're working with. The resultant direct reading of dBm eliminates time consuming calculations. With the relative dB feature, you can set the existing dB reading to zero establishing the input voltage level as the dB reference. Subsequent readings will be indicated as ±dB. All with ac or ac+dc input coupling.

For simplified peaking/dipping measurements, an analog meter complements the digital display. Counter and log output options are available for your system applications.

Match the model to your measurement needs. There's no compromise when buying a Fluke True RMS Voltmeter. The 8920A and 8921A boast 10Hz to 20MHz specifications with a 2mV range to 2MHz. Choose the 8920A with a BNC input or, for floating measurements to 500V, the 8921A with isolated banana jacks.

The 8922A, newest in the series, includes design enhancements for both audio measurements (with specifications to 2 Hz) and rf applications (with an 11 MHz, 2 mV range). Selectable 200 kHz filtering enhances audio performance by eliminating unwanted high frequency noise.



Latch them together, then put them on the bus. Each 8920-Series Voltmeter is housed in the exclusive Fluke portable test instrument package. This system allows convenient stacking and latching of multiple instruments for unrivaled transportability. And by adding the new 1120A Translator, with appropriate instrument options, you can make your new voltmeter IEEE-488 compatible.

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For Demonstration Circle #255 on Reader Service Card

a connection to the board, only a hand tool is needed to feed continuous 30 AWG solid insulated wire into a contact. One or two wires can be inserted into a contact. The contacts are only about one third the height of wrap posts, permitting prototype circuit boards to be mounted in the same space occupied by production boards.

Since the prototype board closely parallels the production board, the designer may move directly from the first to the second type of board without redesigning it. The 3M system, which supplants an earlier one [*Electronics*, April 14, 1977, p. 196], also allows removal of wires without unwrapping or cutting them.

The Scotchflex breadboard components are compatible with all boards with or without plated-through holes. Other system components include a G-10 board that measures 4.5 by 5.5 in. and a wiring tool with a self-contained wire feeder and a cutting tip.

For designers who want to work with their own pc boards, the components can be ordered separately. A kit that includes a board and quantities of individual components is also available. Single kits are priced at $97.50; in quantities of 25 or more, they sell for $81.25 each. In quantities of 1,000 or more, eight-contact solder strips and plug strips are 29¢ each, and the dual in-line sockets are $1.22 each for 1,000 or more.

3M Co., Department EP9-9, Box 33600, St. Paul, Minn. 55133 [393]

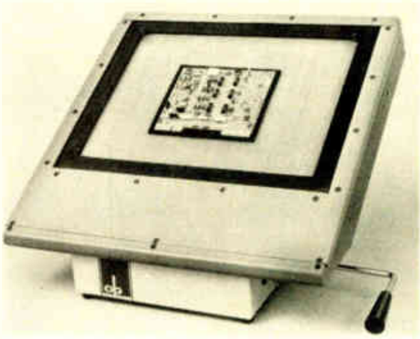
Unit etches polysilicon at up to 4,500 Å min

Intended for the plasma etching of polysilicon wafers, the Plasma Model 700 can etch undoped polysilicon at a rate of 2,200 to 4,500 Å per minute. The machine is easy to use: the operator just loads either 3- or 4-in. wafers into cassettes. The cassette-to-cassette wafer transport system then automatically moves the cassettes to the planar reaction chamber where the wafers are processed one at a time. The unit features a throughput rate of up to 30 wafers per hour. According to the company, tolerances of ±0.3 μm can be achieved.

Tegal Corp., 11 Commerce Blvd., Novato, Calif. 94947 [394]

Test fixture comes with nine different heads

This Ostby and Barton test fixture comes with nine interchangeable test heads of various sizes. Each head can contact up to 1,200 points at a time. The heads lock and unlock

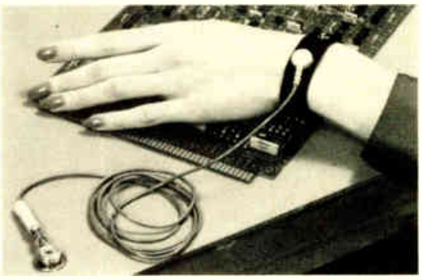


from the fixture's base receiver by means of a cam lock.

Ostby and Barton Co., 487 Jefferson Blvd., Warwick, R. I. 02896. Phone (401) 739-7310 [396]

Wrist strap dissipates static charge

A wrist strap from the 3M Co. combines conductive Velostat brand plastic with insulated copper wire, offering optimum dissipation of static charge. The strap measures 0.5 in. by 9 in. and the ground cord is 4 ft in length with a 1-MΩ resistor. The resistor limits the fault current in the



Series 500 Measurement and Control I/O System

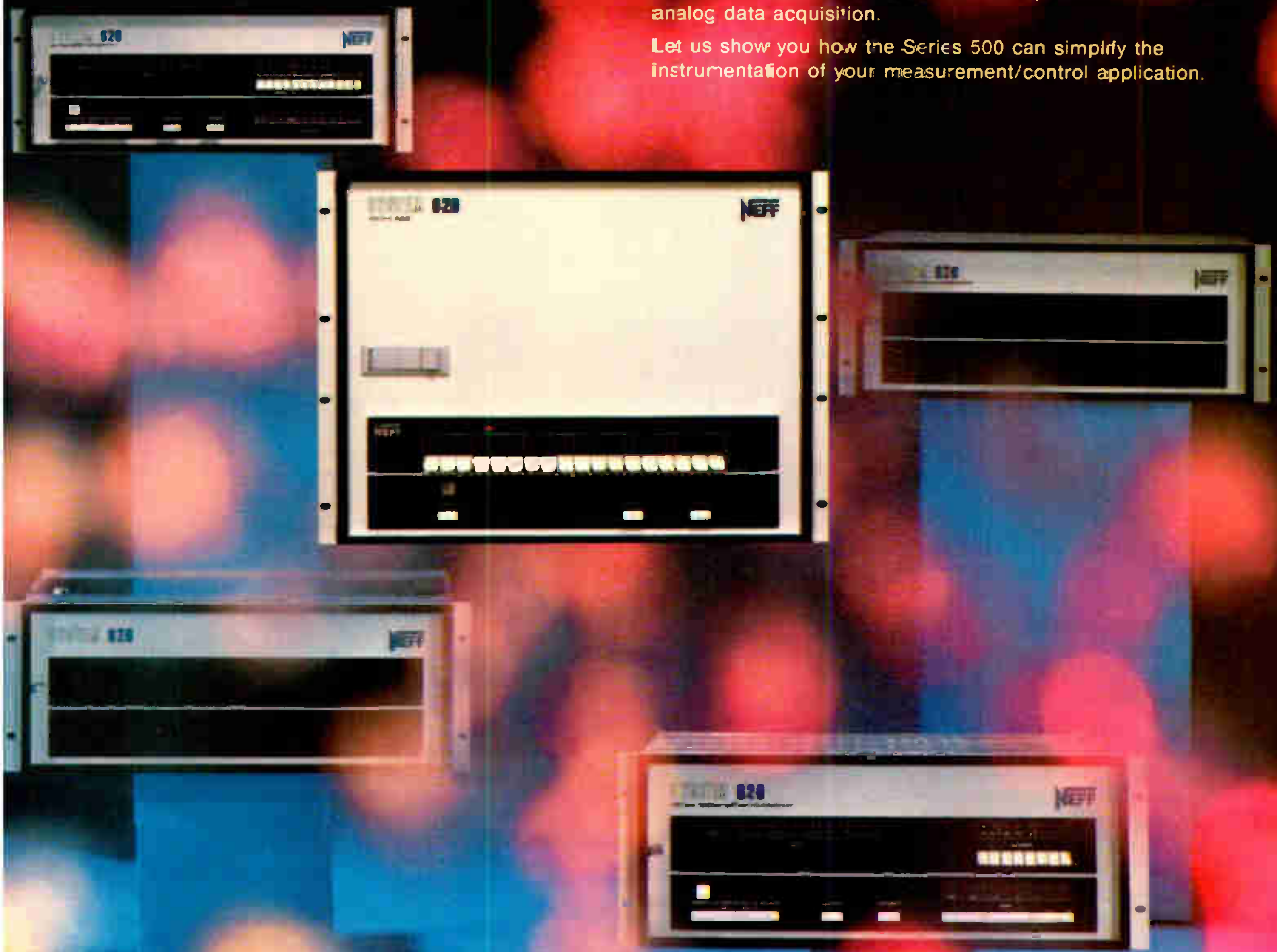
A complete subsystem for all your signals.

The newest member of the Neff System 620 family, the Series 500 Measurement and Control I/O System provides a single, computer-controlled interface for various types of I/O signals commonly used in measurement and control applications. It accepts contact closures, TTL or other voltage levels, frequency inputs and low-level analog voltages. Its outputs include contact closures, voltage levels and analog. In addition, the Series 500 provides the interface to the controlling computer and a serial data link to remote systems.

The Series 500 includes a 4K RAM in which the computer can store scan lists, instructions and control words to operate peripheral devices. Data is returned to the computer over a single DMA channel. Completely integrated and cabled standard interfaces are available for most computers and software drivers are available for most popular operating systems.

Configuring the system for any combination of I/O signals is a simple matter. It's done with plug-in function cards selected for the types of signals to be handled - up to 16 function cards per assembly, expandable to 256 function cards per site. Series 500 supports any of the Neff 620 systems for low-level analog data acquisition.

Let us show you how the Series 500 can simplify the instrumentation of your measurement/control application.



Circle 257 on reader service card

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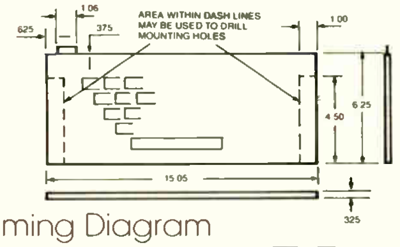
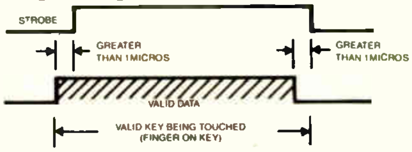
Mechanical Outline



Timing Diagram



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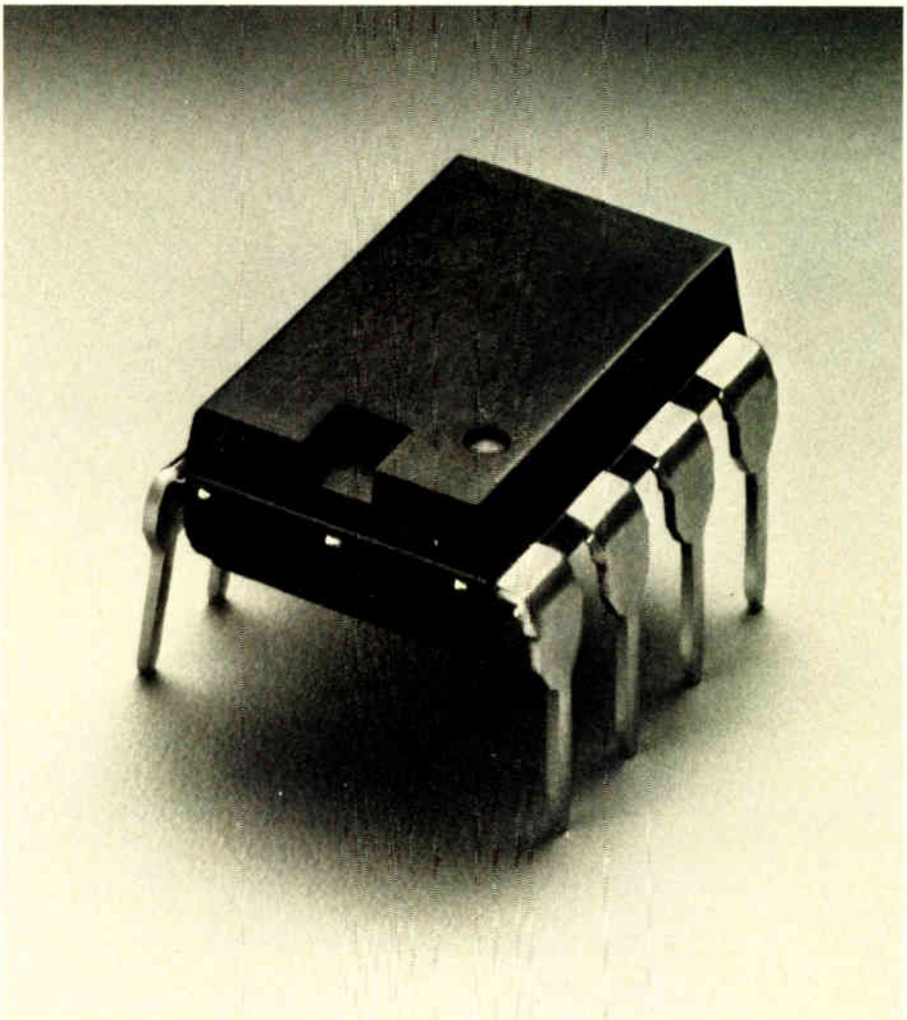
Circle 261 on reader service card

Power Play



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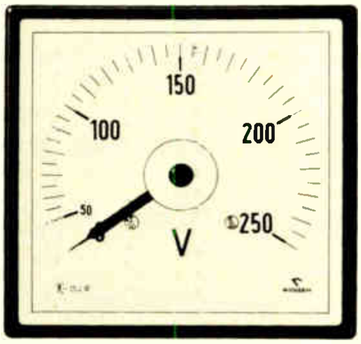
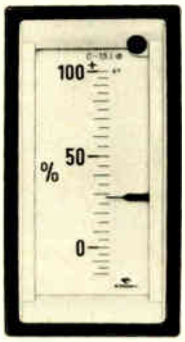


Edgewise



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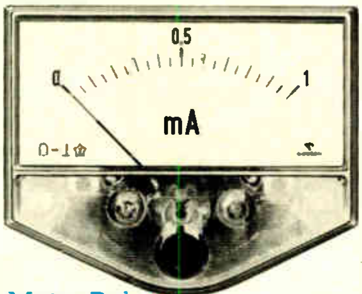

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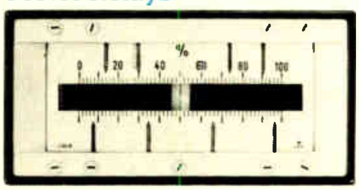

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Computers & peripherals

Drive handles 8-in. hard disks

Aimed at gap between floppy disks and large platters, unit stores 45 megabytes

With its entry into the rigid-disk market—an 8-inch drive—Micropolis Corp. is aiming at a performance niche between floppy disks and currently available 14-in. hard units. The initial products, called "Microdisks" (for original-equipment manufacturers), not only are interchangeable with 8-in. floppies, but pack up to 38% more storage capacity in 80% less space than existing 14-in. drives, according to Stuart Mabon, president of the firm.

"The new drives offer optional capacities of 9, 27, and 45 megabytes," says Mabon, "and are viable candidates as primary mass-storage media in these configurations for on-line data storage." Terming the drives "a new class of storage devices," Mabon believes they will have an impact on both the floppy- and hard-disk markets, "as well as creating a new one."

Designed to be easily interchanged with a typical 8-in. floppy-disk drive, even down to the placement of screw holes, the new units are 8.55 in. wide by 4.625 in. high by 14.25 in. deep. They have an average access time of 34 ms, which Micropolis says is twice as fast as new low-end 14-in. drives. Capacity is determined by the number of disks in the drive. A maximum of three nonremovable platters can be accommodated. The three-platter unit uses five recording surfaces, each with 8.975 megabytes of unformatted storage.

Fast coil. In designing the head-positioning mechanism, the Micropolis engineers chose to use a rotary voice coil rather than a stepping motor. The coil, which is already employed by IBM in its 8-in. drives, according to Mabon, not only is faster than a stepping motor, but also permits a recording density of 500 tracks per inch. Moreover, Mabon expects the density to increase to 1,000 tracks per inch as improvements are made. Winchester drive technology is used throughout.

The lower half of the drive package contains the platters, while the upper half houses the support electronics. Included in that support electronics is an optional intelligent controller board, priced at $500 in large quantities.

The controller, which can handle four drives, allows a choice of a number of hard-sectored formats. It also provides direct or buffered transfers, automatic verification and re-tries, multisector transfers, error detection and correction, and a versatile command structure.

A typical price for a (two-disk) 27-megabyte Microdisk is $1,350 in 1,000-unit quantity. A sample unit will sell for between $3,000 and $3,500. The samples should be ready for delivery next month, whereas volume production is not scheduled until the last quarter of the year.

Micropolis Corp., 7959 Deering Ave., Canoga Park, Calif. 91304. Phone (213) 703-1121 [361]

Desk-top unit turns on to business applications

The Compucorp 625 Mark II is a turn-key system for business applications. About the size of an electric typewriter, it contains a cathode-ray-tube display, dual floppy-disk drives, and a printer.

The computer is offered with extended Basic software and up to 64 kilobytes of memory. It can be supplied with interfaces for a wide variety of external printers, plotters and other peripherals, as well as with various controllers to allow its use in data-acquisition and other real-time scientific applications. The system will be on display in booths 113 and 114 at NCC.

Compucorp., 1901 S. Bundy Dr., Los Angeles, Calif. 90025. Phone (213) 820-2503 [366]

Printer lowers cost of color copies

To produce color graphics, engineers have had a choice of either electrostatic or ink-jet printers. Now a third method—dot-matrix with multicolor ribbon—is available that the manufacturer claims is 50% less expensive than the former and 75% cheaper than the latter.

The Colorplot 100 printer employes a proprietary technology that uses a 1-in. ribbon containing three or more colors and prints on stan-

dard computer paper. This results in a cost per copy of 0.5¢.

With a resolution of 100 dots per inch, the printer can produce a three-color drawing in approximately three minutes. Its bidirectional paper drive positions the graph for successive color applications and permits printing and plotting on the same line. Colors may be printed in any order.

Text can be printed at 150 lines per minute with a seven-by-nine overlapping dot-matrix or 250 lines/min with seven-by-seven dot-matrix. A 96-character ASCII set is

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Circle 265 on reader service card

provided, as are built-in diagnostics and a forms-length switch.

The Colorplot 100's $9,980 price includes installation and 90-day on-site service charges. Delivery time is 60 days.

Trilog Inc., 16750 Hale Ave., Irvine, Calif. 92714. Phone Ray Melissa at (714) 549-4079 [365]

Compact Winchester drive sells to OEMs for $1,800

The Diskos 3350, to be shown at NCC, is a Winchester-type disk drive with its sights set on the original-equipment-manufacturing market. Providing 33 megabytes of storage on a 14-in. disk, the compact, 7-by-17.5-by-20-in. unit sells to OEMs for as little as $1,800. A brushless dc motor eliminates the mechanical brake commonly employed in this type of drive and allows the 3350 to be used in systems powered by dc only. The voice coil positioner design also reduces the unit's size.

Priam, 20730 Valley Green Dr., Cupertino, Calif. 95014. Phone George Toor at (408) 446-4626 [367]

Desk-top terminal queries customers

Exhibitors at next month's National Computer Conference, like other marketers, will be collecting information about potential customers so that they can refine their products and marketing efforts. They should therefore find a device called Tellus interesting, for it can easily gather such information and will also be present at the NCC.

The desk-top unit can act as a stand-alone data-collection terminal or, with the addition of the offered communications interface, as a pollable polling point. Up to 11 questions can be presented by the push-button questionnaire: 10 with a choice of three answers and 1 with a choice of up to 10 responses.

