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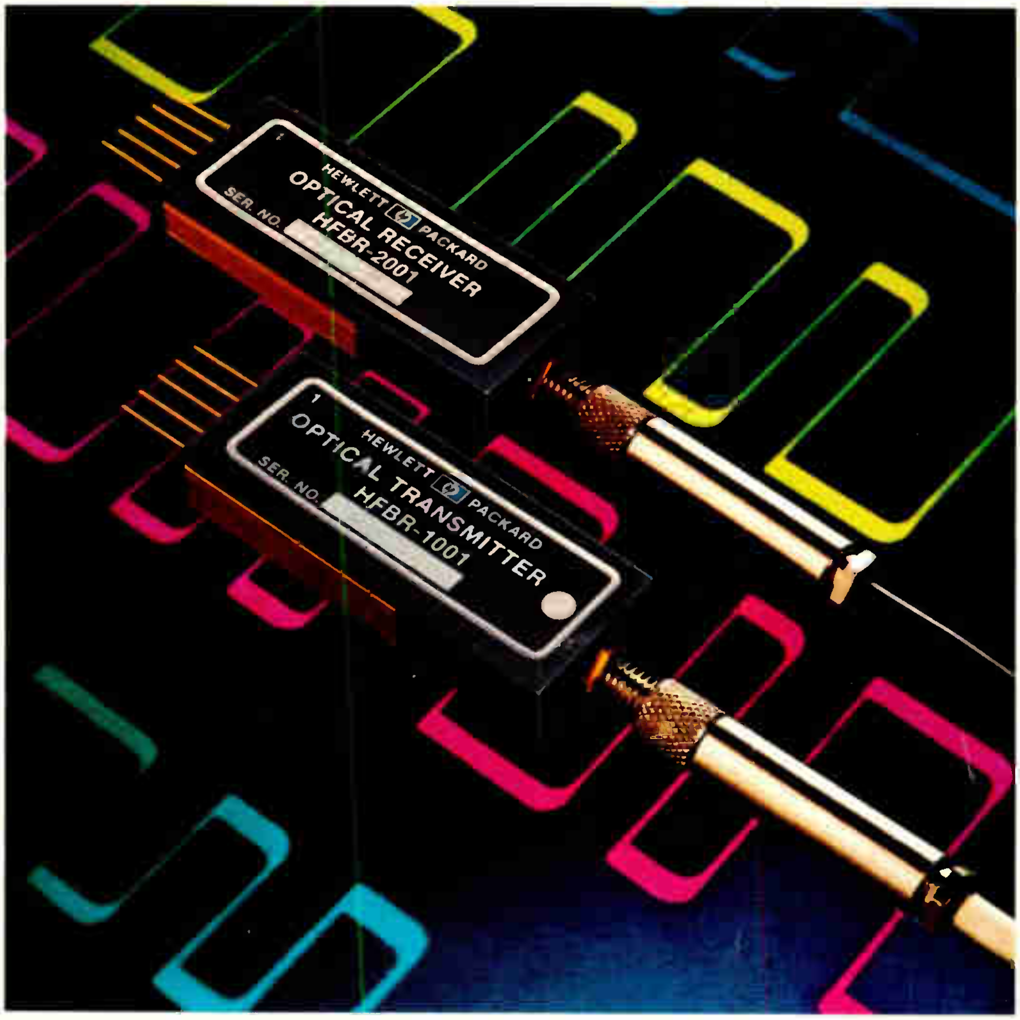

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Electronics

The International Magazine of Electronics Technology

Vol. 51, No. 23 • November 9, 1978

Highlights

Cover: X rays aimed at VLSI mass production, 99
For the 1-micrometer-wide lines coming soon in very large-scale integration, X-ray lithography may win out over the electron-beam and optical processes. It yields the narrowest lines at reasonable defect densities, throughput rates, and cost.

Cover photographed by John Ashworth.

Conference looks at digital satellites, 95
How close are digital-communications satellites? Well, the talk at the fourth International Conference on Digital Satellite Communications focused on the practical problems that must be solved.

Bit-slice chips boost system throughput, 107
Schottky-coupled logic combines the speed of ECL and the low power consumption of TTL in a 4-bit-slice family of chips. They will make a number of advanced computer designs possible for the first time.

Putting fiber-optic data links to use, 118
Data links are beginning to feel the impact of fiber optics, and this start of a three-part series offers guidelines on assessing costs of optical versus cable links. Coming up: charts and graphs that will speed design decisions and a comparison of the do-it-yourself data links available.

And in the next issue ...
Very large-scale integration: a special report on its status ... a family of intelligent controllers for computer peripherals ... part 2 of the fiber-optic data-link series.

Electronics

Publisher's letter

Fiber-optic applications are no longer experimental novelties. In fact the fiber-optic revolution is here and now, prompting us to prepare the three-part series on this subject that starts in this issue (p. 118).

Part 1, written by Jay Uradnisheck of Du Pont Co., Wilmington, Del., is particularly important to engineers getting ready to use fiber optics. It presents the economics, or "value-in-use" calculations, that make it possible to put a numerical value on both the tangible and intangible advantages of fiber optics. In short, the first installment tells how to decide if fiber optics is for you.

Part 2 of the series, to appear in the next issue, takes the designer to the next step. Written by Albert Bender and Steven Strosum of ITT's Electro-Optical Products division, Roanoak, Va., it contains a series of design curves that allows a potential user to make the first pass at a system design without having a detailed understanding of fiber-optic components.

Finally, communications editor Harvey Hindin will wind up the series with a special report on the most common fiber-optic applications—digital and analog data links. Part 3 will compare and contrast data links in operation today and will include an easy-to-use breakdown of all pertinent specifications.

Although the applications are expanding, to many engineers fiber optics is still an unknown. This series is intended to overcome this new-product inertia. "Some engineers," says Harvey, "are resisting fiber optics because they never studied optics in school."

As he points out in the introduction to the series, fiber optics is coming along not so much as a breakthrough but as an ooze-through. "Unlike some developments that never reach the marketplace, fiber optics offers such advantages that it is already being widely applied," Harvey adds.

X-ray lithography has been a do-it-yourself proposition for General Instrument Corp.'s Microelectronics division. The Hicksville, N. Y., unit has not only built its own equipment, but it has been directly involved with a chemical company to develop more sensitive resists and has become involved in making its own masks.

Gregory Hughes, senior X-ray lithography engineer for GI, has been through the process first hand. And his article, starting on page 99, presents the details of this experience. Actually, Hughes has been involved with X-ray lithography for only two years since he left his teaching job at Lawrence University in Appleton, Wis. But considering the state of the technology, this two years makes him senior in the technique.

His next point of concentration is already clear. "The major problem after X-ray lithography is the ability to etch the fine line details and ensure reproducibility," Hughes comments. "This is going to be a production technique, not an R&D technique."

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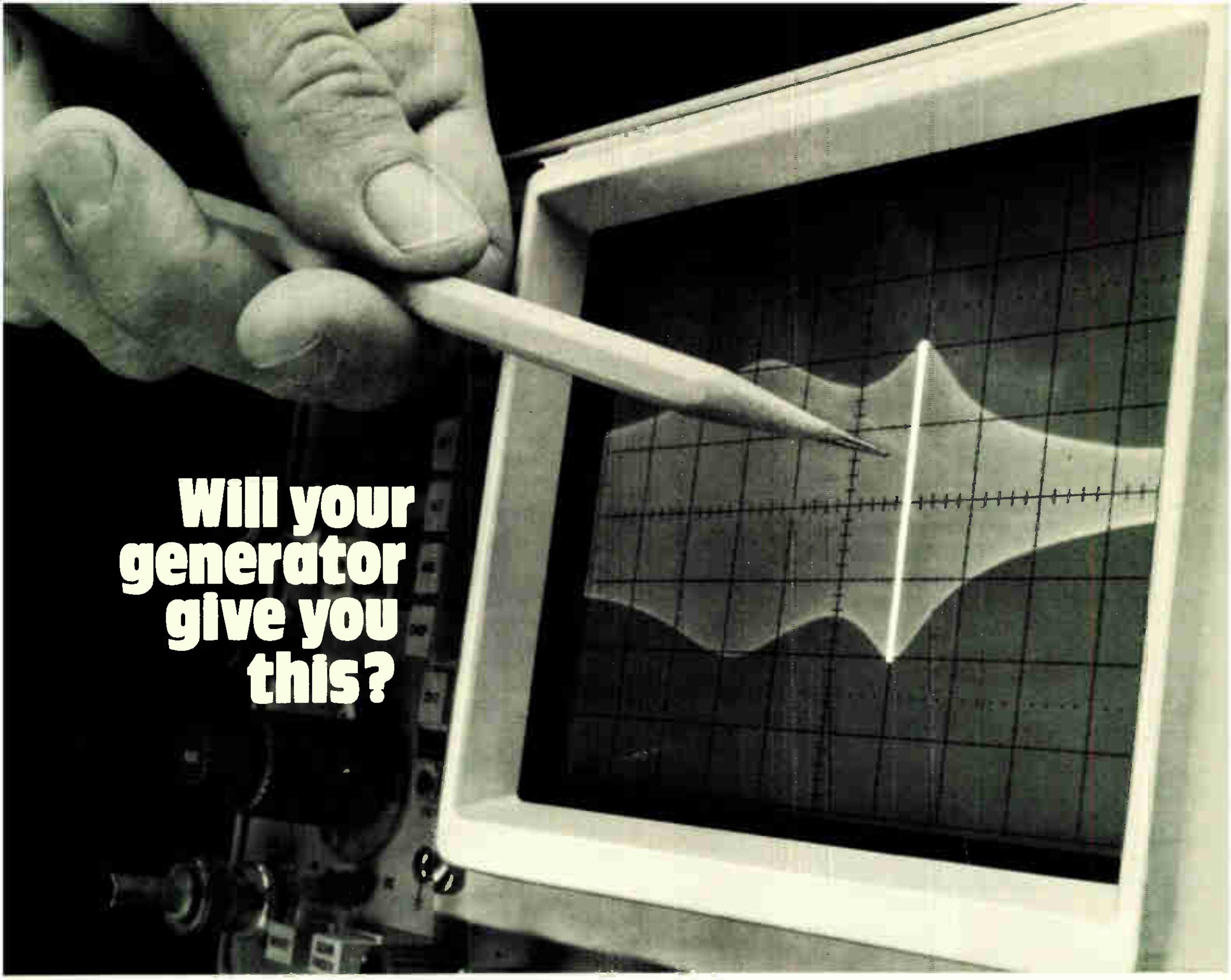

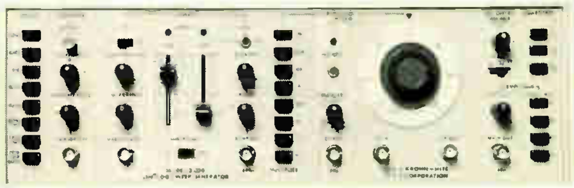

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Readers' comments

Tantalum nitride vs nichrome

To the Editor: We fully agree with the conclusion in "Why the design nod goes to resistors made as thin-film monolithic networks" [Aug. 3, p. 99] that monolithic thin-film networks are the best solution to many design problems, but several points made in the article about the prevailing thin films are misleading.

For one, tantalum-nitride thin film was developed by Bell Laboratories after experiments revealed that nichrome would not survive its 20-year equipment life requirement. Increasingly, tantalum nitride is specified in systems where reliability, as well as resistor stability, is important—for example, the Trident I missile and the Defense Satellite Communications System III.

The best passivation techniques to date have not eliminated the disappearing nichrome phenomenon which occurs in the presence of low moisture levels and low potential difference across the resistor. The military still traces system failures to nichrome corrosion, and this fault feeds the use of tantalum nitride.

Semi-Films has both thin-film capabilities. However, we take great pride in knowing that we have extended Bell Labs' technology to its present state of the art and are the major supplier of reliable, self-passivated tantalum-nitride thin-film resistors and networks to hybrid manufacturers throughout the West.

Frederick R. Maldeis
Semi-Films Division
National Micronetics Inc.
West Hurley, N. Y.

The authors reply: *Hybrid Systems Corp. also has the ability to provide resistors of either tantalum nitride or nichrome. Hence, we supply our customers with what they specify, which today is usually nichrome.*

Present nichrome resistor networks are reliable. A very large majority of the resistors we manufacture are used where high reliability is required, and after exhaustive testing, virtually all these applications have specified the use of nichrome. In fact, a number of programs that previously employed tantalum nitride now call for nichrome.

With regard to Bell Labs' original use of tantalum nitride, it should be noted that the attraction of this metal was based on the use of tantalum in a multifunctional system. This use included tantalum oxide for capacitors and tantalum metal for conductors (in RC filter applications). Also, tantalum provided the desired compatibility with beam lead structures.

The long-term stability problems observed in early uses of nichrome are insignificant today. Hybrid Systems' largest volume chip customers are manufacturers of highly reliable military products. They use nichrome chips because of the performance benefits offered, and they consider risks of moisture contamination very minimal in a well-run hybrid house. Almost all current major military programs have designed in nichrome resistor networks. Further, after shipping millions of dollars worth of chips and packaged networks to this marketplace, we have not received a single return where the nichrome has "disappeared."

The growth in thin-film networks has been substantial, and the growth in nichrome has been the chief contributor. Elimination of long-term stability problems, combined with a lower temperature coefficient, greater tracking stability, and ease of laser trimming, is why, today, nichrome is most often the material of choice.

For the record

To the Editor: Certain statements made in your Sept. 28 article, "Silicon growers try to cut cost/watt" [p. 97], were in error and should be corrected. The silicon-on-ceramic process was not developed in the 1960s and dropped, as stated; rather, work under Government contract was done in that period which predicted that a silicon-on-ceramic technology might be feasible. The actual silicon-on-ceramic work was not started, however, until 1975.

Moreover, the article says that, for the silicon-on-ceramic process to be cost-effective, Honeywell must grow at a rate of 1.5 cm/s in a continuous grower. The number should be approximately 0.15 cm/s.

Paul W. Chapman
Honeywell Technology Center
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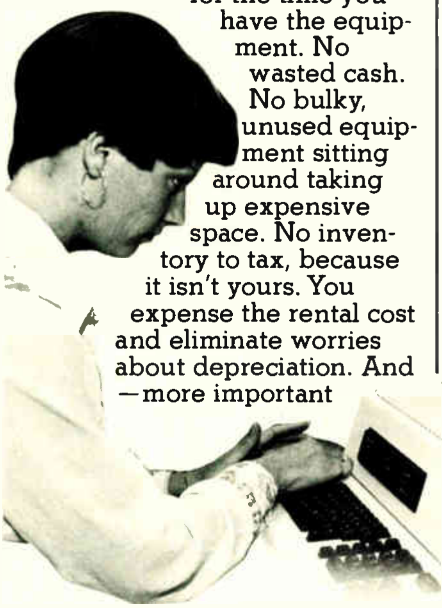

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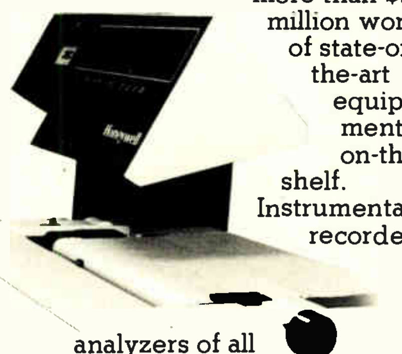

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News update

■ The first Canadian field trials of the all-electronic E-phone are under way in Ontario. A continuation of earlier technology trials conducted by Bell Canada [*Electronics*, Oct. 28, 1976, p. 113], the two-phase field trials will ultimately test 1,000 phones over an eight-month period.

In the first phase, 400 phones will be installed in customers' homes, to test the technology and how users react to the instrument, which was developed by Bell Canada, Bell-Northern Research Ltd., and Northern Telecom Ltd. Phase two will involve an additional 600 installations.

Produced by Northern Telecom, the E-phone has as its heart an integrated-circuit package, built with bipolar, integrated injection logic, that replaces electromechanical parts such as the ringer, transformer-coupled speech network, and dial-pad assembly. Also, the carbon transmitter found in conventional telephones is replaced by a linear transducer. According to a BNR spokesman, if the results of the field trials are satisfactory, Bell Canada will "gradually phase out the use of electromechanical push-button telephones." **Bruce LeBoss**

■ The Canadian electronics trade deficit has grown from $336 million to $1,267 million since 1966 and—despite the formation of the Canadian Advanced Technology Association to help reverse this trend [*Electronics*, June 22, p. 52]—it is still an uphill battle, according to Bell Canada. Bell has been "effectively discouraged" from seeking sources of foreign income by a decision of the Canadian Radio-Television and Telecommunications Commission that $165 million of net profit from a Saudi Arabian project must be treated as ordinary revenues for regulatory purposes. Bell Canada feels that the foreign work was "unconnected with the telephone service in Canada" and that the commission's attitude was detrimental to Canada's international prestige and ability to compete in foreign markets. **Harvey J. Hindin**

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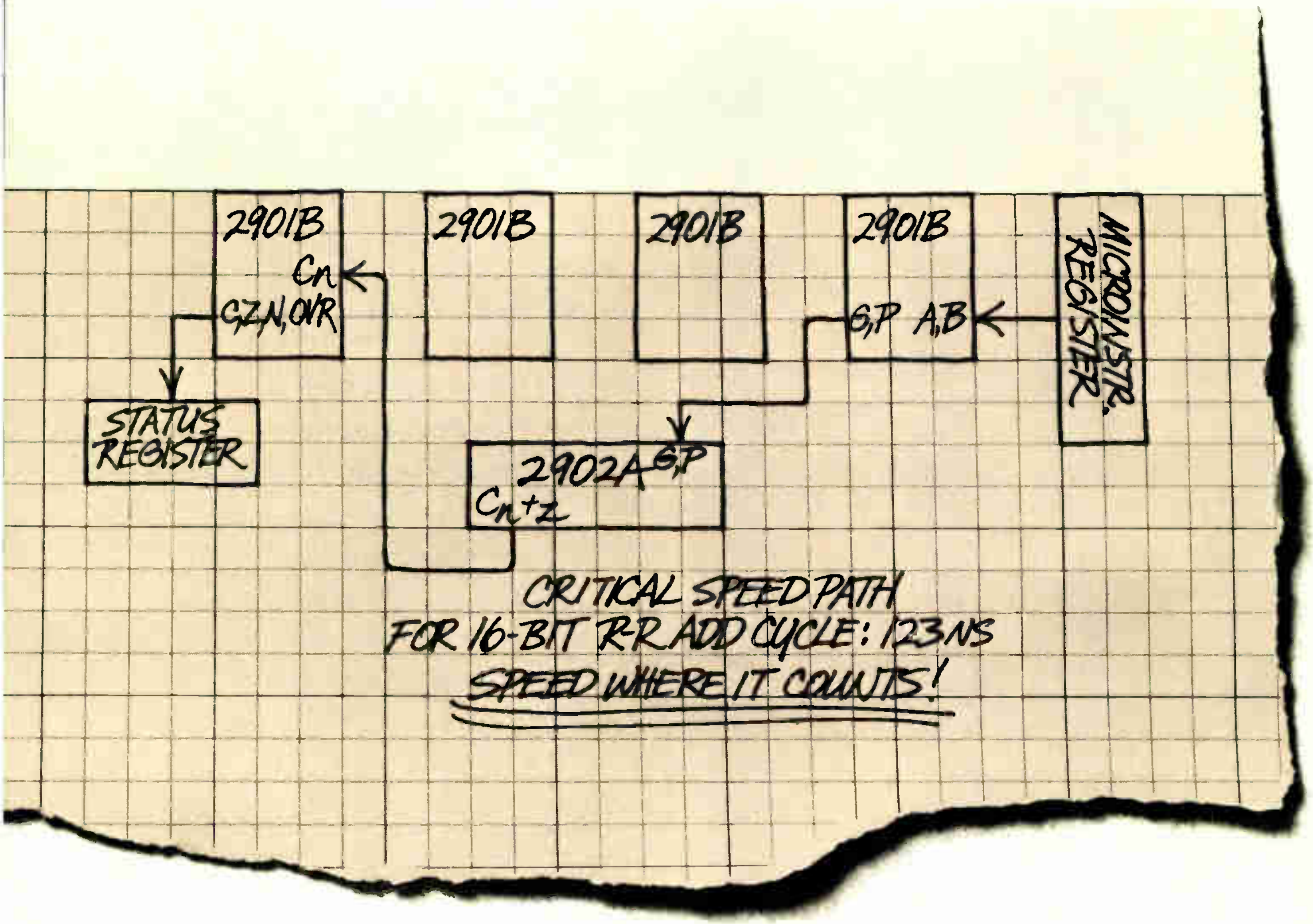

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Griffith to push Xylogics beyond disk-drive controllers

C. Wayne Griffith is a big man with big plans for a company that is small right now. The 6-foot, 4-inch, 240-pound Griffith was recently elected president and chief executive officer of Xylogics Inc., a Burlington, Mass., company whose main business is making microprocessor-based controllers for minicomputer disk drives, mostly for Digital Equipment Corp. and Data General Corp. systems.

"The DEC- and Data General-related market is a good one to be in because it's growing at 35% or more per year," Griffith says. His biggest competitor is System Industries Inc., Sunnyvale, Calif., with sales in 1978 of some $22 million worth of disk controllers and subsystems, a figure that Griffith envies.

A few years. Xylogics is nowhere near that size, but it could be in a few years, if Griffith's plans work out. The nucleus of the company was formed in late 1975 and evolved into Xylogics Inc. a year later. Revenues will reach about $3.2 million this year, Griffith says.

He is used to running far larger operations. "I've run entities as large as $100 million, and I don't want to run anything much smaller," he asserts. While at Burndy Corp., for example, the 45-year-old Griffith, who has a bachelor's degree in economics, handled international operations—manufacturing, engineering, joint ventures, plus acquisitions in Brazil and Japan. "I took it from sales of $18 million to almost $70 million in four years," he says.

And earlier, at Leeds & Northrup Corp., most recently as group vice president, he took an international operation that had lost money on $70 million in sales and made it profitable. Xylogics has been profitable, but Griffith wants more growth, through both acquisitions and an expanded product line.

"We already see other hardware opportunities," he notes. "Our products do control, communications, command, and connection functions. There are interesting segments in each of these, like factory remote data-acquisition networks."

Growth. Xylogics' Griffith looks to acquisitions and expanded lines.

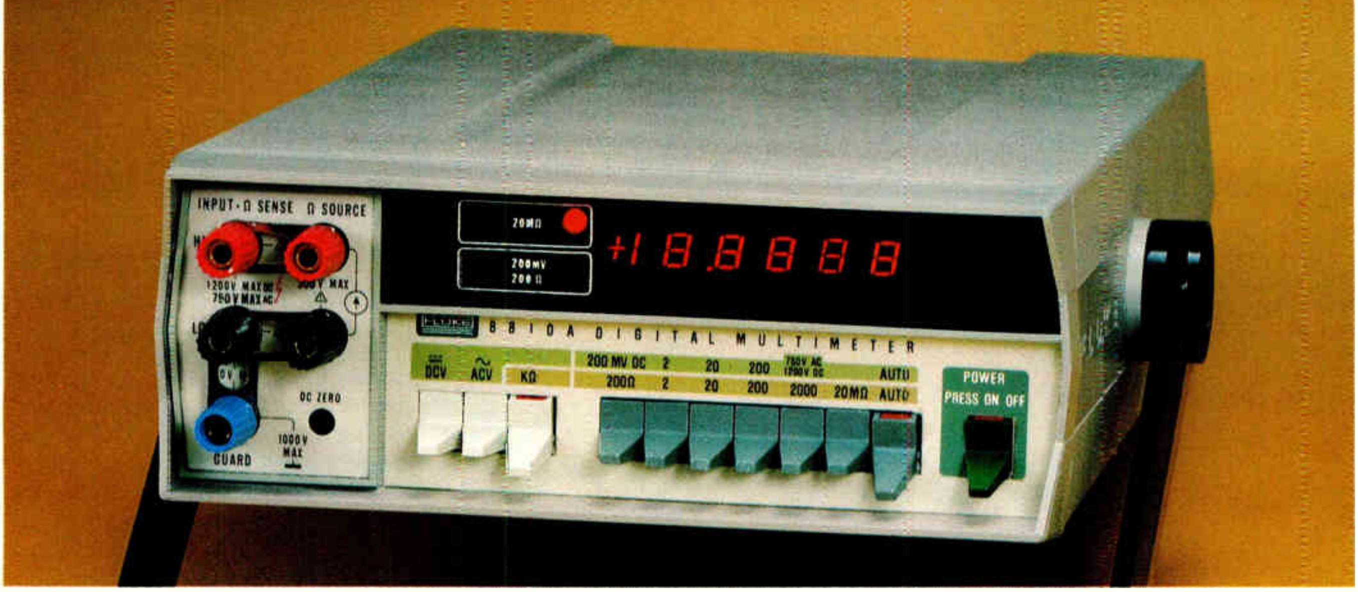
One of his first moves was to restructure Xylogics' board of directors, to give it more expertise. John W. Poduska, vice president for research and development at Prime Computer Inc., is a "superb technologist in the computer field," he points out. And Bruce E. Elmblad, a founder of both peripherals manufacturer Inforex Inc. and Prime "has a strong background of taking small companies and making them significant, worldwide companies," Griffith says.

Hughes's Walker: pruning to get more profitable

The reasoning behind the move is easy to understand. "We weren't profitable enough," is the way W. Scott Walker explains why much of Hughes Aircraft Co.'s microelectronics business is being reorganized.

Walker, a 22-year veteran of Hughes, was recently named general manager of the new Solid State Products division, Newport Beach, Calif. It is the remnant of Hughes's Microelectronics Products division, an organization that had been committed to a hodge-podge of solid-state products, including integrated and hybrid circuits and discrete

HOW COULD THE INDUSTRY STANDARD 5½-DIGIT DMM BE IMPROVED?



The problem was, what could be improved? The 8800A already has made its reputation by providing the accuracy, stability and resolution usually found only in big, expensive lab instruments. And it has four-terminal ohms, 1000 MΩDC input resistance, and full guarding thrown in for good measure.

Combine all this with autoranging, extensive overload protection, and a cost effective price, and it's no wonder the 8800A is the industry's most popular bench/portable 5½-digit DMM.

Now look at the 8810A.

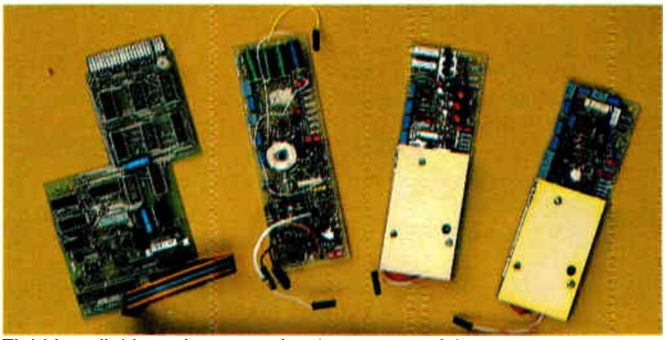
It's modular! You can buy the lab-performance DC mainframe for only $695. Add the six-range ohms converter for $175 any time you wish.

It's got true rms ac! Actually you can choose either the true RMS converter module for accurate measurements of most waveforms at $275, or the average-responding AC converter module at $150. Both are spec'd to 100 kHz.

For data recording, there's a data output option.

It's specified for one year! You know how much money you can save by eliminating the time and expense of shorter re-cal cycles. And this kind of long-term stability is just what you'd expect from Fluke.

So now, in addition to the industry standard 8800A, you have your choice of application-oriented and cost-saving configurations of the new 8810A, choices you'd expect only from Fluke.



Field-installable options snap-in when you need them.

CALL (800) 426-0361*, TOLL FREE. Or, contact one of the more than 100 Fluke offices or representatives, worldwide. In the U.S. and all countries outside of Europe, contact: John Fluke Mfg. Co., Inc., P.O. Box 43210, Mountlake Terrace, WA 98043, U.S.A. Telex: 32-0013.

In Europe, contact: Fluke (Nederland) B.V., P.O. Box 5053, Tilburg, The Netherlands. Tel.: (013) 673973. Telex: 52237.

Prices U.S. only.

*Alaska, Hawaii, Washington residents please call (206) 774-2481.

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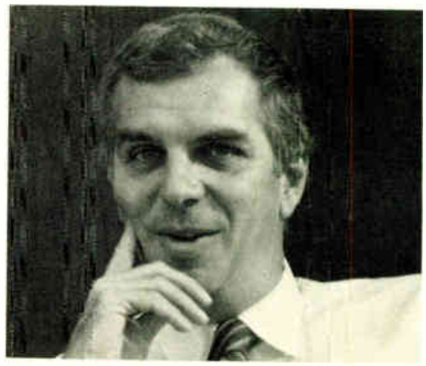


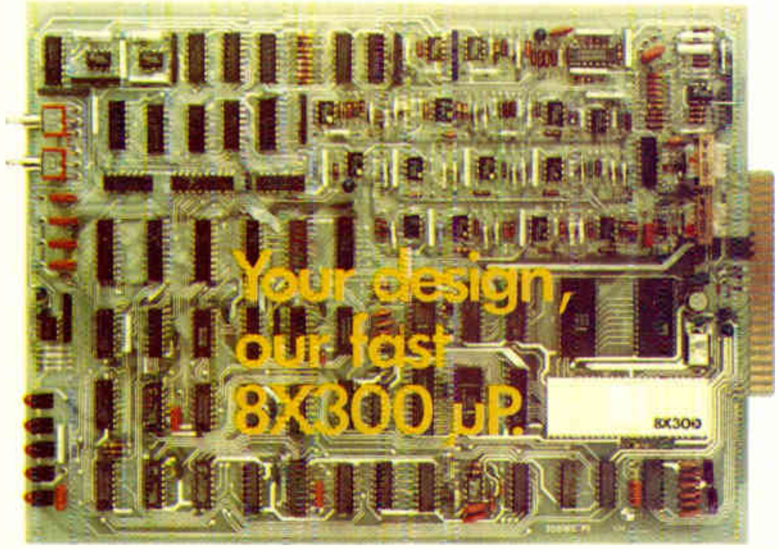
Classical. W. Scott Walker hopes he will run a classic components company.

devices, quartz crystals, electronic watch modules, audio switching systems for the military, and passenger entertainment systems for commercial airlines. The total gross seems healthy enough, although about half of last year's $60 million in sales went to other Hughes divisions. But apparently a clear-cut direction for the organization was missing.

"We're now giving undivided attention to components," says Walker, who holds a Ph.D. in nuclear physics and spent most of his time at Hughes with missiles like Phoenix and Maverick. He sees his job right now as "pruning away technologies rather than launching new ones." No longer will the group hold to its original charter—developing state-of-the-art circuits for military and space systems, then finding commercial customers.

Instead, Walker will keep what he regards as his best lines, not yet saying which he will drop. Perhaps most important will be complementary-metal-oxide-semiconductor technology and the 1800 microprocessor family, together with C-MOS-on-sapphire technology, licensed from RCA Corp. Hughes will be expanding its peripheral chips starting with a new 16-kilobit electrically programmable read-only memory, Walker says. And bipolar products will also have a place, he continues. Staying, as well, will be the crystal and custom hybrid businesses and the watch modules. "If in a year or so people tell me we have built a classic components company here, then I'll feel I have been successful," Walker says. □

Data Communications at 4 million operations/second.



100-square inch, 4800 bps Bell-compatible modem (Universal Data Systems)

Here's the raw, uncompromising speed your datacom design demands: 20 instructions/byte on a T-1 carrier. Compare the 8X300's throughput with MOS devices, and the conclusion is plain: there *is* no comparison. The bipolar 8X300 with its 250ns instruction time leaves the rest at the starting gate.

Whether used in modems, multiplexers or channel adapters, the 8X300's blazing speed can get your data—and your sales—moving. Fast.

The PC board shown is a good example. Our 8X300 is the heart of this compact Bell-compatible OEM modem. It's the first 4800 bps modem in its class to measure only 100 square inches. And it wouldn't have been possible without the 8X300.

Put our 8X300 directly in your data path. And you'll get real-time data processing—even at T-1 data rates. You'll also benefit from bit-level control, unmatched programming ease and reduced parts count.

So if throughput is important to you, it's time you got through to us. We've got a fact-filled, 100-page 8X300 Programming Manual reserved for you. It describes all the instructions you can easily put to work on your next datacom design. For your free copy, contact your local Signetics sales office. Or use the coupon. Make us prove that fastest *is* best, and the 8X300 is why.

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E119

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"Now we make 16 wire-to-post connections as fast as we used to make one.

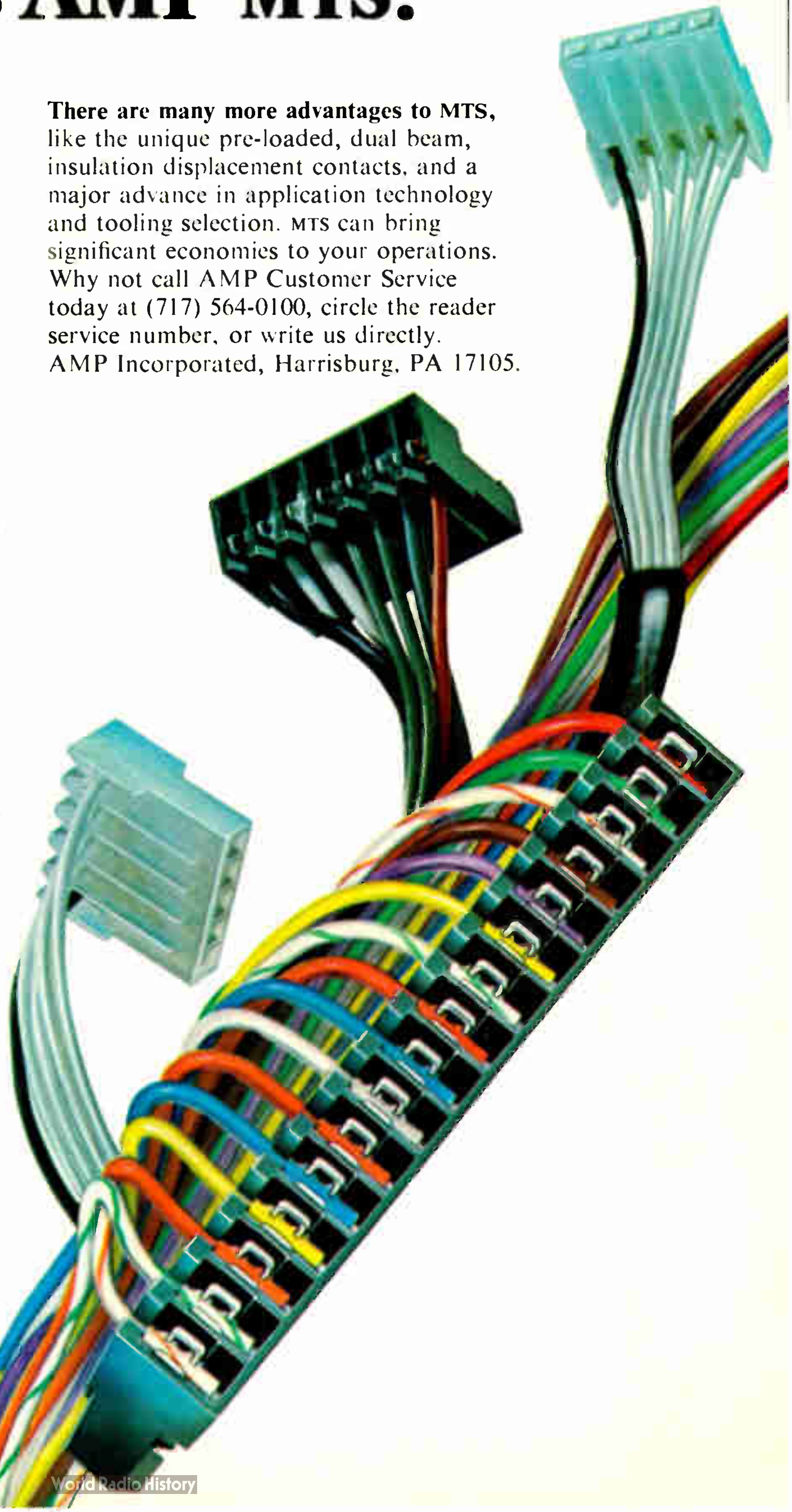
That's AMP MTS."

One stroke is all it takes to make up to 16 terminations on .100" or .156" centers with the new AMP MTS—Mass Termination System. Compare that to ordinary cut, strip, terminate and hand insert systems and it's easy to see why MTS saves so much time, increases quality and reduces rejects. It's the modern wire-to-post interconnection system for .025 and .045 posts.

MTS works with a wide array of wire sizes and types, ranging from discrete wire to ribbon cable, and all without wire stripping. It is compatible with present pin arrays and headers. And it includes a full selection of housings, post header styles and application tooling—from simple service tools to complete harness board tooling and cable makers.

This kind of versatility means MTS can be used in a variety of applications—on radio and TV sets, photographic equipment, copy machines, instruments, appliances, etc. And with every one you can depend on AMP technical assistance, even when you're in the early stages of product development. In fact, that's when we prefer to help. Because then our worldwide product development experience can assist you the most.

There are many more advantages to MTS, like the unique pre-loaded, dual beam, insulation displacement contacts, and a major advance in application technology and tooling selection. MTS can bring significant economies to your operations. Why not call AMP Customer Service today at (717) 564-0100, circle the reader service number, or write us directly. AMP Incorporated, Harrisburg, PA 17105.



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.

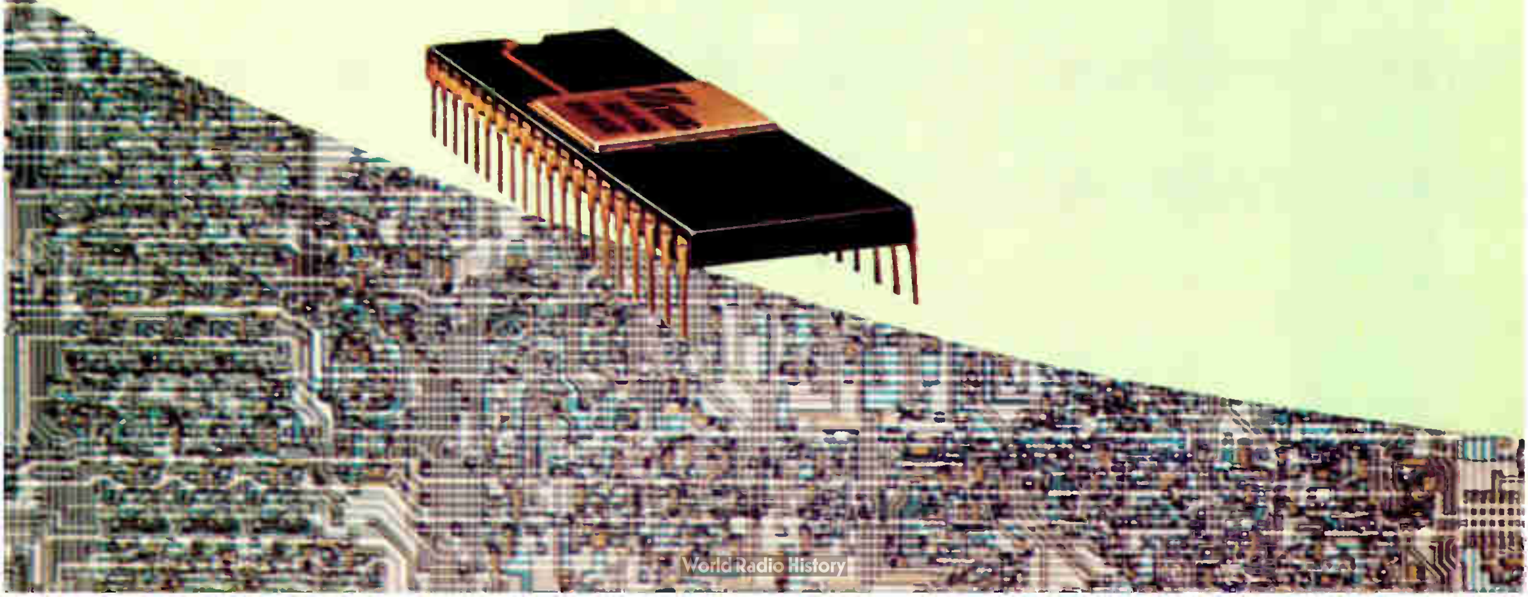
For your serial interface needs, there's the Z80-SIB. It gives you four independent, full duplex channels that can operate in either asynchronous or synchronous modes, as well as programmable baud rates independent of the system clock.

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.



Parallel testing keeps your memory traffic moving.

Your production line is probably spewing out a virtual river of memory devices: RAMs, ROMs, EPROMs up to 65K x 8 bits. Your test system can't be a bottleneck. It must pace the flow, not choke it.

Fairchild developed the Xincom 5581 Parallel Operation Memory Tester specifically to speed throughput and help reduce the cost of testing.

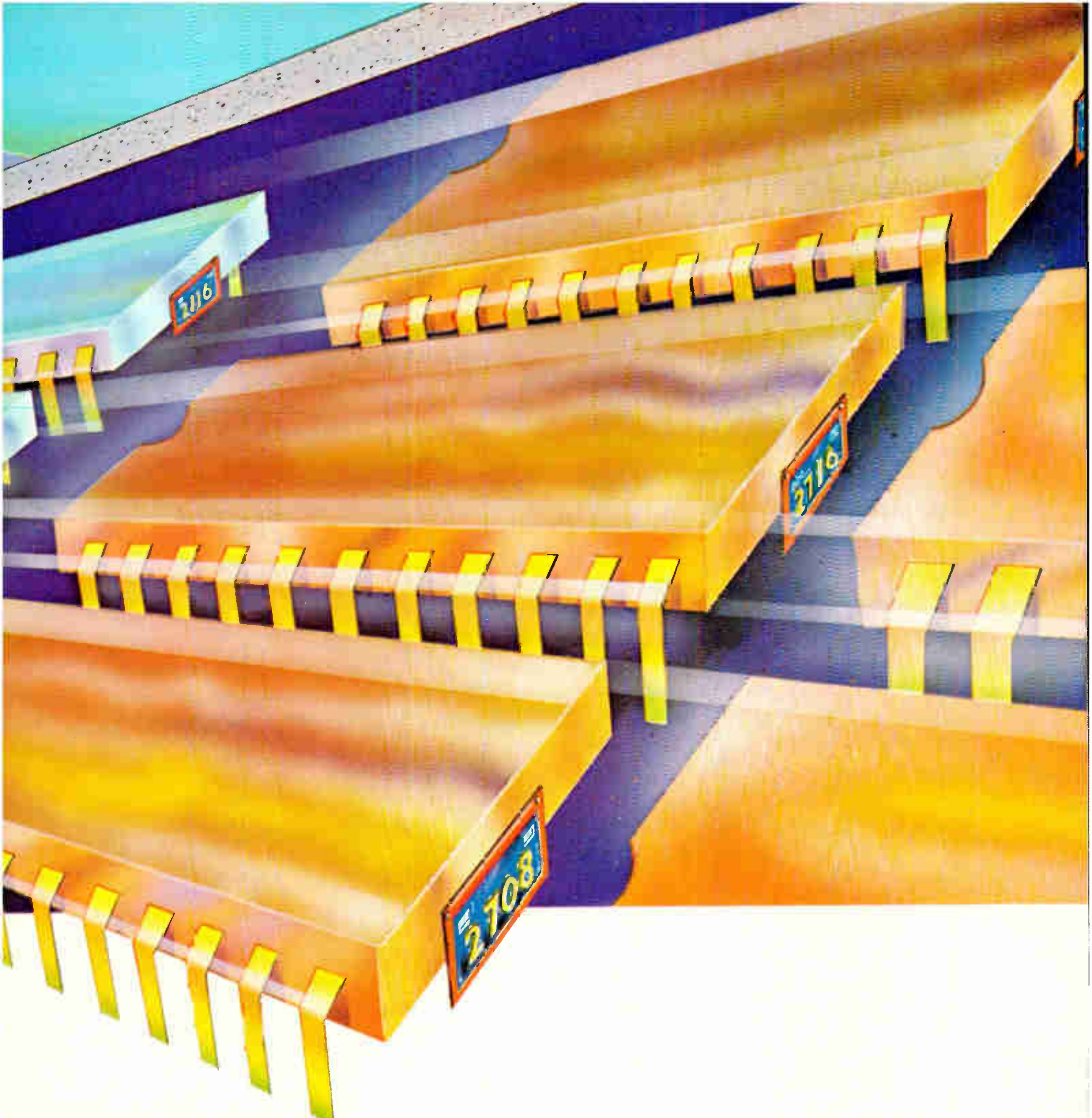
The 5581 is a high performance, functional and parametric memory tester. It can parallel test up to four 65K x 4 bit multiplexed address RAMs. And it's done with only two heads, each with two sockets or connectors for wafer probers or device handlers. Thus, the 5581 combines the throughput of a 4-head tester with the mechanical simplicity of a 2-head system.

In its maximum configuration the 5581 will handle:

- ☐ 65K x 4 bit RAMs with multiplexed addresses, four at a time with two at each test head:
- ☐ 65K x 8 bit RAMs and 4K x 8 bit ROMs two at a time, one in each test head:
- ☐ 65K x 8 bit RAMs or 4K x 8 bit ROMs time sequential with a different device at each head.

On-the-fly timing edge control provides test accuracy and reproducibility for production testing of dynamic MOS and bipolar memories.

The 5581 can be used as a stand-alone tester or as a satellite to the Xincom III distributed test



system. As part of the Xincom III test system, it can store, analyze and process vast amounts of test data or prepare schmoo plots, wafer maps, or trend graphs. You also get compiling and test program editing capabilities.

To really appreciate the accuracy and throughput speed of the 5581 you should see one in action. Since there are numerous systems already installed there's probably one close to you. We'll try to set up an appointment for you to see one. Just give us a call. Fairchild Test Systems Group, Xincom Division, Fairchild Camera and Instrument Corp., 1725 Technology Drive, San Jose, Ca 95110 (408) 998-0123

FAIRCHILD

Circle 23 on reader service card

Dealing with electromagnetic pollution

Electromagnetic pollution, some observers believe, may become one of the top environmental problems of our time because of the rapid proliferation of electronic products worldwide. The scope of the problem has been increasing steadily for some time, so that today there are millions of sources of electromagnetic radiation causing interference with other electronic devices, as well as with biological systems.

For starters, consider that there are 4,500 a-m and 4,000 fm radio stations in this country; 1,000 television stations, point-to-point microwave communications towers, and satellite ground stations; 40,000 circuit miles of overhead extra-high-voltage (345-to-765-kilovolt) ac electrical transmission lines; and 30 million citizens' band transceivers.

Add to this list common sources of electromagnetic energy—electric motors, arc welders, high-voltage switches, microwave ovens, and intrusion protection systems among them—and the potential for electromagnetic pollution is huge.

What's being done about the situation? One of the first steps has been the development of instrumentation for measuring and monitoring electromagnetic fields and power levels around the sources most likely to cause interference. In line with its charter to lead the coordination of measurement programs in the U. S., the National Bureau of Standards has taken a hand in this effort. It recently sponsored a workshop on electromagnetic pollution, aiming it at decision makers, rather than at laboratory researchers, and in fact bringing together manufacturers, consumer groups, and Government agencies for a common dialogue. For its part, the electronics industries have a stake in the development of consistent and compatible measurement methods to help determine the interference characteristics of electromagnetic radiation.

Therefore, the start NBS has made should be encouraged. Right now it is hard to predict the levels for various electronic equipment at which deleterious effects occur, because the information available on the electromagnetic environment is limited. The heart of the problem is that there is an inadequate data base for measurement techniques to establish either the total electromagnetic environment at any point or the susceptibility of a particular electronic system to that environment.

The problems caused by electromagnetic pollution range from merely annoying—TV picture interference—to dangerous—cardiac pacemaker disruption. In between, there are headaches such as computer malfunctions.

In addition, the nonthermal effect of low-level microwave radiation on living organisms is now a subject for much debate. Indeed, the potential biological hazards of low-frequency radiation from an antenna system used to communicate with submerged nuclear submarines led to its cancellation, leaving the Navy with no viable alternative.

The list of direct and indirect dangers or suspected dangers is mounting. It is clear then that more attention has to be paid to the electromagnetic pollution problem in all its forms before the situation becomes worse.

A 32K byte dual floppy microcomputer system for only $2900*complete.

Standard Features:

- Dual 8″ floppys store 500,000 characters on line
- 32K bytes of static RAM
- RS-232 C at 75 to 19,200 baud
- 16 line parallel I/O
- Rack or tabletop mounting
- UL-recognized power supplies
- BUS oriented computer architecture
- Four slots used — four slots open for expansion
- Comes complete with disk BASIC
- Includes Interactive Assembler/Editor
- Main processor is an ultra-fast 6502A
- Has auxiliary Z-80 and 6800 micros which allow execution of virtually all 6502, 6800, 8080 and Z-80 code!
- User programmable interrupt vectors on all three micros

The C3-OEM is an ultra-high performance microcomputer system. Its powerful 6502A microprocessor (now triple sourced) outbenchmarks all 6800- and 8080-based computers in BASIC and machine code using the BASIC and assembler provided standard with this system.

In fact, the C3-OEM executes standard BASIC language programs at speed comparable to small 16 bit minicomputers.

Ohio Scientific has a vast library of low cost software for the high performance 6502A including an on-line debugger, a disassembler, several specialized disk operating systems and applications programs such as our word processor package and a data base management system. However, the C3-OEM is not just limited to 6502 based software. This remarkable machine also has a 6800 and a Z-80 microprocessor.

The system includes a software switch so that machine operation can be switched from one processor to another under software control!

So, one can start with existing 6800, 8080 or Z-80 programs while developing new software for the ultra-high performance 6502A.

The C3-OEM isn't cheap. It's a quality product with mechanical features like UL-recognized power supplies, a three-stage baked-on enamel finish and totally modular construction.

It is the product of Ohio Scientific's thousands of microcomputer systems experience. In fact, all the electronics of the C3-OEM have been in production for nearly a year and have field proven reliability. And, best of all, this machine is available now in quantity for immediate delivery!

A full spectrum of add-ons are now available including more memory, up to 16 serial ports, 96 parallel I/O lines, a video display, a parallel line printer interface and a 74 million byte Winchester disk drive.

*25-49 unit price
1-4 $3590.
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10-24 $3100.

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Meetings

Eighth International Congress on Microelectronics, IEEE, Fairgrounds Congress Hall, Munich, Nov. 13–15.

CompSac 78—Second International Computer Software and Applications Conference, IEEE, The Palmer House, Chicago, Nov. 13–16.

Gomac-78—Government Microcircuit Applications Conference, U. S. Department of Defense (for information, contact Robert D. Larson, Wright-Patterson Air Force Base, Ohio), Del Monte Hyatt House, Monterey, Calif., Nov. 14–16.

24th Conference on Magnetism and Magnetic Materials, IEEE, Stouffer's Inn, Cleveland, Nov. 14–17.

Annual Assembly, Radio Technical Commission for Aeronautics, Sheraton National Motor Hotel, Arlington, Va., Nov. 16–17.

Symposium on Computer-Aided Design of Digital Electronic Circuits and Systems, The Commission of the European Communities (for information, contact Keness Belgium Congress SA, Brussels), Hilton Hotel, Brussels, Nov. 27–29.

Digital Equipment Computer Users' Society (Decus), U. S. Fall Symposium, Digital Equipment Corp. (Maynard, Mass.), San Francisco Hilton, San Francisco, Nov. 27–30.

Autotestcon 78, International Automatic Testing Conference, IEEE, Hilton Mission Bay Hotel, San Diego, Calif., Nov. 28–30.

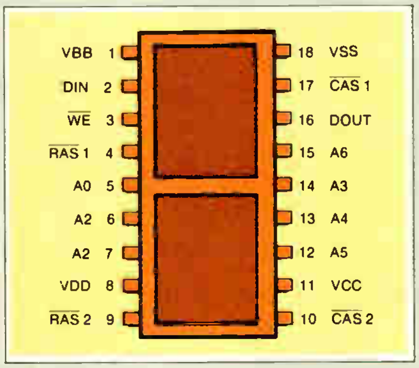
10th Annual Precise Time and Time Interval Applications and Planning Meeting, Naval Electronic Systems Command (Washington, D. C.) at the Naval Research Laboratory, Washington, D. C., Nov. 28–30.

Annual Convention of the Association of Computing Machinery (Mountvale, N. J.), Sheraton Park Hotel, Washington, D. C., Dec. 4–6.

International Electron Devices Meeting, IEEE, Washington Hilton Hotel,

Mostek's 32K RAM. Double up for system density.

Mostek's 32K RAM doubles system density without increasing package count. By utilizing the industry standard 4116 in a dual device package configuration, Mostek now offers a 32K X 1 Random Access Memory module that's pin-compatible with 16-pin 4K, 16K and next-generation 64K dynamic RAMs.



The MK4332D is manufactured by mounting two MK4116 RAMs in leadless chip carriers onto a standard 18-pin DIP mother board. The assembled module has the same package dimensions as an 18-pin cerdip package, permitting the module to be used with standard automated handling and test equipment.

The two chips share common Address, Data In, Data Out, Write Enable, and Power pins. Separate RAS and CAS clocks for each MK4116 are provided for easy device selection and control.

The MK4332D-3 features an access time of 200ns with a cycle time of 375ns. And operating power is just 482 mW active and 40 mW standby (max). It requires a ±10% tolerance on all power supplies (+12V, ±5V).

The MK4332 offers 4116 performance and ease of use but allows greater memory density. Samples of the MK4332 are available now. Full production is scheduled for the 4th quarter, with optional pin configurations available.

For more information on Mostek's 32K RAM, contact Mostek, 1215 West Crosby Road, Carrollton, Texas 75006; Telephone 214/242-0444. In Europe, contact Mostek Brussels; Telephone (49) (0711) 701045.

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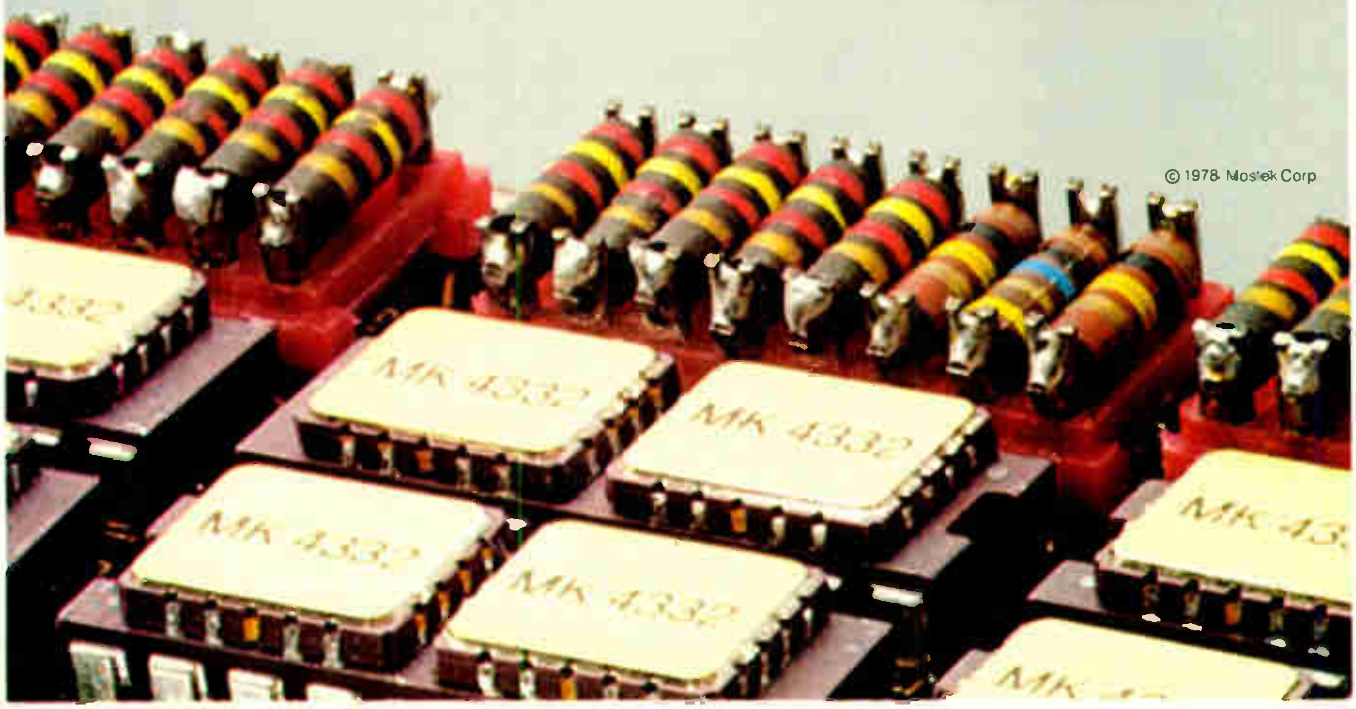

Meetings

Washington, D. C., Dec. 4–6.

National Telecommunications Conference, IEEE, Hyatt Hotel, Birmingham, Ala., Dec. 4–6.

Winter Simulation Conference, IEEE, Deauville Hotel, Miami Beach, Fla., Dec. 4–6.

Midcon 78 Show and Convention, Electronic Conventions Inc. (El Segundo, Calif.), Dallas Convention Center, Dallas, Dec. 12–14.

Computer Networking Symposium, IEEE, the National Bureau of Standards, Gaithersburg, Md., Dec. 13.

Third Biennial University/Industry/Government Microelectronics Symposium, IEEE, Texas Tech University, Lubbock, Texas, Jan. 3–4.

Winter Consumer Electronics Show, Electronic Industries Association, Las Vegas Convention Center, Las Vegas, Nev., Jan. 6–9.

17th Conference on Decision and Control, IEEE, Islandia Hyatt House, San Diego, Calif., Jan. 10–12.

Conference on Reliability and Maintainability, IEEE, Shoreham Americana Hotel, Washington, D. C., Jan. 23–25.

Communication Networks Conference & Exposition, The Conference Co. (Newton, Mass.), Sheraton Park Hotel, Washington, D. C., Jan. 30–Feb. 1.

Wincon—Aerospace & Electronic Systems Winter Conference, IEEE, Sheraton Universal Hotel, Los Angeles, Feb. 6–8.

International Solid-State Circuits Conference, IEEE, Sheraton Hotel, Philadelphia, Feb. 15–17.

ICE 79—International Computer Expo, Marcom International Inc. (Tokyo) and Golden Gate Enterprises Inc. (Sunnyvale, Calif.), Tokyo Harumi Fairgrounds, Tokyo, Feb. 28–March 2.

Move over 2114s. Mostek's 8K static RAM is moving in!

Double your system density by replacing two 2114s with Mostek's new MK 4118 8K static RAM. In addition, you gain significant improvements in speed, power, and design flexibility over older generation 2102 and 2114 static RAMs.

Organized as 1K X 8 bits, the MK 4118 is designed to interface directly with all present and future generation microprocessors. A Chip Select control is provided for easy memory expansion and decoding, and internal latches are available to latch the Address and Chip Select inputs, further simplifying system design. If the Latch function is not needed, it can be bypassed by connecting the Latch control input to +5V (the only power supply needed for the MK 4118). A fast Output Enable function (50% of address access) allows easy control of the data bus in all bus configurations.

MK4118 Family

	Access Time	Cycle Time
MK 4118-1	120 ns	120 ns
MK 4118-2	150 ns	150 ns
MK 4118-3	200 ns	200 ns
MK 4118-4	250 ns	250 ns

All inputs and outputs are TTL compatible, and the MK 4118 is pin compatible with standard 24-pin ROMs, PROMs, and EPROMs, such as the MK 2716.

Advanced circuit design and Mostek's Poly R™ process technology are combined to pack 8K bits of static RAM on a chip comparable in size to 4K static RAMs. Performance, reliability, flexibility, compatibility. The 4118 is the obvious choice. For information contact Mostek, 1215 West Crosby Road, Carrollton, TX. 75006. Telephone 214/242-0444. In Europe, contact Mostek, Brussels; Telephone (32) 02/660.25.68.66013.

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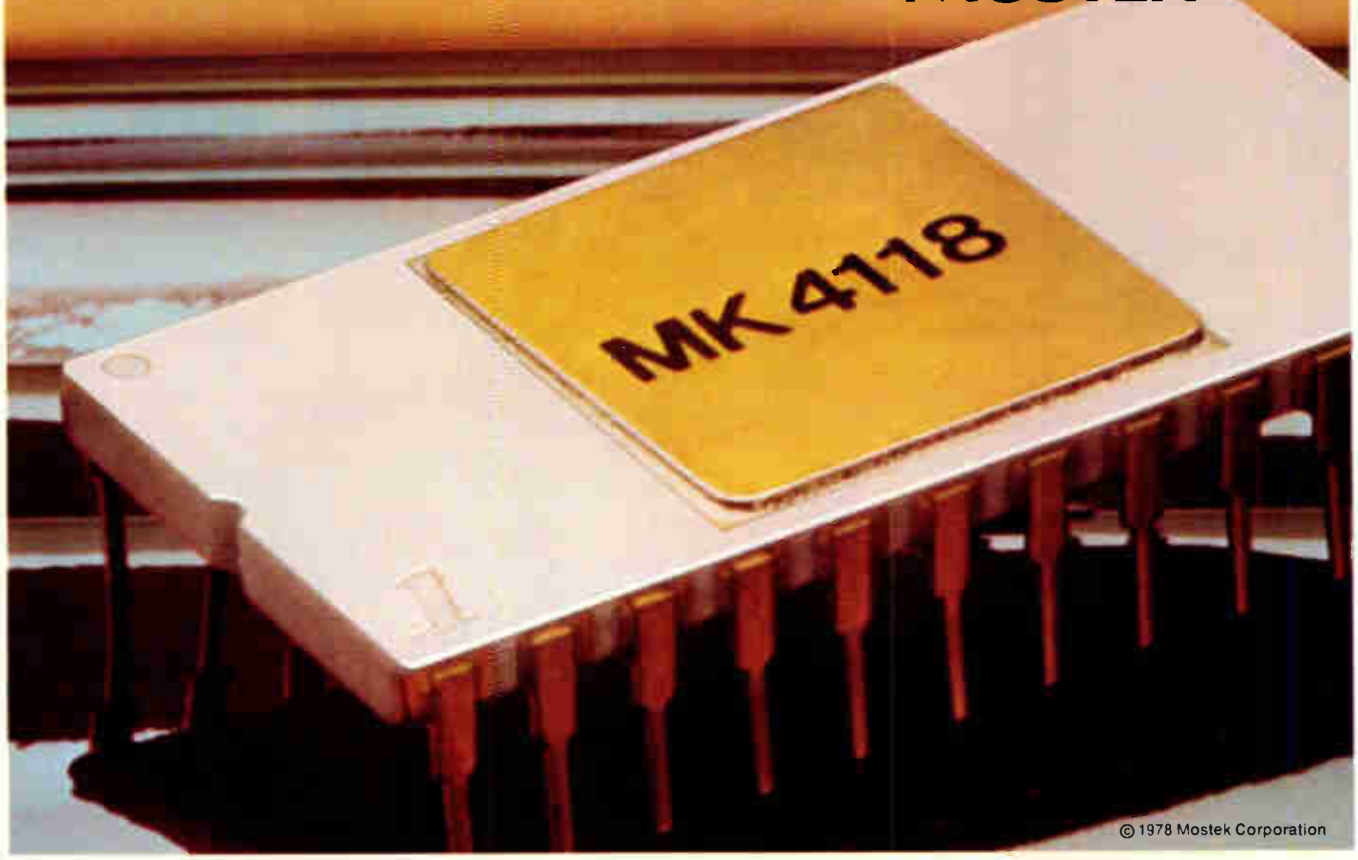


System 45:

Our friendly computer could speed through your tough technical problems...

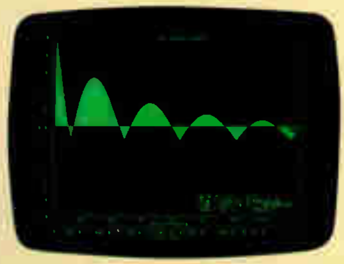
if the boss would just get finished with his.

He has problems, too. The versatile System 45, along with HP-created management programs, can help him with forecasting, project management, basic statistics —even payroll and inventory control. He can also create and access departmental data bases for administrative chores. But you won't wait but a couple of minutes because the System 45 is a speedy workhorse. When it's your turn, you, too, can take advantage of HP programs for applications as diverse and as valuable as differential equations, waveform analysis, eigenvalues and eigenvectors, regression analysis, linear equations and numerical integration to name a few.

You'll get answers fast. System 45 will display a 20 variable, 20 constraint linear programming solution in under five minutes. And tackle a Fast Fourier Transform of a set of a 1,024 full precision data points in less than a minute.

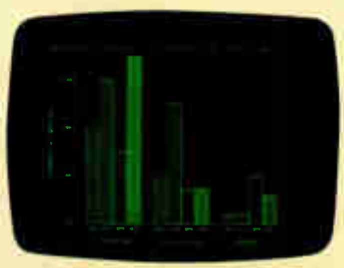
Anyone in your department can easily create and run their own special programs using System 45's enhanced BASIC language.