As a respondent answers a question by pressing a touchkey, a light-emitting diode turns on behind the key to acknowledge the response. Answers can be changed until the user is satisfied, at which point he presses a record button.

The basic, stand-alone Tellus operates from four D-size batteries that provide power for more than 10,000 sets of responses. Available options include an interface to a built-in 12-column printer for local printout of cumulative results, a storage-transaction module that records individual sets of responses, and a communications module with memory expandable to 24,000 characters. Prices range from $1,500 to $3,000 depending on the options the purchaser selects.

MSI Data Corp., 340 Fischer Ave., Costa Mesa, Calif. 92626. Phone Joseph Clark at (714) 549-6000 [363]

System built to quickly copy standard-size or minifloppy

Called Floppy Copy, the IC-450 is a system for initializing, testing, and making multiple copies of standard-size and mini-diskettes. The copier, which can be seen at NCC, has an automatic subsystem for loading disks one at a time from a stack of up to 50 floppies, saving the time and effort of manual loading.

The IC-450 can handle all IBM and most other formats, writing in single- or double-density formats on one or two sides and employing hard- or soft-sectored techniques. If the disk fails to pass the initial, pre-write test, it is ejected into a reject hopper; duplicated disks are automatically fed into an acceptance bin.

The system includes a central processing unit, cathode-ray-tube display, and work-station desk in addition to the stacker-loader. A single-density, single-sided disk system that handles minifloppies only is priced at $19,950. A similar system that handles both standard and minifloppies sells for $29,500. Delivery time is 60 days.

Applied Data Communications, 14272 Chambers Rd., Tustin, Calif. 92680. Phone (714) 731-9000 [368]

System changes graphics without need for redrawing

The NCC will be more colorful than usual this year as competition in the color graphics market increases. Chromatics, for instance, will unveil a system that allows drawing corrections and changes to be made using software routines, without redrawing the original.

Graphics are drawn using a digitizer tablet that reproduces them on a 512-by-512-element, 13-in. cathode-ray-tube screen. Automatic fill routines add color and patterns to large areas of the drawing with a few keystrokes. Corrections can be made using a light pen, and on-screen drawings can be stored on integral dual floppy disks or reproduced using a Xerox 6500 color printer.

Users can create their own software routines using the Microsoft Basic software included with the system. Using the system's Disspla

software, operators can enter coordinate information, raw data, and financial or management information and the system will automatically produce full color graphics.

A basic model CG1339M system comes with a color graphics computer, a CRT on a swivel base, keyboard, dual floppy-disk drives, a 32-kilobyte random-access buffer memory, a color printer interface, and software, which includes Microsoft Basic with extended graphic and alphanumeric functions. It is priced at $21,995; delivery time is 60 to 90 days. Larger, 15- or 19-in.-screen CRTs are available as options.

Chromatics Inc., 3923 Oakcliff Industrial Ct., Atlanta, Ga. 30340. Phone Don McKinney at (404) 447-8797 [364]

Ready to rent, lease or buy test instruments? Let US help.

When you need test equipment you usually need it fast. That means that you can't waste a lot of time looking for the right equipment or sending back equipment that doesn't work the first time. USIR can help.

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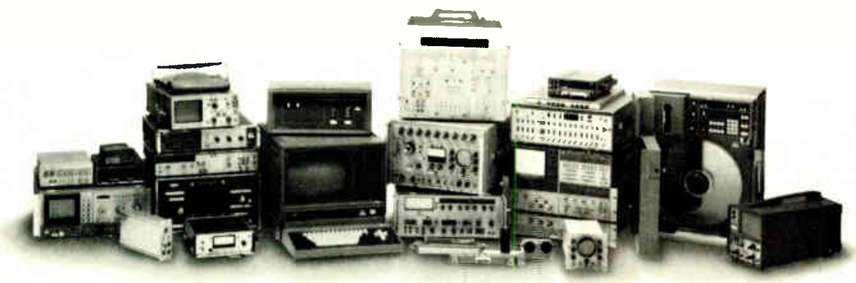
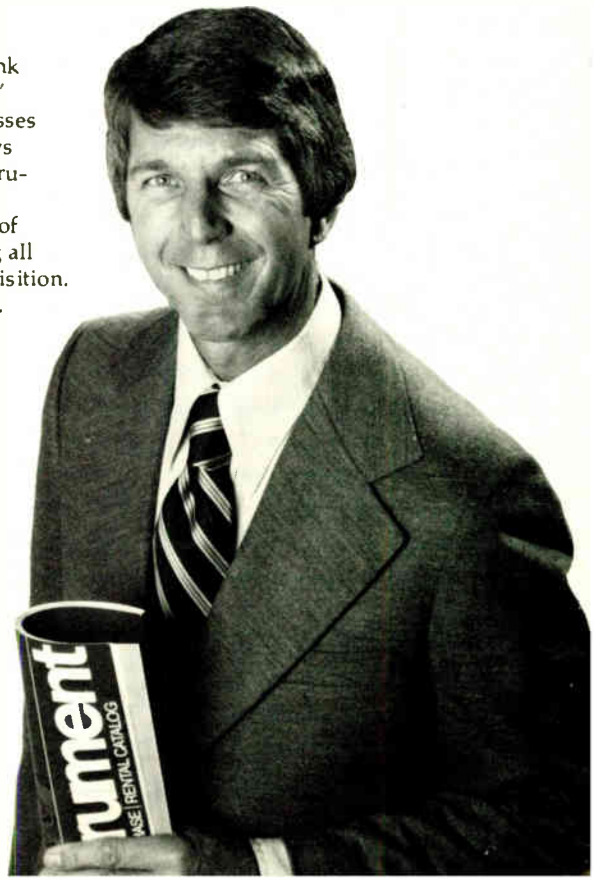
USIR has prepared a kit that will help you find the fastest, most efficient, least expensive way to acquire the instruments you need. The kit includes our Instrument Acquisition Analyzer, a current USIR catalog and our brochure, "Test Equipment—Think Of It As Money." This piece discusses the different ways of acquiring instruments from a manager's point of view considering all the costs of acquisition. Send for it today.





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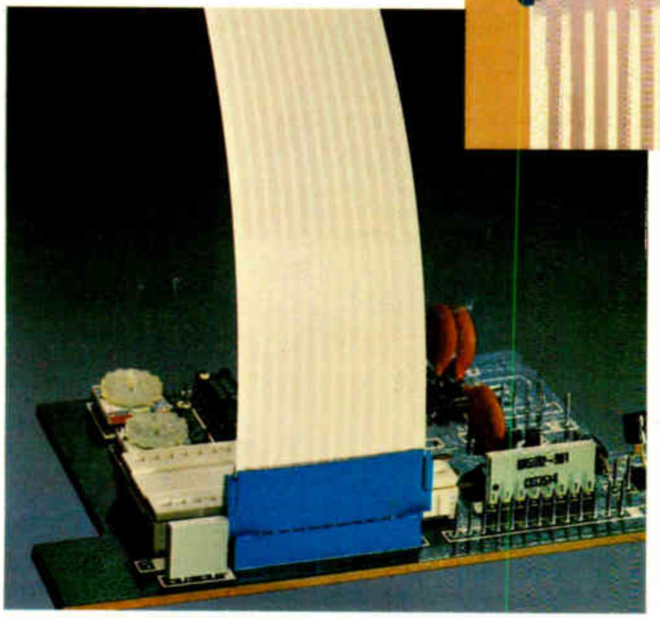
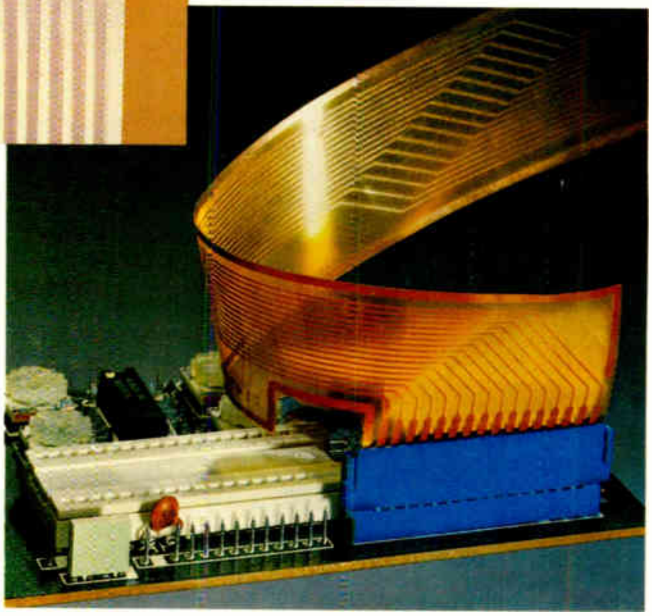
Circle 267 on reader service card

Berg's Clincher* connector mass terminates flat conductors quickly and reliably.



The "Clincher" on flat conductor, flat cable.



The "Clincher" on flat conductor, flex circuitry.

The "Clincher" is a superior connector system for flat conductor, flat cable or flex circuits. It offers high reliability and the lower applied cost of mass termination.

With the "Clincher," all of the flat conductors are terminated simultaneously, within 15 seconds. Cable stripping is not required. The "Clincher" system offers a substantial reduction in total installed cost over individually terminated conductors.

The "Clincher" design uses Berg's proprietary PV* receptacle, a connector of proven reliability for over a decade in data processing and telecommunications applications. The dual-metal construction of the "PV" provides a high normal force to assure highly reliable mechanical and electrical performance.

Berg's "Clincher" accepts a 1 to 2 oz. copper 0.062" wide cable. It is stackable on 0.100" centers in double-row configurations for dense packaging. The "Clincher" mates with 0.025" pins or standard Berg headers to form a complete interconnection system.

Rely on Berg for quality performance to meet your most demanding application needs. For a brochure describing the "Clincher" system, write or call:

The Du Pont Company, Berg Electronics Divison, New Cumberland, Pennsylvania 17070. Telephone: (717) 938-6711.

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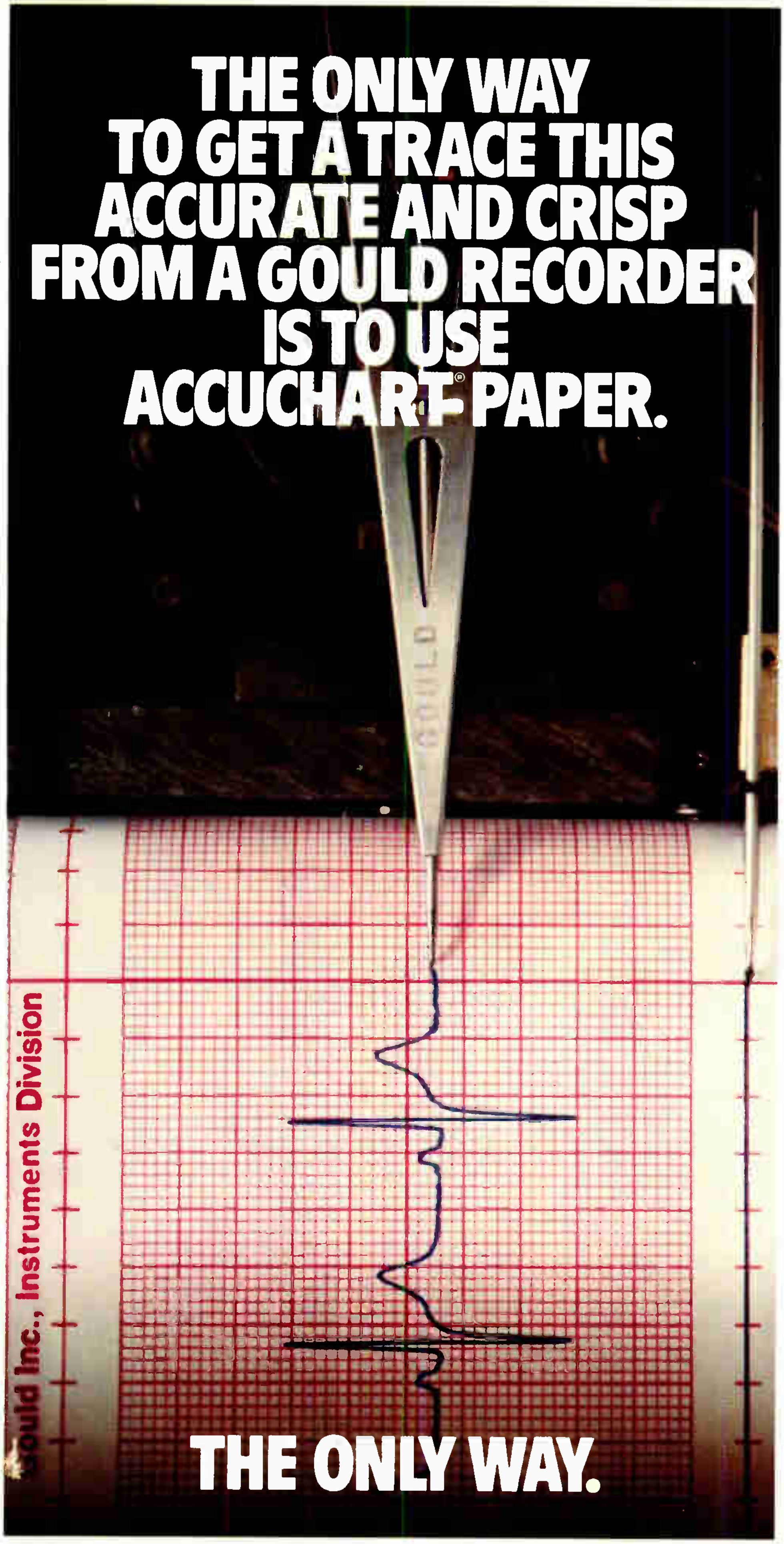
*Du Pont Trademark

Circle 269 on reader service card



That's because Accuchart paper is specially designed and produced by Gould for use in Gould recorders.

Only with Accuchart can you be certain of getting the precise and permanent traces Gould recorders are capable of producing. Unlike other papers, Accuchart will not compromise the accuracy or reliability of Gould recorders.

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Accuchart papers are available in many configurations, including semi-perforated chart rolls for use with either automatic Z-Folder or manually. And you can count on Gould's on-time delivery.

So remember. To get the finest quality traces from Gould recorders, use Accuchart paper. Easily identified by the Accuchart name on every roll. For more information, send for our free handy pocket guide by calling Gould toll free at (800) 325-6400, ext. 77. (In Missouri: (800) 342-6600). Or write Gould Inc., Instruments Division, 3631 Perkins Ave., Cleveland, Ohio 44114.

GOULD

An Electrical/Electronics Company

Circle 271 on reader service card

Data acquisition

D-a converters get cheaper

12-bit monolithic device with 200-ns settling time sells for $13 in thousands

Twelve-bit accuracy costs less than ever with the AD566 monolithic analog-to-digital converter. At $13 each in lots of 1,000 or more, the converter offers impressive specifications as well. Settling time to within half a least significant bit is 200 ns, while full-scale (10% to 90%) switching time is a low 30 ns. The unit is guaranteed to be both linear to within ±½LSB and monotonic over its working temperature range.

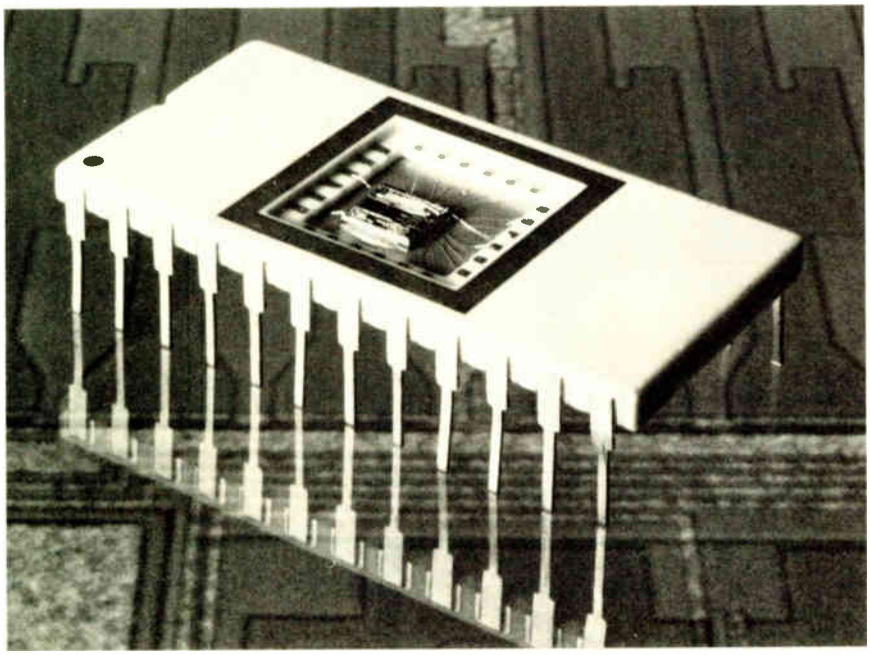
To achieve this performance, the chip's designers combined 12 fast current-steering switches and a laser-trimmed resistor network. The switching network is similar in its dc accuracy and stability to the one developed for Analog's AD562, but it is faster and has a better-damped settling characteristic.

The company is pitching the AD566, in fact, at sockets using its earlier, slower, and costlier AD562. "The 566 uses the same basic current-steering approach," says assistant marketing manager David Kress, "but we have modified the switching cells and ladder network, and—more importantly—have gone to a smaller geometry than the 562's. So we get more speed, lessen power dissipation, and use less chip area. And because the area is smaller, the yield can be higher and our cost can be lower."

In retrofit applications, the AD566 is a pin-compatible replacement for the 562. Multisourced, so far as any d-a converter is multisourced, the 562 is something of an industry standard, so upgrading will make sense to a good many potential buyers.

The 566 accepts C-MOS and TTL input voltages and responds with either a 0-to-10-V positive output or a ±10-V bipolar output. Power dissipation is a low 300 mW, made possible, in part, by the 566's lack of an internal reference.

Several versions are available. The AD566J and K operate from 0° to 70°C; the AD566S and T work from −55° to +125°C and may be purchased with MIL-STD-883 Class-B screening. Both plastic and ceramic dual in-line packaging are offered. Delivery of quantities of 100



Resonance-Free to 34 GHz.

Affordable Amphenol® APC-3.5™ Connectors: When performance is critical above 18 GHz.

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to APC-N

APC-3.5
to APC-3.5

APC-3.5
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Adapters,
actual size

Amphenol APC-3.5 Connectors bring coax convenience to the traditional waveguide system. A wide choice of plugs, jacks and adapters that exhibit resonance-free, low VSWR performance to 34 GHz is available. All at a price low enough for their use in typical applications.

The rugged APC-3.5 has a wide (.020-in.) radial shoulder on the outer conductor that provides high reliability and repeatability after hundreds of matings.

Low leakage is assured because of the high contact force that can be applied to the wide gold-plated beryllium-copper shoulder.

The APC-3.5 can improve performance of existing systems merely by changing from SMA connectors. No system redesign is necessary, since the APC-3.5 mates directly with the SMA connectors.

For more information, call the sales office or distributor nearest you. Or contact RF Operations, Danbury, Connecticut.

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Circle 273 on reader service card

or fewer pieces takes one week; 1,000-unit lots have a delivery time of four to six weeks.

Analog Devices Inc., Route One Industrial Park, Norwood, Mass. 02062. Phone (617) 329-4700 [381]

16-bit a-d converter delivers in 100 μs . . .

Designed for commercial applications, the model 2816 is a high-speed analog-to-digital converter that provides a 16-bit conversion in 100 μs. A 14-bit version, the 2814, converts the analog input in just 50 μs.