You can generate charts and graphs, interface with your instruments, add peripherals for extra storage, input and output. You can solve problems needing up to 62K bytes of



Waveform Analysis

Regression Analysis



Bar Chart

memory. Stated simply, System 45 is powerful, versatile and friendly: a productive, cost-effective tool for practically everyone in your department, even the boss. For brochures describing System 45 and the HP programs of interest to you, call the HP Literature Center toll-free day or night. The number is 1-800-821-7700, extension 302. (In Missouri, call 1-800-892-7655, extension 302.)

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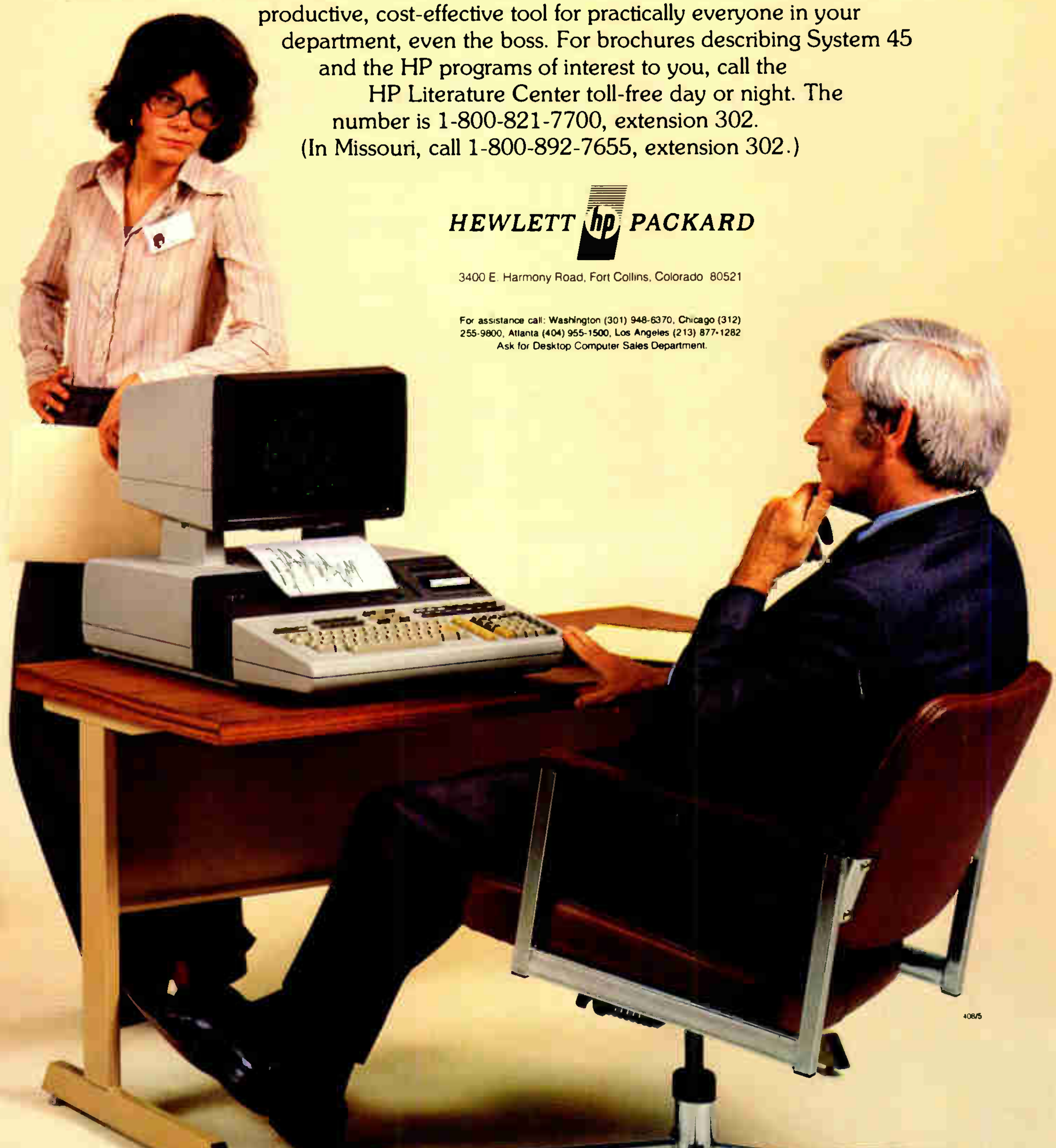
Ask for Desktop Computer Sales Department.



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Andrews Plot

Active Filter Design

RIA QC Plot

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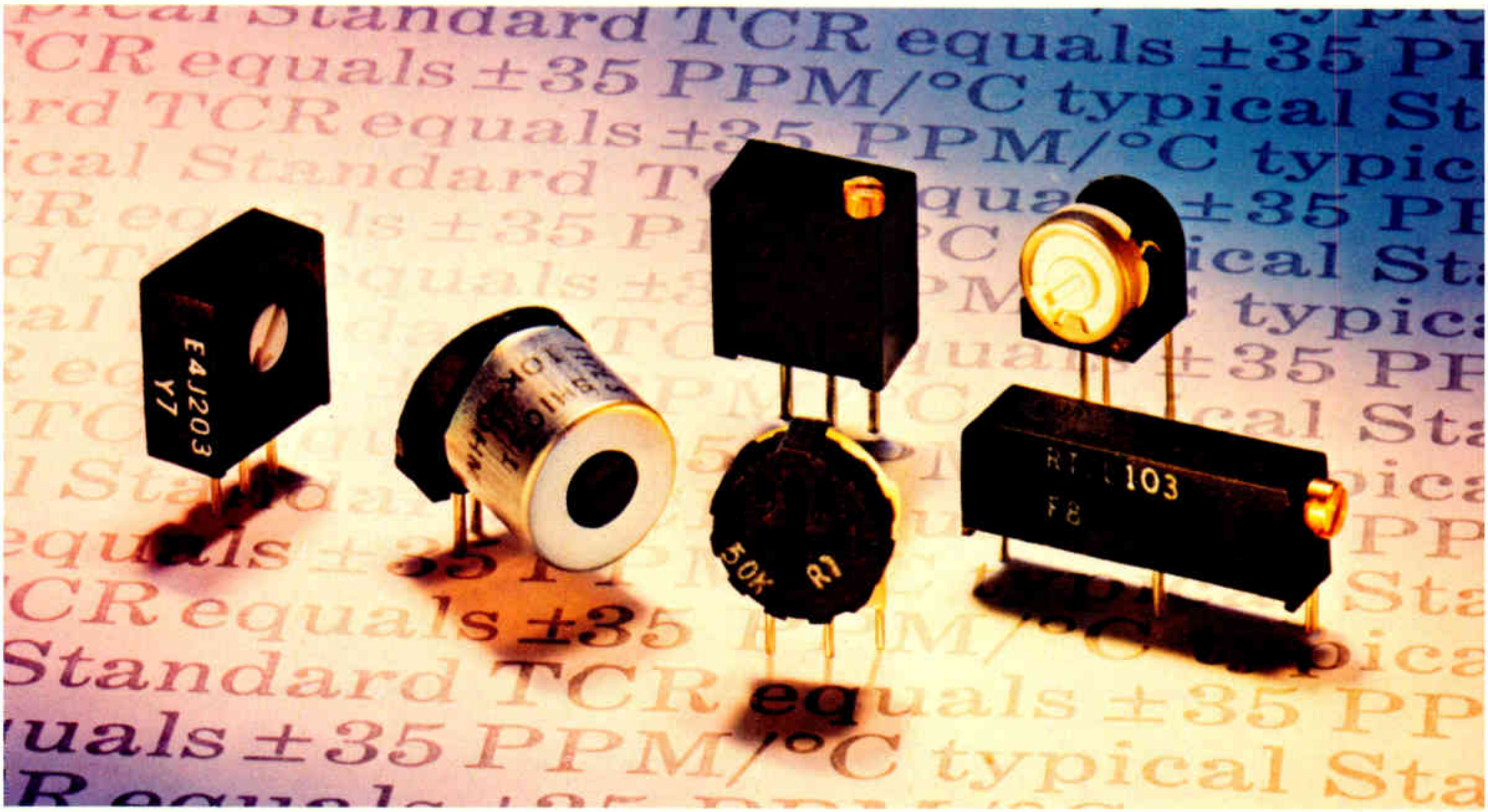
Ours: TCR equals ±35 PPM/°C typical.
Theirs: Extra cost or unavailable.

New cermet resistive element gives A-B trimmers a standard TCR of ±35 PPM/°C typical. Plus a typical 1% CRV. Easy "set-and-forget" adjustability and unmatched stability over a wide temperature range. 6 trimmers, 10 ohms to 2.5 megs., 41 terminal options, variety of sizes, shapes and enclosures. Satisfies the majority of your trimmer applications. We have what you need. Our distributors have them when your need is now. Ask for Publications listed below.

TYPE	TCR LESS THAN 500 OHMS	RESISTANCE RANGE AND TOLERANCE	POWER RATINGS	OPERATING TEMPERATURE RANGE	PUBLICATION NUMBER
A	ALL ±35PPM/°C TYPICAL	10 ohms to 2.5 megs ±10%	0.5 W @ 85°C	−55°C to +150°C	5238
D		10 ohms to 2.5 megs ±20%	0.5 W @ 70°C	−55°C to +125°C	5240
E		10 ohms to 2.5 megs ±10%	0.5 W @ 70°C	−55°C to +125°C	5219A
S		50 ohms to 1 meg ±10%	0.5 W @ 85°C	−65°C to +150°C	5208
*MT		100 ohms to 2.5 megs ±20%	0.5 W @ 70°C	−55°C to +125°C	5241
*RT		10 ohms to 2.5 megs ±10%	1.0 W @ 40°C	−55°C to +125°C	5237

*20 turns nominal. All others single turn.



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Circle 32 on reader service card

Electronics newsletter

Eyes of 64-K RAM world are on Texas

In terms of dynamic MOS random-access memories at least, it looks like Silicon Valley may take a back seat to Texas. Next to join Texas Instruments Inc.'s 64-K dynamic RAM may well be two competing Texas-bred products. **Motorola's MOS integrated-circuit operation in Austin is planning introduction of its 64-K part next month,** with Carrollton-based Mostek Corp.'s MK4164 expected in early 1979. The Motorola contribution to the budding Texas triumvirate is scheduled in sample quantities in the first quarter next year, offering access times of 150 ns and a single 5-V supply requirement.

IC equipment makers cautioned on cost in 1980s

Alarmed by projections of spiraling production costs for very large-scale integrated circuits in the 1980s, semiconductor manufacturer Intel Corp. is admonishing process-equipment makers to hold down prices. **"There will be an upper limit to even the largest VLSI company's capital budget,"** Will Kauffman, director of component production, told a recent dinner meeting of the Semiconductor Equipment and Materials Institute in Palo Alto, Calif. He pointed out that the cost of an average wafer-fabrication module has increased five times since 1972 to $10 million and could jump to $50 million by the mid-1980s.

Standard modem due in January from Rockwell

Jumping into the standard, off-the-shelf modem market, Rockwell International Corp. will have samples of a 2,400-b/s unit ready in January. An entry from the Microelectronic Devices division in Anaheim, Calif., **it consists of three modules—two receivers and a transmitter—and occupies only 25 in.^{2}** It is aimed directly at remote terminals.

Fairchild readies 8-bit-slice ECL family

Calling them the most advanced microprocessor building blocks, Fairchild Camera and Instrument Corp., Mountain View, Calif., is preparing a family of 8-bit-slice, emitter-coupled-logic integrated circuits for a mid-1979 introduction. All four family members—the address and data interface unit, multifunction network, dual-access stack, and programmable interface unit—are bipolar, ECL chips ranging in density from 800 to 1,200 gates on chips approximately 47,000 mil^2, the company says.

Millennium adds 8085 to analyzer's emulation list

With interest growing in its Microsystem Analyzer field-service tool as a test instrument for original-equipment manufacturers, Millennium Systems Inc. of Cupertino, Calif., has broadened the analyzer's capabilities **to include emulation of Intel's 8085 at both 3 and 5 MHz.** In addition to the recently announced deal with Motorola Inc.'s Semiconductor Group, Millennium says it is negotiating with three other semiconductor makers.

One-chip micros with built-in E-PROMs coming

As semiconductor manufacturers gain confidence in processes for making ultraviolet-light–erasable programmable read-only memories, one-chip microcomputers with built-in E-PROM are appearing. **Look for first-of-the year samples of E-PROM versions of Texas Instruments Inc.'s 16-bit 9940 and Mostek Corp.'s 3870.** Fairchild, whose F8 chip set was turned into the one-chip 3870 by Mostek, will build an E-PROM 3870 as well, the F38E70, to be available in spring of next year. Mostek's own route is different: it will take the ROM off the chip and use an off-board E-PROM.

Electronics newsletter

Mostek to serve as second source for Intel 8086

Mostek Corp. has dropped the other shoe: the Carrollton, Texas, company, which second-sources Zilog Inc.'s Z80 microprocessor but won't be able to build the Z8000 because Advanced Micro Devices Inc. signed a contract with Zilog, will instead second-source Intel Corp.'s 8086. Rather than masks, Mostek will receive all the necessary logic specifications it needs to engineer its own functionally compatible version of the 16-bit chip. All Santa Clara, Calif.–based Intel will gain at this time is greater market acceptance; **additional portions of the agreement, however, will be announced next month.**

Flat panels use one-on-one drive circuits

A new company using flat-panel-display technology developed for Westinghouse Electric Corp. plans to have its first product ready within a year. Called PanelVision Inc., the firm is headed by T. P. Brody, who developed the electroluminescent technology for Westinghouse that he is taking with him with the company's blessings. **The display in effect has individual drive circuits lined up behind each of the 25,000 display elements** to eliminate time-multiplexing schemes. Now PanelVision will use that technique to build a 190-column-by-128-row liquid-crystal display.

AMD joins the crowd in 2147 market

After having its own way in the market for high-speed 4,096-by-1-bit static random-access memories, Intel Corp., Santa Clara, Calif., is starting to draw competitors for its proprietary 2147 design. Advanced Micro Devices Inc., in nearby Sunnyvale, plans to have samples ready early in 1979 of its 9147, an edge-triggered device with equivalent 55-to-70-ns access times and comparable power-supply currents of 180 mA in the active mode and less than 30 mA in standby. Made on AMD's scaled-down n-channel MOS technology featuring 3-μm geometries, arsenic source drains, and projection printing, **the 9147 measures less than 17,000 mil^2, or a third smaller than the 2147.** Others reported readying parts are American Microsystems Inc., Fujitsu, Hitachi, Mostek, Motorola, and Texas Instruments. TI also is developing a vertical MOS version to check out that process.

IBM building new chips on automated line

As interesting as IBM Corp.'s new chip technologies (see p. 39) is its highly automated production line. Air tracks move the serially processed wafers from one operation to the next under computer control. **Because each wafer has a serial number, those containing 18-K, 32-K, and 64-K parts can be intermixed.** Instead of quartz boats used to process batches of wafers, trays carry individual wafers through continuous diffusion furnaces whose parameters can be modified while in use.

Addenda

Look for General Telephone Co. of Indiana to install a GTE Lenkurt fiber-optics system to interconnect two switching centers that provide regular service to Fort Wayne customers. To be installed in 1979, this Indiana first will also be **one of the few working optical telephone systems in the world.** . . . . McGraw-Hill Inc.'s annual survey of American industry's capital spending plans shows an increase of 10% above the anticipated 1978 figure. However, an 8% rise in the price of equipment **will hold real growth to a modest 2%.**

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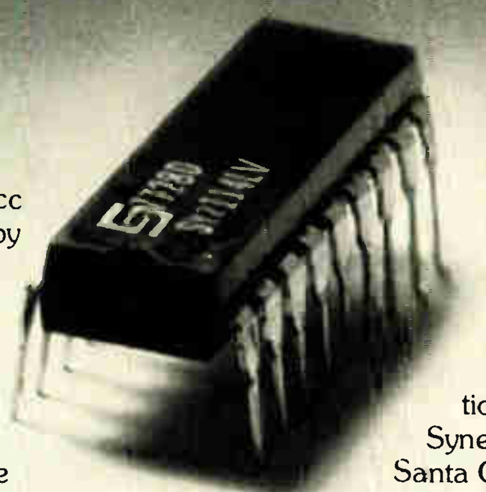

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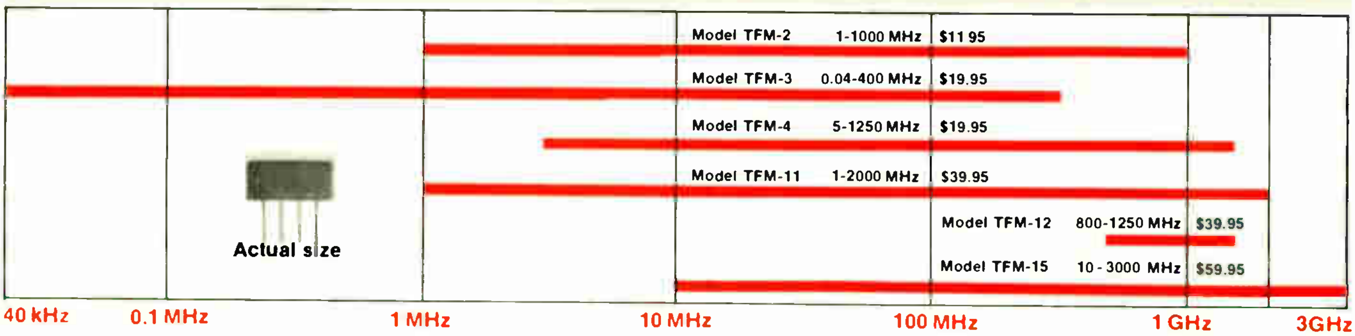

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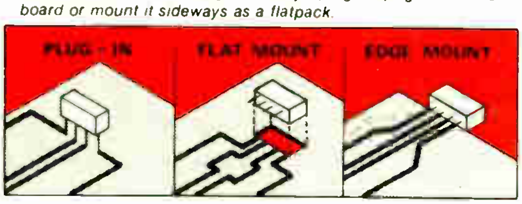

Model	Frequency, MHz			Conv. loss, dB				Isolation, dB												Cost	
				One Octave From Band Edge		Total Range		Lower Band Edge To one Decade Higher				Mid Range				Upper Band Edge To Octave Lower					
								LO-RF		LO-IF		LO-RF		LO-IF		LO-RF		LO-IF			
Model No	LO	RF	IF	Typ	Max	Typ	Max	Typ	Min	Typ	Min	Typ	Min	Typ	Min	Typ	Min	Typ	Min	Quantity	Price
TFM-2	1-1000	1-1000	DC-1000	6 0	7 5	7 0	8 5	50	45	45	40	40	25	35	25	30	25	25	20	6-49	$11 95
TFM-3	04-400	04-400	DC-400	5 3	7 0	6 0	8 0	60	50	55	40	50	35	45	30	35	25	35	25	5-49	$19 95
TFM-4	5-1250	5-1250	DC-1250	6 0	7 5	7.5	8 5	50	45	45	40	40	30	35	25	30	25	25	20	5-49	$19 95
TFM-11	1-2000	1-2000	5-600	7 0	8 5	7 5	9 0	50	45	45	40	35	25	27	20	25	20	25	20	1-24	$39 95
TFM-12	800-1250	800-1250	50-90	—	—	6 0	7 5	35	25	30	20	35	25	30	20	35	25	30	20	1-24	$39 95
*TFM-15	10-3000	10-3000	10-800	6 3	7 5	6 5	9 0	30	20	30	20	30	20	30	20	30	20	30	20	1-9	$59 95

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Circle 38 on reader service card

IBM shows off an unusual new family of dynamic RAMs

Computer maker takes own route: chips use double-metal nitride process, redundant bits in 64-, 32-, and 18-K parts.

From the first use of metal-oxide-semiconductor random-access memories in its mainframe computers in late 1972, International Business Machines Corp. has been content with 2,048-bit chips—even in the face of semiconductor industry progress to 4-K and 16-K devices. Now the computer giant has clambered to the head of the class with a new memory family that contains 18-K, 32-K, and 64-K versions.

But IBM's designs break all the rules that semiconductor makers adhere to: they are large, slow, and power-hungry, and they use uncommon multiple power supplies. What's more, they have redundant storage cells and a built-in programmable read-only memory for masking out bad bits.

The new chips were announced earlier last month as part of the 8100 [*Electronics*, Oct. 26, p. 88] and System/38 (see p. 81) computers, but IBM's General Technology division, Burlington, Vt., which builds the chips it began developing in 1976, delayed for a while before talking about them. Then, at a press conference held on Oct. 31 at its 1.3-million-square-foot semiconductor manufacturing facility, it divulged its unusual n-channel metal-gate technology.

Different. According to James K. Picciano, manager of advanced memory products engineering, the chips are made by optical projection printing and use 2.5-micrometer design rules. But that is where the similarity to the approaches of high-density memory makers ends.

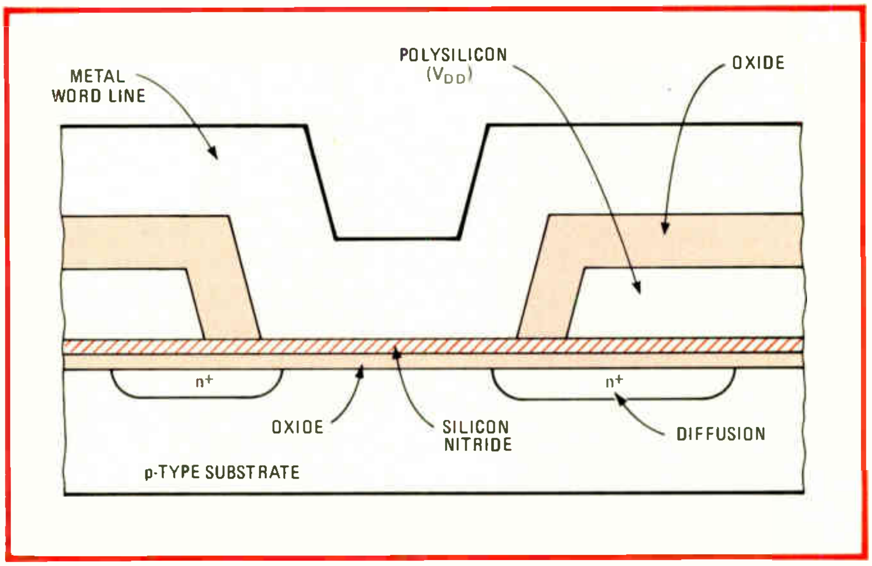
For one, IBM is using a double-metal process—its transistors have metal gates, with a second layer of metal laid down over a polyimide insulating layer to form the interconnecting column lines. Most semiconductor manufacturers use two layers of polysilicon instead. The double-metal structure yields slower speed and larger cells: IBM's 64-K-by-1-bit device, at more than 63,000 mil², for example, is about twice the size of Texas Instruments' TMS 4164, and its worst-case access time of 440 nanoseconds is three times longer. (Also, its power consumption is 360 milliwatts, versus TI's 200 mw.)

As for the other chips, the 18-K RAM (its odd size is due to a 2-K-by-9-bit organization) is a 40,000-mil² chip that is faster than the 64-K part—its worst-case access time is 140 ns—but dissipates a whopping 690 mw. It has 500 redundant bits. The 32-K chip is 60,000 mil² and is organized as 8-K by 4 bits. Dissipating 612 mw, the part has an access time of 190 ns and packs 2,000 redundant bits.

Edward M. Davis, vice president for development and manufacturing, says that to IBM the design is not as unorthodox as it might appear. "The chips are not designed to compete in the semiconductor industry, but rather to meet IBM's systems needs," he explains. For example, the three voltage supplies on the 64-K and 18-K chips (+8.5, +3.5 to 4.0, and −2.2 v) were chosen, he says, "because they are commonly used in IBM computers."

The new memory-cell structure (shown in partial cross section below) uses a combined insulating layer of oxide and silicon nitride, a first for RAMs. The double insulator, says IBM, buys greater reliability and improved yields, since device defects are often attributable to pinholes in insulating layers.

Yield. Apparently, the driving force in IBM's approach has been yield: incorporated into each of its



Odd cell. IBM's 64-K RAM uses n-channel metal-gate transistors. Nitride-oxide sandwich for gate insulator and capacitor dielectric adds to the 63,000-mil² chip's reliability. Not shown is the second metal layer, which forms the column or bit interconnections.

three new chips are redundant bit cells to get more good die per 3¼-inch wafer. Putting in such extra bits to serve in place of bad ones is not even being considered by semiconductor makers for their 256-kilobit designs.

IBM's 64-K chip, for example, has about 2,500 extra memory cells. Fusible links, much like those in programmable ROMs, mask out the bad bits in the final testing stage of production. IBM blows the fuses in order to produce a fully functional 65,536-bit RAM.

Not even in the package has IBM striven for compatibility with standard semiconductors. Instead, it is using a modular scheme to put four chips or more into a 1-in.^{2}, 51-pin ceramic package containing 256 kilobits.

IBM uses a flip-chip technique that allows connections to the middle of each chip. It can also use partial chips—a 64-K RAM with only half that many good bits, for example. Two ceramic carriers, each with four such chips, can be piggybacked to make a 51-pin, 256-K package.

What happens when 64-K parts from the semiconductor manufacturers drop in price? "We're not concerned about the uniqueness of our design cutting us off from outside procurement," says Thomas M. Liptak, president of the division. "We can always build a board with others' 64-K chips that will be compatible," he explains.

IBM also has some unusual plans for its new chips. According to Picciano, the 64-K device is only 30% memory—the large nonmemory area in the chip's center contains a bidirectional data bus and an 8-bit buffer register that is independent of the 64-K array, plus "other functions we can't disclose, since they're not yet used in IBM products."

Other computer vendors, primarily in the minicomputer area, are studying 64-K RAMs. However, since many have just started using 16-K parts, it is likely they will hold off switching. Mainframe vendors will wait for faster speeds before going to denser devices. □

Semiconductors

V-MOS makes gains in power devices at General Electric, in frequency at Tektronix

Ever since Siliconix Inc. introduced its first commercial vertical-groove metal-oxide-semiconductor power FET in 1976, V-MOS has been hailed as the process of choice for power devices. Now these field-effect transistors are proving their worth in applications that exploit their fast switching rate and low turn-on resistance—mainly in switching power supplies.

At this year's International Electron Devices Meeting in December, researchers will reveal how they have extended the operating voltage and frequency of developmental V-MOS power devices in the laboratory. Power semiconductor manufacturer General Electric Co. and component user Tektronix Inc. have come up with some novel ways to get more out of V-MOS.

Using what they call an ion-implant junction termination extension (JTE) technique, engineers at GE's corporate research and development center in Schenectady, N. Y., have extended V-MOS power FETs to a 600-volt breakdown level. This unusual ion-implant technique has enabled GE to attain from 85% to 95% of the ideal breakdown voltage at the block junction compared to the 50% to 80% possible with other passivation technologies. GE implants p-type material laterally into the device, thereby extending the pn junction area for 2 to 3 mils needed for the high breakdown voltage (see part a of figure).

Balancing specs. As if that were not enough, GE has attained 7-ohm turn-on resistance from the transistor, a major accomplishment considering that for a device with a fixed breakdown electric field the ideal on-resistance is the square of the ideal breakdown voltage of the drain region. By extending the electric field through the JTE technique, GE was able to strike a balance to obtain an optimum on-resistance for a desired breakdown voltage. Another technique to reduce on-resistance was to have the gate region overlap the drain region so the gate current spreads from a larger area to the drain. The amount of overlap was determined by the desired cut-off frequency for this device—15 to 20 megahertz.

GE's research engineer, V. A. K. Temple, wants "to be able to stretch the breakdown to a 700-V level, a comfortable margin for products powered off a 220-V ac line."

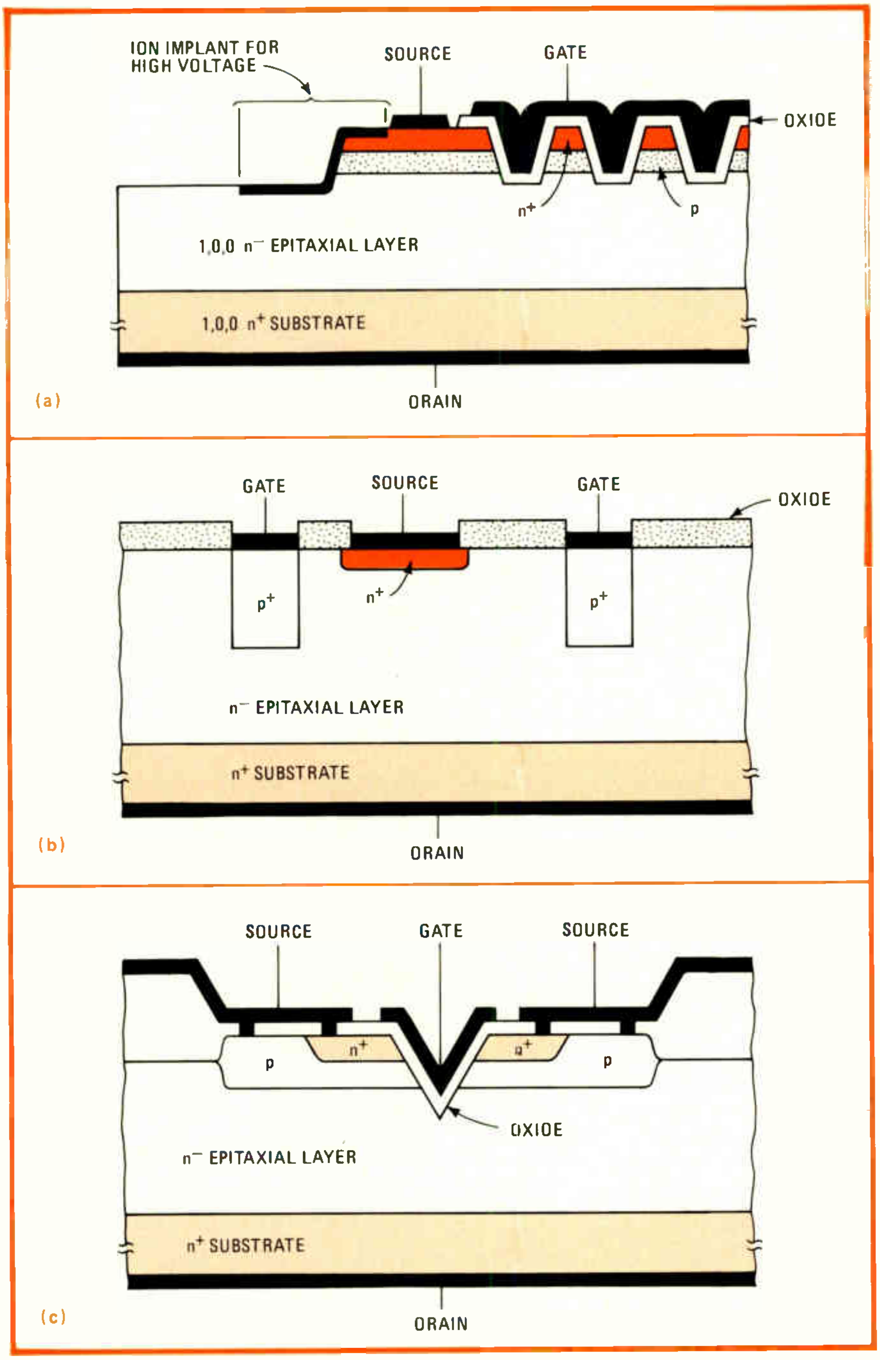
Elsewhere in the GE research center, Jayant Baliga is working on another kind of FET; this one a surface-gate JFET for signal circuits that have breakdown voltages exceeding 200 V and differential blocking gains greater than 30. That is six times higher than previously attained blocking gains for surface-gate devices.

Extensions. The superior gain, a ratio of drain-source voltage to gate-source voltage at breakdown, is accomplished by extending the gate walls vertically into the p-type material instead of using a conventional V-groove structure (part b of figure).

The vertical walls provide better depletion-layer punch-through in the p channel because the channel walls are further apart than at the bottom of a V groove. The rectangular structure retards the penetration of the drain potential into the channel region, as well, to maximize switching control of the device.

Also, the rectangular gate structure eliminates serious current-loss problems associated with metal discontinuities occurring at the edges of similar devices with V grooves. All of this, however, is at the expense of increased on-resistance. At a typical gate bias voltage of 4 V, the on-resistance is 16 ohms.

Meanwhile, Tektronix Inc. of



V-MOS power. Extending the pn junction by implanting ions 2 to 3 μm laterally along the n− epitaxial region produces breakdown voltages that reach 85% to 95% of the ideal breakdown for GE power FET (a). A high blocking gain is achieved in GE surface-gate junction FET (b) by the p+ rectangular-walled gate region, 25 μm deep, formed in the n− epitaxial layer. The nonplanar structure permits the interconnection of large-area devices with little parasitic capacitance in the Tektronix V-MOS transistor (c). Microwave frequency operation is achieved by producing devices with submicrometer gate lengths.

Beaverton, Ore., which produces many of its own components for its instruments product line, is developing a V-MOS device that can work at 1.5-gigahertz frequencies. Tektronix achieved this frequency by ion-implanting the submicrometer channel structure with boron and arsenic.

On a 30-by-35-mil die, a 6-ohm-cm epitaxial layer is grown on a highly doped n+ 1, 0, 0 substrate (part c of figure). After a short initial oxidation and silicon nitride deposition, the channel is implanted with boron. In a sequential masking step, the source is implanted with arsenic and annealed.

The fine-line V groove openings are etched anisotropically and an oxide layer is deposited in a pattern that results in lower gate capacitance. The breakdown voltage of 100 V at a 0.5-A drain current was reached by using gold contacts for wire bonding to the pads. □

Lasers

Lasers link computer and traffic lights

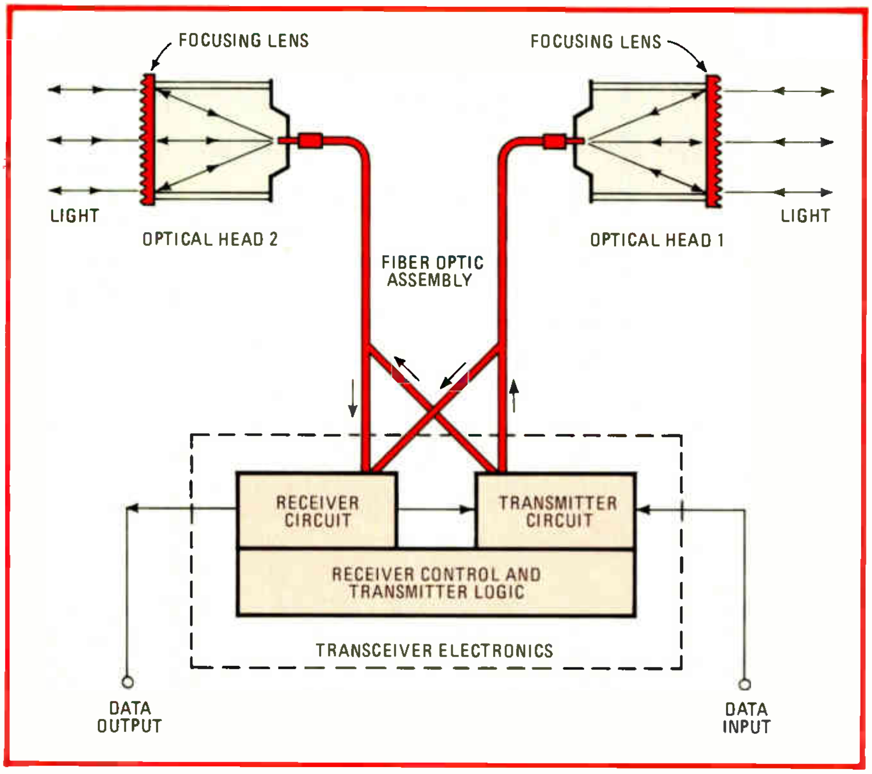
The digital computer in a traffic-light control system is usually coupled to the lights by leased telephone lines or dedicated city-owned cables. Either system is costly, disrupts traffic when it is being installed, and is often an eyesore.

Now the first free-space–transmission laser link between the computer and the traffic signals is being installed at several intersections in Atlanta, Ga. Though it is difficult to make direct cost comparisions, the laser links will be far less expensive than buried cable at $15 a foot.

"The system transmits information over an extremely low-intensity laser beam whose power is about that of a normal flashlight beam," says Ralph Mancuso, research section head of traffic and transportation systems at the Sperry Systems Management operation in Great Neck, N. Y.

Simple. Furthermore, he says, the system is conceptually simple: "A master computer sends commands via the laser beams to the intersection controllers that govern the traffic signals. It is programmed to respond to changing traffic flow data received over wires from vehicle detectors buried in the roadway."

The laser system can control traffic in urban grids ranging from 2 to 500 intersections. In Atlanta, four



Duplexing. Laser head at each intersection is connected to transceiver by a single duplexed fiber-optic bundle, eliminating need for two separate optic systems.

lights at intersections outside the North Georgia Regional Postal Center will be supervised.

Extensive tests of this installation's system have already answered the obvious questions of what happens to the laser light transmission when there is fog and whether the laser radiation is dangerous to humans or animals.

It turns out that the system will send messages with adequate signal-to-noise ratios up to 10 miles in clear visibility and 2,000 feet in heavy fog—more than adequate for this application. Moreover, the Bureau of Radiological Health Standards has certified it as safe for eyes. In addition, the narrow beam width (1 to 5 milliradians) of the transmitted radiation and the mounting of the transceiving heads high up on poles make it unlikely that passersby will get any exposure.

At each intersection there is an optical transceiver (single- or multiple-head) that faces another one at an adjacent intersection (see figure). Each transceiver not only acts as a data repeater but also communicates with a microcomputer located in a cabinet at the intersection. The microcomputer processes data from the roadway traffic sensors, sending it to the control computer via the laser path.

The source for each transmitted beam is a gallium-arsenide injection laser diode having a typical peak power output of 10 watts at a pulse repetition rate of 2,000 pulses per second. A silicon avalanche photodiode is the receiver.

Moving along. At each controlled intersection, the pulsed laser energy from an adjacent intersection's transmitter is sensed by the avalanche diode, and the resulting electrical output is amplified and sent to the laser driver circuits for retransmission to the next intersection. It also goes to the microcomputer, which communicates with the traffic light's control system.

A fiber-optic link (for simplicity and reliability) is used to couple plastic Fresnel lenses in the optical heads to the transceivers. These lenses transmit and receive in a duplexed mode for each head.

Duplexing is accomplished by combining each of the fiber-optic bundles separately connected to the transmitter and receiver diodes into a single bundle whose tip is at the focal plane of the lens. This eliminates the need for the two separate optics systems usually employed.

Why lasers? The Sperry system operates in the near infrared light range, which humans cannot see—a psychological advantage. But the main reasons for using the laser, rather than noncoherent light, are range and signal-to-noise ratio.

According to Mancuso, these capabilities result from the laser transmitter's being able to produce relatively high pulsed output power compared with fairly low average power input (watts versus milliwatts). In addition, the narrow beamwidths of lasers allow simple lens optics and filters matched to the laser's wavelength. Such a filter rejects background light due to sunshine or artificial sources and contributes to the system bit error rate of 1 part in 10^6.

"The system is designed to be flexible," says Mancuso, pointing out that a segment of the link between two intersections may be connected with two-wire lines if the line of sight is obstructed. ☐

Health

Illness at National traced to gas leak

It took a week's worth of investigation before a mysterious illness plaguing National Semiconductor Corp.'s Danbury, Conn., plant was diagnosed. Diborane, a p-type boron dopant used in making integrated circuits, had been leaking into the wafer-fabrication area of the plant causing nausea, dizziness, and headaches among National's employees. The gas, an irritant to the central nervous system, can be lethal.

The problem surfaced on Tuesday, Oct. 17, when seven employees became ill and were rushed to Danbury Hospital. A search by the abbott

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Occupational Safety and Health Administration and the local fire department uncovered no cause, but the plant was evacuated the next day when 13 more employees complained of similar symptoms.

Initially, a team of health, safety, and industrial experts were confused about the source of the problem. In fact, suggestions were made that the problem was "psychogenic illness"—a mass hysteria phenomenon with no health-related cause. A few assembly-line workers may complain of labored breathing and nausea and the illness spreads through the plant simply by the power of suggestion.

Uh uh. Dr. Samuel Epstein, an expert on occupational medicine from the University of Illinois who was brought in to check the Danbury situation, nixed this possibility. "Every time there isn't a clear answer to a problem, management figures that it couldn't be their fault, so they label it psychogenic illness and blame it on the workers.

"National made tentative suggestions to that effect, but our results showed that the problem was caused by a leaking gas cylinder, which, coupled with poor ventilation, seems to be the logical cause of the illness."

An unusual occurrence? Not really, says Dr. Epstein. "It could happen, and is happening, in industries all over the country. Generally, these incidents are a reflection of poor ventilation, gas leaks, and bad handling of toxic chemicals."

Problems such as this have arisen elsewhere, from Litton Industries Inc. in Grant's Pass, Ore., where a leaking valve caused episodes of illness, to Essex International Co., Kittanning, Pa., where increasing the ventilation was enough to cure workers' ailments.

"It occurs more often than not," says Ken Gerecke, an industrial hygienist for the Occupational Safety and Health Administration, "but generally there's no publicity—the company brings in a maintenance man to fix that particular problem, and work continues."

National Semiconductor is, however, taking strong remedial steps. On Dr. Epstein's recommendations, it plans to improve the ventilation system, put extra enclosures around furnaces, install an automated monitoring system, and also hire a company nurse.

"I'm very pleased with the company's reaction to my suggestions," says Dr. Epstein. "They're going to a significant expense to make working conditions safer."

Thus National employees, none of whom remains hospitalized, can expect to find better conditions at work and a smaller chance of being hit by a "mysterious illness." Employees at other electronics plants across the country may have to wait until such an incident occurs before they are accorded the same safety, says Dr. Epstein. "Companies need to develop anticipatory approaches—to practice basic industrial hygiene." □

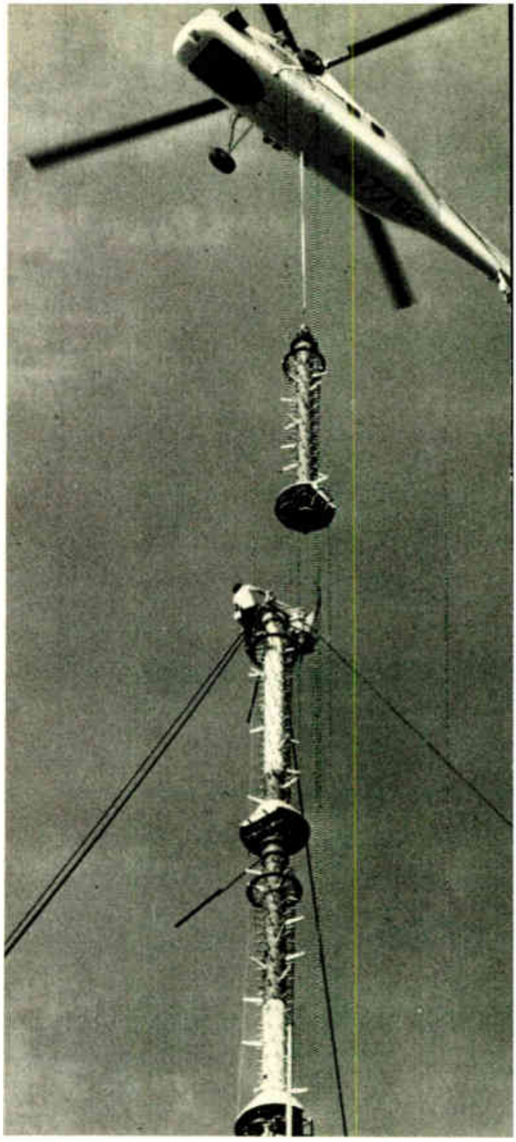
Broadcasting

Station's customers to get antennas

Though common enough in other areas of communications, particularly fm radio, the transmission of circularly polarized signals has been approved by the Federal Communications Commission for television broadcasting only since May 1977. Because it boosts signal strength, more than 10 TV stations have been quick to adopt the approach, and the latest to do so—WQTV, Channel 68, in Boston—is equipping its pay-TV subscribers with circularly polarized receiving antennas as well.

The first station in the ultrahigh-frequency band to go on the air, WQTV is new and will combine traditional programming with an over-the-air pay-TV service. It will outfit each subscriber with a decoder and the special antenna.

Why the double-ended interest? When a TV transmission is restricted to the horizontal plane, some of it misses indoor or rooftop receiving antennas not aligned with the horizontal, so that the viewer may see a weak or "snowy" picture. A circularly polarized signal, in contrast, contains equally strong vertical and horizontal components, so that more signal is intercepted by an antenna, regardless of its orientation.



Up in the air. Helicopter lifts final section of circularly polarized transmitting antenna built by Jampro division of Cetec Corp. to its perch atop the Prudential Center in Boston.

Ghost-free. When the receiving antenna is also circularly polarized, picture quality improves still further because of the reduction in multipath distortion, or "ghosts." These occur when a TV set receives two or more identical but out-of-phase signals. The strongest comes directly from the source, but the others—reflections from obstacles like tall buildings or hills—can combine to degrade picture quality. Conventional, single-plane receiving antennas pick up all these signals.

Circularly polarized receiving antennas, on the other hand, are selective—they accept only signals with a polarization pattern that matches

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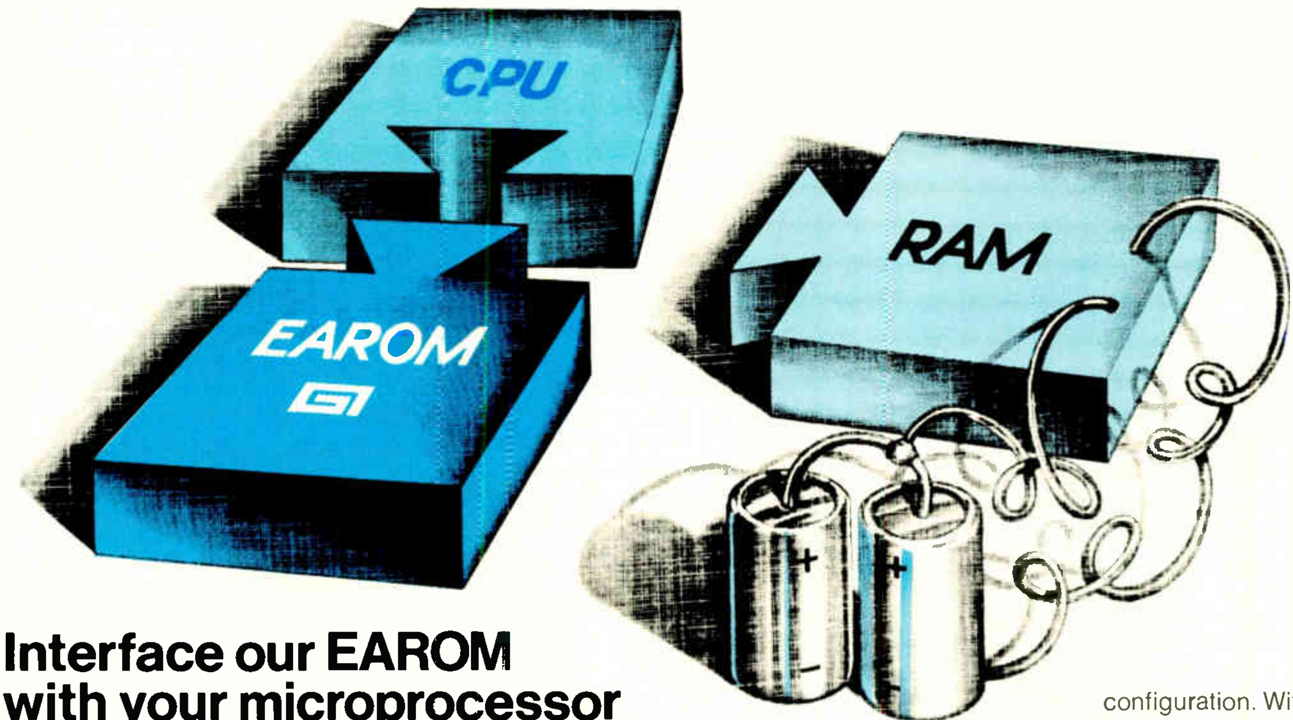

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their own. This pattern is clockwise or counterclockwise, referring to the direction of rotation of the signal's electric-field vector. When such a signal bounces off an obstacle, its polarization pattern reverses. A clockwise signal, for example, becomes counterclockwise, so it is rejected by a clockwise receiving antenna. Ghosts are reduced; thus picture quality improves.

WQTV's general manager, Fred Horowitz, believes that the $4 to $6 the station expects to spend for each receiving antenna is money well spent. "We feel we owe our subscribers the full benefit of this newly available technology," he says. Also, he realizes, a better picture, especially in fringe areas, should mean more subscribers.

Horowitz is considering three suppliers for the antennas, which will be installed with the decoder for a hefty $90 installation fee. Exactly what the antenna, which goes on the customer's roof, will look like is uncertain because the technology is so new and no such devices are yet available generally. The antenna could, however, be taller than a conventional TV rooftop receiving unit, with tuned, spirally shaped elements attached to a central mast.

Boon to uhf. The supplier of the transmitting antenna, which is a three-section, 63-foot-high, omnidirectional unit, is equally enthusiastic about the future of circular polarization. "It can make uhf competitive with vhf, especially in troublesome receiving areas like cities and mountainous regions," says Robert A. Nelson, president of Cetec Corp., whose Jampro division in Sacramento, Calif., is installing a transmitting antenna with 1.2 megawatts of effective radiated power for WQTV.

About the only drawback of the approach from a broadcaster's viewpoint is its higher power requirements. Since the signal has a vertical as well as a horizontal component, transmitter output power must be doubled. The additional radiated power is all in the vertical plane, so it does not interfere with horizontally polarized signals on the same or adjacent channels. □

Business

Senate hears of industries' needs

Looking for suggestions on how U. S. high-technology companies can maintain market dominance, increase overseas trade, and invest in the equipment necessary to keep up, Sen. Howard Cannon (D., Nev.) chairman of the Commerce, Science and Transportation Committee, got an earful recently from several key computer and semiconductor industry executives.

But what may have been new for Cannon at the Oct. 30 hearing in San Francisco was what the electronics industries have been promoting for some time: that the Government encourage investment through lower taxes, enforce trade agreements to lower international market barriers, and create an environment for technological innovation.

Specifically, Wilfred J. Corrigan, chairman and president of Fairchild Camera and Instrument Corp., Mountain View, Calif., said that the U. S. semiconductor industry generally recommends that the Government negotiate removal of the "most onerous barriers," such as the 17% tariff on integrated circuits entering the Common Market and exclusion of non-Japanese components from contracts with Nippon Telegraph and Telephone Public Corp. He also called on the Government to enforce antidumping laws more vigorously, pressure Japan to import more U. S. products, and consistently promote export programs.

VLSI subsidies. On the investment side, Corrigan called for special credits for a fast write-off of high-technology equipment used to manufacture ICs and for Government subsidies of very large-scale integration research by private industry, "but without restricting covenants." He also urged President Carter to sign the Revenue Act of 1978 lowering the maximum capital gains from 49.1% to about 25%, which Carter says he will do.

Agreeing that barriers to free trade should be minimized, IBM Corp.'s Eric Bloch, vice president, Data Systems division, Hopewell Junction, N. Y., pointed out that "today more than 40 countries impose tariff rates on imported computer products that are at least double the U. S. rate." Furthermore,

Motorola losing Heikes

Motorola Semiconductor's year-long push toward an aggressive worldwide marketing stance has caused a major internal casualty. Vice president and assistant general manager Robert R. Heikes, the No. 2 figure in the Phoenix-based Semiconductor Group headquarters, is leaving. "The divisions are becoming more independent, by my own decision, but there was less and less use for me in [my] role," he says.

Big winner in a recently announced realignment is vice president Pasquale A. Pistorio, who assumes the additional title of general manager of a new international division with total responsibility for technical development, manufacturing, and marketing in the international arena, says a company statement. Pistorio's former second in command, Charles E. Thompson, will move up to his old position, director of world marketing. The foreign marketing managers will report to Pistorio, and Thompson will be responsible for domestic marketing and strategic planning for worldwide marketing. Both report to John Welty, Semiconductor Group general manager. A source says there were disagreements between Heikes and Motorola chairman Robert W. Galvin and other top executives. The differences focused on the realignment. Says an industry observer: "Heikes didn't think that Pistorio should have authority over manufacturing and technical development."

Kidder Peabody analyst Sal Accardo believes the departure of the 53-year-old Heikes "is a big loss to the company. He was a great talent, a conceptual strategic thinker the company sorely needs."

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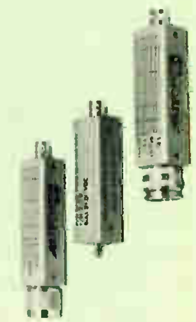

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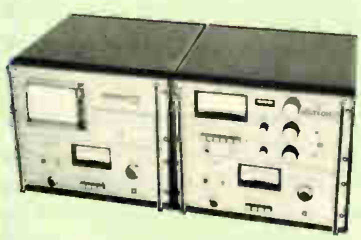

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he declared, "the Government can contribute even further by becoming a well-informed and sophisticated user of computers, as this would spur new endeavors and applications."

No final exam. But "we don't need R&D for R&D's sake alone," cautioned George H. Heilmeier, vice president of corporate research, development, and engineering at Texas Instruments Inc., Dallas. Before joining TI, he directed the Defense Advanced Research Projects Agency. Defense Department research and development programs are generally successful because they are user-oriented, he said, but "few Government technical establishments have this incentive or 'final exam.'"

Sen. Cannon said his committee also wants to find ways to counter some disturbing trends, among them that "basic research funds, the U. S. market share, and our favorable trade balance in components and computers all declined in recent years. The future of semiconductors and computers has . . . profound implications for our economic future." He also said that before his committee considers new investment tax breaks it would like to wait six months to see how the Revenue Act affects new investment. □

Solid state

Multitechnology chip is counter base

If there were a single integrated-circuit technology that is fast and dense and uses little power, Hewlett-Packard Co.'s multiple-register counter chip for its recently announced 100-megahertz counter would have been a trivial design project. However, fast technologies are typically not very dense, and dense technologies are not very fast, so HP's IC development team at its Santa Clara (Calif.) division had to combine technologies.

Mixing technologies is not a new idea. After all, there are operational amplifiers built with bipolar and field-effect transistors, and National Semiconductor Corp. makes a 4-bit-slice microprocessor, the 2901, of emitter-coupled and integrated injection logic. But combining fast, dense digital logic with analog circuits on the same slice of silicon is like "trying to put several different species of animals into one cage harmoniously," says Bosco Wong, project leader for the counter chip. It was a full-fledged battle trying to deal with interfacing the various technologies while maintaining good noise control and balanced power allocation, he says.

EFL + I^2L. Wong's team spent a year and a half alone just experimenting with I^2L circuits before it undertook the actual design effort, which lasted two years. To gain high speed, the least-significant-digit, or front-end, portion, of the counter's register chains was laid out in emitter-function logic—a more dense offshoot of the fast emitter-coupled logic. The higher-order chain portions, needing density more than speed, were done in I^2L, which is three times denser than EFL.

Whereas the majority of the circuitry is made up of these two bipolar digital technologies, the remaining portions of the chip are a miscellany of conventional bipolar analog processes. During the chip's mask design, the team spent much effort to minimize "cross-coupling among the EFL signals, uneven power distribution for different areas of the chip, propagation delays in critical signal paths, and bias-line IR drops in the I^2L circuit blocks," Wong says.

Fast and versatile. The chip, which is 116 mils on a side, gains even greater density by the use of dual-layer metalization. Although its maximum frequency specification is 125 MHz, Wong says the front-end circuits can work at speeds up to 1 gigahertz. Though designed for HP's 5315A counter [*Electronics*, Sept. 28, p. 174], the chip's range and versatility strongly imply that it will be used in other applications.

For one thing, in its 40-pin package the chip directly interfaces with an 8-bit microprocessor—a Mostek 3870 designed into the HP counter. On the bus, it performs like a standard random-access memory. Furthermore, its multiplicity of counting functions, low power consumption (600 milliwatts, typically), and self-calibration feature make it a likely candidate for use in future counters. Wong confirms this, adding, "It is too time-consuming and expensive to develop a custom LSI chip for a single product." □

Automotive

Cheap sensors coming from TI

When it comes to the new electronics systems for automobiles, not all the big bucks will be going for microprocessors, says Klaus C. Wiemer. The discrete products development manager at Texas Instruments Inc.'s Electronic Devices division in Dallas, Wiemer is leading TI's effort to capture discrete circuit sales in the huge automotive field.

"The big gap today is in the lack of low-cost, mass-producible sensors, switches, and other components needed for automotive systems, as well as for other microprocessor applications," he says. Actually, only $1 out of every $10 to be spent on the new automotive systems goes toward the microprocessor itself, he notes.

Sights set. Accordingly, Wiemer has his sights set on sensors—discrete components that provide the inputs to the complex electronic control systems being designed for the automobile. And things are already happening. During the first quarter of next year, TI plans to be in production of a planar silicon temperature sensor designed for use with automotive exhaust-gas recirculation systems, Wiemer says. With a 1-second response time in air that compares to 30 seconds for some exhaust-gas sensors now in use, the Minitherm device will use the same tiny, 15-by-15-mil chip employed in the company's TSP102 temperature sensor, introduced in April last year. But it will have a scaled-down plastic

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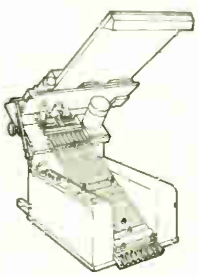

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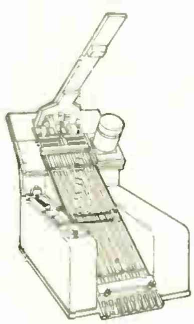

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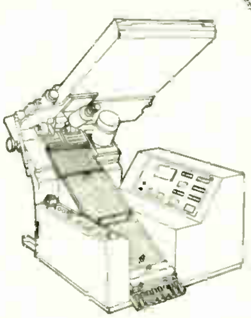

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The Minitherm sensor employs the spreading-resistance function of silicon, used by the industry for years for materials characterization, but never to build a precision tèmperature sensor, Wiemer points out. The resistivity of the silicon is primarily a function of the diameter of a single metal contact placed on top of the chip. Since the contact diameter can be precisely controlled through photolithographic techniques, Wiemer explains, a much more accurate device is possible than with conventional methods of producing nonplanar silicon sensors, in which accuracy depends on controlling the physical dimensions of each silicon bar sawed from a crystal. Under the old approach, tolerance variations from target resistivity can be limited to ±20% at best, Wiemer says. By contrast, the Minitherm, like its larger relatives, will be available with tolerances of ±1, ±2, ±5, and ±10%.

Such selectivity is possible because of high-volume automated testing techniques, Wiemer says. Each 3-inch-diameter slice of silicon contains some 25,000 of the tiny sensor chips, which vary in resistivity because of small lateral variations in the original crystal itself. Through a computer-controlled technique perfected by TI, the raw chips are automatically probed at a rate of 10,000 per hour and sorted into bins according to tolerance prior to device assembly.

Parts such as the TSP102 and metal-packaged TSM102 are currently price-competitive with other types of temperature sensors that sell for 50 cents to $1, Wiemer indicates. But as yields improve and volume picks up, prices on the new spreading-resistance planar parts are expected to drop to as low as 10 cents each.

Possibilities. "If you look at the fairly elaborate automobile that will be produced by 1985, you can come up with about 16 different functions to be performed by sensors," Wiemer figures. About half of those 16 are temperature sensors, while the others handle functions such as flow, position, and fluid-level detection, he says.

The new TI temperature sensors are currently in the design-in stage at several automotive houses. As the next step, Wiemer plans a similar high-volume approach to production of a low-priced planar silicon flow sensor, for replacement of the relatively expensive mechanical devices currently in use. He also foresees the

News briefs

Tandem concept goes nationwide

Tandem Computers Inc. of Cupertino, Calif., has extended its concept of operating computers in tandem for extra system reliability so that it can be applied to geographically dispersed systems. A new Guardian/Expand operating system available next March allows up to 255 Tandem model 16 computer systems to be interconnected over standard communications links. And a new programming language, called Enform, permits each network element to access data at other points. The operating system also includes software that automatically routes messages over the fastest path. Communications in the network use Tandem's packet-switching end-to-end protocol, which is compatible with the international X.25 standard.

Australians show ultrasound system

Ausonics Pty of Sydney, Australia, unveiled its new Octoson diagnostic ultrasound imaging system at the conference held last month in San Diego, Calif., by the American Institute of Ultrasound in Medicine. The programmable Octoson is the first commercially available system to scan and position the patient fully automatically. The patient lies on a membrane above a tank of warm water in which an array of eight transducers is immersed, so that he or she can be scanned from various positions instead of only from above. Octoson will be sold in the U. S. by the firm's New Berlin, Wis., subsidiary, Ausonics Corp.

Amdahl, Itel add new mainframes

Buttressing their plug-compatible product lines against IBM mainframe computers, two California companies plan to ship new higher-performing additions in 1979. Amdahl Corp. of Sunnyvale is to add a new top-end machine, the 470V/8, which has a 26-nanosecond machine cycle time, a new high-speed buffer, and a "prefetching" technique that predicts what is logically the most consecutive data likely to be called into the buffer. Lower down, Amdahl adds a -II version that performs 10% better than the 470V/5. Itel Corp. of San Francisco also adds a second model to its AS/6 computer that has 10% to 25% better performance.

U. S. Awacs heading toward NATO buy

The West German defense ministry has come out in favor of the Boeing Co.'s E-3A Airborne Warning and Control System, raising hopes that the year-long guessing game over whether European members of the North Atlantic Treaty Organization will opt for the U. S.-developed aircraft may soon end. At stake is a $2-billion-plus purchase of 17 Awacs. What reportedly helped overcome the Bonn defense minister's earlier coolness is the promise of substantial subcontracts to West German firms. The contracts, extracted during negotiations with officials in Washington, D. C., are valued at about $260 million and are primarily for airborne electronic equipment.

Nipper given broader role at RCA

The famous trademark of the little fox terrier, Nipper, listening raptly to his master's voice on an old phonograph is being rejuvenated by RCA Corp. Nipper joined RCA in 1929 when it acquired the Victor Talking Machine Co., which had been using the trademark on phonographs and records since 1901. The company will now use it on a much wider range of products, as well as on its vehicles, advertising, and sales literature.

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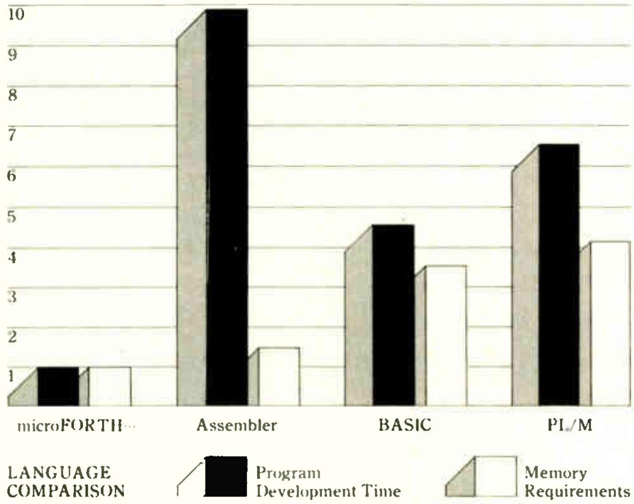

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Military

Spending on space to lift off in next decade

A steady 1.5% annual growth pace projected for U. S. military electronics neither surprises nor much excites suppliers. But for one equipment category, military space, indications are much rosier, according to the 10-year forecast for the Government electronics market unveiled by the Electronic Industries Association late last month in Los Angeles.

Using constant 1979 dollars, the EIA projects the electronic content of space activities to grow from $1.2 billion in fiscal 1979 to $3 billion in fiscal 1987. "This represents an average annual increase of 11.6%," reports Wesley S. Sherman, coordinator of the requirements committee that put together the forecast. He is special assistant to the vice president of Government relations at GTE Sylvania Inc.

Just last year, the EIA forecast put 1987 space funding at $2.7 billion. "The increase [to $3 billion] not only represents a better understanding of what lies ahead in space programs, but was a real eye-opener to us as well," Sherman says.

Looking up. Why this unexpected upswing? Keen military interest in satellites for reconnaissance and defense is pushing the prospects, says Frank Forthoffer, an official with Lockheed Missile & Space Co. and the person mainly responsible for the projections.

He points out that the increase over the next 10 years surfaced when the Department of Defense asked for more funds for space in the fiscal 1979 budget. The increase will go toward many projects at various stages of completion, says a spokesman for the Air Force's Space and Missile Systems Organization, El Segundo, Calif., which oversees space activities for the U. S. military.