The 16-bit device is linear to within ±1 least significant bit, the 14-bit unit to within ±½ LSB. Their maximum temperature coefficient of nonlinearity is ±0.5 ppm/°C.

The modules consume a maximum of 1.5 W and produce serial and parallel output data. Their offsets can be adjusted by a screw on the

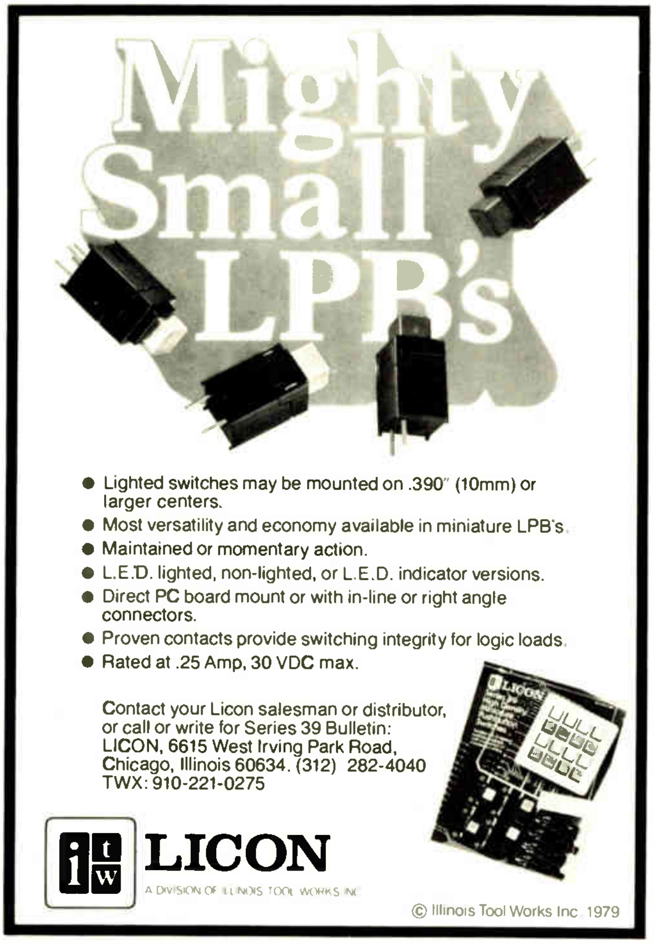
side of the module case. Warm-up time is at most 15 minutes.

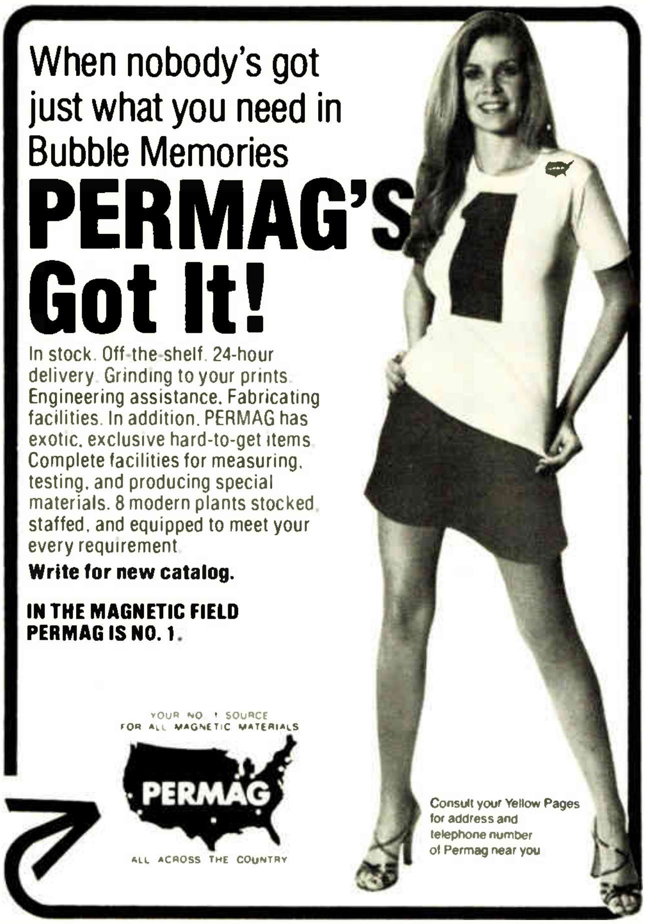
In single quantities, the 2816 is priced at $450 and the 2614 at $350. Delivery time is four to six weeks.

Dynamic Measurement Corp., 6 Lowell Ave., Winchester, Mass. 01890. Phone (800) 225-1151 toll free [383]

. . . while three-state unit gives 12 bits in 2 μs

For fast conversion of analog signals into 12-bit digital data, the ADC594-12 provides an output in a maximum of 2 μs, typically in 1.8 μs. The 2-by-4-by-0.4-in. module in-





cludes a clock, a precision voltage reference, and a thin-film resistor network. Monotonic operation is guaranteed over the 0°-to-70°C operating range.

For use with microprocessors, the unit's output is buffered to permit three-state operation. Input ranges of 0 to −10 V, ±5 V, or ±10 V are pin-selectable. The unit consumes 1.75 W and works from ±15-V and +5-V supplies. In single quantities, the ADC594 is priced at $299; its delivery time is four to eight weeks.

Hybrid Systems Corp., Crosby Drive, Bedford Research Park, Bedford, Mass. 01730. Phone Paul Goss at (617) 275-1570 [384]

16-bit s-d converter fits in 14-bit package

Capable of converting synchro data into 16-bit digital form with a maximum error of ±1 arc minute, the model 1661B s-d converter comes in a 3.125-by-2.625-by-0.82-in. package—the same size housing as units that offer only 14-bit resolution.

With a 400-Hz input carrier, the unit can track changes at velocities up to 1,050°/s and accelerations up to 240°/s². Outputs are compatible with complementary-MOS and TTL circuitry and are provided in parallel, positive binary-coded form.

The 1661B is available in versions that work in the 0°-to-70°C or −55°-to-+105°C ranges and ones that are qualified to MIL-STD-202, 883B or MIL-M-38510. It is priced at $750. Delivery is from stock to six weeks.

Transmagnetics Inc., 210 Adams Blvd., Farmingdale, N.Y. 11735. Phone Fred Haber at (516) 293-3100 [385]

SABRE X. The lab recorder/reproducer your lab won't outgrow.

You know how your projects can expand and change. And a limited capability magnetic tape recorder won't always have the necessary capacity, and versatility to meet your new requirements.

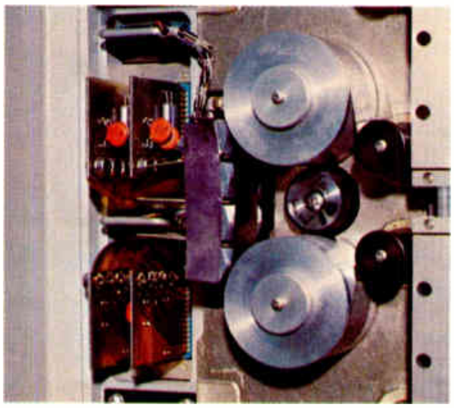
Enter the Sabre X.

This is the largest, most versatile lab recorder we offer. It comes complete with microprocessor control and full capacity for up to 88 hours of recording time on a single tape. In addition, it has features you won't find on any other recording system.

For example, the Sabre X offers 10 bi-directional electrically switchable tape speeds from 15/32 ips, fast forward and fast rewind speeds of 320 ips in phase lock, a high density PCM, wide band servo and vacuum tape tensioning system. At 240 ips, Sabre X provides full 4MHz direct record/reproduce bandwidth or an 8 Mb/s per track HDR data rate.

The microprocessor-controlled tape transport features a programmable end-of-tape and shuttle. It also has a built-in diagnostic/alarm system that constantly monitors crystal reference, vacuum level, AC line voltage variation, all DC power supplies and heat sink temperatures of the reel drive and capstan power amplifiers.

Don't get stuck with a lab recorder you'll outgrow; specify the Sabre X. For a free copy of our new, illustrated SABRE X catalog and complete specifications, contact Ron Johnson at (813) 371-0811. Or simply circle the number on the reader service card.



Sangamo Data Recorders P. O. Box 3041
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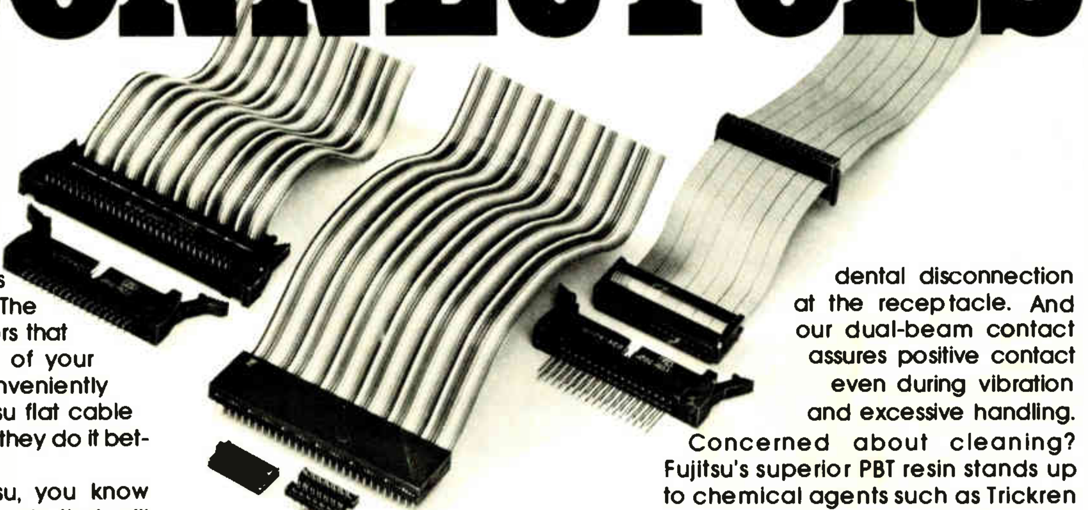
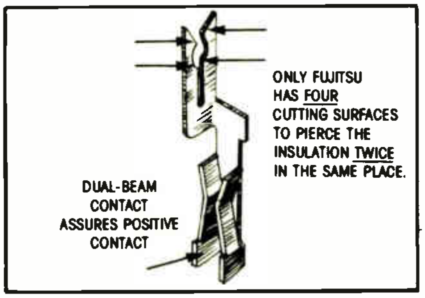
FUJITSU: FLAT CABLE CONNECTORS

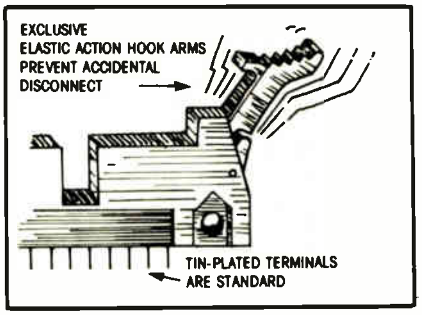


Flat cable connectors are easy enough to find. The trick is finding connectors that can handle every one of your needs consistently, conveniently and economically. Fujitsu flat cable connectors do it all. And they do it better than most.

When you buy Fujitsu, you know you're getting components that will always fit your usage because our connectors are compatible with 3M and other major brands. You won't be getting hit-or-miss construction, either. Thanks to Fujitsu's standardized automated manufacturing. Each piece must meet our rigid quality control standards before it is shipped.



Assembling Fujitsu connectors is a snap, too, because of their simplified design. Like u-contacts that pierce the insulation twice at the same place to provide a gas-tight metal surface that is electrically reliable. And can withstand excessive pulling forces. And when you order Fujitsu flat cable connectors, you know you will always get tin-plated terminals that improve solderability and prevent gold contamination of the solder bath. Can your source say that?



A Fujitsu exclusive is the ingenious elastic hook arm that prevents accidental disconnection at the receptacle. And our dual-beam contact assures positive contact even during vibration and excessive handling.

Concerned about cleaning? Fujitsu's superior PBT resin stands up to chemical agents such as Trickren and Chlorosen which can't be used on cheaper, conventional thermoplastics.

Fujitsu considers it a point of pride, as well as good business, to cater to your company's needs before, during and after the sale is made. Our warehouse is stocked to supply your company with samples of our fine products. And Fujitsu can match *any* source's lead time for processing and shipping ... at a competitive price.

The FCN-700 series offers vertical, right angle and wire wrap plugs *and* open or closed covers for both end-cable and through-cable applications.

Considering all these points, you'd be smart to come to the source with the best connections. Where quality, reliability and service are part of our product. Fujitsu.

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Circle 116 on reader service card

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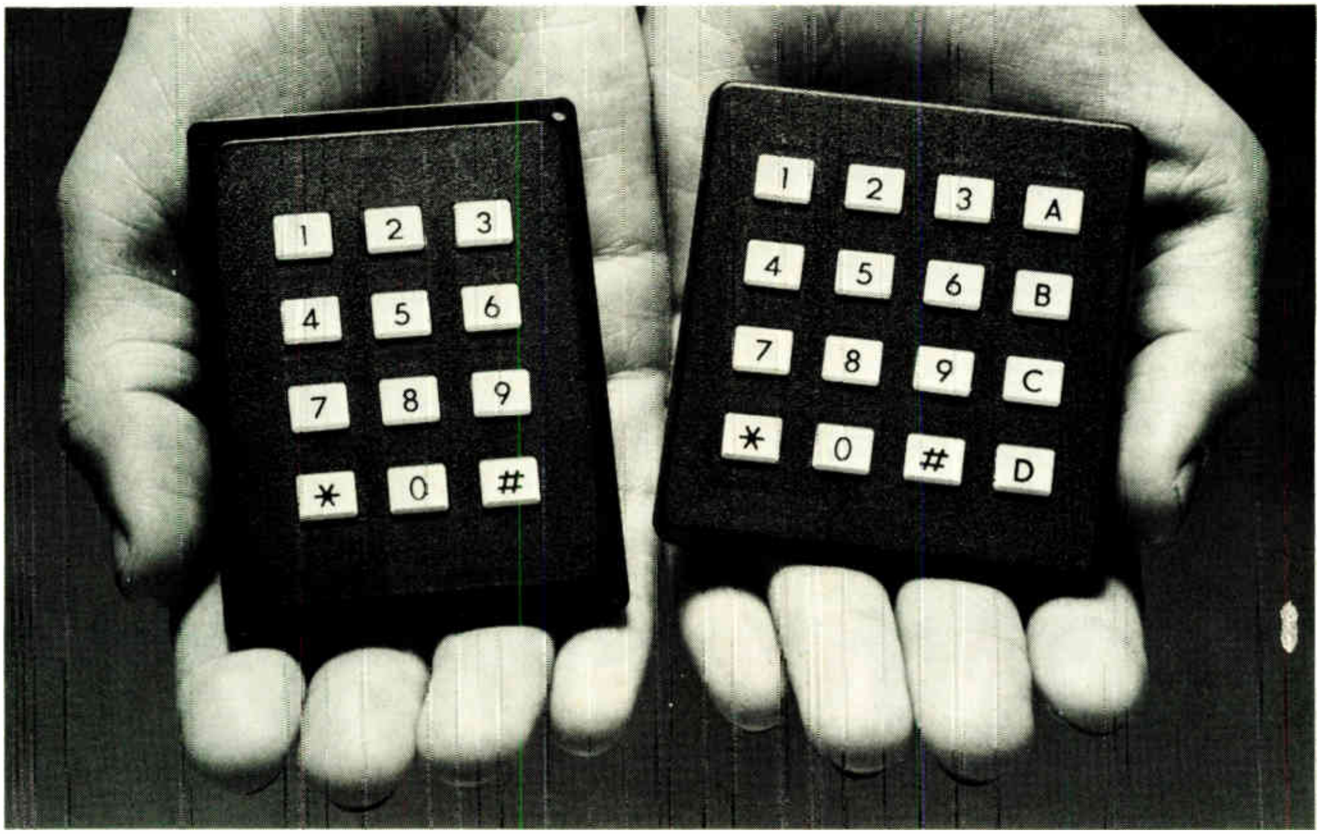

Our KL MINIKEY™ low profile keyboard gives you the stroke and tactile response of a full-size keyboard, in a clean, compact design.

Fast, positive contact closure and tactile feel are assured with our designed-in "over-center" mechanism—you won't find any artificially induced feel in a Minikey.

And our low profile is really low. Keytops extend only .070" (1.78 mm) above the face of the keyboard. Total keyboard depth, including keys, is less than .312" (7.92 mm). Great for space-saving! Great for appearance!

Minikeys are available with 12- or 16-key arrays, rear or front mounts, and a variety of output codes. They can interface with all digital logic circuitry, including TTL and CMOS, and can be used in dual-tone telephone systems.

Prices range from $5.10 to $6.50, in quantities of 100. For further information, send in this coupon or phone your nearest Digitran technical representative or distributor.

Marketing Services Dept.,
Digitran, 855 S. Arroyo Pkwy., Pasadena, CA 91105

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Norplex G-30 laminates and prepregs are premium grade high-temperature base materials using polyimide resin with glass fabric reinforcements.

Developed for use in high-performance printed wiring boards and multilayer circuitry, G-30 polyimide laminates make possible design concepts that cannot be attained with epoxy-base materials. Because of their stability during fabrication and higher operating temperatures, these Norplex laminates are especially suited for microelectronics and guidance systems, computer logics and communications equipment.

Norplex G-30 laminates and prepregs have been approved and listed as qualified products for the military specifications. MIL-P-13949E, MIL-P-55617B and MIL-G-55636B.

Other advantages of G-30 laminates and prepregs are their excellent X- and Y-axis dimensional stability, low Z-axis expansion, moisture resistance and outstanding electrical characteristics.

Technical information and assistance is available on these and other laminates from the Norplex Technical Service Department.

Norplex Division, UOP Inc., 1300 Norplex Drive, La Crosse, WI 54601. 608/784-6070. European Headquarters: Wipperfürth, West Germany. Pacific Headquarters: Kowloon, Hong Kong.

Norplex® laminates by UOP

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Circle 117 on reader service card

Products newsletter

Five development packages from Intel include workshop fee

A total of five development packages, each of which contains hardware, software, and user services, is being offered by Intel Corp., Santa Clara, Calif., to help users set up microcomputer development systems with a minimum of wasted effort. Two system packages are available: the DS002, based on the model 220 microcomputer development system, and the DS003, which is based on the model 230. **Included in both systems are Intel's Credit text editor, membership in the Insite user's library, and tuition for attendance at one of the company's microcomputer workshops.** To form the complete development package, the user adds one of three support packages to the system package, depending upon whether he intends to use an 8080, an 8085, or an 8086 microprocessor. (The combination of the DS002 system package and the 8086 support package is not offered.) Complete package prices range from $20,600 to $28,520.

100-MHz scope pushes and pulls for more popularity

While holding its price to that of the original 465 ($2,495), Tektronix Inc., Beaverton, Ore., will introduce an improved, B version at NCC of what could be the most popular 100-MHz scope of all time. Added to the unit are push-pull vertical-mode selection buttons that let the operator choose **channel 1, channel 2, differential mode, and A-trigger view in any combination,** giving him altogether a much clearer picture of the system under study. Other new features include simultaneous trigger view with zero delay, a minimum magnified sweep time of 2 ns, and light-emitting-diode function indicators.

Color terminal aids IC design

Claimed to be the first color graphics display to be offered in a commercial integrated-circuit design system, the MRD (for multicolor raster display) is a 20-inch unit that hooks directly up to the GDS II graphics design system from Calma Corp., Sunnyvale, Calif. Calma product marketing manager John Claiborne says that **the color display will reduce errors by making it easier for users to distinguish between IC layers.** The unit will sell for between $61,600 and $78,100, depending upon options, and has a delivery time of 120 to 160 days.

Calculator values keep rising

The trend toward cheaper yet more capable pocket calculators continues. The latest scientific unit from Texas Instruments Inc., Dallas, is a 54-function machine dubbed the Slimline TI-35. Among its more noteworthy features are a memory that retains data even when the power is turned off; the capability to do trigonometric functions in degrees, radians, and grads; keys for finding the mean and standard deviation for both sample and population data; and a factorial key. **The unit has a suggested retail price of $25.**

SSS cuts memory and microprocessor prices

Solid State Scientific Inc., Montgomeryville, Pa., has lowered the prices of its μMOS 1800 microprocessor and C-MOS memory product families an average of 15% for the plastic-packaged devices. The 100-piece price for the SC1802LE is now $7.35, and the SCP1852LE I/O port is now only $1.35. The company attributes the price reductions to yield improvements.

LAST YEAR, AN IMPRESSIVE 389 NEW OEMs JOINED DATA GENERAL.

HERE'S WHY.

1. Because we've got an aggressive new product introduction policy that produces goods, not excuses.

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5. Because we'll go right to their customer with them to help close a big sale.

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Data General Corporation, Westboro, MA 01581, (617) 366-8911. Data General (Canada) Ltd., Ontario, Canada. Data General Europe, 61 rue de Courcelles, Paris, France, 766.51.78. Data General Australia, (03) 89-0633. Data General Ltda., Costa Rica, Latin America 22-79-42. Data General Middle East, Athens, Greece 952-0557.

Tone Receivers, two ways from two sources.

Two tone receivers with versatile performance capabilities are available from two sources, ITT and Mitel.

Both offer the 88205 single package Hybrid DTMF Receiver System.

Or ITT's 3044 and 3045 DTMF group filters, along with additional limiter circuitry, can be used with Mitel's MT 8820 — or any other similar decoder chip — to design your own tone receiver.

You will find all of these components to be of high quality, and packaged with reliability to meet your most stringent demands. Specify them for your next central office, PABX, key system, mobile paging system or signaling application.

For more information, contact: ITT North Microsystems Division, 700 Hillsboro Plaza, Deerfield Beach, Florida 33441. Phone (305) 421-8450, TELEX & TWX: 510-953-7523.

ITT North

Microsystems Division

Circle 119 on reader service card

New products/materials

An organic flux solvent, Contour Number 50, is formulated for quick removal of all types of organic soldering flux. The aerosol solvent should be applied one hour after soldering to remove oil, dirt, or dust from the surface to be cleaned. The cleaner may be used on most surfaces, but can cause surface crazing on polycarbonate and styrene-based polymers. The nonflammable material is packaged in a 16-oz can and a free sample is available when requested on company letterhead.
Contour Chemical Co., Special Products Division, 70 Concord St., North Reading, Mass. 01864 [476]

An anhydride-hardened epoxy semiconductor encapsulant is intended for power transistors and other semiconductor devices that operate at elevated temperatures. Designated Plaskon 4001, the molding compound contains proprietary hardeners seldom found in anhydride systems that make it very moisture-resistant. As molded, the material has a dielectric constant of 4.04 and a dissipation factor of 0.009, both measured at 100 Hz. When exposed for 16 hours to 15-psig steam, the dielectric constant rises to 4.43 and the dissipation factor goes up to 0.022. After 72 hours, these figures become 5.10 and 0.088, respectively. Other specifications include a glass-transition temperature of greater than 200°C and a coefficient of thermal expansion of 35 ppm/°C.
Allied Chemical Corp., Specialty Chemicals Division, 2829 Glendale Ave., Toledo, Ohio 43614 [479]

A silver-epoxy adhesive is formulated for bonding and sealing applications at temperatures up to 190°C. Tra-duct 2924 is an electrically conductive material that is particularly useful for the repair of electronic modules, integrated circuits, and waveguides. The adhesive may be applied at room temperature, but should be cured at 90°C to ensure the bond's strength. Contained in a variety of Bipax packages, the material is available from stock.
Tra-Con Inc., 55 North St., Medford, Mass. 02155 [480]

Need receiver

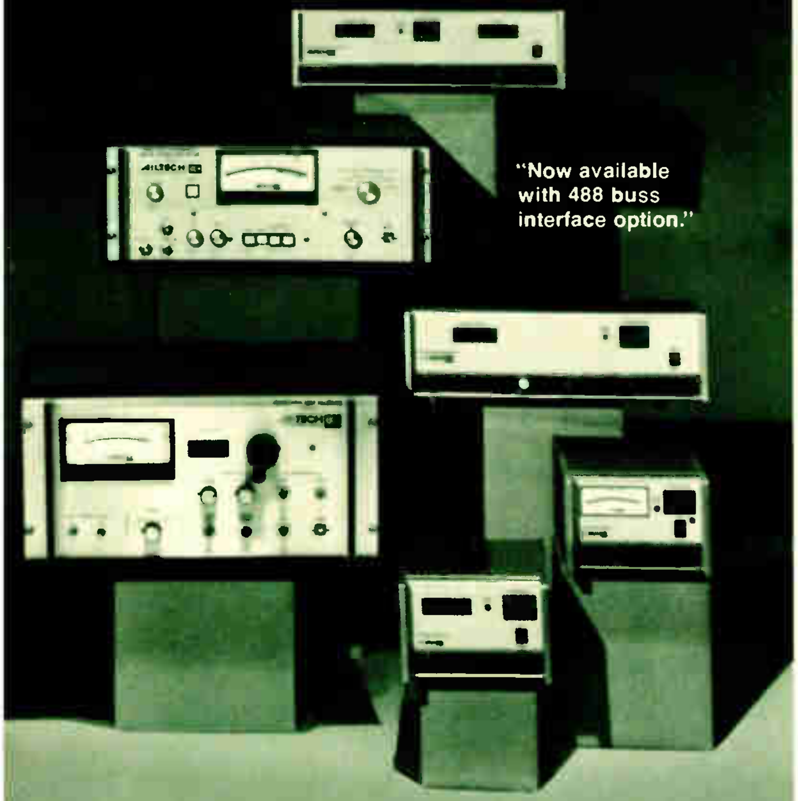
NOISE

measurements?

Ailtech has the box that can do it!

Ailtech's 75 Precision Automatic Noise Figure Indicator (PANFI) can **MEASURE** amplifier and receiver noise figure with accuracy (± 0.15 dB) and precision (0.05 dB resolution). To **MONITOR** repeated measurements, there's the 7300 System Noise Monitors. They're available in analog and digital configurations and are ideal for amplifier production tests ***including simultaneous gain measurements*** and on-line radar receiver noise monitoring. Ailtech can **GENERATE**, with a comprehensive line of broadband solid state and gas-discharge devices for laboratory or system requirements; and can **CALIBRATE** RF and microwaves noise sources with the Ailtech 82 Noise Calibration System.

Measure, Monitor, Generate, Calibrate — Ailtech knows the whole story. And we'd like to tell you that story. Write today, we'll send it to you.



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DIVISION CUTLER-HAMMER

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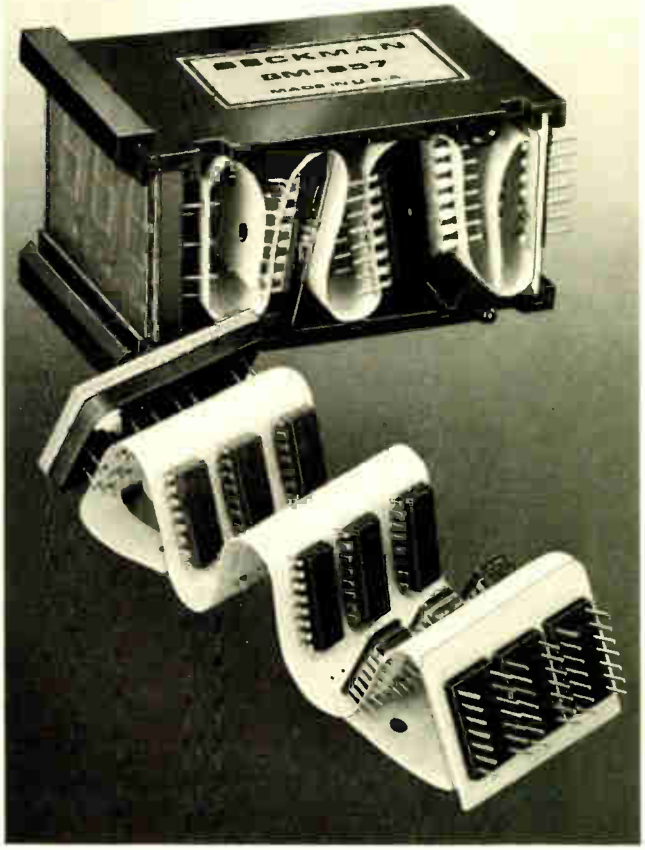
FRANCE • LA GARENNE-COLOMBES • TELEPHONE 7807373
UNITED KINGDOM • CROWTHORNE • TELEPHONE 5777
GERMANY • MUNICH • TELEPHONE (089) 5233023
HOLLAND • AMSTERDAM • TELEPHONE 31-2977-29376

MEMBER OF CUTLER-HAMMER INSTRUMENTS & SYSTEMS GROUP

Circle 122 on reader service card

FLEX CIRCUITS MEAN SECURITY



Add security to your design and do several jobs at once with R/flex circuits.

Heightened reliability and lowered costs are assured by elimination of multiple circuit boards and jumpers.

Labor savings, too, with components mounted directly on the circuit—manually or automatically inserted. Stiffeners can be added where needed.

R/flex circuits can be made in one or more layers in a variety of shapes and sizes, with or without plated-through holes.

ROGERS

Rogers Corporation
Chandler, Arizona 85224
(602) 963-4584

EUROPE Mektron NV, Gent, Belgium JAPAN Nippon Mektron, Tokyo

For Information Only 123
For Immediate Need 124

A lot of complex thinking goes into the Teletype* model 40 printer. And, incredibly, it all fits on this 9″ by 19″ circuit card.

More brains; less brawn.

That's the advantage of an electronic printer like our 300 LPM model 40 series. The LSI (Large Scale Integration) circuitry tucked underneath the printer can perform functions with greater reliability than mechanical hardware.

And it can perform them in a fraction of the time with a fraction of the parts. Plus, fewer moving parts means less maintenance and increased printer life.

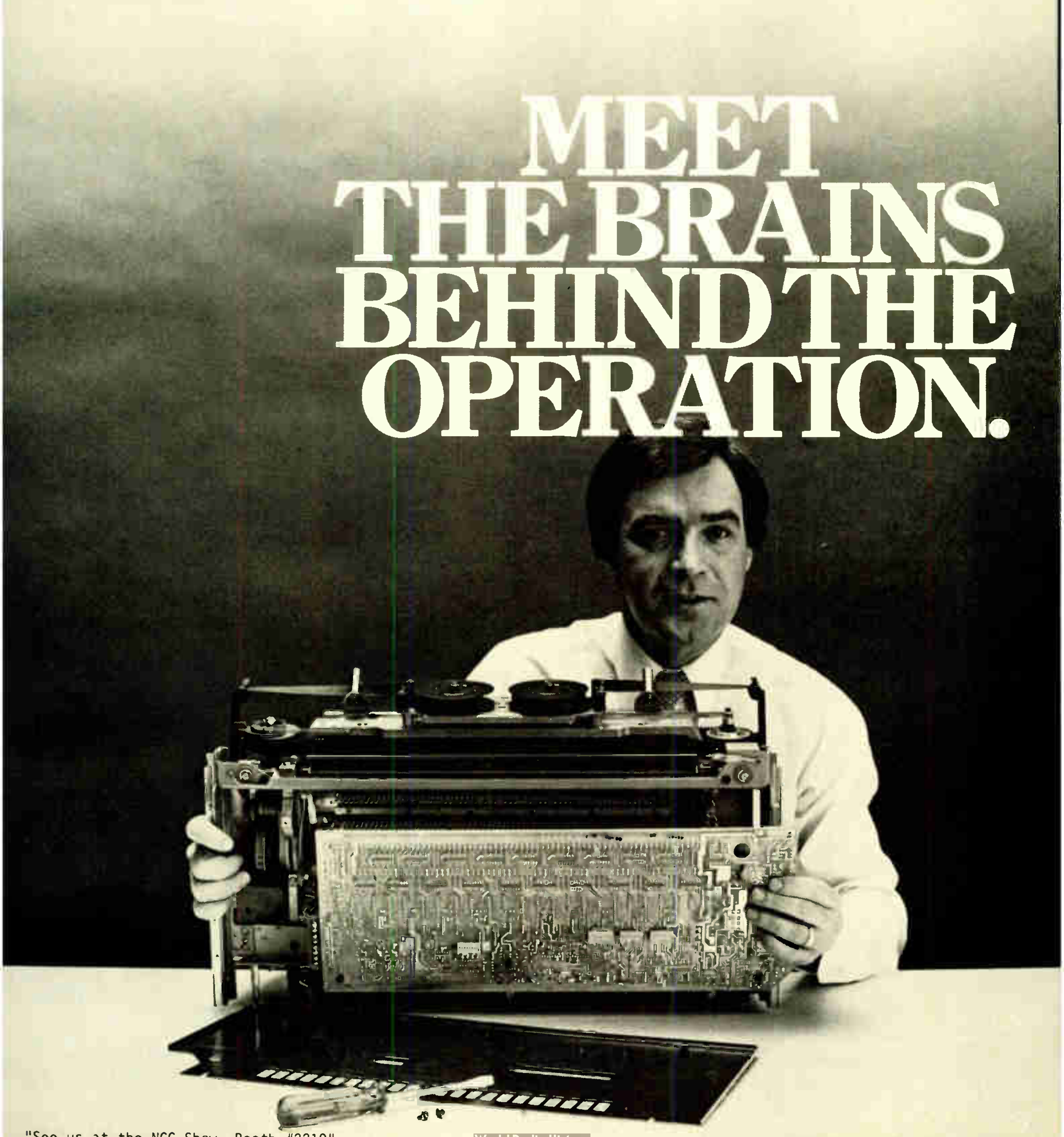
All you have to do is plug it in.

Just attach the AC power and a serial signal source and your model 40 is ready to go to work. There are 32 switch-selectable options and self-diagnostics available at no additional cost. Housed in an attractive cabinet, if you need one. And our technical assistance is never extra.

So for not much money, the brains behind our operation can become the brains behind yours.

Teletype Corporation
5555 Touhy Avenue, Dept. 3185, Skokie, IL 60076.
Telephone (312) 982-2000.

Circle 125 on reader service card



"See us at the NCC Show, Booth #2219"

*Teletype is a trademark

LEADER OF THE PACK!

With a Data I/O System 19, you'll always be "top dog."

It's impossible to stay on top of every new development in IC technology—frightening too—especially when it's time to buy a PROM programmer.

Today, there's a lot more in the world to program than PROMs. The programmable logic devices you're specifying today could be dumped next year in favor of a brand new device that can do four times as much and cut the "real estate" in half.

Smart engineers, who want to stay in front of the pack, buy the programmer that won't leave them behind—the Data I/O System 19.

With a System 19 you can program a bipolar PROM, MOS EPROM, FPLA, FPLS, FPGA, PAL, PMUX, programmable port, diode matrix or μP/EPROM. And that's just the beginning of what this remarkable system can do to keep you on top.

Best of all, Data I/O's System 19 is priced within just about everyone's budget.

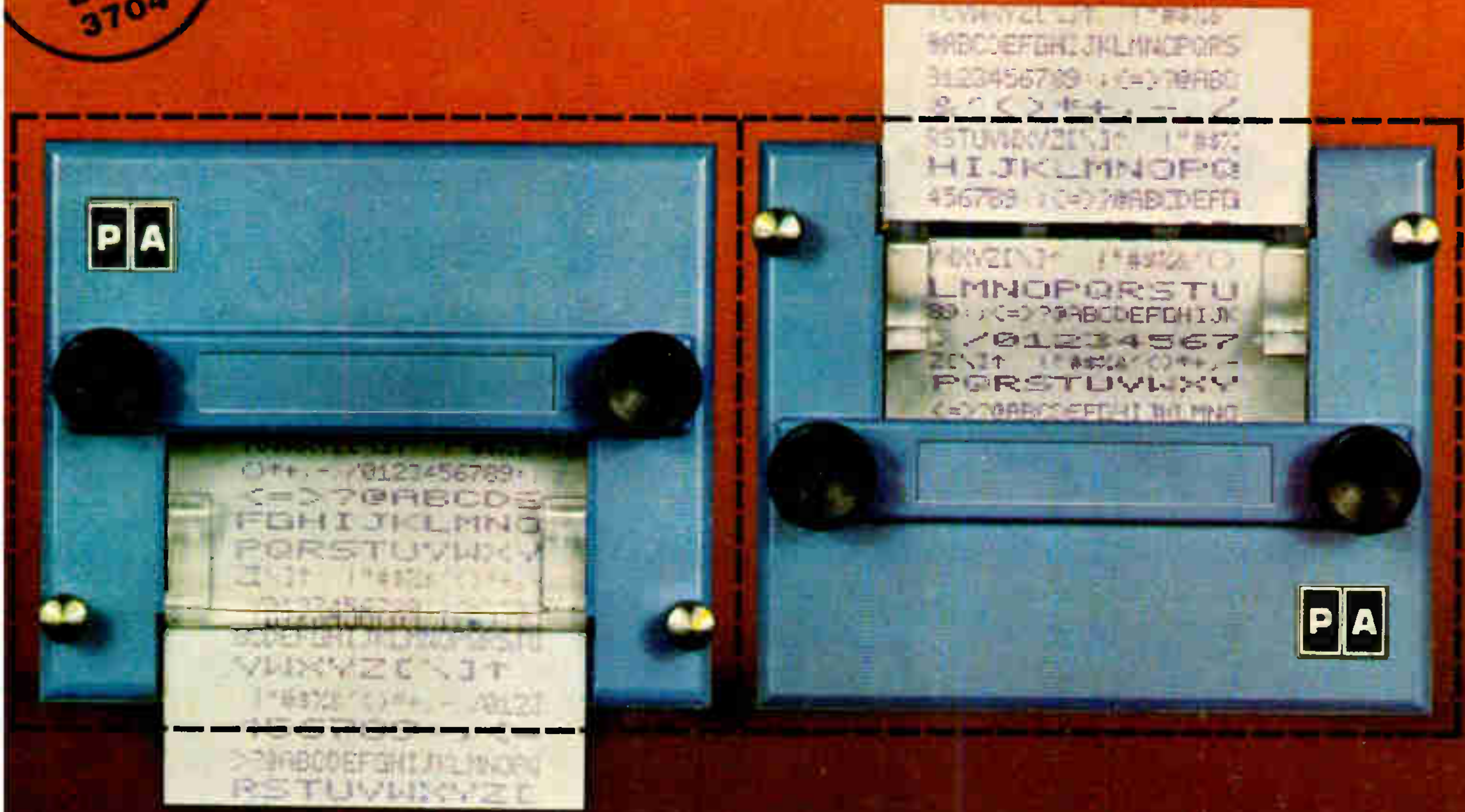
You haven't shopped around until you've looked at Data I/O. Let us show you the difference. Circle reader service number or contact Data I/O, P.O. Box 308, Issaquah, WA 98027. ***For answers fast, call toll free: 800-426-9016.***

Good idea! DATA I/O

Programming systems for tomorrow...today

Our 20 column alphanumeric text/data printer fits a 3-inch space.