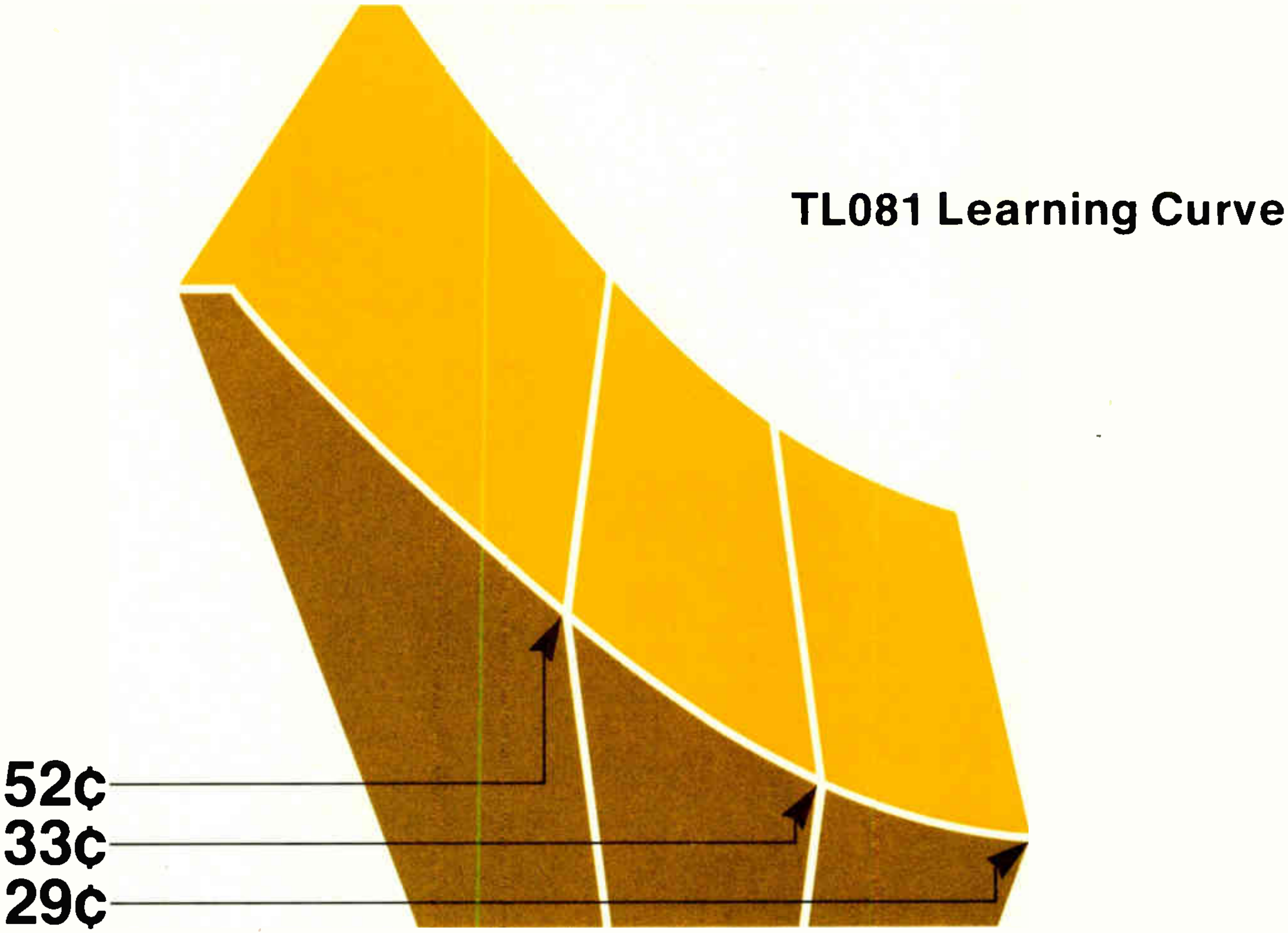
Included in these plans are DOD space payloads, slated to go into orbit on NASA's space shuttle from Cape Canaveral, Fla., beginning in 1980. These launches will peak in 1983–84, with Vandenberg Air Force Base, Calif., starting up in 1983. Also in sight are the global positioning system (Navstar) and the defense satellite communications system phase two and three. Communications projects may also include laser communications satellites and a dedicated Air Force system for nuclear command and control, in addition to highly classified reconnaissance birds.

Cheaper launchings, made possible by the shuttle, could spur space work, sources say. Though these opportunities look good, Forthoffer cautions: "Because space starts at a lower dollar base than some other categories, the percentage increases seem more dramatic."

Overall, the total electronic market for military equipment will grow from $17.3 billion in fiscal 1979 to $20.6 billion in 1983 and $25.1 billion through 1988, according to the EIA. Equipment categories in the forecast include electronics and communications, which will continue to account for about one fourth of total spending as military services push to add new communications systems.

Missiles, too, will experience steady growth through 1985 when either a new missile or a variant of an existing one will be developed. The EIA also thinks the MX missile will go into full development in fiscal 1980.

On the other hand, spending for aircraft electronics will drop from $3.8 billion in 1979 to $3.7 billion in 1988 owing in part to the B-1 cancellation and also because no new generation of aircraft is being proposed, Sherman notes. Ships, too, will have a low growth rate because of the lack of a shipbuilding program on which the Navy, the President and Congress can agree. □



New low prices and low noise. TL081 Series BIFET op amps.

With the second price reduction in less than a year, Texas Instruments offers high performance BIFET op amps at close to the cost of μA741s.

In addition, recent improvements have further lowered the noise level to 22 nV/$\sqrt{\text{Hz}}$.

The TL081 family of op amps combine high-impedance JFET inputs with low-distortion bipolar outputs. And, what's more, prices are now lower than ever.

TL081 now 29c each in 100's.

This single, 8-pin plastic DIP compensated op amp is pin-equivalent to μA741 and others. Cost is very close. Yet it offers performance like this:

- Input resistance – $10^{12}\ \Omega$ typical
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This new monolithic op amp is designed to replace expensive discrete or hybrid amplifiers in precision instrumentation. Only $3.93 in 100 piece quantities, it features low noise – 18 nV/$\sqrt{\text{Hz}}$ – as well as extremely low input offset voltage.

Texas Instruments now offers the most complete selection of BIFET op amps in the industry. In addition to the TL081 series, TI has developed a low power TL061 series and a low noise TL071 series. All families offer duals and quads as well as singles.

Send for data sheet

Want more information? Ask for data sheets on TL081 op amps. Call your nearest TI distributor or write Texas Instruments Incorporated, P.O. Box 225012, M/S 308, Dallas, Texas 75265.

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The L135 has the highest diagnostic throughput, the lowest operating cost. No other test system comes even close.

1. The L135 finds bad LSI devices on long buses.

The Electronic Knife does it. It takes just a few more probes after regular guided probing finds the failing bus. Without the Electronic Knife, you're faced with trial and error replacement of LSI chips. Or skilled technicians tying up the system for an hour or more per bad IC.

2. The L135 makes fewer diagnostic probes – by an order of magnitude.

State-sensitive trace does it. Most LSI boards are loaded with multi-input LSI chips linked through "wired-and" bidirectional buses. These often require hundreds of diagnostic probes per fault. State-sensitive trace cuts the number dramatically.

3. The L135 produces immediate probe commands.

The on-line circuit model with a large random-access memory does it. With circuit structure immediately accessible, the operator does not wait for commands between probes. Other test systems that use fault dictionaries often delay each command several seconds, adding minutes to each diagnosis.

4. The L135 mechanizes probing.

The M150 Automatic Prober does it. Seven to ten times faster than a human operator, the M150 speeds up board diagnosis even more because its operation is both error-free and fatigue-free.

The L135 delivers the highest quality of testing, thereby slashing costs for diagnosis later at systems test and service out in the field.

5. The L135 emulates LSI-board operating environments.

5-MHz clock-rate testing does it. To ensure adequate board quality, you usually have to run LSI boards at clock rates as the last step in testing. Only the L135 provides test rates of up to 5-MHz, the speed of many microprocessors seen in today's products.

6. The L135 emulates and tests CPU sets.

Multiple drive/compare phase control does it. During clock-rate testing, the test system must first replace the CPU set and then test it at speed. The associated microprocessors usually receive multi-phase inputs and generate multi-phase outputs. The L135 provides the necessary, easy-to-program, precise phase controls over driver inputs and comparator strobing.

7. The L135 tests and diagnoses analog circuits.

Integrated ac-dc-parametric capability does it. The L135 offers many analog force-and-measure functions through matrix connections, all completely integrated into system hardware and software. If these capabilities aren't integrated into the test system, they must often be added to accommodate the increasing analog content of LSI boards. That prolongs test time and slows diagnosis considerably.

8. The L135 tests at dc and clock-rate on the same channel.

All-speed pin compatibility does it. In clock-rate testing, high-speed tests are usually applied on the same pins tested earlier with dc. The L135 allows you to apply both types of tests at the same system channel, eliminating the need for awkward switching or extra channel capacity.

9. The L135 has enough clock-rate channel capacity for the big jobs.

444 I/O pins does it. Big LSI boards have upwards of 250 edge-connector pins, all active. In addition, you need simultaneous access to dozens of internal test points and devices invisible to the edge connector. The L135 offers the highest clock-rate channel capacity, enough for all foreseeable LSI boards.

10. The L135 cuts total programming time.

The P400 Automatic Test Generation System does it. The P400 automatically generates all the dc patterns and diagnostic data for the toughest part of most LSI boards: the jungle of random digital logic, as well as those portions containing modeled LSI devices. Total programming time is shorter. The best of the so-called "automated test generation" techniques offered by other systems still require manual pattern-writing. That takes longer and costs much more.

The L135 cuts the time needed to get products into the production line and out to the market place.

11. The L135 cuts system time for debugging.

Immediate-response debug software does it. During test-plan debugging, the L135 responds to the test engineer's commands and displays results immediately. Total debugging time is cut to a fraction because the test engineer is not distracted by system delays; he can concentrate on his circuit and his test plan.

12. The L135 readily assembles the many parts of LSI test plans.

Structure-merge programming does it. Test plans originate in many places: manual patterns and circuit models, learned data from known good boards, circuit and device simulators, automatic pattern generators, etc. The L135's structure-merge software and its straightforward protocol assembles them all into a coherent package, saving your engineers hours of tedious and costly work.

For more information on these and other L135 features, write Teradyne, Inc., 183 Essex Street, Boston, Massachusetts 02111.

TERADYNE

Circle 55 on reader service card

Washington newsletter

Controversy rises over FCC docket on land-mobile radio

The Federal Communications Commission docket on domestic public land-mobile radio service is being called "a prescription for multiple litigation" by 31 radio common-carrier companies. They say that Docket No. 18262's provision that only one system using cellular technology will be licensed in any local market represents "a certain death warrant for RCC [radio common-carrier] two-way business in that market," since Bell System companies are developing that technology and expect to apply for its exclusive use. **"Every Bell cellular application will have to be opposed vigorously by the local RCCs, who cannot be expected to simply fold up their businesses,"** the carriers contend.

TI setting up Dallas–London satellite link

Texas Instruments Inc. will become the first U. S. company to establish a high-speed digital data link using communications satellites to an overseas location. **To begin operation next spring are two duplex 56-kb/s channels between TI's offices in Dallas and London.** American Satellite Corp., the Germantown, Md., domestic satellite operator, will provide TI with a 10-m earth station in Dallas for communications with an Etam, W. Va., earth station linked directly to an Intelsat station for the overseas hop.

For domestic service, ASC says it has signed contracts to provide additional 5-m earth stations to Boeing Computer Services Inc. and Sperry Univac. Boeing's fourth station in the Washington suburb of Vienna, Va., will provide one 56-kb/s duplex channel to corporate headquarters in Kent, Wash., in addition to stations already on line in Philadelphia and Wichita, Kans. Univac's third station will link Salt Lake City with stations that began operation in September at its Minneapolis headquarters and Blue Bell, Pa.

Cubic Corp. hit by Washington subway on fare system

Malfunctioning automated fare-collection systems are driving riders and revenues away from Metro, Washington's new $5 billion metropolitan subway system, **and the system's board is weighing legal action against its contractor, Cubic Western Data,** a subsidiary of Cubic Corp., San Diego, Calif. Fare-card vending machines, which sell tickets in denominations ranging from 25¢ to $20, are out of order 15% of the time, Metro reports, and entrance and exit gates activated by the tickets malfunction about 10% of the time. Cubic says its system is meeting contractual requirements, but it is being challenged on that claim by the transit authority. The company is scheduled to deliver $53 million in electronic hardware by the time Metro is completed in 1983.

DOE negotiating 45 photovoltaic awards totaling $8 million

The Department of Energy is negotiating contracts with five companies and eight universities to investigate the photovoltaic potential of thin-film "emerging materials" for solar cells. The awards are part of a new DOE package of 45 awards totaling more than $8 million. **Materials include boron arsenide, polyacetylene, copper selenide, indium phosphide, cuprous oxide, cadmium telluride, and arsenides of zinc and silicon and of cadmium and silicon.** Thirteen other contracts cover thin-film amorphous semiconductor materials with the potential of making very low-cost solar cells because of inexpensive processing; 9 awards expand on current efforts to increase the conversion efficiency of thin-film polycrystalline silicon; and the remaining 10 studies deal with photovoltaic-mechanism theories and experiments.

Washington commentary

Teletext: getting America into the competition

There is no final agreement yet on a generic name for what shapes up as the world's next big telecommunications market, although industry specialists seem to be settling on "teletext." Teletext services use the vertical blanking interval of a television broadcast signal to carry digitally encoded data to subscribers. Similar services using telephone lines or TV cables are being dubbed "videodata" for now, although it is widely believed that teletext will ultimately prevail as a single name for both techniques.

Regardless of what they may be called, there is widespread agreement in the United States that it has fallen behind Great Britain, France, and Canada in developing consumer and commercial applications of such services. They embrace everything from electronic mail, shopping, and funds transfers to entertainment, education, home security, and appliance control.

The leaders in Europe

Neither the concept nor the technology is new, of course, even though the U. S. is only beginning to explore applications at the consumer level. Britain, on the other hand, has had a one-way broadcast system called Ceefax in operation for two years and is hard at work on two others. One is a two-way videodata system that the Government originally called Viewdata before renaming it Prestel; the other is an independent, two-way teletext system called Oracle.

As for France, it is ready to inaugurate teletext experiments with a system called Antiope. Its goal is to make its digital signals compatible with both broadcast and wire transmission systems. Canada's Department of Communications said in August that it will develop a teletext system having graphics it believes superior to those used in Britain and France. Moreover, the department's John Madden says technology developed in Ontario field trials next year will be transferred to industry as quickly as possible to accelerate market growth.

American concern for the nation's failure to apply much in the way of teletext technology got official recognition in late October during a day-long symposium at the National Academy of Sciences. The meeting, sponsored by the National Research Council's board of telecommunications-computer applications, featured 10 U. S. experts in teletext but drew fewer than 100 registrants, a good many of whom were from foreign companies and governments.

There are many, many questions and unresolved issues for the U. S., said the teletext advocates. Over electronic mail, for example, does the U. S. postal service or the Federal Communications Commission have jurisdiction? Are videodata services properly defined as "data processing"? If so, should FCC rules be amended to permit telephone companies like AT&T that have the lines to offer such services? The FCC has scheduled its first serious look at teletext technology and the questions of policy it raises for Nov. 8.

A telecommunications industry lawyer at the meeting, John Bartlett of Washington's Kirkland and Ellis, proposed a refreshingly novel approach that would speed up the resolution of these questions. The FCC, the postal service, and the Justice Department should begin working together to permit widespread competitive development of teletext services before industry lawyers become heavily involved and slow down the process. Besides limiting legal participation, Bartlett told the NAS symposium, the Government should permit the services to develop within as loose a framework as possible in order to let technical standards evolve competitively.

NAS panelist Al Curll from Texas Instruments Inc. in Dallas said his company is promoting a broadcast standard of two TV lines using 20 rows of teletext with 32 characters each. TI is providing decoders for the British Oracle system, but its proposal stems from its work in the field with Salt Lake City's KSL-TV.

The world marketplace

Lawyer Bartlett's cautious approach to standards sounded eminently sensible to one French representative of the Antiope system in the NAS audience. He also called for work on a world standard so that automated language translators might be developed to facilitate worldwide data exchange and produce a truly international marketplace.

But however the world market evolves, the certainty is that U. S. broadcasters and telephone companies, as offerers of teletext services, must accelerate their programs if they expect U. S. technology to have an impact in that marketplace. This time the U. S. communications industry cannot blame bureaucratic inefficiency for the country's failure to move quickly into a developing market. After the NAS symposium, one member of the audience likened America's slow progress in teletext to earlier horror stories of lost markets in transistor radios and video tape recorders. But those disasters need not be repeated. The U. S. telecommunications industry still has time to recoup—if it wants to.

Ray Connolly

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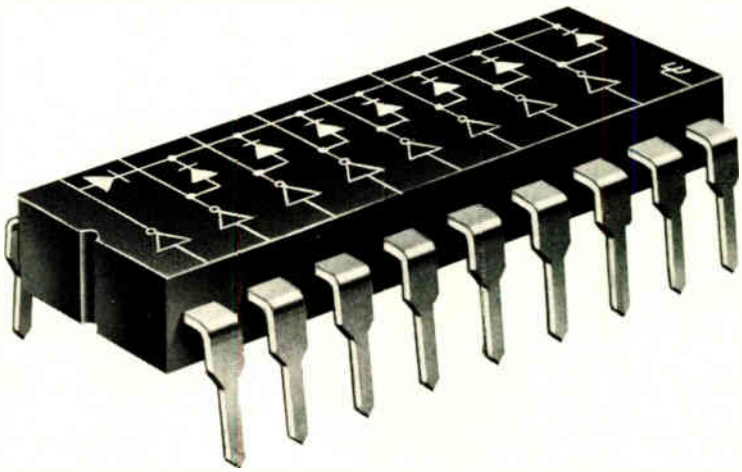

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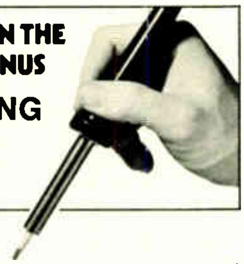

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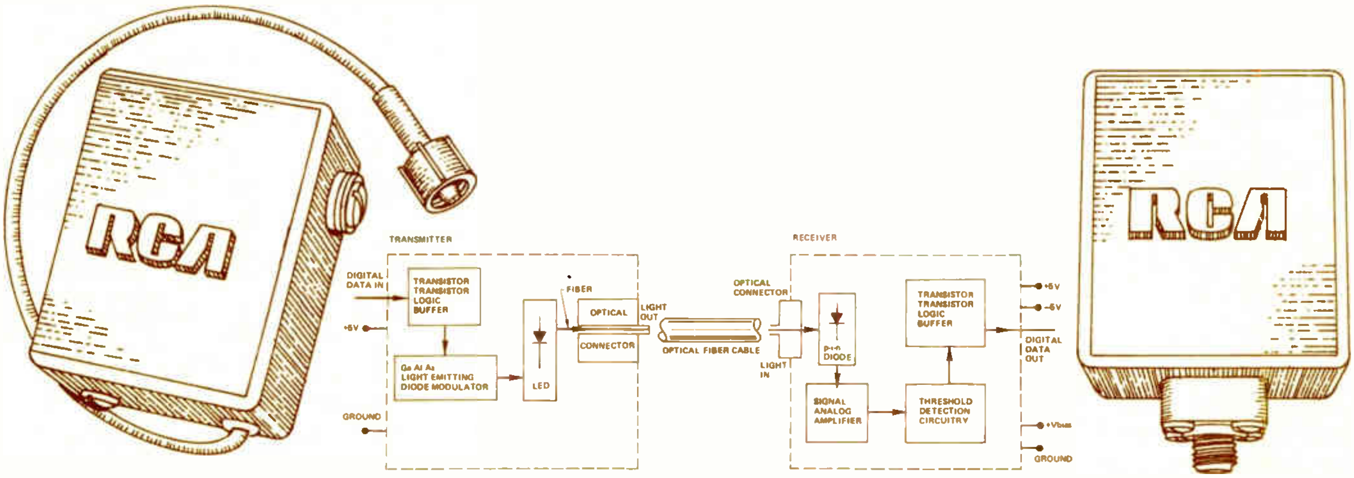

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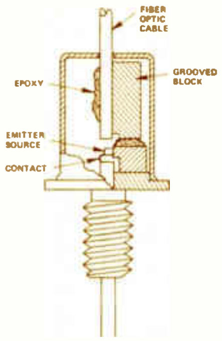

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NRZ coding	20	5	2	Mb/s
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RCA

Circle 62 on reader service card

International newsletter

Philips manufactures test microcircuits with E-beam projector

An experimental English electron-beam projector for VLSI lithography has produced its first microcircuits at the Philips Research Laboratories, Redhill. **Philips believes the system can be developed to achieve 1-μm line widths and 0.2-μm mask alignment accuracies on the wafer.** A flood electron beam projected onto a target wafer for 30 s has produced both bipolar circuits and precision bubble-memory masks. The circuit masks are fabricated by Philips' fast electron-beam pattern generator (see p. 68).

Siemens plans new models to chase IBM

With two families of large computers to be ready for delivery next year, Siemens AG is taking dead aim at IBM's markets. One family is the four-model 7700 series with central processing units that cover the computing-power range of up to 4 million operations per second. These CPUs will have 64-K memory chips from an as-yet-unnamed U. S. firm, as well as from Siemens, which is developing its own version. **The other entry is the four-model IBM-compatible 7800 large-computer family.** Its CPUs cover a range from 2.4 million to well over 9 million operations per second. With these processors from Fujitsu Ltd., the 7800 series is the first major result of the product and know-how exchange [*Electronics*, May 11, p. 63] that Siemens has with the Tokyo-based firm.

Optical fibers may appear in array radars

For improved tuning, linearity, and efficiency in phased-array radars, scientists at the Microwave Research Unit of University College in London plan to synchronize the microwave Impatt diode source in each array element with a common laser array-reference signal. This setup would replace complex synchronizing circuitry. **Microwave-modulated illumination carried by an optical-fiber bundle would connect the arrays to the directly modulated semiconductor laser.** It also appears that highly desirable electronic steering of the beam may be possible by selective delay of the signals along each fiber.

NEC launches easy-to-operate office computer

Aiming at users wanting office computers for unskilled operators, Nippon Electric Co. is launching its updated System 100 line with what is called an integrated tutorial operating system. As many as 16 work stations may be connected to the multitasking central processing unit. **The system uses a newly developed 16-bit MOS microprocessor** and comes in three models with a main semiconductor memory capacity up to 192 kilobytes. Among peripherals available are two 64-megabyte fixed disks with 48.3-ms average access times and a 1.2-megabyte/s transfer rate and four 1-megabyte double-sided, double-density floppy disks with 209-ms average access times and a 62.5-kilobyte/s transfer rate. Basic costs in Japan for the three models range from $36,000 to $66,000, with more extensive exports planned than with the version introduced five years ago.

Free-trade zone in India grows; new firms come

After four years of operation, Bombay's Santacruz Electronics Export Processing Zone (Seepz) has exported over $12.5 million of various electronics components, including integrated circuits, says the Indian Commerce Ministry's Department of Export Production. Most of the products from the free-trade zone [*Electronics*, Sept. 16, 1976, p. 89] go to U. S. **Exports are growing at an annual rate of 22%, with new ventures crowding in to join the 26 there now,** says P. A. Bhat, head of the

Electronic Component Industries Association. Starting soon is a document-printer assembly operation, Tata Burroughs Ltd., a joint venture of the U. S. computer firm and the Tata conglomerate of India. A firm already established in Seepz, International Power Semiconductors Ltd., will be manufacturing sophisticated epitaxial power transistors for International Rectifier Corp. of Los Angeles.

Philips unveils optical disks for mass storage

Optical disks will eventually slash the cost per bit for mass data storage so drastically that computer makers will have to rethink their storage concepts. That is the conviction at Philips Data Systems, which is developing a laser-diode optical recording system. Based on techniques devised for video long-play hardware, **the new system packs 10^{10} bits on a double-sided, grooved, 12-in. transparent disk,** equivalent to some 500,000 typewritten pages and 10 times more than magnetic disk packs, Philips maintains. Bits written into the disk can be read out directly afterward; despite the high capacity, the mean access time for any address on the disk is 250 ms.

Hughes develops technique for nonvolatile memories

Add to the list of nonvolatile memory technologies a low-power complementary-MOS variant from Hughes Microelectronics Ltd., called Novram. The Glenrothes, Scotland, company is using its electron-tunneling floating-gate process in a six-digit car odometer that can store data indefinitely and can be read in the nonvolatile mode for up to 10^7 operations without data degradation at a ±5-V supply voltage. **The device behaves like a normal random-access memory until a 12-V pulse freezes data permanently.** In this mode, the odometer consumes as little as 50 μW, and even less in the RAM mode. In the U. S., Hughes Aircraft Co.'s microelectronics operation is developing an equivalent n-MOS process for high-density data-storage applications.

Addenda

Siemens AG, which owns 80% of the California-based optoelectronic components maker Litronix, **is bidding for the remaining 20%** of the shares. . . . Olivetti is celebrating its first deal with China. **It will sell some $500,000 of communications-terminal concentrators** to unspecified Chinese buyers through the Hong Kong–based trading company, China's Resources. . . . Sweden will pay $6.75 million toward the $175 million total cost of France's earth-observation satellite, SPOT. After the satellite is launched in 1983, **Sweden will have the right to limited use for civil purposes.** . . . The British Post Office is expected to **order trunk and short-haul fiber-optic telephone systems within the next few months.** It has issued specifications for three types, including a 140-Mb/s trunk system with 10-km repeaters. . . . ITT says a merger of its UK subsidiary STL with Plessey Telecommunications [*Electronics*, Oct. 26, p. 63] **is not in the cards now.** . . . The West German glass maker Schott will start **mass-producing communications optical fibers early next year.** The range will extend from standard types to high-quality gigabit versions that can simultaneously handle more than 15,000 telephone channels or 30 color TV programs.

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Vector-scan E beam aims for wafers as well as masks

Electron-beam machine intended for production line achieves higher throughput with vector scanning

Launching itself into the market for electron-beam lithography systems with a bang, Philips Gloeilampenfabrieken is beginning manufacture of systems that are much faster than most of those offered for sale by others. The Dutch-based firm's vector-scanning EBPG-3 can both make masks and generate patterns directly on the wafer.

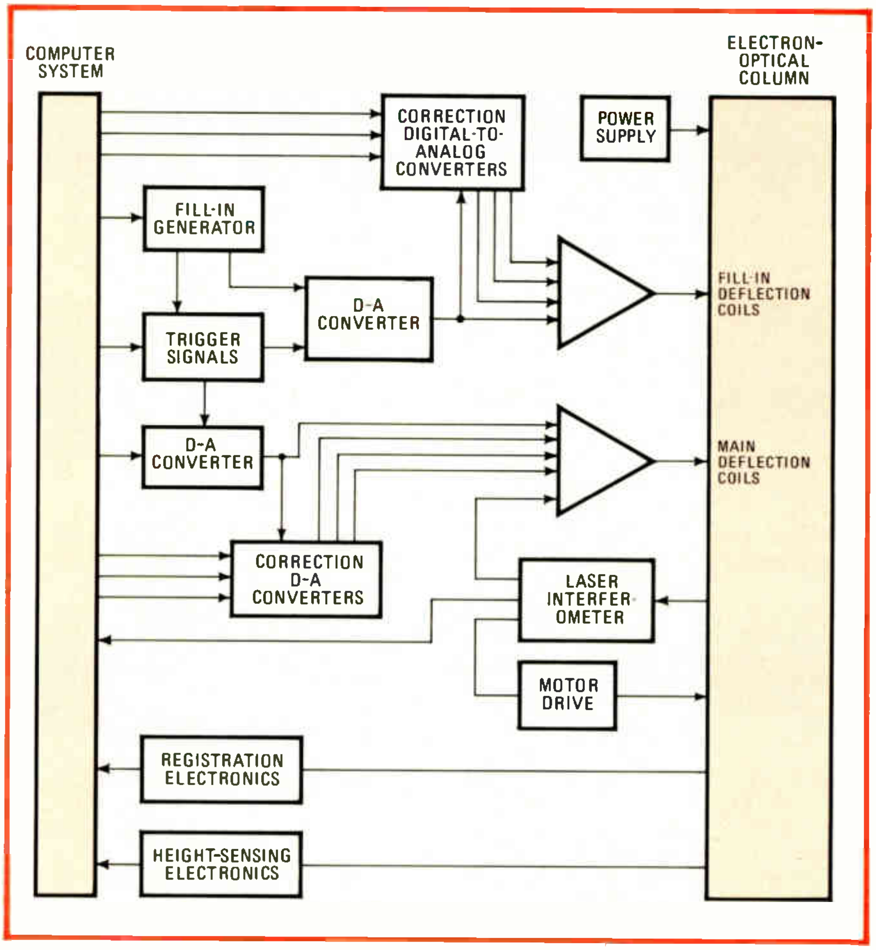
Philips appears to be somewhat ahead of its rivals in getting to market a vector-scanning system intended for writing patterns on chips. Most other production-line systems available for purchase are raster-scanning units, such as the new Toshiba EBM-105 [*Electronics*, Aug. 17, p. 70].

There are at least two other vector-scanning machines on the market. Japan's Jeol Ltd. is offering its JBX-6A, successor to an earlier, slower unit. The Tokyo company says it can expose wafers directly, but probably will be used primarily for mask making. The UK-based firm, Cambridge Scientific Instruments Ltd., offers its EBMF-2, which it says is suited for development work.

Two prototypes are now going through their test paces at the Philips Research Laboratories in the UK, where the design was conceived. The first commercial version is being readied for use on the production line at Valvo, the components-making Philips subsidiary in Hamburg, West Germany.

Performance. Under typical conditions, the EBPG-3 can produce lines with a minimum width of 0.4 micrometer with an accuracy determined by the alignment error between successive exposures, which is typically within ± 2 μm. Under ideal laboratory conditions, the machine is capable of writing lines down to 0.1 μm, says Ronald A. Beelard, lithographic project leader in the Eindhoven, Netherlands, Science and Industry division, which is manufacturing the machine.

The Philips machine can operate as much as three times faster than raster-scanning systems. The system throughput is 20 minutes for a 3-inch-diameter wafer with 2-μm lines in a medium-complexity pattern and



Fast scanning. Philips' electron-beam lithography unit uses vector scanning for higher throughput on production lines.

with 30% of the area exposed to the beam. With 0.8-μm lines, the time is about 65 min.

Such a speed is a bit faster than the JBX-6A, but slower than that of IBM Corp.'s vector-scanning EL-1 [*Electronics*, Nov. 10, 1977, p. 96], which, however, is not for sale. Coming soon from Electron Beam Microfabrication Corp., San Diego, Calif., is a vector-scanning unit with a throughput that will at least equal that of the EBPG-3.

Why vector? It is the choice of the vector-scanning method over the more common raster-scanning that boosts throughput. The beam scans only those areas requiring pattern exposure (see diagram), whereas the raster-scanning machines must scan the whole mask or wafer with the beam being switched on and off according to the desired pattern. However, the vector technique needs more elaborate control and deflection electronics to steer the beam.

Another major advantage of vector-scanning machines is easy correction for proximity effects of electron scattering.

The system can accommodate wafers or masks up to 6 by 6 in. with a maximum patterned area of 5 by 5 in., or 127 by 127 millimeters. That capacity is more than enough for the semiconductor industry's current requirements, points out Gary A. M. Janssen, marketing manager for lithography equipment. The price for the EBPG-3 is nearly $2 million. □

Europe

Electronic mail service is poised for takeoff, consultants' study predicts

European electronic mail service, now a drop in the mail bag, will boom in the 1980s, say two British consulting firms. About 50% of the mail may well be delivered by EMS within a decade, they predict.

The postal services' study from Mackintosh Consultants Ltd., Luton, Beds., and Communications Studies and Planning Ltd., London, estimates that the 1987 installed base of EMS terminals could hit $4 billion, compared with $5 billion in North America then. A key factor will be sharply decreased equipment costs, says Mackintosh, while postal service costs rise.

Cheaper. In fact, the consultants' break-even analyses suggest that by 1982 a good bit of Europe's correspondence could be mailed electronically more cheaply than by standard delivery systems. Major new market segments will unfold for electronics equipment makers, they say.

The consultants believe it is still unclear what types of electronic delivery systems will prevail, but in the long run they are giving the edge to Teletex, a new German development. It is a high-speed digital Telex with word-processing capabilities, and it can communicate with the 250,000 European Telexes in place.

Compared to facsimile systems or video delivery systems, Telefex has higher speed and lower transmission costs, and it may be able to combine characters and graphics. It could replace the electronic typewriter in offices: a secretary might type the letter and send it from her desk.

The Bundespost is looking for draft Teletex standards from the international telecommunications consultative body, CCITT, by 1980, but it might go ahead with the service even though the lack of an international agreement could cut off a major share of business. Still, the new service could open up markets for the makers of semiconductor, bubble and floppy-disk memories. Equipment companies like IBM and Siemens are readying machines for intracompany use that will send both text and graphics.