See Us At The NCC Show Booth 3704



Cut them out and try them on for size.

Tired of paying for expensive stand-alone printers? Tight on panel space? Then consider dedicating only 3x3½ inches of panel space and building in our super-mini OEM impact printer.

Check the application advantages. Versatility, for example. You can use our 120 cps, 20-column alphanumeric mini alone, or in configurations teamed with its own microprocessor interface and power supply. Feed it either parallel or serial ASCII input, at speeds up to 1200 bps. Use its full alphanumerics and enhanced characters (from 8 to 14 characters per inch) to flag emergencies.

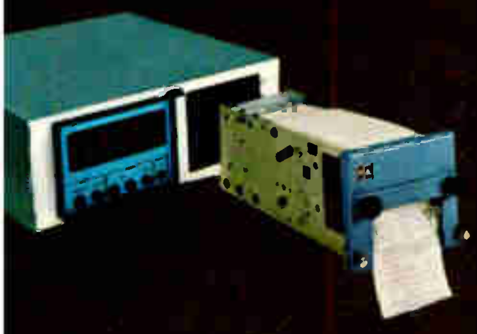
Even make it stand on its head to give you "first line up" text print format, as well as "first line down" data printing.

And all the while, economize by using ordinary adding machine roll paper.

Whether your application is in POS or telemetry, inventory control or blood analysis, you won't get all that from any stand-alone printer. And, you won't match the way our DMTP-3 purrs along using a unique print head and 5x7 dot matrix instead of a conventional (and limited) drum.

Now add in the advantages of a replaceable 75,000-line life ink cartridge that eliminates messy ribbons, and you can see for yourself how the DMTP-3 makes dedication pay.

The final proof: these prices in quantities of 100's: printer $154, controller $130, power supply $88. Delivery from stock. Buy just the printer or buy the complete system. For more details, call or write today.

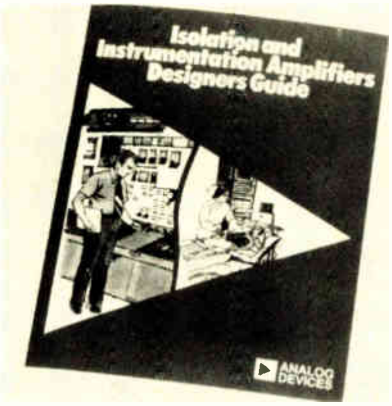


PRACTICAL AUTOMATION, INC.
Trap Falls Road
Shelton, Conn. 06484
Tel: (203) 929-5381

Circle 126 on reader service card

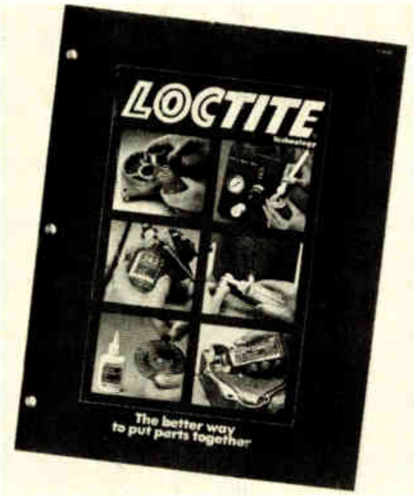
New literature

Amplifiers. To enhance the knowledge of engineers who use isolation and instrumentation amplifiers, this 20-page guide goes into the theory of these devices and explains how they can be applied to industrial control,



instrumentation, and biomedical designs. Analog Devices Inc., Route 1 Industrial Park, P. O. Box 280, Norwood, Mass. 02062. Circle reader service number 421.

Adhesives. "Loctite Technology: The Better Way to Put Parts Together" contains data on more than 60 thread sealants, instant adhesives, primers, O-ring splicing kits, safety solvents, and application devices. The 48-page manual covers specification and application of these mate-



rials for manufacturing and maintenance. It is available for $2 from Loctite Corp., North Mountain Road, Newington, Conn. 06111.

Z80 system design. The Zilog data book is for design engineers who intend to use Z80 products in personal microcomputer systems. The 132-page volume has sections on the Z80 family of metal-oxide-semiconductor large-scale integrated microcomputers and memories, the MCB series of microcomputer board products, and the ZDS-1 development system series. Send $5 to Zilog Literature Department, 10340 Bubb Rd., Cupertino, Calif. 95014.

Analog panels. A 40-page catalog on analog panel instruments covers 18 instrument categories, accessories, and special instrument features and options. Complete specifications and

detailed dimensional information are listed. LFE Corp., Process Control Division, 1601 Trapelo Rd., Waltham, Mass. 02154 [424]

Glossary. The "Glossary of Programmable Controller Terms" will acquaint users of programmable

THE DSD 440. TOTAL DEC® RX02 COMPATIBILITY,

AND MORE.

The DSD 440 is the only alternative to the DEC RX02 that's 100% software, hardware and media compatible with LSI-11, PDP®-11 and PDP-8 computers, including those with extended memory. It can be configured as an RX02 for DEC double density or IBM 3740 single density recording, or as an RX01 for backward operating system compatibility.

MORE

A 512-byte hardware bootstrap is built into all PDP-11 and LSI-11 interfaces. It loads system software automatically from either single or double density diskettes. Extensive self-testing is DIP-switch selectable with the "Hyperdiagnostics" that run without being connected to a computer. The low profile 5¼-inch DSD 440 features write protection and diskette formatting.

FASTER

The optimized DSD 440 microcode increases system throughput when using the RT-11 foreground/background monitor. In particular, the DSD 440 with an LSI-11 runs fill and empty buffer operations 20% faster than an RX02.

FOR LESS

The DSD 440 is the RX02 compatible flexible disk system that combines high performance and advanced features with fast delivery... at a lower price. For further information, call or write Data Systems Design today. A data sheet and price list will be forwarded to you immediately.

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Circle 128 on reader service card

New literature

controllers with some common definitions of aspects of the operation and maintenance of programmable controllers. This glossary fits neatly into a pocket, making it a handy reference, though of course it is not definitive. Ask for publication SD60, from Marketing Services, Allen-Bradley Co., Systems Division, 747 Alpha Dr., Highland Heights, Ohio 44143 [425]

Asian electronics. "The Asian Electrical/Electronics Trade Directory 1979/80" lists 3,700 electrical and electronics companies located in the area around Japan. This 632-page directory presents information about countries previously uncataloged, including Thailand, the Philippines, and Indonesia. In addition, details are provided for Hong Kong, Taiwan, Singapore, Malaysia, and Korea. The companies are grouped by the type of product they supply, import, distribute, or service. The directory sells for about $150 and is available from Mackintosh Publications Ltd., Mackintosh House, Napier Road, Luton, Beds., LU1 1RD England.

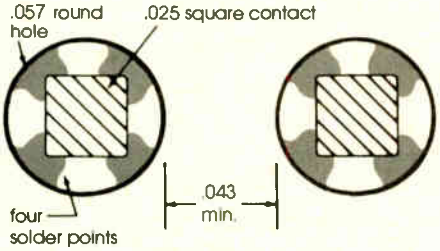
Inductor design. "Inductor Design in Switching Regulators" briefly describes the overall operation of switching regulators and primarily discusses Molypermalloy powder and ferrite—two core materials used for the inductor in a switching regulator. The catalog gives step-by-step procedures for core selection to simplify inductor design. A dc bias core selector chart and a ferrite dc bias core selector chart are also given. [430]

Measuring electrostatic voltage. An 11-page catalog, "Instruments to Measure Electrostatic Voltage and Field," is an informative guide to an Isoprobe line and other instruments for measuring electrostatic voltage and field. The catalog provides the features, applications, and specifications for each of the instruments. A complete price list is included. Monroe Electronics Inc., 100 Housel Ave., Lyndonville, N. Y. 14098 [431]

No more square tails in round holes.

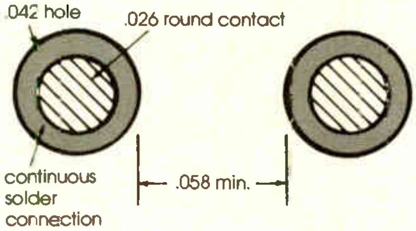
Introducing the wave solder PC connector.

What an electronic design engineer will make-do with in a pinch is astonishing. For example – converting wire wrap* PC connectors to wave solder.



How it's done: you saw off the square .025" tail and push it through a .057" round hole in the PC board. You get only 4 contact points for solder. And there's room for only one tracing between holes. But, so what... it works.

At last – The obvious answer



Our own design engineers, not afraid of doing the obvious and simple thing, have done just that. They've taken a series of our PC wire wrap connectors – and given them .026" round tails. Everything else stays the same: the insulator, semi-bellows contacts, pin and row spacing.

So what?

So – the .026" round pin slips into a .042" round hole in your PC board for an excellent solder connection. So – you can now get multiple tracings between rows.

We have two tail lengths: a .200" short one and a .250" longer one to take the AS400 Solderpak** System. These are available in connectors with contacts on .100", .125" and .156" centers, and in layouts from 6 to 50 positions.

Use our coupon and we'll send you all the details.

There's more. There are some things we haven't told you – including materials and other details you need to know. Ask us for the literature.

NAME ____________________

TITLE ____________ TELEPHONE ____________ EXT. ______

COMPANY ____________________

ADDRESS ____________________

CITY ____________ STATE ____________ ZIP ______

Viking CONNECTORS

/21001 Nordhoff Street, Chatsworth/CA 91311 U.S.A.
(213) 341-4330/TWX: 910-494-2094

*A registered trademark of the Gardner-Denver Company. **A registered trademark of the Raychem Corporation.

Circle 130 on reader service card

PTK lights CRT's

HIGH VOLTAGE FOR CRT APPLICATIONS

COMMERCIAL
2 to 30kV, 3 to 30 watts, high voltage power supplies. Custom flyback transformers.

MILITARY
Mil grade units for ground, ship and aircraft.

L.V. / H. V. COMBO'S
High voltage power supplies combined with a multiple output low voltage switcher.

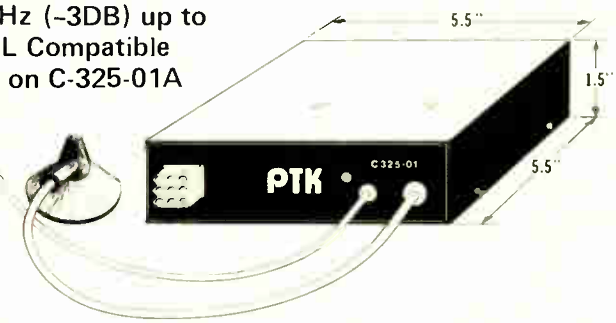
SPECIALS
Miniature and sub-miniature high voltage power supplies to 20kV. Ultra stable or ultra low ripple designs.

Send for Data Package on standard product lines, or call Factory for technical assistance.

C-325 Series

MAJOR FEATURES:

The C-325 Provides All Voltages (except heater) for High Resolution Shadow Mask Color CRT's ● Anode is 20 - 25KV @ 1.2ma ● Focus is 4.75 - 6.25KV @ ±15μA ● G2 is 75 - 750V @ ±5μA ● G1 is -200V @ 500μA ● Provision for Capacitively Coupled Dynamic Focus Voltages 300Hz to 250KHz (-3DB) up to 1KV Peak to Peak ● TTL Compatible On/Off Control ● Input on C-325-01A is 38V ±2V ● Operating Temperature is 0 - 70°C Case ● Input, Output and Mechanical Options Available ●



3 YEAR WARRANTY

PTK Corporation 1173 Los Olivos Avenue, Los Osos, CA 93402 (805) 528-5858

Circle 132 on reader service card

The biggest problem with your IEEE bus...

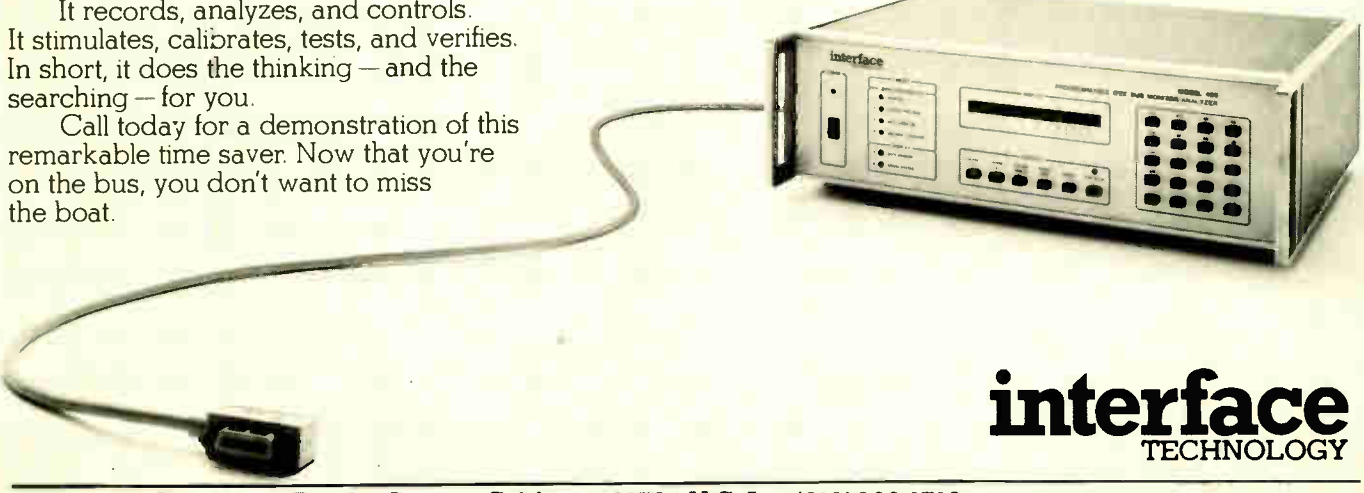
So your new equipment conforms to IEEE standards. Great. But your system doesn't work. Not so great. Either your interface or your software isn't compatible. But which one?

Look no further. This is Model 488. The IEEE Bus Monitor/Analyzer from Interface Technology.

It records, analyzes, and controls. It stimulates, calibrates, tests, and verifies. In short, it does the thinking — and the searching — for you.

Call today for a demonstration of this remarkable time saver. Now that you're on the bus, you don't want to miss the boat.

...is finding why your bus has a problem.



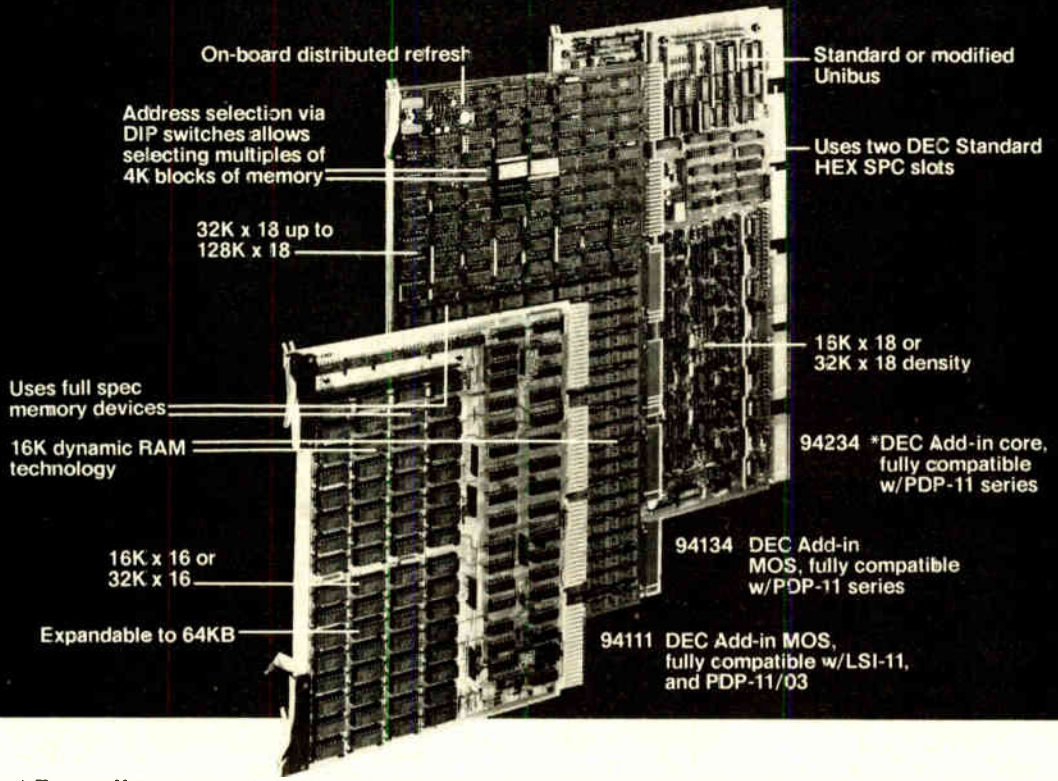
interface TECHNOLOGY

852 North Cummings Road • Covina, California 91724 U.S.A. • (213) 966-1718

France MB Electronique • **Switzerland/Spain** Instrumatic AG • **W. Germany** Kontron Electronik GmbH • **UK** Wavetek Electronics Ltd. • **Japan** Tokyo Electronics Trading Co., Ltd.

Circle 133 on reader service card

Add-on quality, Add-in quality with OEM memory from Control Data.



Control Data offers a complete line of semiconductor and core memory that's fully compatible with today's processors. Enclosures, too. And all are built with the same concern for quality that goes into every product we manufacture.

You see, Control Data believes in improving upon basic design when we make memory for mini-computer processors. All chips in our semiconductor memory are "full-goods." So you get all the quality and density you pay for. We use IC sockets instead of hardwiring our chips, so servicing is easier.

When your *PDP-11 needs more memory...

Add-in our 94234 Core Memory Module. It's fully compatible, of course, but you also get the inherent reliability and non-volatility of core memory technology.

94270

Our *Add-on* core is fully compatible too, and fits into your PDP-11/70 rack. It gives you up to 512 Kbytes in a 10½ inch enclosure housing two power supplies, one back plane, one controller circuit board, two to eight memory modules (in pairs), four interconnect cables and four terminator circuit boards.

And when you need better semiconductor memory...

Our 94134 MOS RAM module is fully compatible with your PDP-11/34 and uses either the standard or the modified unibus connector. Maximum configuration is 128K x 18, but smaller densities are also available. Refresh is automatic.

Our 94111 MOS RAM has block address selection via switches for the standard configuration of 16K or 32K x 16. It is pin-to-pin, voltage, signal, hardware and software compatible with *LSI-11 and PDP-11/03 systems.

Put quality behind your nameplate. Call us at 612/830-6018 or send us the coupon below.

*DEC LSI and PDP are registered trademarks of Digital Equipment Corporation.

Jack Middlestaedt, Product Sales Manager
Control Data Corporation, Computer Memory Division
8001 East Bloomington Freeway, Bloomington, MN 55420

Please tell me more about memory for my ________ processor.

Name ________ Phone ________

Company ________ Title ________

Address ________

City ________ State ________ Zip ________

CONTROL DATA CORPORATION

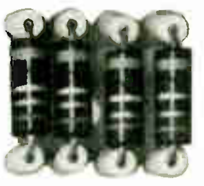
More than a computer company

Circle 134 on reader service card

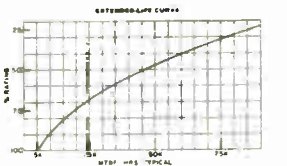
1
Thermally engineered—ventilation holes

2
Sheet Metal: 0.125in Aluminum
Finish: Grey, Fed. Std. 595 No. 26081

3
Sprague electrolytic capacitors



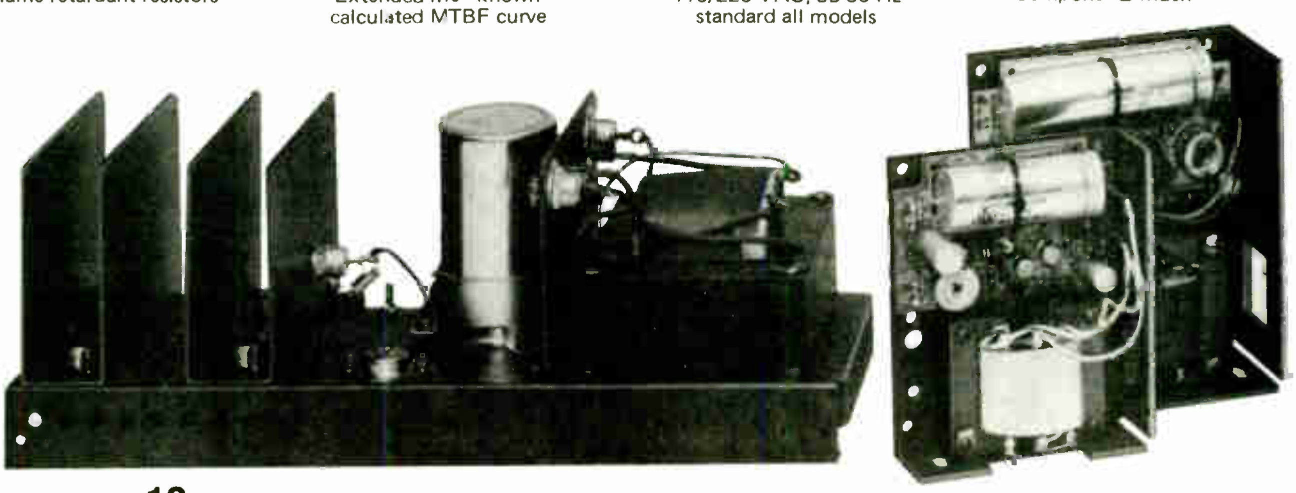
8
Flame retardant resistors



9
Extended life—known calculated MTBF curve

10
110/220 VAC, 50-60 Hz standard all models

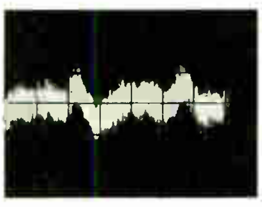
11
Listed in Underwriter's Laboratories Recognized Components Index



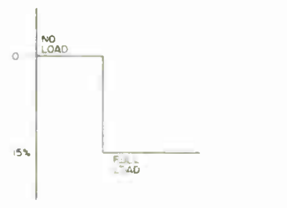
12
56 models, 6 power packages, single dual and triple outputs

0.03%

16
Temperature Coefficient ...0.03%°C



17
Ripple ... 1.5 mV RMS



18
Regulation
Load 0.15% for 100% load change
Line 0.15% for 105 to 125 VAC

19
Convection cooled—3 mounting positions, no external heat sinks or forced air cooling required

24 reasons why you shou
power supplies from La

6 Amp Monolithic OV Protectors
$5.00 Qty 1 $3.40 Qty 1000

TO-3 PACKAGE, NO EXTERNAL COMPONENTS NEEDED

LAMBDA OVERVOLTAGE PROTECTORS
L-6-OV, L-12-OV, L-20-OV, L-35-OV Series

General Description

The Lambda overvoltage protector prevents damage to the load caused by excessive power supply output voltage due to improper adjustment, improper connection, or failure of the power supply. Load protection is accomplished automatically by effectively short circuiting the output terminals of the power supply when a preset limit voltage has been exceeded. The trip-point limit voltage cannot be adjusted. To reset overvoltage protector, remove AC input to power supply allow overvoltage protector to cool, and reapply power.

Overvoltage Protector Absolute Maximum Ratings

PARAMETER	SYMBOL	L-6-OV SERIES MIN	L-6-OV SERIES MAX	L-12-OV SERIES MIN	L-12-OV SERIES MAX	L-20-OV SERIES MIN	L-20-OV SERIES MAX	L-35-OV SERIES MIN	L-35-OV SERIES MAX
On State Current	I_{DC}	–	6A	–	12A	–	20A	–	35A
On State Voltage	V_{DC}	–	2.6V	–	1.3V	–	1.4V	–	1.6V
Non-Repetitive Peak Surge Current*	I_p	–	70A	–	200A	–	260A	–	350A
Standby Current	I_S	–	25mA	–	5mA	–	5mA	–	5mA
Operating Temperature (Blocking)**	T_{CB}	-40°C	+100°C	-40°C	+100°C	-40°C	+100°C	-40°C	+100°C
Operating Temperature (Conducting)***	T_{CC}	-40°C	+150°C	-40°C	+140°C	-40°C	+140°C	-40°C	+140°C
Storage Temperature	T_S	-40°C	+150°C	-40°C	+125°C	-40°C	+125°C	-40°C	+125°C
Power Dissipation @ 25°C Derate	P_D	150 Watts @ 1.5°C/W above 50°C							
Thermal Resistance	$R_{\theta JC}$		1.0°C/W						

*For sinusoidal current duration of 8.3 milliseconds max.

**Case temperature for overvoltage protector in non-conducting or "OFF" state.

***Case temperature for overvoltage protector in conducting or "ON" state. Power must be removed and case temperature allowed to drop to 71°C before application of output voltage.

The overvoltage protector must be mounted on external heat sink to maintain case temperature below rated limit. When the overvoltage protector is used with a Lambda power supply, the power supply chassis acts as the heat sink. The L-L-12-OV, L-20-OV, L-35-OV, overvoltage protector is supplied with mating connectors for pins on overvoltage protector (+V and -V engraved on unit).

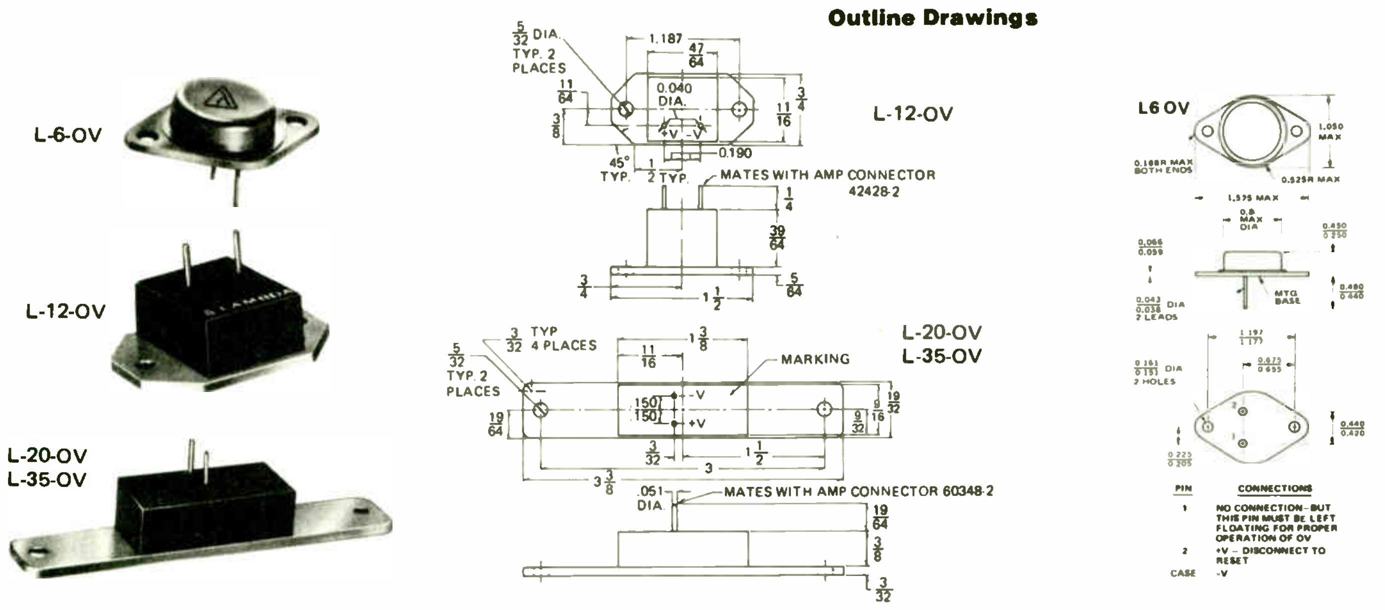
OVERVOLTAGE PROTECTORS

NOM SUPPLY VOLTAGE (VOLTS)	TRIP POINT VOLTAGE[A] (VOLTS)	6 AMP MODELS	QTY 1	PRICE QTY 100	QTY 250	QTY 1000	12 AMP MODELS	QTY 1	PRICE QTY 100	QTY 250	QTY 1000	20 AMP MODELS	QTY 1	PRICE QTY 100	QTY 250	QTY 1000	35 AMP MODELS	QTY 1	PRICE QTY 100	QTY 250	QTY 1000
5	6.5 ± .2 (6.6 ± .2)[B]	L-6-OV-5	$5	$4	$3.75	$3.40	L-12-OV-5	$11	$8	$7.50	$6.80	L-20-OV-5	$16	$11.20	$10.50	$9.50	L-35-OV-5	$20	$14.40	$13.60	$12.30
6	7.4 ± .2 (7.3 ± .2)[B]	L-6-OV-6	5	4	3.75	3.40	L-12-OV-6	11	8	7.50	6.80	L-20-OV-6	16	11.20	10.50	9.50	L-35-OV-6	20	14.40	13.60	12.30
9	10.5 ± .5 (10.5 ± .4)[B]	L-6-OV-9	5	4	3.75	3.40	L-12-OV-9	11	8	7.50	6.80										
10	13.8 ± .5 (11.0 ± 0.5)[B]	L-6-OV-10	5	4	3.75	3.40															
12	13.7 ± .4 (13.7 ± .4)[B]	L-6-OV-12	5	4	3.75	3.40	L-12-OV-12	11	8	7.50	6.80	L-20-OV-12	16	11.20	10.50	9.50	L-35-OV-12	20	14.40	13.60	12.30
15	17.0 ± .5	L-6-OV-15	5	4	3.75	3.40	L-12-OV-15	11	8	7.50	6.80	L-20-OV-15	16	11.20	10.50	9.50					
18	20.5±1.0	L-6-OV-18	5	4	3.75	3.40															
20	22.8 ± .7	L-6-OV-20	5	4	3.75	3.40	L-12-OV-20	11	8	7.50	6.80	L-20-OV-20	16	11.20	10.50	9.50					
24	27.3 ± .8	L-6-OV-24	5	4	3.75	3.40	L-12-OV-24	11	8	7.50	6.80	L-20-OV-24	16	11.20	10.50	9.50					
28	31.9 ± 1.0	L-6-OV-28	5	4	3.75	3.40	L-12-OV-28	11	8	7.50	6.80	L-20-OV-28	16	11.20	10.50	9.50					
30	33.5 ± 1.0						L-12-OV-30	11	8	7.50	6.80	L-20-OV-30	16	11.20	10.50	9.50					

[A] VOLTAGE TOLERANCE MAINTAINED OVER 0-71°C DUE TO POWER DESIGN

[B] FOR L-6-OV ONLY

Outline Drawings



SPECIFICATIONS

Regulated voltage

regulation, line . . . 0.15% for 105 to 125 VAC
regulation, load . . . 0.15% for 100% load change
ripple and noise . . . 1.5mV RMS, 5mV pk-pk with either positive or negative terminal grounded
remote programming resistance . . . . . . 200 ohm/volt
temperature coefficient . . . . . 0.03%/°C

AC input

line . . . . 105-125 VAC/210-250 VAC, 47-440Hz (derate 10% at 50 Hz). Consult factory for operation at frequencies other than 47 to 63 Hz.

Efficiency

minimum. . . . . . . .25% for 5V, 6V models. 35% for 12V, 15V and triple output models. 48% for 20V, 24V, 28V and dual output models

Overshoot

no overshoot on turn-on, turn-off or power failure.

Ambient operating range

continuous duty from 0° to 60°C

Storage temperature range

–55°C to +85°c

Controls

simple screwdriver output voltage adjustment over voltage range.

Remote sensing

provision is made for remote sensing to eliminate effects of power output lead resistance on DC regulation. Connected for local sensing at factory.

Overload protection

external overload protection; automatic electronic current limiting circuit limits the current to a preset value

Tracking Accuracy

(Dual and Triple Output Models Only) 2% absolute voltage difference, 0.2% change for all conditions of line, load, and temperature.

Mounting

three mounting surfaces on packages Z, Y, X, W; two mounting surfaces on packages V & R; three mounting positions (all models).

Finish

Gray, Fed. Std. 595 No. 26081

Physical Data

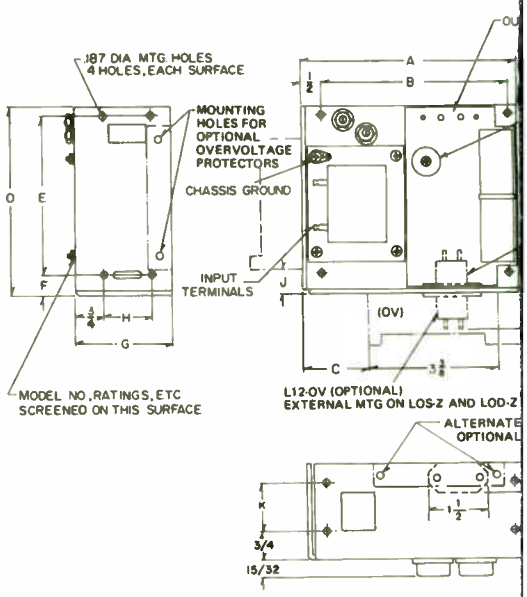
PACKAGE MODEL	WEIGHT LBS. NET	WEIGHT LBS. SHIP	SIZE (INCHES)
LO-Z	2	2-1/4	4-7/8 x 4 x 1-5/8
LO-Y	4	4-1/4	5-5/8 x 4-7/8 x 2-1/2
LO-X	6-1/2	7	7 x 4-7/8 x 2-3/4
LO-W	7-3/4	8-1/4	9 x 4-7/8 x 2-3/4
LO-V	10-1/4	11-3/4	4-7/8 x 13-3/4 x 4-7/8
LO-R	14-3/4	16-1/4	4-7/8 x 16-3/4 x 4-7/8

Guaranteed for 90 days

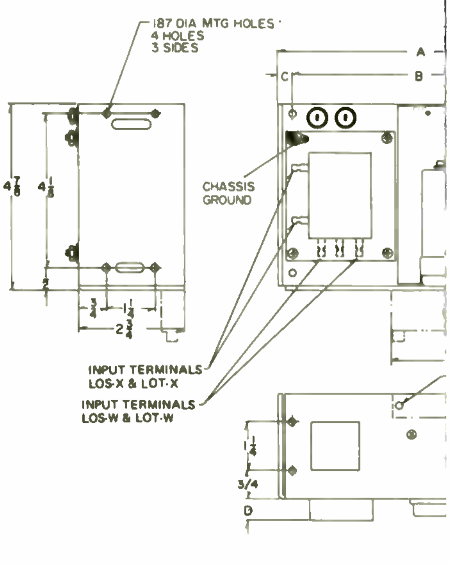
90 day guarantee includes labor as well as parts. Guarantee applies to operation at full published specification at end of 90 days.

DIMENSIONAL DRAWIN

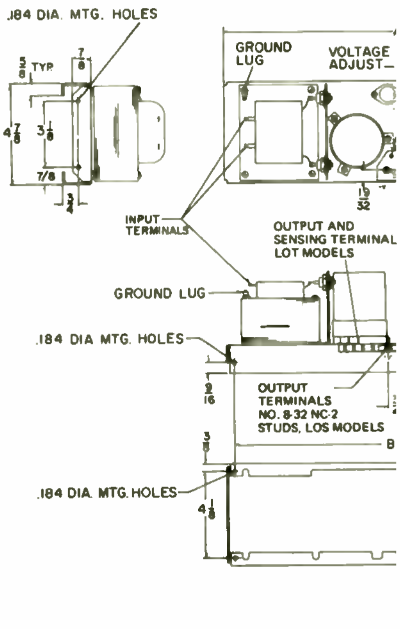
LO-Z an



LO-X and



LO-V and



Why Lambda is the world's largest manufacturer of low-cost, open-frame power supplies.

QUALITY

Only the Lambda LO series gives you all these high quality features.

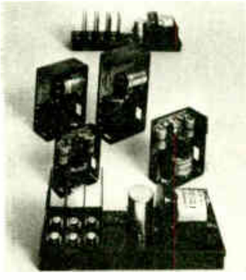
- All hermetically sealed semiconductors.
- Balanced thermal design with a known, defined level of quality.
- Sprague electrolytic capacitors.
- Quality controlled through Lambda manufacture of all its own sheet metal, transformers and P.C. boards.
- Purchased components rigidly specified by Lambda.
- Plated through hole printed circuit board.
- Flame retardant resistors.
- Teflon wiring in hi-temp location.

You'll get fewer failures with Lambda LO series power supplies. And the cost of failures is more important than the costs of repairing low-cost power supplies.

Costs to repair	Your Estimate	Lambda Estimate
Packing for shipment	—	$10
Cutting No Charge Purchase Order	—	25
Freight Charges (2 ways)	—	15
Receiving, incoming test and inspection	—	25
Total to implement guaranteed repair		75
To get cost of failure add:		
Field Service Call	—	200
Cost of down time (actual and product reputation)	—	?
		275+
3 failures will cost you		825+
15 failures will cost you		4125+

If you spend as much as $10 each for on-site repair of 15 failed low-cost power supplies, you will save $970 on the cost of implementing the guarantees.