The study points out there is considerable work going on with facsimile systems. Mackintosh says Europe has 25,000 fax systems, compared with 150,000 in the U. S., most of them Group 1 analog systems that transmit one page of 2,000 characters in 6 minutes.

However, interest is rising in Group 2 analog systems, which transmit a page in 3 minutes. Moreover, the CCITT has developed a standard for Group 2 that presages easy international message exchange.

The West German telephone network will begin Group 2 fax transmission next year. Other postal and telephone authorities are planning

Will European post offices go electronic?

The course of electronic mail service in Europe will be greatly influenced by the role of the postal-telephone administrations, says the consultants' study. While it could mean increased telephone business, it probably would cause considerable job loss on the post-office side—and the postal unions are strong. Moreover, the government agencies are wary about committing themselves to untried electronic systems with unclear cost trends.

However, the study notes that there is a high concentration of mail: in France and the UK, for example, some 30% of the mail flows between just 5,000 businesses and government units. Should these users shift to EMS, the impact on the postal authorities would be dramatic.

Thus the post offices have two choices, the consultants say: they must develop their own EMS, or else they must streamline carrier service.

With the first option, what the study envisions for various European countries is a three-stage development through the 1980s. The first, involving about 6% of total mail flow, would be terminal-to-terminal communications between business and government organizations. Next the governments would offer post-office-based EMS transmission with carrier delivery, adding another 19% of total mail flow. Finally, adding public input terminals with delivery to individual receive-only facilities or by carrier would insure that half of the total mail flow would go by EMS.

similar systems, including France.

Moreover, planning is already under way in Europe for Group 3 digital fax systems (a page in a minute). Service could begin by 1982, if CCITT standardization goes smoothly. U.S. Group 3 equipment is already on the market.

Video impact. A key question beyond the 10-year period covered by the study is the impact of video systems, such as Viewdata, which is undergoing market trials. The British Post Office plans to extend Viewdata so that it will serve as a message service as well as for information retrieval and will also connect to Telex machines or line printers. Moreover, the Dutch and West German post offices have bought Viewdata know-how; France is working on a rival system.

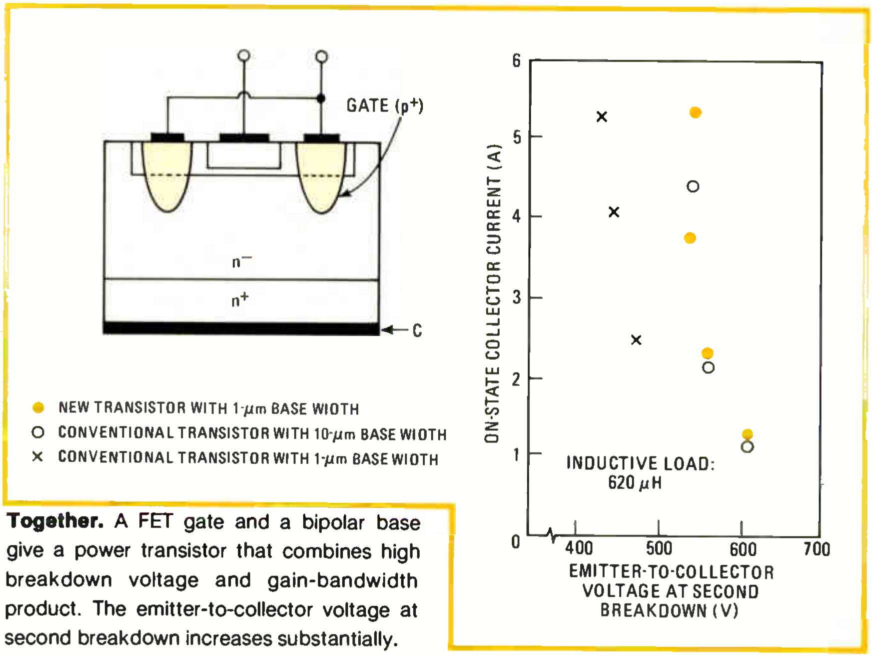
The immediate EMS market—the mail that flows between a relative handful of business and government units—will also open up new possibilities for equipment makers. For example, the value of the installed base of EMS terminals in the UK is expected to reach $200 million by 1982 and $800 million by 1987.

However, Mackintosh says that for any market to develop, there must be terminal compatibility. Two solutions are possible, the firm says: conversion at the terminal, the private branch exchange, or in the phone network is one; or standards such as those under development for Teletex-Telex compatibility. ☐

Japan

Structure reconciles power parameters

Many switching applications require both a high collector-to-emitter breakdown voltage and a high gain-bandwidth product, a combination that often defeats bipolar power transistors. But these conflicting requirements are reconciled in a new structure devised by solid-state designers at Mitsubishi Electric Corp. They have grafted a field-effect-transistor gate structure onto the base of a standard bipolar transistor.



Together. A FET gate and a bipolar base give a power transistor that combines high breakdown voltage and gain-bandwidth product. The emitter-to-collector voltage at second breakdown increases substantially.

The gate extends into the collector region and pinches off at a lower voltage than that at which the base punches through. Thus most of the supply voltage appears as a drop across the depletion region rather than extending into the base.

Applications. The new structure will be especially useful in switching regulators and class D amplifiers where high voltage ratings and good pulse response are needed, says Yoshinori Yukimoto, development group leader at the company's semiconductor laboratory in Itami. Mitsubishi hopes to have a commercial device available in six months or so and says it has even better-performing devices in development.

To form the gate of the device shown in the figure, two p^+ diffused regions extend about 4 micrometers into the collector, with a center-to-center spacing of about 10 μm. In addition to preventing punch-through of the base, the extra diffusion reduces extrinsic base resistance and so improves the high-frequency and switching performance of the transistor.

The new transistor has a higher breakdown voltage than the conventional transistor when both have the same base width: for example, 200 volts versus 20 v with a base width of 0.2 μm. Conversely, for the same breakdown voltage, the base width is thinner: 1 μm vs 10 μm for a 500-v breakdown voltage.

The new structure increases the gain-bandwidth product to four times that of the conventional transistor: to 80 megahertz for the same 500-v breakdown voltage. The thinner base and the carrier lifetime control in the base decrease storage time from 2.6 to 0.24 microsecond. Fall time decreases from 0.34 to 0.07 microsecond because of the high gain-bandwidth product; similarly rise time drops. Also, dc current gain increases because a larger percentage of electrons injected from the emitter is transported across the thinner base region.

Lifetime control. The dc current gain is only slightly larger for the new transistor: 36 vs 30. But this is because the control of carrier lifetime was used to obtain maximum reduction in base-charge storage, says Yukimoto. Without such control, the gain for the new device is about 100. The transistors under development are for switching circuits, but devices without the controlling process will be developed for linear circuits.

Another feature of the new transistor is the increased emitter-to-collector voltage at second break-

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down when an inductive load is turned off (see graph). With an on-state collector current of about 2.4 amperes, the new transistor with a 1-μm-wide base and a conventional 10-μm transistor would be destroyed at slightly over 550 V, whereas a 1-μm-wide transistor would be destroyed at about 450 V.

The Mitsubishi device has the same low input and high output impedance as a standard bipolar transistor. One of its attractions will be that a circuit engineer can use it in the same manner as a bipolar device with the same voltage rating and gain-bandwidth product. □

Great Britain

Software house seeks Viewdata expansion

Small-business systems and domestic microcomputers are the targets of programs in a variant on the Cobol computer business language devised by the British software company, CAP-Microsoft Ltd. However, the firm seeks a novel delivery system: Viewdata, the British Post Office's computerized information service, going on line in 1979.

What CAP-Microsoft has in mind is much easier use of Viewdata's encyclopedic volume of data, plus the addition of several business-oriented data-retrieval and data-processing programs to the BPO's computer store. However, the post office has not yet endorsed the concept, although the firm says it is showing interest.

The London member of the CAP-CPP group of companies has devised Viewdata Terminal Programming, an extension of its Microcobol [*Electronics*, May 25, p. 33]. This high-level programming language was designed for microprocessor-based systems having limited memory and processing power.

Thus, VTP programs distributed via Viewdata's telephone links can run on any microprocessor-based terminal—with the aid of a resident interpreter program. The terminals could be Viewdata-equipped television sets with a built-in microprocessor or business minicomputer systems to which a full Viewdata interface is attached.

The company has demonstrated the feasibility of its concept using a Zilog Z80-based terminal tied to a conventional Viewdata TV receiver. One byte of program replaces two hexadecimal characters of a standard Viewdata transmission. Error checks are performed and programs in intermediate code are loaded into a store for subsequent processing by the resident interpreter.

The concept is similar to that devised by the rival Teletext information service for transmitting computer programs [*Electronics*, Sept. 28, p. 74]. A universal programming language such as Microcobol could be used in both applications.

Easy access. With a properly equipped Viewdata terminal and VTP system, the user could much more easily gain access to the data he seeks. Present subscribers must work through a tree-structure index or else refer to a directory and call up the desired pages for viewing. However, CAP-Microsoft proposes to add VTP retrieval programs to Viewdata.

"We have a very simple and useful key-word program that pulls out all the relevant pages," says project manager Edward C. Sedman. "You could call up British Rail timetables, type in Birmingham and London, and the computer program would pick up all the relevant pages."

Own data bases. Businesses also could establish their own protected data bases within the BPO data bank. Both the firm's central operations and its offices around the country could feed information into the protected base. Moreover, processing programs could be distributed to the branches and could be updated or changed at will.

Sedman says his company is collaborating with the Hirst Research Laboratories of the General Electric Co. Ltd., where an integrated terminal for business applications is under development [*Electronics*, Sept. 14, p. 63].

Further down the line, he says, a major software industry will open up to serve a new generation of microprocessor-based small-office computer systems. The vendors will use Viewdata because it provides low-cost program distribution and permits easy program updating. They will use VTL because it permits semi-skilled operators to use the system. □

Information please. For Britain's fully interactive Viewdata information service, a software house is proposing modifications that could increase its versatility and ease of use.

Which CRT family now includes a simple, character-mode terminal with bright, high-resolution display, two full pages of continuously scrolling memory, familiar typewriter-like keyboard with embedded numeric keypad, comprehensive character and line editing, eight preprogrammed function keys, self-test and optional built-in 120 cps hard copy?

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Editing? On a simple CRT? Sure, because editing gets more work done faster. The 2621's comprehensive editing includes character and line insert and delete, clear line and clear display. What's more, the 2621 keeps your input separate from your CPU's so you can edit data before sending it to your CPU. And all without rewriting a line of your system's software.

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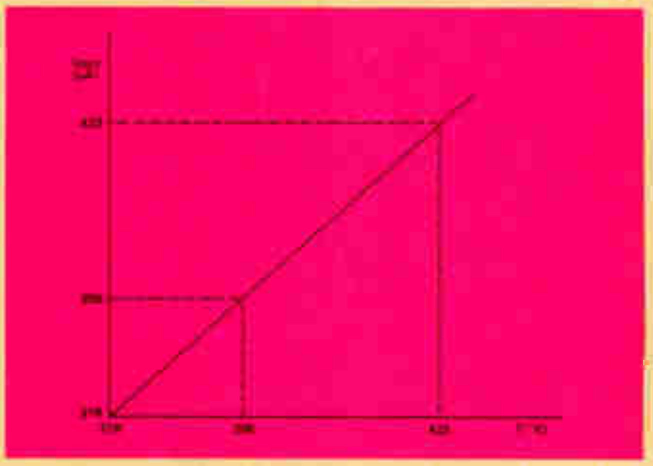

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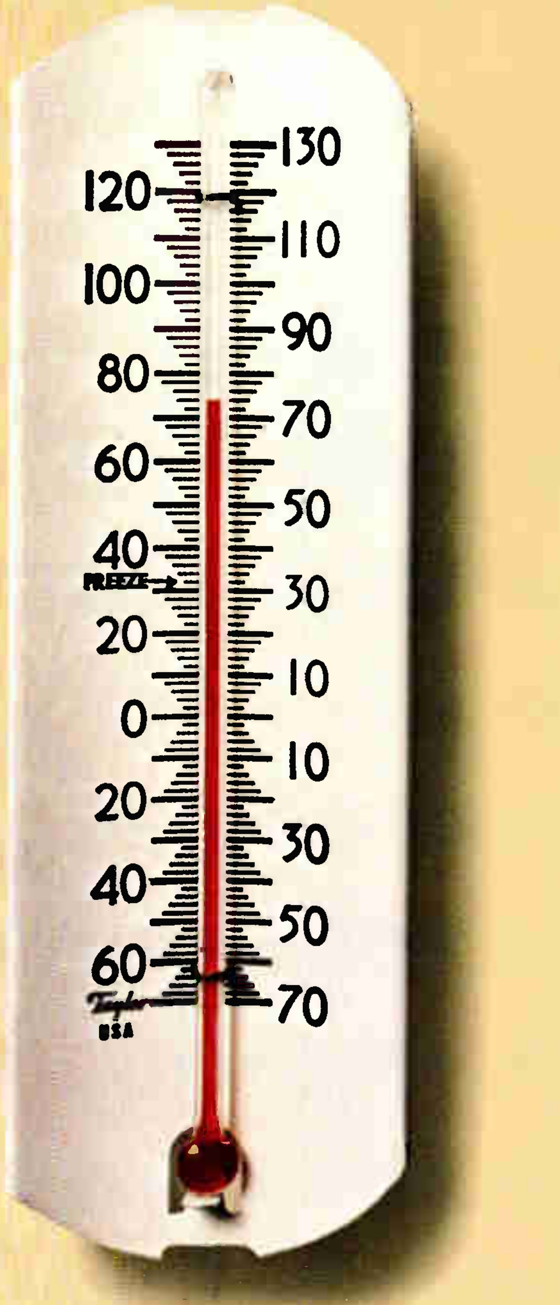

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Circle 80 on reader service card

New IBM architecture bows

System/38, succeeding System/3, has two types of microcode and a data-base management of 280 trillion bytes

by Anthony Durniak, Computers Editor

International Business Machines Corp. has moved to a dramatic new architecture and operating system—its first in almost 10 years—with the introduction late last month of the System/38 small-business line. Moreover, its introduction serves notice that IBM's General Systems divison, which will make and market the new series, will not be outdone by its big mainframe marketing brother, the Data Processing division, which raised eyebrows earlier in October with the distributed-processing abilities of its new 8100 [*Electronics*, Oct. 26, p. 88].

Although the new architecture is shrouded in the corporate wrap of mystery, evidence of its existence is found in the 38's two types of microcode, both stored in random-access memories, and a sophisticated data-base management scheme estimated to control some 280 trillion bytes of logical address space.

At its heart is a new programmable transistor-transistor-logic array (see "IBM marches farther into LSI"). The use of the 65,536-bit memories introduced with the 8100 last month [*Electronics*, Oct. 12, p. 33] and a new 36,768-bit RAM bring the price of its memory to new lows (see p. 39). With the power of a small mainframe computer, the System/38 also serves to increase the overlap between the two IBM divisions.

Blueblood. As expected, the System/38 is taking over for the nearly 10-year-old System/3—with more than 40,000 installed, one of the most successful and widely used computers in the industry's history. Such healthy family bloodlines, industry observers say, will make the new system a strong contender in the increasingly competitive business-computer market, especially against machines from such companies as Digital Equipment Corp., Hewlett-Packard Co., and Prime Computer Co.

Although William Becklean, the IBM watcher at brokerage house Bache Halsey Stuart Shields Inc. in Boston, says that the new machine is "underwhelming" when compared on a price basis, he admits it offers striking new functions. "IBM has decided to use technology to get an easier-to-use computer. As such, the System/38 is not particularly aggressive in the traditional price-performance comparison, But its key features are buried in its increased operational functionality."

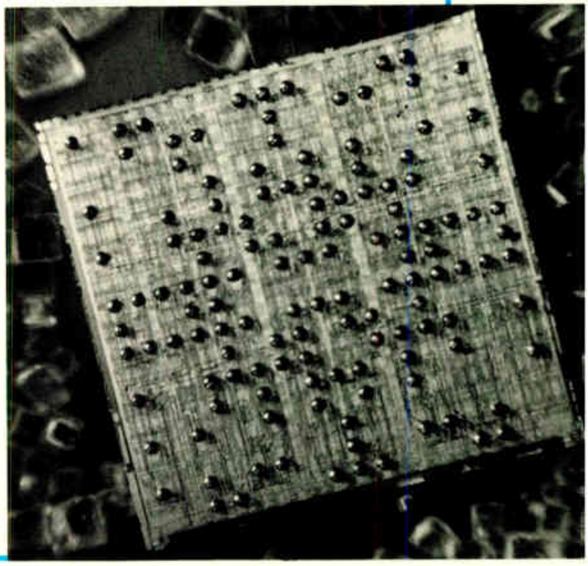
According to Donald H. Brown, research vice president at another

IBM marches farther into LSI

IBM Corp. is plunging deeper into the realm of large-scale integration with the introduction of the programmable transistor-transistor-logic array (right) used in the new System/38. Switching speed of these chips is between 3 and 5 nanoseconds, says Irv Abzug, manager of logic product programs at the Data Systems division in East Fishkill, N. Y. Measuring 179 mils on a side, the chip contains more than 7,000 transistors, diodes, and resistors arranged into 704 Schottky TTL circuits, Abzug says. An advantage of the technique is its open part number set, he adds. The 704 logic cells can be linked in an almost infinite variety of ways.

IBM achieves 134 pinouts using its flip-chip packaging technique. This method allows connections to be made to the middle of a chip with a solder dot that is reflowed after the chip is flipped over into its package. The chip is packaged on a ceramic carrier with 116 pins. It uses −1.5- and −4.25-volt power supplies and dissipates 1 watt.

To design the interconnections between the 704 logic cells, IBM has developed a computer-controlled electron-beam pattern generator that writes directly onto the chip the pattern for the last two layers of metal and their interconnections. Then, when the design is finally set, the same computer data is used to produce a conventional optical mask for mass production of the chips.



broker, Dean Witter Reynolds Inc., New York, this approach is what makes the System/38 "the second major machine to define a computer architecture and functionality for the 1980s. It and the DEC VAX 11/780 [*Electronics*, Nov. 10, 1977, p. 36] are the first machines to capitalize on recent components advances and make major new definitions."

The feature that provides most of the increased functionality in the System/38 is the single-level memory management scheme. According to an IBM spokesman, the machine has a virtual address 6 bytes long. At 8 bits per byte, that equals a 48-bit address—or enough for 280 trillion bytes of virtual storage.

The company says that with the single-level memory, data is referenced by symbolic names, freeing the user from worrying about addresses, transient areas, program overlays, partitions, volume labels, or other storage-management considerations. Main and disk storage are managed by the System/38 to appear as a single virtually addressed storage space.

Separation. Under the same unbundled software policy as the 8100, the new operating systems and software needed to manage the single-level memory are separately priced. The Control Program Facility operating system has a license fee of $400 a month, while the RPG III programming language, the only one supported on the System/38, has a fee of $60 a month. The data base utility fee is $30 a month.

For users wishing to move programs and data files from their System/3s to System/38s, a conversion and recompilation is necessary; a conversion utility program to assist in the job is available for a one-time charge of $1,300. A spokesman says once the data is converted, tape, cards, or diskettes can be used to transfer it to the System/38.

Although IBM will not discuss the bus size, or structure, of the System/38 or the size of its 16 general-purpose registers, more evidence of the machine's new architecture is seen in its extensive use of microcode. One type, called horizontal, is stored exclusively in control store, while vertical microcode resides in the single-level memory system. The firm will not specify what the two kinds do, but a spokesman says many of the traditional operating system functions are in microcode on the System/38.

Means business. IBM's new System/38 gives small users some functions found in big systems such as data base, virtual storage and computer-aided programming.

The System/38 central processing unit is available in two models. The model 3 can have 512 kilobytes to 1 megabyte of main memory with a cycle time of 1,100 nanoseconds using the new 64-K RAM; the model 5 can have from 0.5 to 1.5 megabytes of main memory but uses a new 32-K RAM for a memory cycle time of 600 ns. The model 3 uses IBM's new 18-K RAM for its 4,000 32-bit words of microinstruction control store with a cycle time of 400 ns, whereas the faster model 5 uses a 1,096-bit RAM for its 8,000 words of control store with a cycle time of 200 ns.

Prices for the basic model 3 CPU range from $70,210 to $88,780; price tags on the larger model 5 go from $99,645 to $136,215. In comparison, DEC's VAX systems go from $130,000 to $185,000 and HP's 3000 Series III systems range from $115,000 to $250,000.

A small model 3 configuration of the System/38 with 512 kilobytes of memory, one 64.5-megabyte disk drive, a printer, and two cathode-ray-tube terminals can be purchased for $115,345 or leased on a three-year contract for $3,444 a month.

At the other extreme, a model 5 with the full complement of 1.5 megabytes of memory and 387.1 megabytes of disk storage, two printers, four tape drives, 32 locally attached CRT terminals, 8 workstation printers, and 60 remote CRT terminals is priced at $760,995, or $20,960 on lease.

The price of memory increments is surprisingly aggressive: $20,000 a megabyte on the model 3 and $28,000 on the faster model 5. IBM's Data Processing division prices the same 64-K RAM in its 8100 at $18,000 a megabyte, yet charges $110,000 a megabyte for its System/370 mainframe computer add-on memory. Hewlett-Packard, with one of the lowest memory prices in the minicomputer industry, charges $32,000 a megabyte. □

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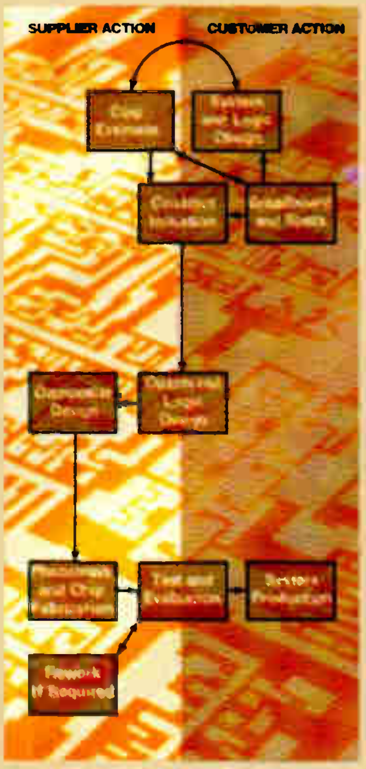

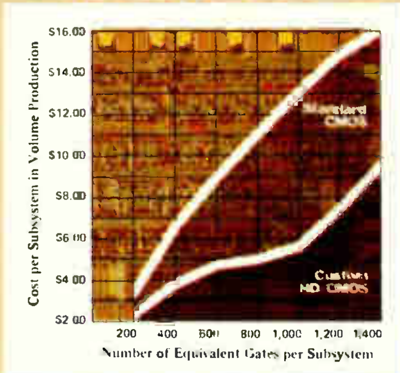

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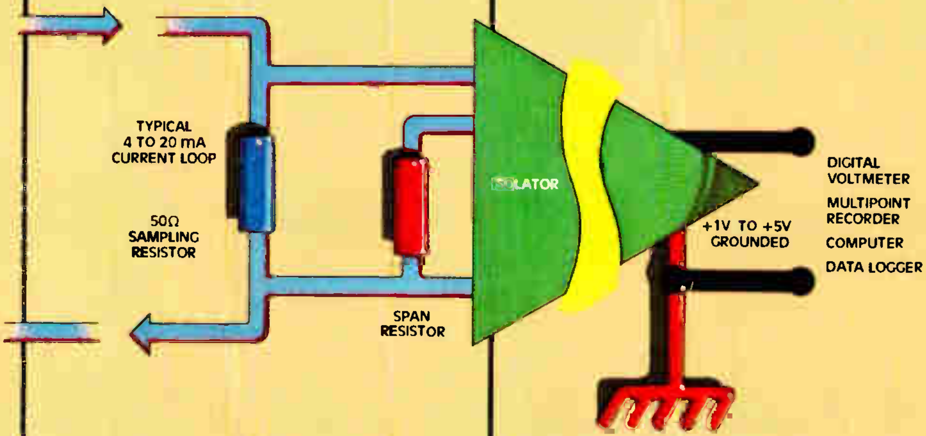

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You and your career

Is the activities board falling short?

Many IEEE members want a push in bread-and-butter areas, but USAB chairman Weinschel favors broad approach

by Gauri Bhatia, McGraw-Hill Publications Co.

One of the Institute of Electrical and Electronics Engineers' longest lasting headaches—what matters should concern its United States Activities Board—shows little sign of abating. Not only that, but to the familiar debate over whether the board should limit itself to professional matters such as pensions, age discrimination, and wage busting, a new accusation has been added this year: that the board has become too deeply involved in industry- rather than engineer-oriented matters.

Not so, says USAB chairman Bruno O. Weinschel. The president of Weinschel Engineering Co. in Gaithersburg, Md., insists that the board is working on both professional and technical problems and that each deserves equal concern.

"We are in no way neglecting the professional aspects of USAB," says Weinschel. "Industry and employment go hand in hand. Of course, we are concerned about economic benefits for our members, but we also want to use the IEEE's expertise to improve the quality of the world."

Opposition from within. On the other hand, Robert A. Rivers, leader of the IEEE's manpower task force, maintains, "The USAB should be working on what interests and benefits the members, not the employer, or society as a whole, or the pure advancement of technology. The organization has become industry-oriented this year. There are enough others capable of addressing industry's interests. We should be serving our members' needs."

Faith Lee, chairman of the IEEE's professional activities committee chapter in Princeton, N. J., agrees. "USAB doesn't understand the problems of the average engineer—the poor slob who's raising three kids on $18,000 and has no job security or pension plan. These are the issues that really matter."

Although there is some agreement that bread-and-butter matters should come first, which of them should get priority is a point of contention. Opinions vary with the age, location, and experience of the particular engineer.

Embattled. Bruno O. Weinschel, chairman of the U. S. Activities Board, answers critics by saying that the board can handle both professional and industry problems.

Older engineers suggest that the board should be combatting age bias, those in the Cape Canaveral area worry about wage busting—the practice of threatening EEs with layoffs unless they take pay cuts when a service contract must be renewed—while engineer-owners recommend stepped-up lobbying to ease capital flow and taxes.

"I hear a lot of talk," shrugs Weinschel. "But very few people seem to realize the amount of slow, plodding work one has to do to even make a dent in these problems. A bill has to go through Congress, the Senate, the White House—all of which takes a couple of years and a lot of lobbying. And it's changed so often along the way that it might not even resemble the bill you wanted."

Who cares? Areas in which the board has been trying to exercise what muscle it has include wage busting and lobbying for the Investment Incentive Act and the Limited Employee Retirement Account Act. As for the former bill, the effort receives its share of disdain from professionally oriented members. "The bill is sure to benefit industry," says Robert Bruce, past chairman of the professional activities committee for Long Island, "and perhaps there will be some fallout to indirectly benefit the engineer."

Of greater interest to members is the retirement bill, since it would permit mobile professionals not vested in employer-sponsored plans to create independent retirement accounts. The board has been pushing this bill for 2½ years. Members' response has been good, as it tends to be on matters that directly affect their well-being. □

Electronics abroad

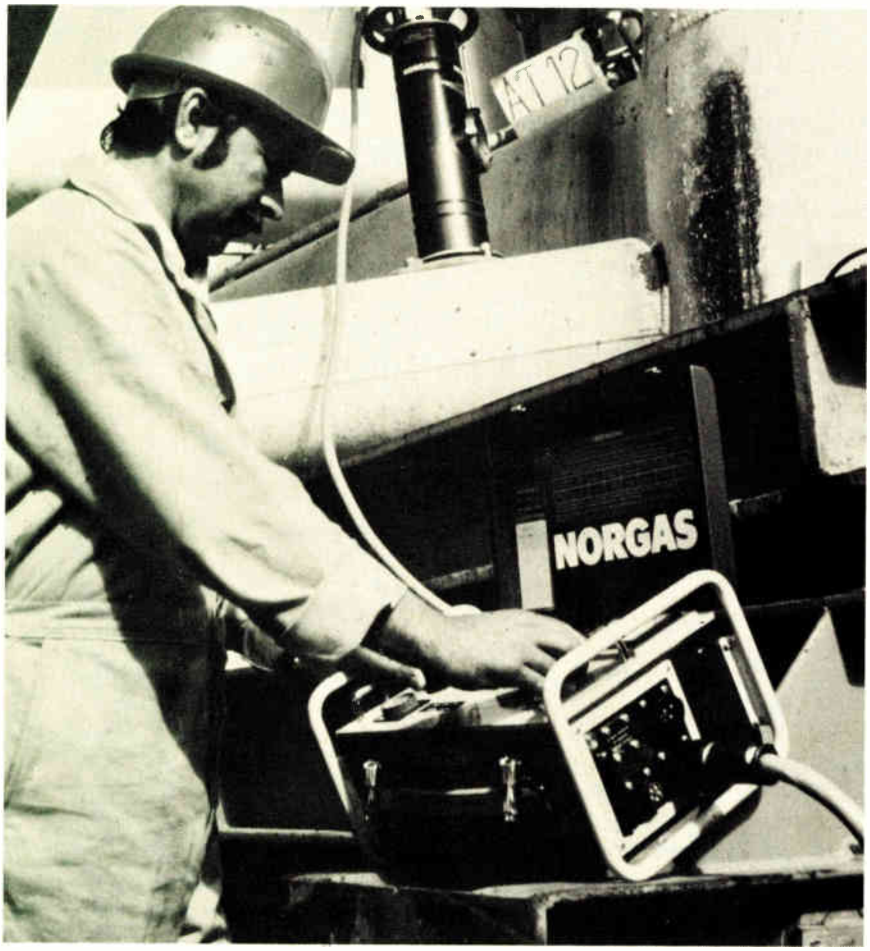
Smiling Danes peer out of niches

Policy of cultivating worldwide markets that are too small to attract the giants keeps electronics industries healthy

by Alfred Pedersen, McGraw-Hill World News, Copenhagen

There are very few melancholy Danes in the electronics business these days. In fact, as they take a deep breath after their triennial trade fair, Elektronik 78, held late last month, Danish hardware makers are exuding confidence. "Not since 1973 has optimism been so high among electronics companies," maintains Frede Ask, top executive officer of the Association of Electronics Manufacturers in Denmark.

The numbers coming out of the government's statistical office justify their confidence. The latest figures for production of electronics equipment and components by the industries' 200-odd firms peg the output for 1977 at some $800 million, with nearly $600 million going to export markets. Judging from their order backlogs and their crystal balls, the major manufacturers see total growth of at least 10% in 1978. And they are forecasting much the same growth—albeit with some problems—for 1979.



Close look. Andrus X-ray test equipment being used to check welds in steel construction for a drilling platform in the North Sea. Set includes tube head, control unit, and cables.

Ask almost any Danish electronics producer why business looks buoyant and likely he will credit his "niche policy." Because their home market is so small, Danish electronics companies have traditionally tried to develop products with a worldwide market that is big enough to keep a small company going but too small to attract the giants and their crushing competition. By specializing in one or two offbeat but high-technology products, a surprising number of Danish companies have won dominant world positions.

Hospitals to hi-fi. Thus, Radiometer A/S is a world leader in blood-gas testing equipment for hospitals, Storno A/S is Europe's top exporter of portable radiotelephone equipment, and Soren T. Lyngso A/S has a major world share of maritime engine controls. Brüel & Kjaer A/S is probably the world's largest manufacturer of vibration-measuring instruments. Three Danish companies—Danavox A/S, Oticon A/S, and Topholm Westermann A/S—add up to an international force in hearing aids. And Bang & Olufsen A/S, the Danish leader in consumer electronics, has found its niche through styling and quality.