The lowest cost power supplies are those with the fewest failures regardless of guarantees and initial price ..... Lambda quality means LO series power supplies have fewer failures than any other low-cost, open-frame power supplies



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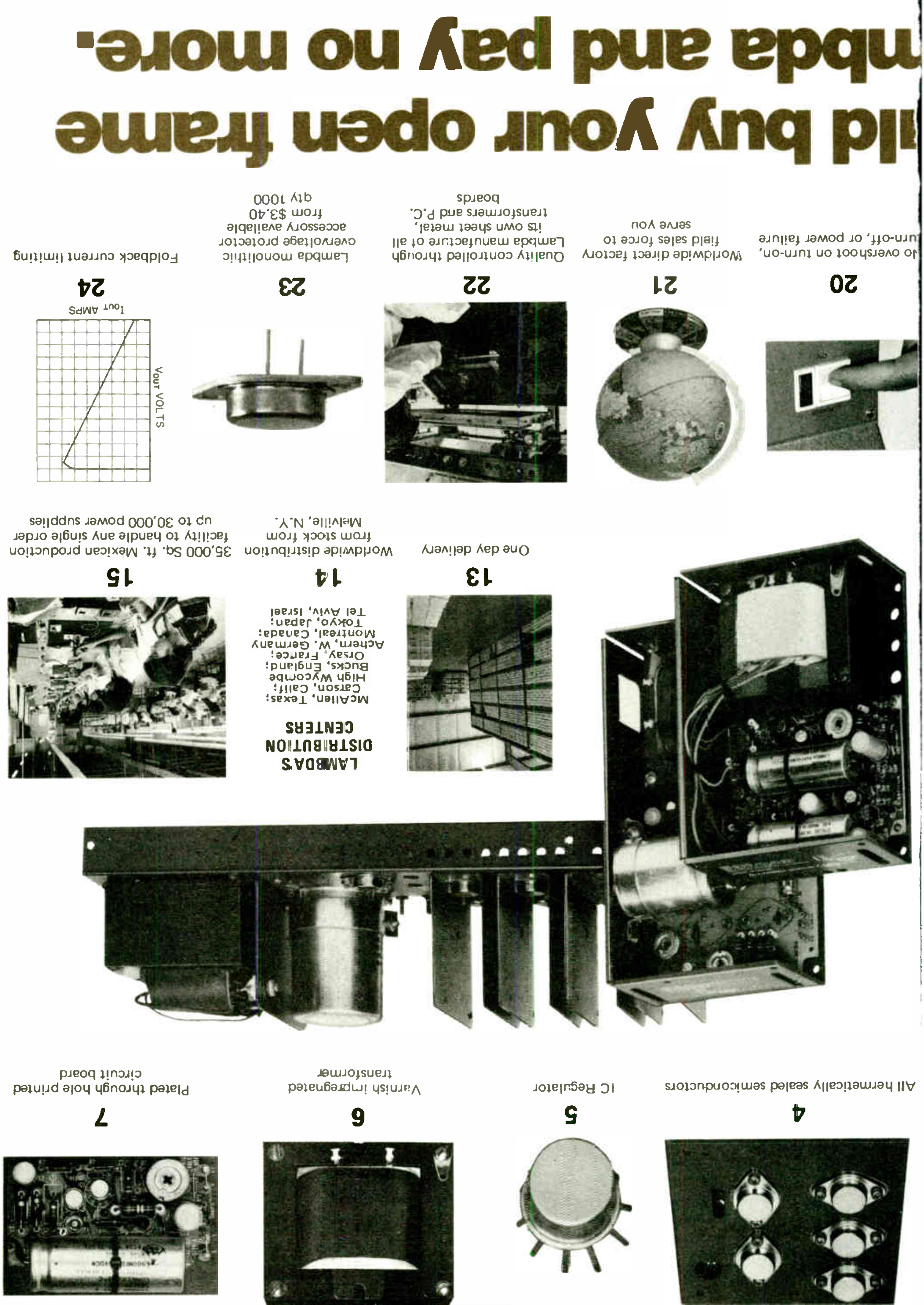


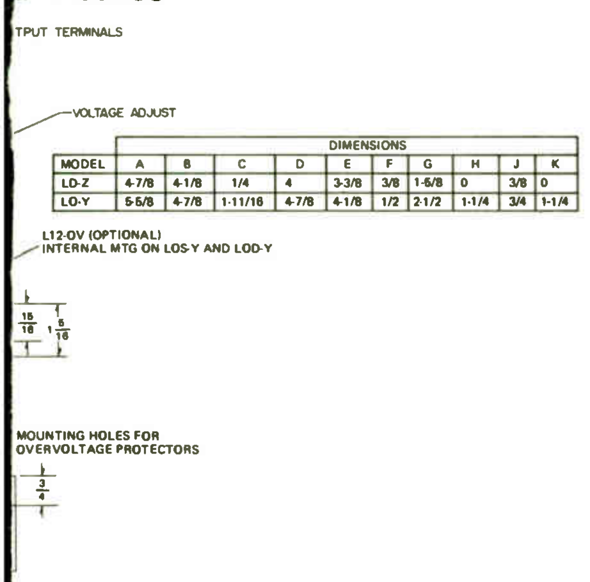
VOLTAGE & CURRENT RATINGS LO SERIES

MODEL	REGULATION (LINE OR LOAD)	RIPPLE (RMS)	VDC	MAX. CURRENT (AMPS) AT 40°C	50°C	60°C	PKG. SIZE	DIMENSIONS (INCHES)	PRICE QUANTITY 1	25	100
5V, ± 15 to ± 12 VOLTS * ADJ.				**TRIPLE OUTPUT**							
LOT-X-5152-A	0.15%	1.5mV	5 ±15 to ±12	3.0 0.50	2.2 0.375	1.4 0.20	X	7 x 4-7/8 x 2-3/4	$ 97	$ 80	$ 72
LOT-W-5152-A	0.15%	1.5mV	5 ±15 to ±12	6.0 1.0	4.5 0.75	3.0 0.40	W	9 x 4-7/8 x 2-3/4	121	100	90
LOT-V-5152-A	0.15%	1.5mV	5 ±15 to ±12	9.0 2.0	7.3 1.4	5.2 0.75	V	4-7/8 x 13-3/4 x 4-7/8	169	140	126
LOT-R-5152-A	0.15%	1.5mV	5 ±15 to ±12	12.0 3.0	9.5 2.2	7.0 1.2	R	4-7/8 x 16-3/4 x 4-7/8	199	165	149
± 15 to ± 12 VOLTS* ADJ.				**DUAL OUTPUT**							
LOD-Z-152	0.15%	1.5mV		0.50	0.37	0.25	Z	4-7/8 x 4 x 1-5/8	52	43	35
LOD-Y-152	0.15%	1.5mV		1.0	0.75	0.50	Y	5-7/8 x 4-7/8 x 2-1/2	61	50	40
LOD-X-152	0.15%	1.5mV		2.0	1.4	0.80	X	7 x 4-7/8 x 2-3/4	90	75	61
LOD-W-152	0.15%	1.5mV		3.0	2.2	1.4	W	9 x 4-7/8 x 2-3/4	105	87	70
5 VOLTS ± 5% ADJ.				**SINGLE OUTPUT**							
LOS-Z-5	0.15%	1.5mV		3.0	2.4	1.8	Z	4-7/8 x 4 x 1-5/8	41	33	27
LOS-Y-5	0.15%	1.5mV		6.0	4.9	3.8	Y	5-5/8 x 4-7/8 x 2-1/2	65	53	44
LOS-X-5	0.15%	1.5mV		9.0	7.6	6.2	X	7 x 4-7/8 x 2-3/4	81	66	54
LOS-W-5	0.15%	1.5mV		12.0	10.5	8.5	W	9 x 4-7/8 x 2-3/4	105	85	70
LOS-V-5	0.15%	1.5mV		17.0	14.5	11.5	V	4-7/8 x 13-3/4 x 4-7/8	124	101	91
LOS-R-5	0.15%	1.5mV		25.0	21.5	17.5	R	4-7/8 x 16-3/4 x 4-7/8	164	134	120
6 VOLTS ± 5% ADJ.											
LOS-Z-6	0.15%	1.5mV		2.5	2.1	1.6	Z	4-7/8 x 4 x 1-5/8	41	33	27
LOS-Y-6	0.15%	1.5mV		5.0	4.3	3.5	Y	5-5/8 x 4-7/8 x 2-1/2	65	53	44
LOS-X-6	0.15%	1.5mV		8.5	7.1	5.7	X	7 x 4-7/8 x 2-3/4	81	66	54
LOS-W-6	0.15%	1.5mV		10.0	9.0	7.3	W	9 x 4-7/8 x 2-3/4	105	85	70
LOS-V-6	0.15%	1.5mV		15.5	13.0	10.3	V	4-7/8 x 13-3/4 x 4-7/8	124	101	91
LOS-R-6	0.15%	1.5mV		23.0	20.0	16.5	R	4-7/8 x 16-3/4 x 4-7/8	164	134	120
12 VOLTS ± 5% ADJ.											
LOS-Z-12	0.15%	1.5mV		1.6	1.3	1.0	Z	4-7/8 x 4 x 1-5/8	41	33	27
LOS-Y-12	0.15%	1.5mV		3.3	2.8	2.3	Y	5-5/8 x 4-7/8 x 2-1/2	65	53	44
LOS-X-12	0.15%	1.5mV		5.7	4.8	3.9	X	7 x 4-7/8 x 2-3/4	81	66	54
LOS-W-12	0.15%	1.5mV		7.0	5.8	4.6	W	9 x 4-7/8 x 2-3/4	105	85	70
LOS-V-12	0.15%	1.5mV		10.8	9.0	6.7	V	4-7/8 x 13-3/4 x 4-7/8	124	101	91
LOS-R-12	0.15%	1.5mV		16.0	13.5	10.5	R	4-7/8 x 16-3/4 x 4-7/8	164	134	120
15 VOLTS ± 5% ADJ.											
LOS-Z-15	0.15%	1.5mV		1.4	1.2	1.0	Z	4-7/8 x 4 x 1-5/8	41	33	27
LOS-Y-15	0.15%	1.5mV		2.8	2.5	2.1	Y	5-5/8 x 4-7/8 x 2-1/2	65	53	44
LOS-X-15	0.15%	1.5mV		4.8	4.0	3.2	X	7 x 4-7/8 x 2-3/4	81	66	54
LOS-W-15	0.15%	1.5mV		6.3	5.2	4.0	W	9 x 4-7/8 x 2-3/4	105	85	70
LOS-V-15	0.15%	1.5mV		9.5	7.6	5.6	V	4-7/8 x 13-3/4 x 4-7/8	124	101	91
LOS-R-15	0.15%	1.5mV		14.0	11.5	8.8	R	4-7/8 x 16-3/4 x 4-7/8	164	134	120
20 VOLTS ± 5% ADJ.											
LOS-Z-20	0.15%	1.5mV		1.0	0.8	0.6	Z	4-7/8 x 4 x 1-5/8	41	33	27
LOS-Y-20	0.15%	1.5mV		2.4	2.1	1.8	Y	5-5/8 x 4-7/8 x 2-1/2	65	53	44
LOS-X-20	0.15%	1.5mV		3.8	3.2	2.5	X	7 x 4-7/8 x 2-3/4	81	66	54
LOS-W-20	0.15%	1.5mV		5.2	4.2	3.2	W	9 x 4-7/8 x 2-3/4	105	85	70
LOS-V-20	0.15%	1.5mV		7.7	6.0	4.3	V	4-7/8 x 13-3/4 x 4-7/8	124	101	91
LOS-R-20	0.15%	1.5mV		11.5	9.5	7.1	R	4-7/8 x 16-3/4 x 4-7/8	164	134	120
24 VOLTS ± 5% ADJ.											
LOS-Z-24	0.15%	1.5mV		0.9	0.75	0.55	Z	4-7/8 x 4 x 1-5/8	41	33	27
LOS-Y-24	0.15%	1.5mV		2.2	1.9	1.6	Y	5-5/8 x 4 x 2-1/2	65	53	44
LOS-X-24	0.15%	1.5mV		3.3	2.8	2.2	X	7 x 4-7/8 x 2-3/4	81	66	54
LOS-W-24	0.15%	1.5mV		4.8	3.8	2.8	W	9 x 4-7/8 x 2-3/4	105	85	70
LOS-V-24	0.15%	1.5mV		6.6	5.2	3.8	V	4-7/8 x 13-3/4 x 4-7/8	124	101	91
LOS-R-24	0.15%	1.5mV		10.5	8.3	6.0	R	4-7/8 x 16-3/4 x 4-7/8	164	134	120
28 VOLTS ± 5% ADJ.											
LOS-Z-28	0.15%	1.5mV		0.8	0.65	0.45	Z	4-7/8 x 4 x 1-5/8	41	33	27
LOS-Y-28	0.15%	1.5mV		2.0	1.7	1.4	Y	5-5/8 x 4-7/8 x 2-1/2	65	53	44
LOS-X-28	0.15%	1.5mV		3.1	2.5	1.9	X	7 x 4-7/8 x 2-3/4	81	66	54
LOS-W-28	0.15%	1.5mV		4.2	3.3	2.4	W	9 x 4-7/8 x 2-3/4	105	85	70
LOS-V-28	0.15%	1.5mV		5.9	4.6	3.3	V	4-7/8 x 13-3/4 x 4-7/8	124	101	91
LOS-R-28	0.15%	1.5mV		9.3	7.5	5.6	R	4-7/8 x 16-3/4 x 4-7/8	164	134	120

* ± 15 to ± 12 volts are each dual tracking outputs;

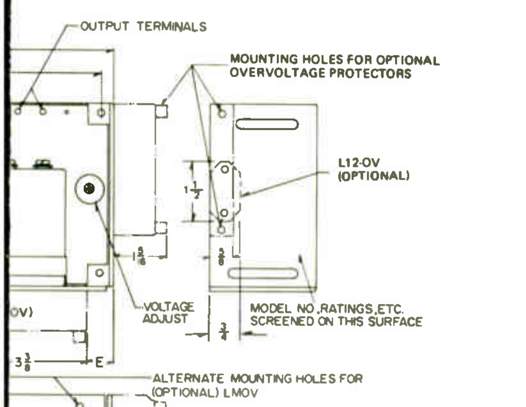
GS LO SERIES SUPPLIES

d -Y series



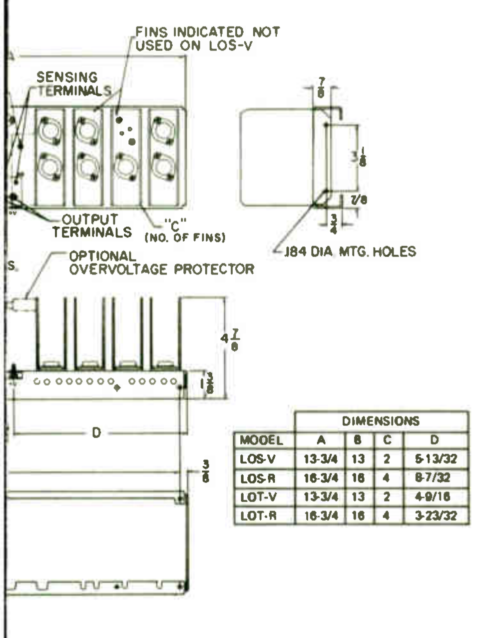
MODEL	DIMENSIONS A	B	C	D	E	F	G	H	J	K
LD-Z	4-7/8	4-1/8	1/4	4	3-3/8	3/8	1-5/8	0	3/8	0
LO-Y	5-5/8	4-7/8	1-11/16	4-7/8	4-1/8	1/2	2-1/2	1-1/4	3/4	1-1/4

-W series



MODEL	DIMENSIONS A	B	C	D	E
LO-X	7	6-1/4	3/8	1/2	7/16
LO-W	9	8	1/2	9/16	1-1/4
LOT-X	7	6-1/4	3/8	3/8	7/16
LOT-W	9	8	1/2	3/8	1-1/4

-R series



MODEL	DIMENSIONS A	B	C	D
LOS-V	13-3/4	13	2	5-13/32
LOS-R	16-3/4	16	4	8-7/32
LOT-V	13-3/4	13	2	4-9/16
LOT-R	16-3/4	16	4	3-23/32

FEATURES

Convection cooled

no internal fans or blowers or external heat sinking required because of proven thermal design using heavy gauge aluminum chassis and ventilation holes

Regulation

regulation, load — no load to full load -0.15%.
regulation line — 0.15%.

Foldback current limiting

6 package sizes

up to 28 VDC, up to 25 A
available in single, dual and triple outputs

Ripple

1.5 mV RMS

Ambient operating temperature range

continuous duty from 0°C to +60°C

Temperature coefficient

0.03%/°C

AC input

105 to 125 VAC or
210 to 250 VAC, 47-440 Hz

3 mounting positions

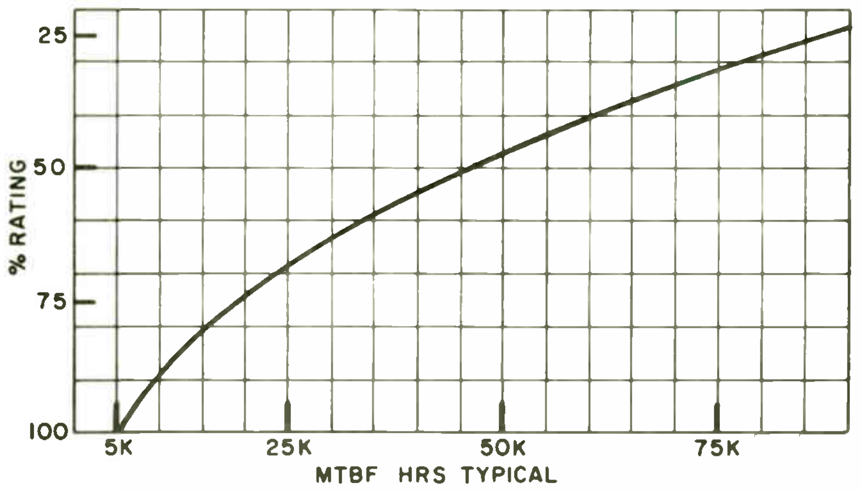
No overshoot or turn-on, turn-off, or power failure

Integrated circuit regulation

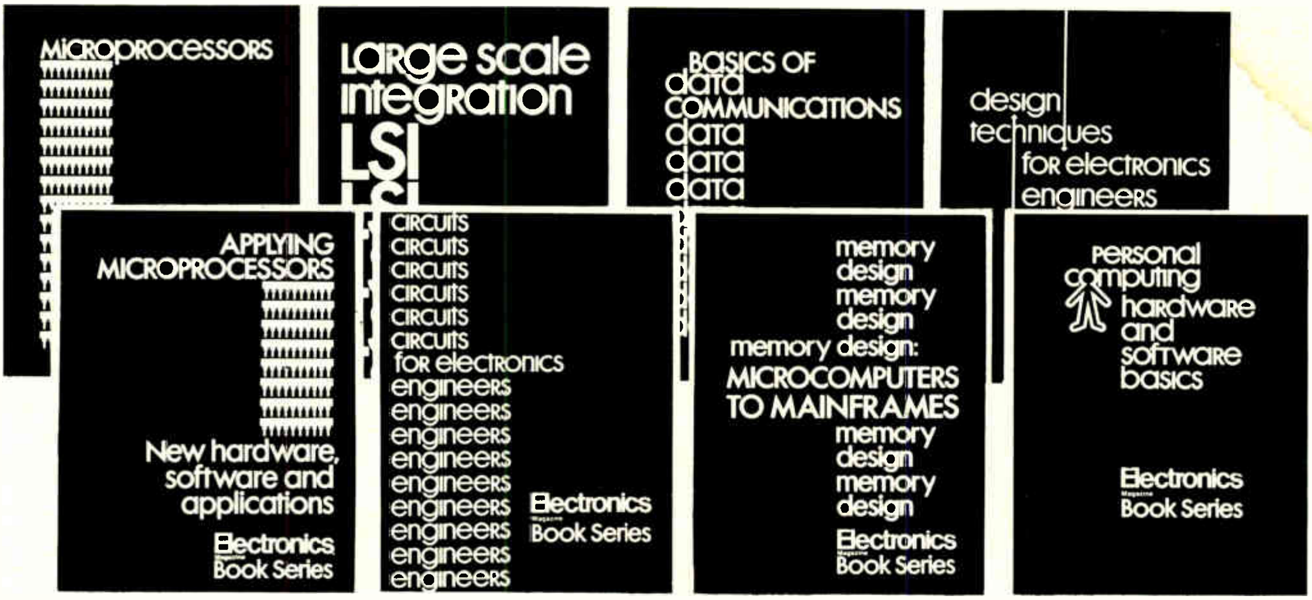
integrated circuit provides regulation system, except for input and output capacitors, rectifiers and series regulation transistors.

Job-rated calculated MTBF at worst-case condition (minimum voltage output, full load, 40°C, 125 VAC input) all models approximately 5000 hours for increased life at maximum conditions derate current as follows...

EXTENDED-LIFE CURVE



10% current derating	10,000 hours MTBF
20% current derating	15,000 hours MTBF
30% current derating	25,000 hours MTBF
40% current derating	33,000 hours MTBF
50% current derating	45,000 hours MTBF
	(Equivalent to LAMBDA LX series)



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If change is the game, obsolescence is the penalty for losing. Obsolescence of products, of technology and, unfortunately, of people. We can't change this fact. But we can help you cope with it.

Give us one hour of reading time every two weeks and we will keep you aware of what's going on around you and around the changing world of electronics technology.

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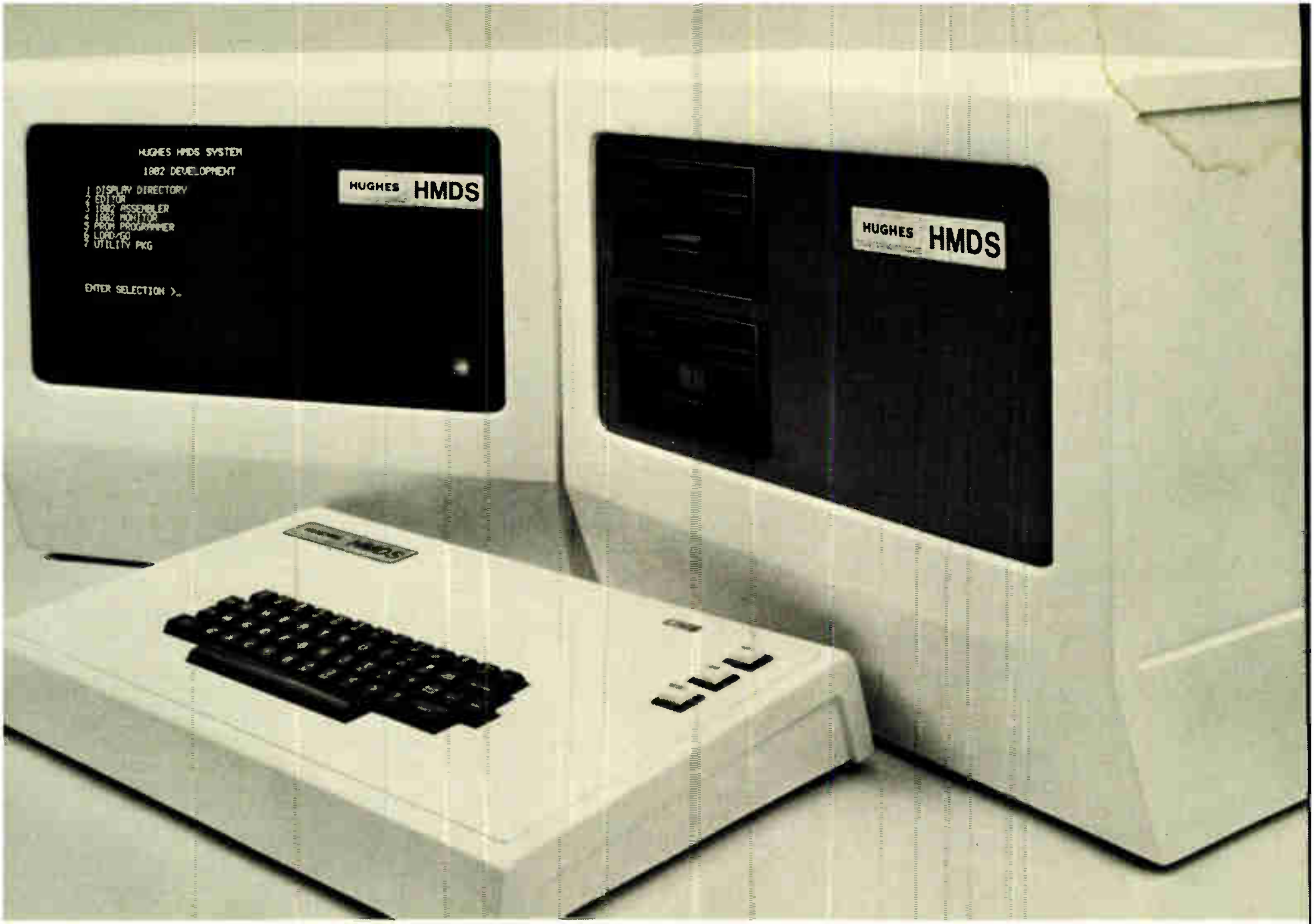

The Hughes Microprocessor Development System... an important addition to the 1800 CMOS microprocessor family

Hughes again brings its high-technology leadership and high reliability performance to the microprocessor users with a powerful development system for 1802 Microprocessor Products.

The **Hughes Microprocessor Development System** (HMDS) solves the problem of developing software and hardware for 1802 Microprocessor based designs. The HMDS contains an easy-to-use assembler plus editor and monitor software and in-circuit-debug for real time hardware development. High-level languages, PROM programmers and support of additional industry standard Microprocessors are just some of the available options.

THE 1800 MICROPROCESSOR FAMILY

(Available Now)

Number	Function
HCMP 1802	CPU
HCMP 1822	256 X 4 RAM
HCMP 1824	32 X 8 RAM
HCMP 1831/2	512 X 8 ROM
HCMP 1833/4	1024 X 8 ROM
HCMP 1852	I/O Adapter
HCMP 1853	3 to 8 Decoder
HCMP 1854	UART
HCMP 1856/7	Bus Buffer/Separator
HCMP 1858/9	Memory Latch/Decoder
HCMP 1861	TV Interface

HUGHES

HUGHES AIRCRAFT COMPANY
SOLID STATE PRODUCTS DIVISION

Hughes offers a complete line of Microprocessor related devices including Hughes new Liquid Crystal Display Drivers (HLCD 0437 and HLCD 0438) along with those listed in the table.

Other advanced products will be announced soon. For further information on the growing Hughes product line call or write: Gary Des Rochers, Hughes Semiconductor Products, 500 Superior Avenue, Newport Beach, CA 92663, (714) 759-2907 (800) 854-3515. In Europe: Hughes Microelectronics Ltd., Clive House, 12-18 Queens Road, Weybridge, Surrey KT13 9XD, England. Telephone 932-47262.

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Many positions in the electronics industry throughout the U.S. Affiliate and employer contacts in every major marketing area.

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The Optimum System Approach.

It's the concept that we base our engineering on at the Space Information Systems Operation...a dynamic approach to design that allows us to build in specific capabilities and maximize flexibility and cost efficiency. Within the Space Information Systems Operation we have all the necessary resources to build and deliver an optimum system. We can provide requirements analyses, system design and engineering, hardware and software design and development, maufacturing, procurement, logistics support, system maintenance, system operation, maintenance and user documentation, and programmer, operator and analyst training.

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We are an equal opportunity employer, m/f.

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Electronics

If you know where you're going, you've got a good start... but that's all you've got.

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Positions require individuals with electronic and mechanical drafting experience. Should have minimum 2 years drafting training and/or several years experience. Checkers must have the above experience plus a minimum of 2 years checking experience.

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RCI is a technical search firm with an outstanding reputation representing a broad base of nationwide clients serving the Electronics Industry. If you are interested in advancing your career, call us or send your resume or a brief hand written description of your background including present salary and geographic preferences, in confidence to:

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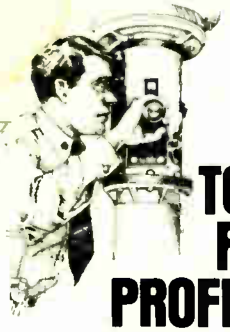

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Electric Boat Division

Groton, CT 06340

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AN EQUAL OPPORTUNITY EMPLOYER

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BSEE with 7 years experience required. Knowledge of antenna and preamp design plus R. F. techniques with 1—10 KW transmitters and receivers necessary. Ability to interface signals with computers a real plus.

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P-8958
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ELECTRONIC ENGINEERS

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The Milton Bradley Company has propelled itself into the electronic game and toy arena in a most dramatic and successful fashion in the last two years. This momentum is continuing in a most encouraging way. Consequently, we are seeking additional talented electronic personnel with both hardware and/or software experience and knowledge to expand our inhouse electronic product development capability. We have immediate openings for the following types of personnel:

Senior Electronic Product Engineers

Qualified candidates will have a minimum of ten years electronic consumer product experience with a BSEE degree or the equivalent thereof.

Electronic Product Engineers

This position requires a minimum of 5 years electronic consumer goods experience and a BSEE or equivalency.

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3 to 5 years experience in microcomputer programming and knowledge of microcomputer assembly languages is required.

Electronic Technicians

1 to 3 years experience as a technician in an electronic consumer goods environment is preferred. An AS degree in electronics would be an asset.

In addition to scenic beauty in the immediate locale we offer proximity to skiing, sailing, surfing and several other quality factors of life.

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(On the Texas Gulf Coast)

Intermedics, Inc., the fastest growing major medical devices company in the United States today, and the world's second largest manufacturer of cardiac pacemakers, has expansion openings for the following:

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Requires BSEE or BS in Physics with 3 to 5 years of experience in reliability and components applications. Must be able to perform circuit analysis and component application studies. Will also perform worst case analysis, failure modes, and effect and criticality analysis. (FMECA) Experience working with timesharing systems would be a plus.

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Requires BS in EE, Physics, or Statistics. Will perform statistical studies on reliability functions such as math modeling, design of experiments and ANOVA. Will also perform circuit analysis and represent Reliability Department in design reviews.

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BSEE or BSME with ASQE-CQE a plus. Desired experience would be in areas of quality auditing, nonconformance reporting, process capability analysis and corrective action systems. Aerospace experience or experience in commercial electromechanical systems preferred.

Several positions with excellent growth potential and top salary opportunities based on qualifications and experience. Full relocation, company paid benefits, and excellent working conditions await you.

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EMPLOYMENT SERVICES

Electronic engineering growth posi-tions with clients located nationally. Our service is enhanced by the fact that I am an EE with 20 years in industry and over 10 years in placing professionals on an employer fee paid basis. Send your resume to Joe Torcassi, Director, J. Anthony & Associates, PO Drawer AD, Lynchburg, OH 45142. 513/364-2305.

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POSITIONS VACANT

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RESUMES

Resumes—Complete instructions and examples; $4. Consultants, Box 567—J. Bergenfield, N.J. 07621.

FACULTY POSITIONS VACANT

Applicants are invited for a faculty position in Electronics at Centralia College to begin September 10. Centralia College is situated in a rural community 1½ hours from both Portland and Seattle. Bachelor's degree in electronics or related field with two years applied experience in semi-conductor physics, digital logic and micro-processors desired. To apply, send resume, transcripts and arrange for three letters of recommendation to be forwarded to S. Scott Horner, Personnel Officer, P.O. Box 639, Centralia, WA 98531. Screening will begin June 11, 1979. An Equal Opportunity Employer.

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The successful applicant must have a proven managerial background in digital hardware and electric power systems. Responsibilities will include managing a joint effort directed towards a digital protection and control system for a transmission substation. In addition, excellent communication skills and the ability to interface effectively with all levels of personnel is necessary. A B.S.E.E. degree and expertise in electric power systems, digital systems, digital hardware, and a knowledge of protective relaying are required. (Advanced degree desirable.)

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Responsibilities will include the design of new, advanced solid-state analog and digital equipment, providing programming for microprocessor-based automatic test equipment. Requires a B.S.E.E. degree and related experience. 20% travel required.

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This position will involve the design of new and advanced solid-state test equipment with provisions for automatic data retrieval, and will provide programming for microprocessor-based automatic test equipment. Requires a B.S.E.E. degree with specialization in microprocessor technology, and hardware/software capability. Background should include familiarity with analog and digital microprocessor circuitry.

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GENERAL ELECTRIC

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Electronic Engineers

Stanford University is seeking engineers (4) to participate in a research project in Antarctica. The program provides opportunities for individuals to participate in all phases of research including design and testing of electronics systems, field operations, data analysis, and interpretation of results. The program also provides unique opportunities for acquiring thesis material for the PhD in electrical engineering or physics.

Employment covers period from August 1, 1979 to March 15, 1981. Approximately 14 months of this period will be spent in Antarctica during which time the salary per month will be $1875. All foul weather clothing, food, living accomodations and transportation will be provided at no cost to the individual.

Qualifications: electrical engineers and or physicists who have successfully completed their undergraduate studies or equivalent; on-hand electronic experience; familiarity with RF systems, minicomputers, analog and digital circuits, and antennas.

Submit resume to: Sheri E. Renison, Old Pavilion, Serra & Galvez Streets, Stanford University, Stanford, CA 94305. Equal Opportunity Employer Through Affirmative Action.

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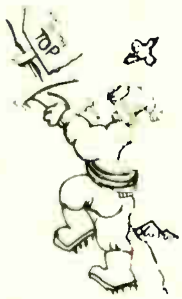
Electronics

If you know where you're going, you've got a good start...

but that's all you've got.



The Woodward Governor Company manufacturer of prime mover controls exclusively since 1870 has immediate need for:

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Position requires individuals with understanding of discrete, integrated circuit, and microprocessor components, to generate technical manuals and other product support materials for new electronic controls used on broad range of prime mover applications.

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Background should include succeessful performance as Logic Engineer, experience with the conceptual design and implementation of large scale central processors working closely with the systems architecture staff. Requires 5 years experience in the design of large scale processors with architectural exposure. Experience in the design of microprogrammed processors using latest technologies, (TTL, ECL, etc.) is very desirable. BS/MS or equivalent is desired also.

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Great moments in history
Sir Isaac Newton

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Call us COLLECT today to schedule an interview with us: **(213) 882-0623.** During the conference we may be reached at **(212) 759-6553** from 10a.m. - 6p.m. on June 4-7.

As computer technology advances, PCC's Peripherals Division is a stride ahead, bringing it all together in products and services for original equipment manufacturers and computer systems end-users. Our capabilities extend throughout North America to international locales, and encompass peripheral equipment, subscriber maintenance, micro-computer and data entry systems...and more. The careers:

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Requires BS degree or equivalent and a minimum of 5 years related experience in baseline cost definition and control, master scheduling, value analysis, plant layouts, etc.

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Principal Engineer - Electrical

Requires BSEE, MSEE desirable and at least 8 years experience with computer disk and/or tape peripheral digital circuit design.

Sr. Mechanical Engineer

Requires BSME and a minimum of 5 years experience in the development of disk drives including thermal analysis, precision mechanisms and electronic packaging.

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Assume responsibility for product schedules, labor efficiency, material usage, as well as cost center budget development. We prefer a Bachelor's Degree and require at least 5-10 years of related supervisory experience within an electro-mechanical manufacturing environment.

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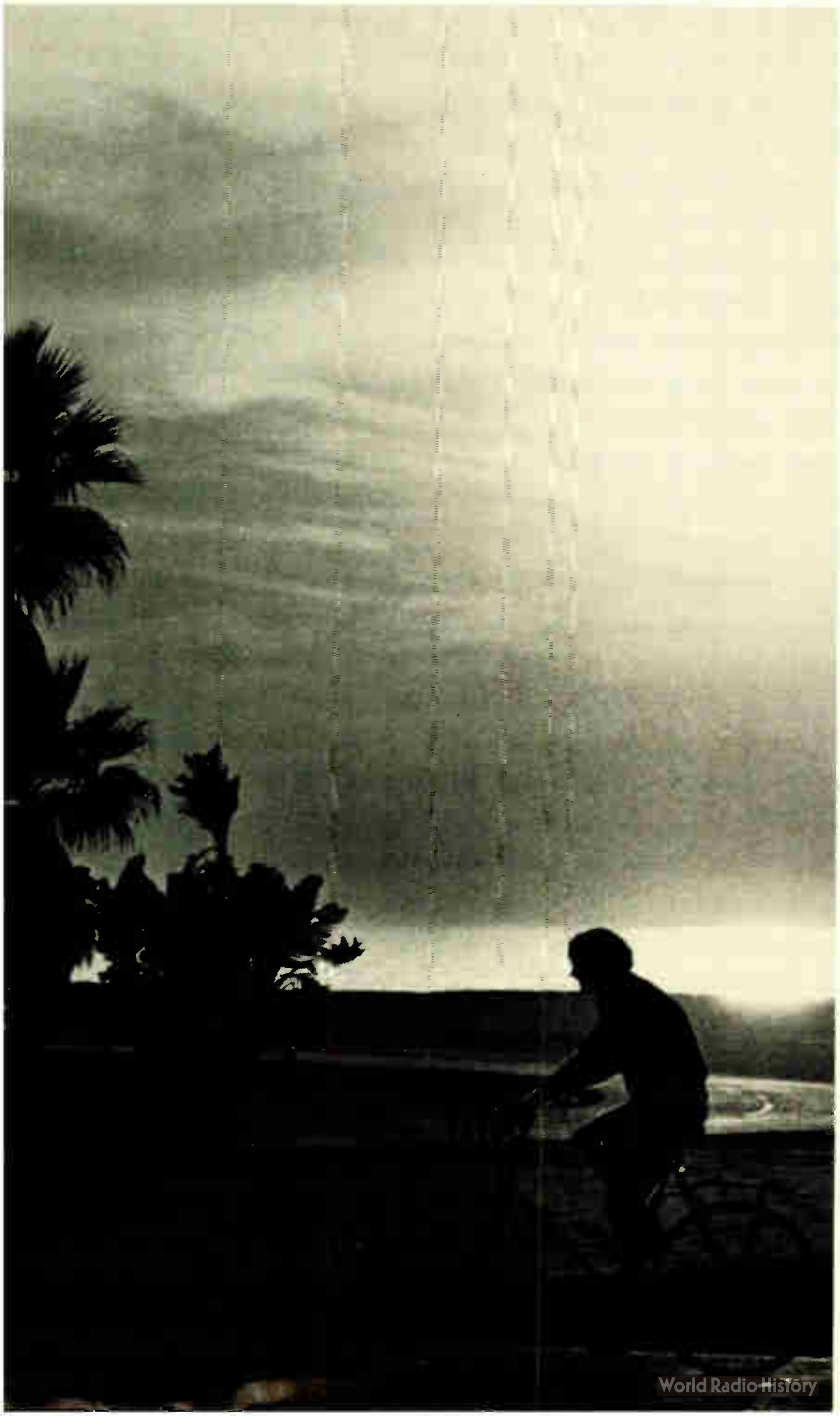

Instead of sounding like the Chamber of Commerce, we'll be factual about how you can grow out here. As an engineer at Hughes.

1. **We'll put some challenge into your life.** We're into some of the most sophisticated radar projects on earth (or in space). Like building the weapon systems for the F-14, and the radar system for the F-15 and F/A-18 fighter aircraft. And radar for the U.S. Roland. And the "eyes, ears and voice" for NASA's Space Shuttle. You've got to be good to work on them. And working on them can make you better.

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3. **We'll help you have some great weekends.** You'll find many of your associates at Hughes live adventurously on weekends and vacations. Deep-sea fishing. Ghost town exploring. Hang gliding. Rock hounding on the Mojave. Scuba diving. Activities like these help you grow as a person. Under the same sun that makes our trees grow taller, our oranges grow bigger.

So if you're ready to grow—professionally and personally—we're ready to help. Because we've got some unusual openings now. We need Systems Analysis, Software Engineers, Hardware Engineers, Production Engineers, Quality Assurance Engineers, and many others. Write: Professional Employment, Hughes Radar Systems Group, Dept. EL, 2060 Imperial Highway, El Segundo, CA 90245.

HUGHES

HUGHES AIRCRAFT COMPANY

RADAR SYSTEMS GROUP

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■ For more information of complete product line see advertisement in the latest Electronics Buyers Guide
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