Working in the niches, of course, means working worldwide: Danish electronics producers export about 70% of their output, and they are edging into second place—behind machinery—among Denmark's export industries. Their biggest customers are their neighbors: West

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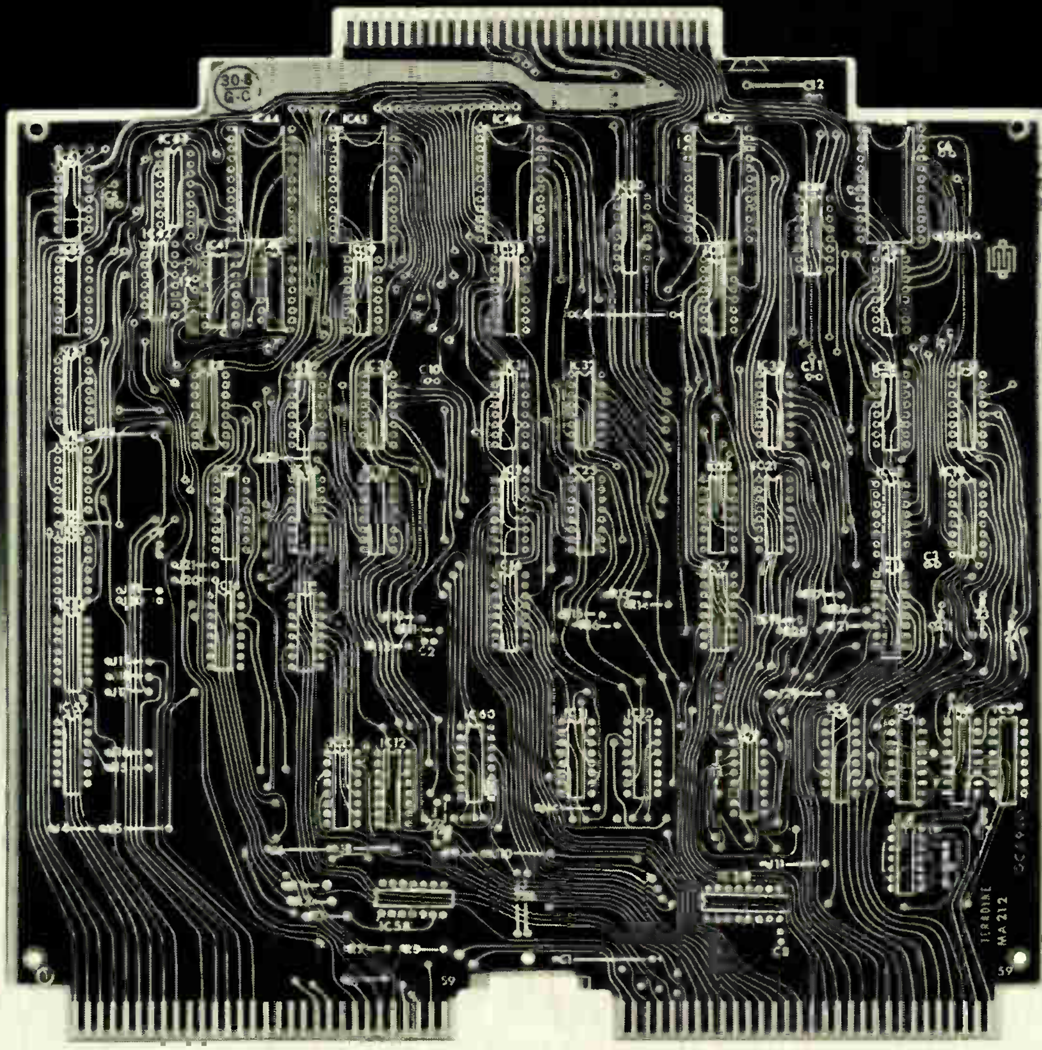

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Probing the news

Germany, England, and Scandinavia. But next comes the United States, proof that the Danes can compete almost anywhere in their own special fields.

Christian Rovsing A/S is a textbook example of a Danish company that succeeded by having the right high-technology product at the right time. A couple of years ago its CR 80 processor began to catch on with U. S. manufacturers, winning approval from Litton Data Systems division in 1977 as an assembly in Litton's own range of hardware. With this boost, last year's Electronics division sales of about $5 million represented a 130% increase over 1976. Says divisional vice president Jan Stig Nielsen: "A few years ago we were working to get our products accepted. Now we're reaping the benefits. I don't have to worry about sales any more—we've got orders for several years." To make doubly sure, the company has recently opened a sales office in Los Angeles to push its activities in California, where it finds most of its U. S. business.

Another company whose future looks good in the U. S. is A/S Regnecentralen, which introduced its modular RC 8000 computer several years ago. The firm now has an agreement with Lockheed Electronics Co., Plainfield, N. J., to use this system for subscriber inquiry services in telephone systems. The first unit will be installed shortly by a Bell company. Regnecentralen's president, C. C. Sandberg, says that Lockheed assesses possibilities for sales at 30 units a year, which would almost double RC 8000 sales.

A future. Even if Lockheed has overestimated the market, Regnecentralen will be doing well. In recent years, the company has logged sales increases of 35% a year for its hardware, its programs, and its services (the company started originally as a service center for Danish customers). Hardware sales were up during the 1977–78 fiscal year from the equivalent of $22.5 million to $35.5 million. "There's a future for a company of our size," says Sandberg.

In consumer electronics, Danish flagship Bang & Olufsen now reports booming sales of its hi-fi gear in the U. S. Sales there shot up 40% during the 1977–78 operating year, and the company expects the trend to continue as Americans continue to spend on quality products. Ortofon Manufacturing A/S, a subsidiary of Harmon International, logged sale increases of 30% for its record-player cartridges this year and has hopes of another 25% increase in the year ahead. Ortofon is counting on a new low-mass integrated pickup.

Mining, as they do, narrow veins of technology gives Danish electronics producers some sorely needed leverage. For one thing, they have close ties to customers that are willing to share research and development costs in order to stay on the leading edge. For another, their "niche" products are not particularly susceptible to the ups and downs of the world economy. And by eschewing volume-run, labor-intensive products, they can cope with the high wage levels in Denmark, where the worst-paid workers get slightly more than $5 an hour.

"As long as we can continue to produce equipment that is little affected by the world economy, we can continue to operate in a high-wage area," says Soren Engle, president of AEMD and director of Vitrohn Elektroteknisk Fabrik A/S, a major resistor maker.

Financing R&D. But there is always the problem of financing the R&D necessary to keep up front in technology. Most companies seem able to put back about 10% of their sales to generate new products.

"We made an important decision two years ago to tighten up our spending to find the money we needed for product development," says Johan Schroeder, president of Radiometer. "We had been budgeting 10% of our sales [$28 million in 1977] for R&D, but we decided to increase this to 13% or 14%. We haven't reached this goal yet, but we're getting close."

Another manufacturer says he gets the necessary R&D funds by trimming things like administration. Perhaps the most effective fund-raising method is reported by a Brüel & Kjaer spokesman: "We just go out and sell a little more." □

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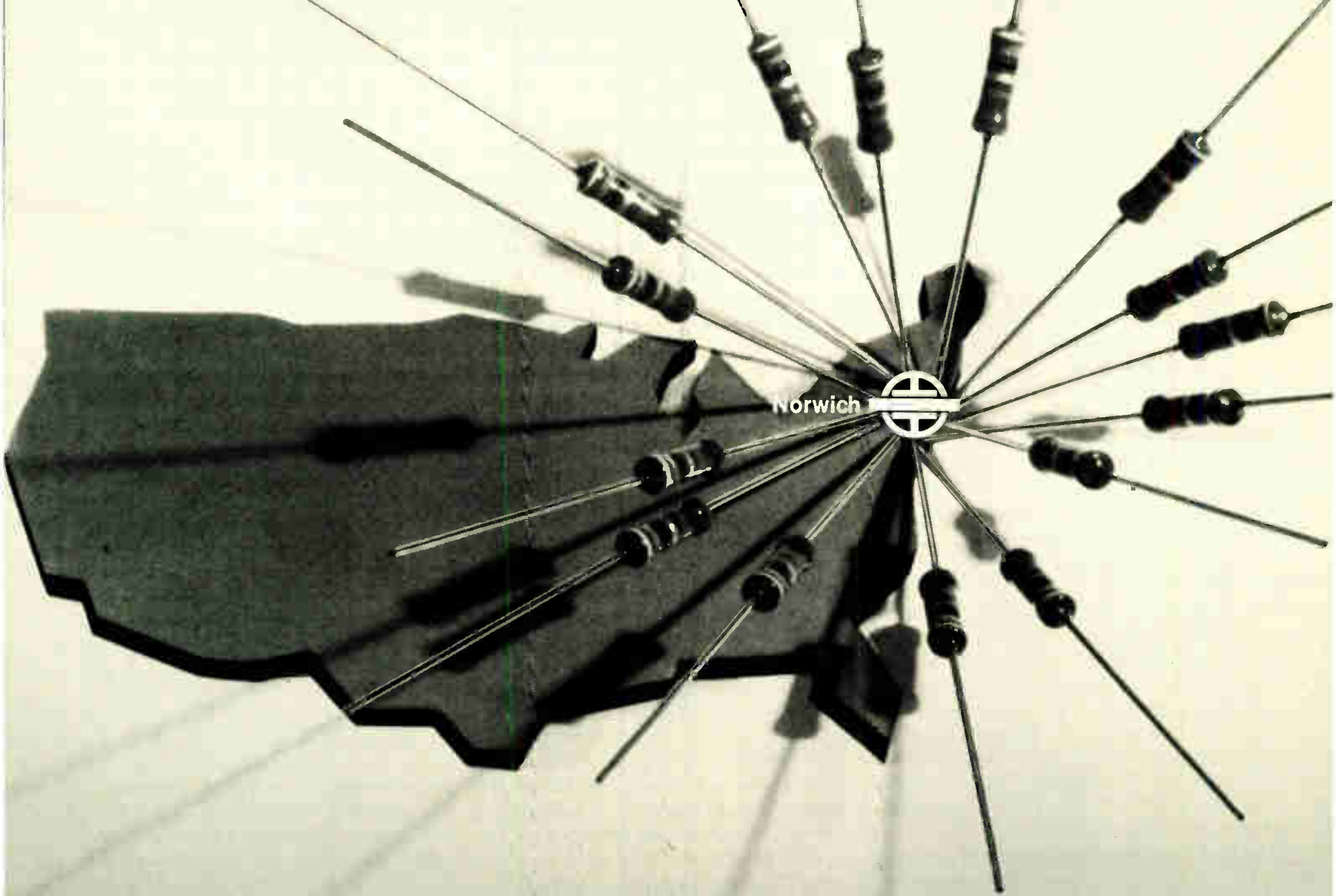

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Circle 89 on reader service card

Communications

That boom you hear is ham radio

Equipment makers are big gainers, as eased regulations on licenses benefit CB refugees and graduates of ARRL training

by Vincent Biancomano (WB2EZG), Circuit Design Editor

Fueled initally by the citizens' band fever, a boom in ham radio is currently under way, much to the delight of manufacturers of communications equipment. Not only are many CBers turning to amateur radio, but the general Government deregulation policy has eased the requirements for obtaining a license, and the American Radio Relay League, the hams' spokesman, is successfully pushing a nationwide training program to expand the ham population.

As a result, 28,000 new operators are expected to swell the total this year to 366,000 licensed hams, up from last year's 338,000, 1976's 288,000, and 1975's 276,000.

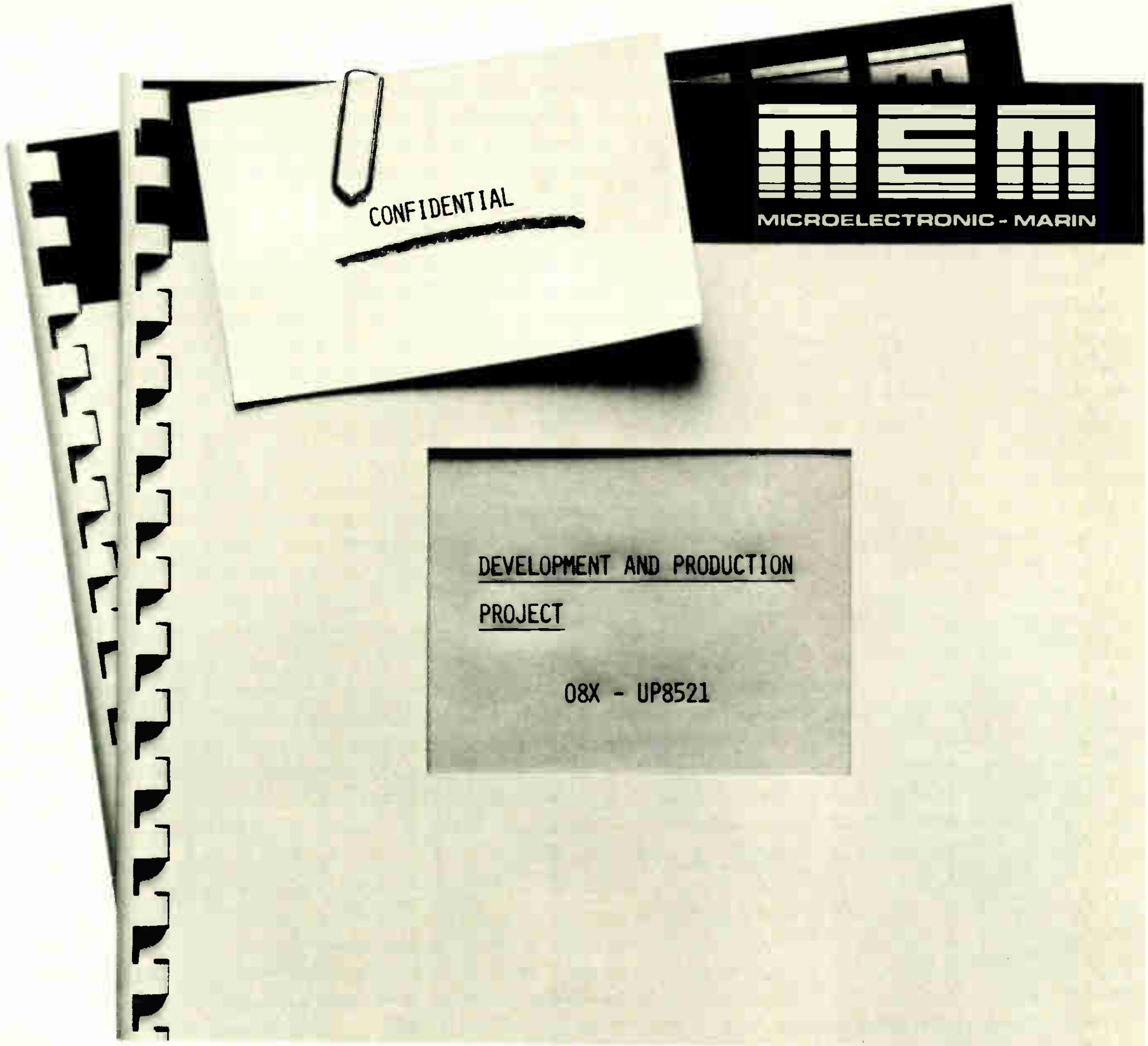
While those numbers do not repeat the staggering growth of CB, they are impressive when measured against the no-growth, and even shrinkage, of the ham population in some recent years. More importantly, the reward for manufacturers is likely to be a solid, high-profit market, because most people involved in ham radio foresee long-term expansion, not the bottoming out of the market that proved so disastrous in CB.

Scott Anderson of Jade Computer Products, Hawthorne, Calif., certainly believes so. In charge of exhibition-show coordination and outside marketing for the firm, which is perhaps the largest distributor of computer items to hams, he says: "The market is growing faster than our own company because our average ham customer is spending more on computer products than on transmitters and receivers *per se*. We foresee no change in this trend for a long time to come."

Even one of the best-known consumer-based companies, which usually would be interested only in a high-profit situation, is taking a closer look at ham radio. Radio Shack (Tandy Corp.), Fort Worth, Texas, will introduce its DX-300 general-coverage receiver, with digital readout of channel frequencies, at the end of the year. Says a spokesman, "We will watch the sale of this receiver very closely in order to reevaluate our position with regard to manufacturing ham equipment at a future date."

As for the companies that have ham product lines, a new cast of characters is reaping the rewards that old-time ham radio makers always sought, but never realized. The old names like Collins Radio Co., National Radio Co., Hallicrafter Co., and Hammarlund Inc. are all but gone. In their place are firms like Trio-Kenwood Communications Inc. of Japan, which made a name

Whistles and bells. Typical of the new look in ham gear is the Astro 200A hf transceiver from CIR Industrie (part of Cubic Corp.). It is small, light, versatile, and expensive.



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Probing the news

previously in the hi-fi and stereo equipment field; Yaesu Musen Co., also Japanese, which has been marketing ham goods in the U.S. for about six years; Dentron, Twinsburg, Ohio, a company which prides itself on being "all American;" Wilson Electronics Corp., Las Vegas, Nev., a relatively new manufacturer of ham antenna systems; and Lunar Electronics, San Diego, Calif., a producer of very-high-frequency amplifiers that was started by a ham engaged in moon-bounce experiments several years ago.

Quality. The equipment sold to hams is of very high quality, permitting excellent communications with any part of the world under the right ionospheric conditions. The technology and design sophistication of the gear approach what is found in commercial equipment: digital frequency synthesis and readout, broadband amplifier circuits that require no tuning, speech-processing circuits, noise blankers, receiver incremental tuning, and split-frequency operation (receiving on one frequency and transmitting on another). These features are already standard or fast becoming so.

Today transceivers are the staple of the ham radio operator, rather than a separate transmitter and receiver, and most of them are solid-state, except for the final amplifiers and drivers, and mounted on printed-circuit boards that are sometimes of the plug-in variety and filled with many of the operating frills desired by hams.

Microprocessor- or memory-based equipment (from Curtis Electro Devices, Mountain View, Calif., and HAL Communications Corp., Urbana, Ill.) is finding use in electronic keyers, repeater- and satellite-controlled applications, automatic loggers and terminals, and a myriad of other areas open to the ham. Slow-scan television systems are readily available, too.

Needless to say, the gear is not cheap, for ham radio is big business now. Gone are the days of the one-tube transmitter and three-tube receiver that cost a few dollars but could occasionally span oceans on a single ionospheric hop. Most present-day hams do not build their own equipment, parts are expensive, and tubes (if ever used) are not made to the same high specifications they once were, anyway. The average amateur nowadays does one of two things: he (or she) either spends $700 to $800 for a high-frequency (1.8–30-megahertz, or 10–160-meter in ham circles) state-of-the-art transceiver, such as the Kenwood TS-520S, or Yaesu's FT 101, and a further $300 to $400 for antennas and accessories such as split-frequency controllers, microphones, phone-patching equipment, and signal-monitoring scopes, or he settles for a rig in the $300-to-$400 range (the HW-101 from Heath Co., Benton Harbor, Mich., or the Century 21 from Ten-Tec, Sevierville, Tenn.)—and considerably fewer operating conveniences. Running a 1-kilowatt linear amplifier (Yaesu FL-2100B or the Alpha 76A from Ehrhorn Technological Operations Inc., Canon City, Colo.) will set the ham back anywhere from $500 to $1,200. The alternative is to buy used gear, but even then, the cost can be high.

Several outfits (Kenwood, Yaesu, and R. L. Drake Co., Miamisburg, Ohio) are now producing equipment for the very-high-frequency bands. The 420-MHz range is at present the one most manufacturers are shooting at. This is a big jump from just a few years ago, when most amateurs had to build their own equipment if they wanted to operate on 144 MHz and above. But the cost of using Oscar 7 and 8, two ham satellites operating in these regions, or in having moon-bounce or meteor-shower contacts, can be pretty high, too: a good transceiver for 144 MHz (2 meters) costs $700. Drake's UV-3 three-band vhf system, which can operate at 144, 220, and 440 MHz, costs about $1,500.

Although most hams pride themselves on being special—separate from CB—the gap is fast closing both administratively, so far as the FCC is concerned, and commercially, so far as manufacturing interests are concerned. Those who would wish to preserve the spirit and self-image of amateur radio must now deal with the consequences of popularity. □

Medical electronics

Lab blends medical, IC know-how

Stanford unit is developing ultrasonic imaging systems and transducer packages for heart research

by William F. Arnold, San Francisco regional bureau manager

Although medical equipment manufacturers increasingly incorporate integrated-circuit technology into their products, it's often difficult for commercially oriented companies to support the broad interdisciplinary skills needed to develop advanced electronic instruments. So Stanford University's Center for Integrated Electronics in Medicine attacks this problem by combining the expertise of the engineers in the Stanford Electronics Laboratory and the physicians in the School of Medicine to develop instruments for a wide range of medical fields.

The center, which has a new five-year $4.6 million grant from the National Institutes of Health, has two major focuses, according to its director, Prof. James D. Meindl:

- Noninvasive, high-resolution ultrasonic imaging systems that enable a patient's organs to be examined without surgery, X rays, or radioactive dyes. One recent development is a microprocessor-based phased-array eye scanner [*Electronics*, Oct. 12, p. 41]. When necessary, the center designs and builds its own ICs, such as a monolithic cascaded charge-coupled device that acts like an ultrasonic lens.
- Transducer packages, accessible through radio telemetry, that can be implanted in laboratory animals so that researchers can track the long-term results of disease or drugs to better understand pathological mechanisms. The transducer packages, a little larger than a wrist watch, monitor such things as blood flow, blood pressure, organ size, and heart beat. For research into fetal heart development, Meindl says, the center is working with the University of California at San Francisco Medical Center to implant a transducer into a sheep's womb. The center also has designed two low-power custom timing and radio frequency amplifier ICs for an implantable pulsed-doppler ultrasonic blood-flow meter.

"There are opportunities to use sophisticated electronics to fulfill human needs, and this center is a way to meet them," declares Meindl, who came to Stanford 10 years ago with the idea of such an organization in mind. Pointing out the proximity of the Palo Alto, Calif., campus to technology-rich Silicon Valley, the 45-year-old professor says, "It would be difficult for a company to support the high technology we have available here."

The center, with its budget of approximately $3 million a year, is part of the IC lab and the lab itself is one of six labs in the $10-million-a-year Stanford Electronics Laboratory. The IC lab, the largest of its kind in a U. S. university, has 100 persons working for it, many of them Ph.D.s or doctoral candidates, and has in-house access to any of the processing technologies used by commercial IC manufacturers.

Imaging. Stanford decided eight years ago, Meindl recalls, that "one of the most promising areas to apply integrated electronics in medicine was ultrasonic imaging," which along with computerized axial X-ray tomography, has sparked an explosion in diagnostic instrumentation over the last five years. But available ultrasonic scanners generally could not combine high-resolution imaging with real-time scanning of moving organs.

Director. James D. Meindl runs Stanford's Center for Integrated Electronics in Medicine, part of its famed Electronics Laboratory.

Although the ultrasonic program developed the eye scanner and a blood-flow meter, the main effort is to perfect what is called the theta phased array system, Meindl says. Shaped like the Greek letter theta, it consists of a horizontal array of ultrasonic detectors inside a circular array of emitters and it is designed to permit noninvasive examination of organs inside the rib cage.

Called the C³D, the cascaded charge-coupled device employs the variable delay-line characteristics of CCDs to get the electronic focusing capability. The chip is a 20-input surface-channel device divided into four sections, two for beam steering and two for focusing, under the control of five independent clocks. It allows the scanner to form a pencil beam of sound and scan with it. □

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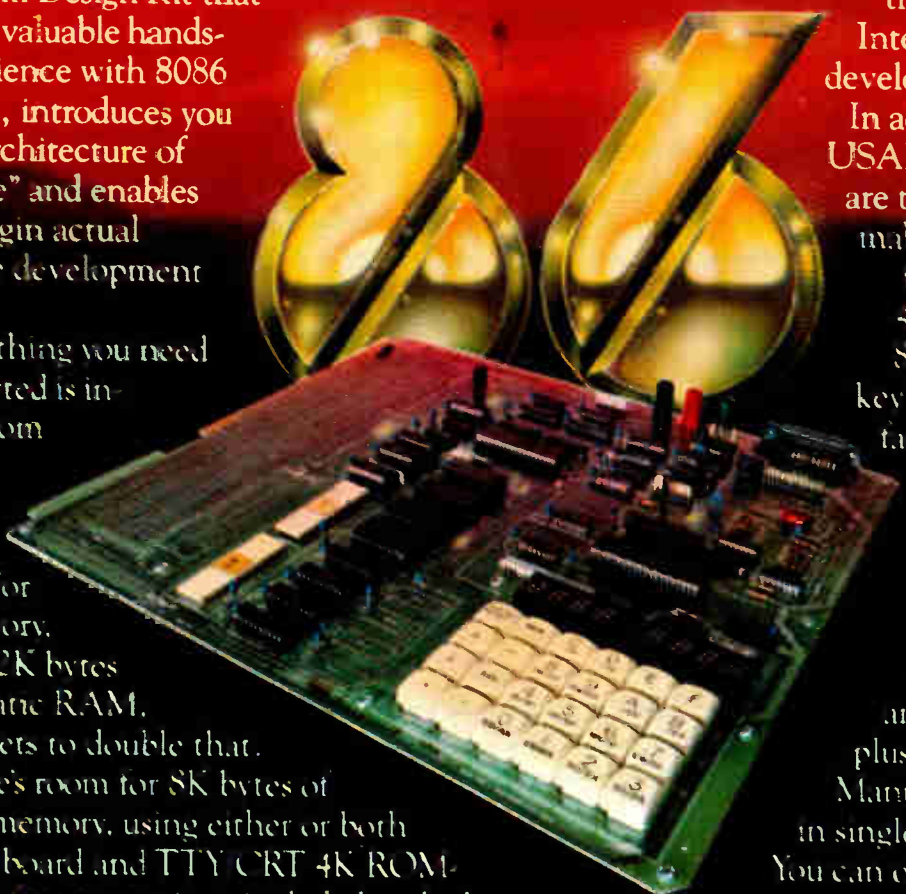

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Circle 93 on reader service card

Communications

TDMA is in the air at Montreal

Despite problems associated with the technique, representatives at world conference on digital satellites agree it is ready to arrive

by Harvey J. Hindin, Communications & Microwave Editor

Everyone in communications agrees that the day of digital transmission satellites is drawing closer. But they also agree that even as the technology moves ahead, there is a slew of practical problems that must be solved before the airline passenger over the Atlantic can expect to talk to, say, an associate in an automobile in Oslo.

Those problems and their possible solutions formed the backdrop late last month for the Fourth International Conference on Digital Satellite Communications. Held in Montreal, the meeting attracted heavy hitters from around the world. Much of their conversation was of technological advances, such as clever coding and modulation techniques that increase reliability, flexibility, and channel capacity—and the technique most discussed was TDMA—time-domain multiple access.

But TDMA is not just around the corner. Although as a concept it has been around for 10 years, and although it has been implemented in several places—most notably by Telesat Canada—it will be the mid-1980s before TDMA arrives throughout the world. Ken-ichi Miya, director general of Japanese communications conglomerate Kokusai Denshin Denwa Ltd., says it will take several years for systems such as Intelsat, the international satellite communications consortium, to even introduce the prime digital multiplexing technique of TDMA into its network.

Problems remain. One reason for this delay and the paucity of operational TDMA systems is that not all of the problems have been solved in converting conventional frequency-domain multiple-access fm operation to TDMA, especially when it incorporates such new techniques as digital speech interpolation—which improves transmission efficiency by a factor of two or better.

Some of the problems were summarized by A. K. Jefferis, head of the telecommunications department of the British Post Office (see "Time-domain multiple access"), who says that TDMA has nevertheless arrived and predicts that a voice channel will be had for about 7 cents per minute.

However, to convince skeptics that the various government agencies and private companies around the world really believe demand will increase and TDMA and other digital techniques will come along, it is only necessary to look at the new services and systems proposed, under test, or in production. Examples are:

- International computer communications to be provided by a proposed "broadcast packet satellite channel system" (from Comsat General Corp.).
- Low-cost data transmission using demand-assigned TDMA, with the low cost the result of not pushing device-performance characteristics to their limits (from the European Space Research and Technology Center).
- Linkage of a data processor in France with one in the U. S. at bit rates approaching those of a computer channel (from IBM France using the Symphonie satellite).
- Heavy-route message service with the Telesat Canada Anik-C, a 90-megabit-per-second system using quadriphase-shift-key modulation (from Telesat Canada).
- The advanced Westar satellite-

TIME-DOMAIN MULTIPLE ACCESS

Why?	Why not?
Increases satellite capacity, so that fewer or simpler satellites and earth stations are needed	Causes transition problems in satellites already operating
Improves reliability because of digital technology	Requires new investment in earth stations
Provides a match to the introduction of terrestrial digital technology	Requires new maintenance arrangements with economic complications
Makes data transmission more efficient with less error	Creates interface problems with earth stations due to different standards of various countries
Improves circuit quality and hence reception	Requires new techniques to be learned
Allows for easy transition to satellite switched TDMA later	Makes customers apprehensive because of its complexity

Probing the news

switched TDMA satellite that will maintain interconnectivity with multiple spot beams (from Western Union).

The systems indicate the optimism of their makers about the future of satellite communications. This optimism is based on both market and technological grounds.

One of the biggest present and potential users, American Telephone & Telegraph Corp.'s Long Lines, is a case in point. In the words of Billy B. Oliver, vice president for engineering planning, "Bell no longer bad-mouths satellites." One reason is an acceptance of the facts of life.

But Bell also has managed to solve a major problem: echoes on satellite circuits due to transit delays. Customer complaints had not been stopped by conventional solutions, and it was not until an adaptive echo canceler was developed that the problem went away. According to Bell surveys, the canceler makes satellite-based lines as good in quality as submarine cable lines.

Reducing the rate. The Montreal conferees had another major concern: methods to save bandwidth. Interframe and interfield coding techniques have reduced the bit rate of broadcast-quality television signals to 20 to 30 Mb/s. Better still, picture coding for some teleconferencing systems has sufficient quality for practical use at a low bit rate of 6 Mb/s. Still, most authorities agree that voice transmission will continue to constitute a large part of future satellite communication traffic—but even this usage may end up with a lower required transmission rate. For example, though 16 kilobits/s is needed with adaptive delta modulation, a voice encoder may operate at 2.4 to 4.8 kb/s at an affordable cost, thanks to large-scale integration.

The communications industry hopes that as prices go down because of increased channel capacity and the ever-falling price of LSI, overall usage will be stimulated, requiring overall higher capacities. Here again, digital techniques have advantage, since they also provide for increased flexibility of circuit operation and adaptability to new services. In the background, however, are recent advances that may make analog technology competitive even longer.

Perspective. To provide some perspective on how much progress there has been in bandwidth capability, Santiago Astrain, director general of Intelsat, notes that in the century from 1850 to 1950, the rate went from the 10 bits/s of the Morse telegraph key to the computer-related 4.8 kb/s. And this 48,000% increase has evolved into a current rate of 80 Mb/s and even higher.

Although this capacity will go a long way toward solving man's need for the acquisition, storage, and processing of information, the need is not universal. "It must be noted," he says, "that the great majority of Intelsat's 102 member countries are not planning a rapid conversion to digital transmission techniques. Many of them have extensive investments in analog frequency-division-multiplexing equipment and semiautomatic switching centers, and their current levels of traffic do not justify conversion."

As a global service, Intelsat must be flexible enough to service all forms of traffic and interconnection systems regardless of the modulation used. This flexibility is inefficient from a technical and operating viewpoint, but it is necessary in order to provide demand service for real customers and their needs.

Even worse, Intelsat's system bridges conflicting standards—for example, Europe's differ from Japan's and North America's in hierarchical grouping standards and companding law. For Intelsat, says Astrain, "the introduction of digital satellite transmission techniques that directly interface with digital terrestrial signals will necessitate having to meet these difficulties directly."

Notwithstanding these difficulties, the new breeds of satellites are on their way and will eventually be adopted by all countries as they become cost-effective for each nation's special considerations. Evidence that the developing nations are vitally concerned comes from the attendance at the conference of representatives from Nigeria, Kuwait, Zaire, China, Tanzania, and Uganda. □

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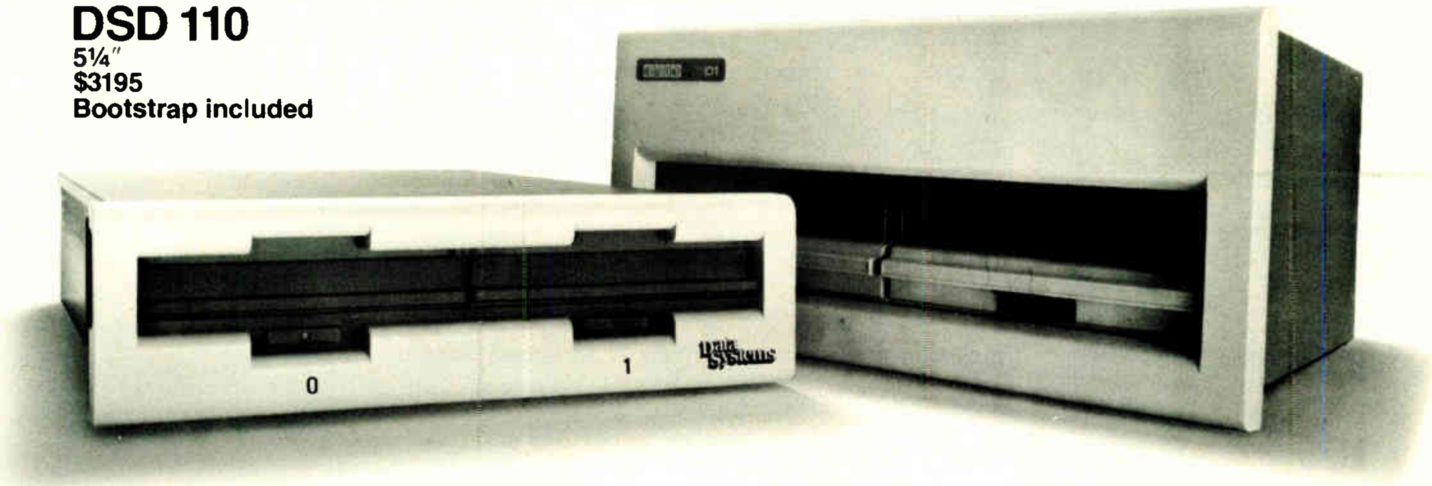

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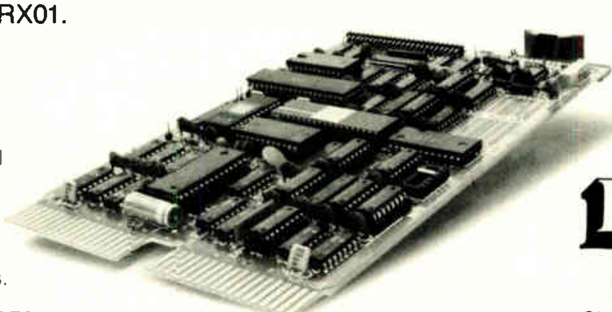

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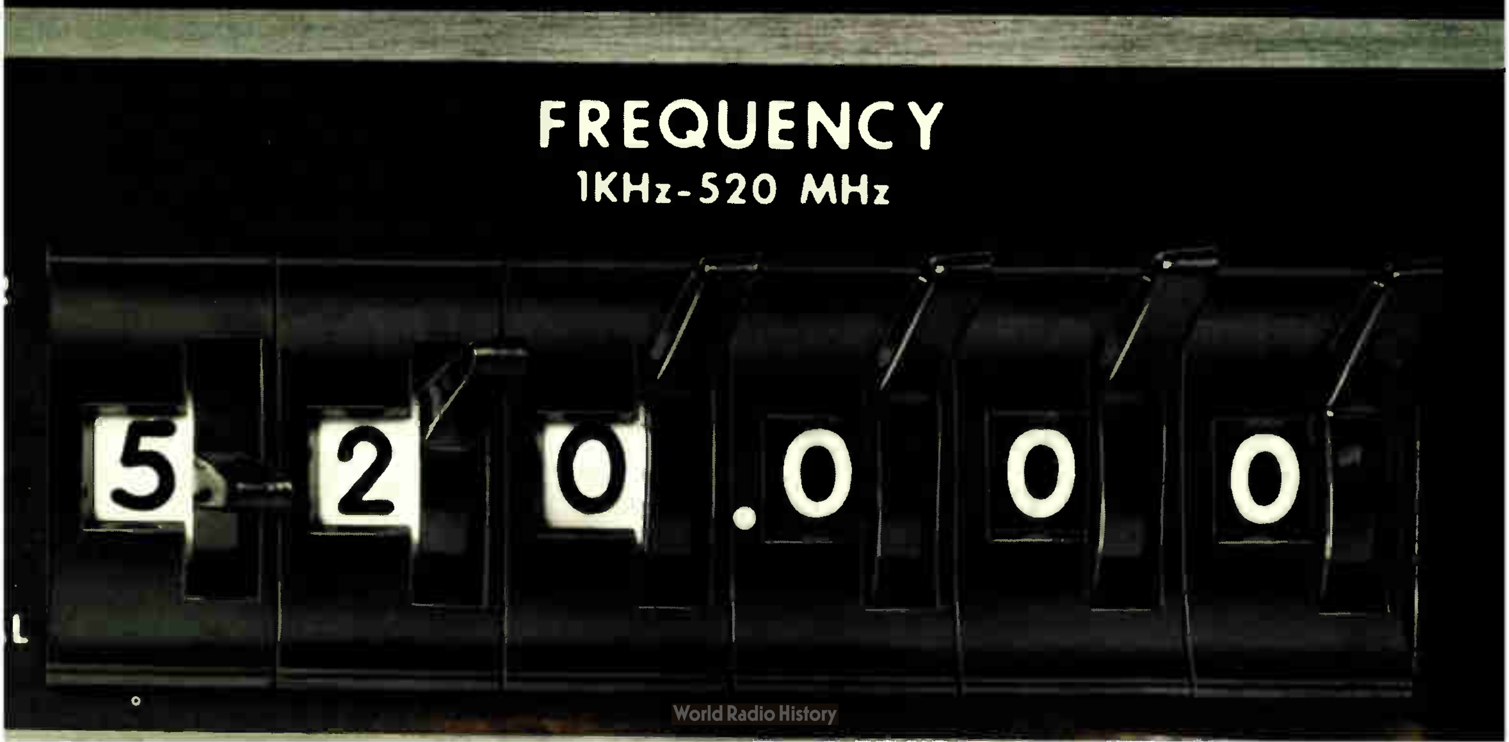


Technical articles

X-ray lithography breaks the VLSI cost barrier

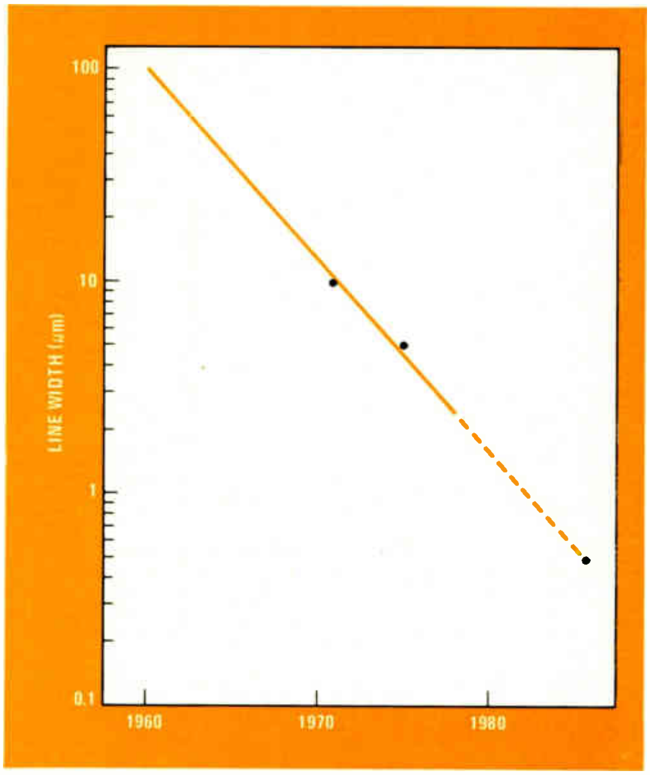
Relatively simple X-ray systems promise mass production of very large-scale integrated circuits with 1-μm line widths

by Gregory P. Hughes and Robert C. Fink, *General Instrument Corp., Microelectronics Division, Hicksville, N. Y.*

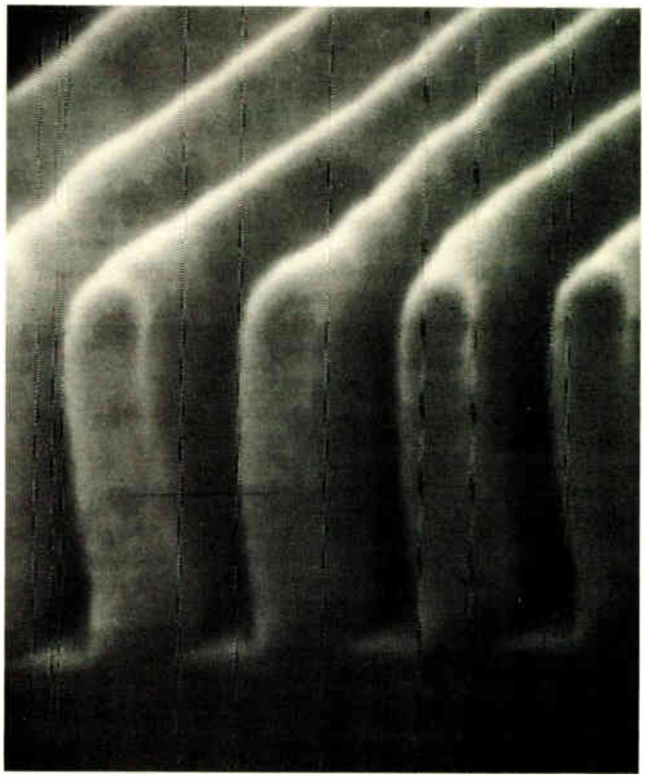
☐ As the designers of integrated circuits struggle to cram more devices on to silicon chips, ever smaller geometries are called for. If present trends continue, lines 2 micrometers wide will be common after 1979 and 1-μm widths will be standard after 1982 (Fig. 1). To produce lines as fine as this, integrated-circuit makers will have to decide which lithographic process will be their best choice. And though the electron-beam and optical direct-step-on-wafer process are popular today, a third process in development, X-ray imaging, could be the most powerful technology yet (Fig. 2).

X-ray imaging has produced lines as narrow as 0.16 μm and can do so at a cost that is relatively low compared with that of competitive methods. Already shown to be economically and technically viable for single-mask devices like surface-acoustic wave devices and bubble memories, it is on the way to becoming equally suitable for producing complex multimask devices of all types. Moreover, it is the one lithographic technology that is easily downward-compatible in device geometry: a system using X rays today to produce devices with 1-μm geometries will work just as well tomorrow for 0.5-μm geometries.

Table 1 shows a Dataquest comparison of X-ray lithography with the other wafer-imaging techniques currently in use in either production or research: contact printing, projection lithography, and electron-beam lithography (see also "X-ray lithography's competi-



1. Narrowing lines. If minimum line widths for production large-scale integrated circuits continue to decrease, 1-micrometer-wide lines will be in production by 1982, followed by 0.16-μm-wide lines in 1986. Both widths are well within the capabilities of X-ray lithography.



2. SEM. This scanning-electron micrograph shows a grating with 1,600-angstrom line width in PMMA photoresist that has been exposed to a copper X-ray source. (Courtesy, P. X. Flanders, Lincoln Laboratories, Massachusetts Institute of Technology.)

tion"). As it shows, the X-ray approach yields the narrowest lines at reasonable defect densities, throughput rates, and cost. The figure of merit listed calculates the cost-effectiveness or profitability of a process and is determined by the empirical relationship:

$$\frac{\text{throughput}}{(1+0.15\ \text{defects})^8 \times \text{cost} \times (\text{line width})^2}$$

In these terms, X-ray lithography is the most promising of all the choices available, one of the major reasons being the relative simplicity of the basic X-ray system.

Basic X-ray lithography

An X-ray lithography system resembles an ultraviolet-light one in that it consists of a radiation source, mask, and wafer coated with a photoresist (Fig. 3).

The radiation source is an X ray whose energy must be soft enough to be absorbed by and expose the photoresist yet great enough not to be absorbed by the X-ray window or the photomask substrate. The X-ray mask cannot be simply a glass plate because that would absorb too much of the X-ray flux; instead it must be a thin substrate that is relatively transparent to X rays, overlaid by a dark field area of a material that will absorb X rays. Gold is usually used for this absorber, the counterpart of the emulsion or chromium mask used in UV lithography. Lastly, the silicon wafer must be coated with a photoresist that will absorb enough of the X rays to be exposed in a short period of time.

Figure 4 shows a basic system. The radiation source is mounted in a vacuum chamber and passes its X rays first through a thin window (usually 25-μm-thick beryllium), then through a helium atmosphere at standard pressure, and finally through the mask, exposing the resist on the wafer. Typical geometries that have been proposed for 3-inch wafers place the X-ray source 20 to 50 centimeters away from the wafer and keep mask and wafer 3 to 25 μm apart to avoid the damage to both that could result from contact between them.

X-ray sources create a number of design problems unique to them. Since the wavelengths involved range from 2 to 50 angstroms, there are no convenient mirrors or lenses that can be used to collimate the rays. This means that the ideal X-ray source would be a point source far enough away from the target for the X rays to appear to arrive in a parallel beam.

Unfortunately, a series of compromises with distance and divergence must be considered since the intensity from a source is inversely proportional to the square of the distance from it. Moreover, the X-ray source is not a true point source. The size of the source and the divergence of the beam cause two types of distortion: penumbral and geometric, respectively.

Penumbral distortion can be determined from the geometry of Fig. 3. Because of the gap, s, between the wafer and the X-ray absorber (mask), the definition of the X-ray absorber becomes blurred by the X rays arriving from the finite-source geometry. The following relationship results:

$$\delta = s(d/D)$$

where δ is the minimum attainable line resolution, d is

X-ray lithography's competition

Conventional contact printing has long been the production mainstay of the integrated-circuit industry. This technique, which may be of the hard, soft, or proximity type, puts a photomask next to a wafer and an ultraviolet light source behind the mask. Resolution is excellent when the mask and wafer are placed in hard contact, but this causes many defects, such as abrading, spalling of resist films, plucking and transfer of resist film, scratching of masks, etc. A soft contact minimizes these defects but diminishes resolution.

The proximity mode of contact printing, in which there is a slight mask-to-wafer separation, further reduces defects but also diminishes resolution and causes feature distortion because the transmitted light is diffracted. The magnitude of this feature distortion depends on the actual spacing variations across a wafer.

To avoid these problems, projection wafer printing puts a large space between wafer and mask. It entered the production environment during 1973 in static systems that used refractive optics to flood-expose wafers. But the procedure's growth was limited by the impossibility of producing refractive lens systems with an effective spectral bandwidth for wafers larger than 2¼ inches. Scanning slit projection techniques with reflective optics yielded manufacturing systems capable of handling wafers up to 100 mm, or 4 in., across. These systems use the entire lamp output, and the optical system is inherently 1:1 because its design is telecentric. The masks used are the same as for conventional wafer printing.

Step-and-repeat projection printing is based on refractive optics. In this method, a small area is printed from a mask which is photocomposed at 2×, 4×, 5×, or 10×. The process is then repeated many times to cover a single wafer. With far-ultraviolet, resolution will be better.

Electron-beam technology is now generally accepted as the way to generate masks for fine-line lithography. Currently three approaches are being tried: flood exposure, raster scanning, and vector scanning.

Flood-exposure electron imaging has reached only the prototype stage. It uses ultraviolet light to illuminate a photocathode layer that is deposited as a patterned surface on an optical mask. The photocathode then generates a patterned emission of electrons. This technique becomes prohibitively difficult because of field nonuniformities.

Scanned electron-beam systems use raster- or vector-scanning schemes. In the raster-scanning schemes developed by Bell Labs [*Electronics*, May 12, 1977, p. 97], the scan lines are generated by periodically deflecting the beam over a line of limited length. The entire substrate is covered by moving it while the beam is scanning. In the vector-scanning approach, the electron beam is deflected on the substrate and modulated to draw a desired pattern [*Electronics*, Nov. 10, 1977, p. 96].

It is obvious that the demanding requirements of either raster- or vector-scanning electron-beam systems require an extremely large investment in the fabrication of precise, sophisticated equipment.

the source diameter, and D is the distance between the mask and the source. The effect of this distortion is to produce nonvertical walls in the photoresist and thus create an uncertainty for subsequent processing of the geometry being printed. In most X-ray lithography systems this is controlled to within 1,000 Å. Given a typical X-ray source 5 mm in size and a source-to-wafer distance of 20 cm, the gap between mask and wafer must be 4 μm or less for this control.

The geometric distortion in X-ray lithography arises from the fact that it is a projection system: the image does not lie directly on the wafer but is a projection of the mask on the wafer by the X-ray source. The degree of this distortion, Δ, is dependent on the location of the image on the wafer:

$$\Delta = s(\omega/D)$$

where D is the source-to-wafer distance and ω is the distance from any point of the wafer to the perpendicular projection of the X-ray source to the wafer, as shown in the left insert of Fig. 3.

This distortion looks like an error in the image compared to the mask. It is a serious problem with circuits that require superposition of one photo level on the next, but is much less serious with single-level high-resolution circuits like bubble memories and surface-acoustic-wave devices.

To be more precise, the problem is not the distortion but the variation in distortion from one photo level to the next. This variation arises from an inability to keep the gap spacing constant. If the variation in the gap is ds, the variation in the geometric distortion $d\Delta$ is:

$$d\Delta = Ds(\omega/D)$$

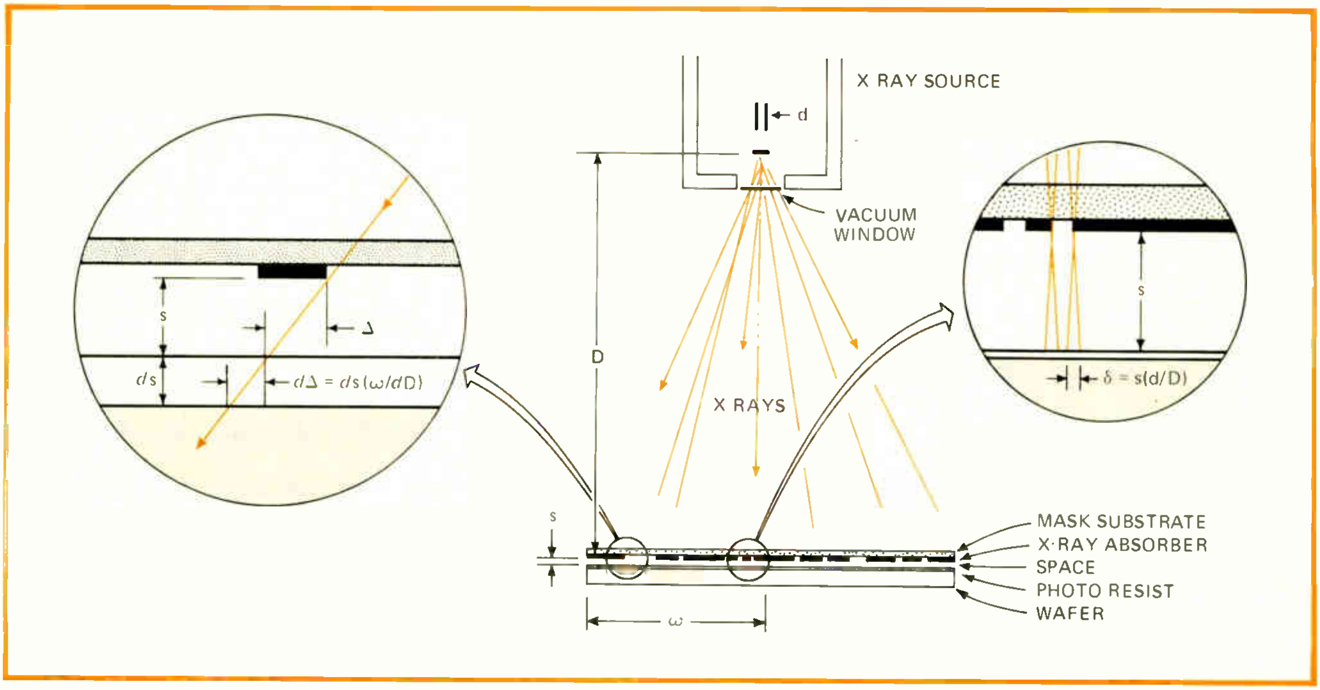
To hold $d\Delta$ to 1,000 Å over a 3-in. wafer when D is 20 cm requires a control of ds to less than 0.5 μm. This is difficult mechanically for the mask-and-wafer holder and also requires the flatness of a wafer to be controlled with great precision through the various steps of high-temperature wafer processing.

The main components of a basic X-ray system—X-ray sources, masks, photoresists, and mask-to-wafer alignment mechanisms—can be implemented in a variety of ways. To begin at the beginning, the choice of the X-ray source affects most of the rest of the X-ray system, and that in turn demands a consideration of the relative advantages of hard and soft X rays.

Sources

A wide range of X-ray wavelengths could in theory be used to improve upon the resolution of UV systems. They extend from very soft X rays, having approximately a 50-Å wavelength, to hard ones with approximately a 2-Å wavelength. Unlike sources in electron-beam or optical systems, none of these has any significant problem with diffraction. In fact, the diffractions in the exposures made with mask-to-wafer gaps as large as 1 millimeter barely differ from those made with a 1-μm gap.

Hard X rays have the advantage of not being easily absorbed in the vacuum window and X-ray mask substrate—and the disadvantage of not being easily absorbed in the photoresist, so that it takes a greater flux



3. X-ray lithography. In X-ray lithography, the mask is kept out of contact with the wafer to avoid defects. But the mask-to-wafer gap gives rise to a geometric distortion that is variable from mask to mask (left, insert), as well as to penumbral distortion (right insert).

to cause a satisfactory exposure of the resist.

A further problem is created by the byproduct of the inelastic collision of X rays with matter: photoelectrons. These can have energies as great as the incident X rays but unlike them are not directional, so they can blur a mask pattern. This happens to the extent of the range of the photoelectron, which generally varies with the square of its energy and with the medium. Therefore, with hard X rays, photoelectron energy can significantly degrade pattern resolution—exactly the problem that causes the so-called proximity effect in electron-beam lithography.

Soft X rays have the opposite kind of problem, being much too easily absorbed by a vacuum window and X-ray masks. This cuts the flux output to the point that vacuum windows are not considered feasible—although those X rays that do get through to the photoresist will have a greater chance of getting absorbed in it and thus the exposures will require less incident flux. Even this creates a problem, however, since soft X rays tend to be absorbed in only the top layer of a photoresist.

Therefore most present-day systems are designed around a compromise, medium-energy X ray. Though systems have been designed around hard X rays from targets made of palladium (λ = 4.3 Å) and soft X rays from targets of carbon (λ = 44 Å), the aluminum X ray (λ = 8.34 Å) is generally favored today.

The maximum range of photoelectrons from the aluminum X ray is 0.1 μm, so that resolution is good. Typical systems with the aluminum source will absorb 70% of the original X-ray flux in the vacuum window and mask and allow 30% to be transmitted to the wafer. Most resists will then absorb about 5% of the X rays incident on them.

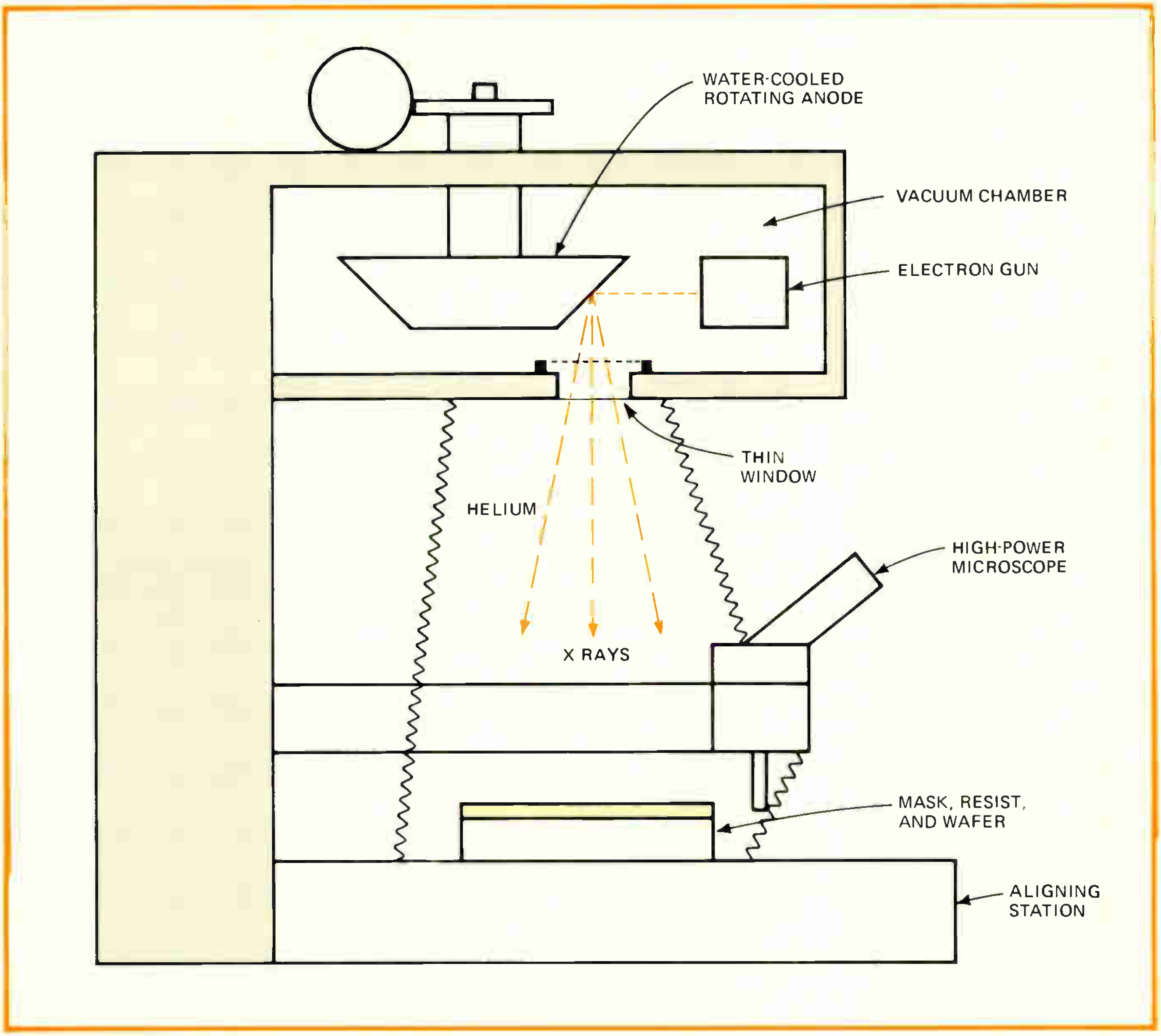
Once the X-ray wavelength is selected, a commercially feasible source with sufficient X-ray brightness must also be selected. A number of possibilities have been suggested and tested. These range from electron storage rings to the traditional electron-beam-generated source.

The electron-beam–generated X ray is created as an energetic electron knocks a tightly bound electron out of the target material it strikes. This vacancy is then filled by another bound electron falling into the vacancy and giving off an X ray whose energy is dependent on the difference between the two electrons' energy states. The energy of this characteristic X ray is also dependent on the material with which the electron is interacting.

A side effect is the so-called bremsstrahlung radiation coming from the electron-electron interaction when an incident electron is simply deflected, thus being accelerated and giving off electromagnetic radiation. Figure 5 shows a typical intensity versus energy curve of the characteristic peak superimposed upon the background bremsstrahlung when the incident electron has 20-kiloelectronvolt energy. Although the absolute intensity of the Al peak is two orders of magnitude greater than the bremsstrahlung, the bremsstrahlung still contributes about 10% of the power absorbed by the photoresist.

To obtain a useful source from electron-beam–generated X rays, the beam must be focused to a small spot to limit penumbra distortion. The flux of the beam must also be high to make exposure times short. The trouble with this procedure is that the system acts like an evaporator melting the aluminum target.

For the source not to evaporate, therefore, it must be water-cooled. But water-cooling it prevents it from handling more than 1.5 kilowatts of electron-beam power in a 6-mm-diameter spot. To handle more power, the source must also be continuously rotated out from under the hot spot to allow it to cool down. Typical systems with 10-cm-diameter rotating aluminum anodes can handle 15 kW. If a silicon-source X ray (λ = 7 Å) is used, though, the same rotating anode can handle 25 kW



4. High power. Block diagram of a high-power X-ray lithography station shows the source mounted over the wafer-to-mask aligning mechanism. Optics for aligning are on a sliding mount so that they can be moved out of the way during exposures.

TABLE 1 COMPARISON OF PHOTOMASKING TECHNIQUES

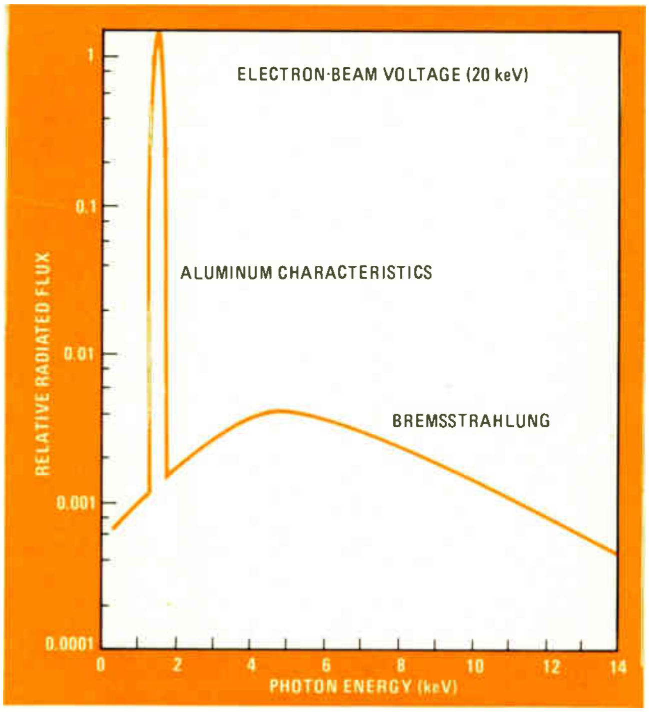
	Typical line width (μm)	Equipment cost (× $10^3)	Achievable defect level (per cm²)	Throughput (wafers/hr)	Figure of merit (× 10⁶)
Contact	3	30	2.5	50	14
Projection	2	185	1	65	29
Ultraviolet projection	1	200	1	50	82
Step-and-repeat projection	1	350	1	20	19
Electron-beam	0.5	1,500	0.5	10	15
X-ray	0.3	300	1	20	218

SOURCE: DATAQUEST

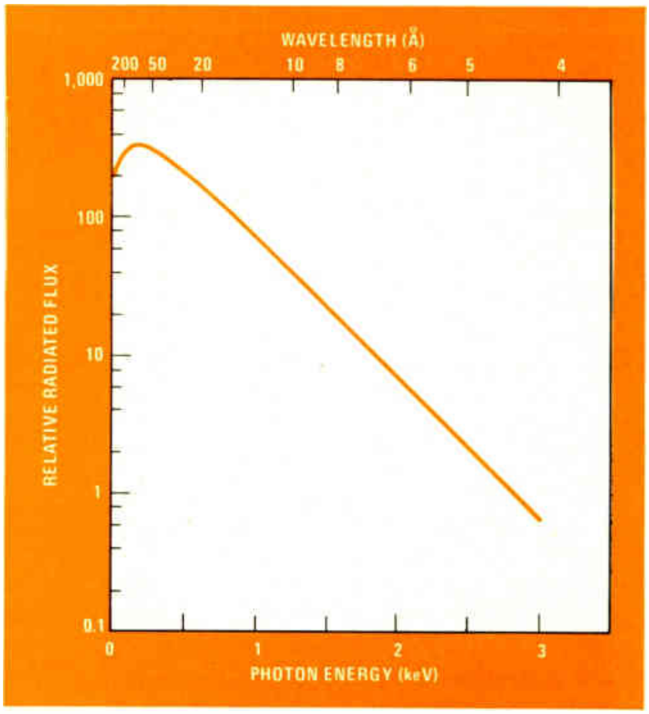
TABLE 2 CHARACTERISTICS OF X-RAY RESIST MATERIALS

Resist	Type	Sensitivity (mJ/cm²)	Resolution (μm)
PMMA	positive	1,000	0.1
PBS	positive (electron-beam)	100	0.5
FPM	positive (electron-beam)	100	0.5
PGMA-EA	negative (electron-beam)	50	0.5
DCPA	negative	10*	0.5*
TI XR79	negative	1.5	0.5
Hunt experimental	negative	8	0.5

*when exposed to palladium radiation



5. Electron-beam-generated X rays. An aluminum anode struck by a 20-keV electron gives off the characteristic radiation at 1.5 keV (8.34 Å) plus a background bremsstrahlung radiation. The bremsstrahlung contributes about 10% to the photoresist exposure.



6. Synchrotron radiation. The curve represents the unfiltered radiation from a 0.7-GeV electron storage ring with a 100-mA beam and 12-kilo-oersted magnetic field at a distance of 7 meters from the source. Note the peak intensity is in the very soft X-ray range.

because the melting point of silicon is higher.

Even with 15 kw of input electron-beam power, exposure time with some resists can be a problem. With a typical system, using a 15-kw rotating anode and a source-to-wafer distance of 20 cm, exposure will take 2 minutes with the fastest commercial photoresist PGMA-EA—Bell's electron-beam negative resist. It should be noted that there are other proprietary resists under development by Texas Instruments and Hunt/General Instrument that improve this time significantly.

The electron storage ring

Synchrotron radiation has often been suggested as the ideal X-ray source. The synchrotron continuously accelerates a pulse of very energetic electrons around a circular path, creating radiation of a spectrum that is fairly broad, depending on the beam's energy and radius of curvature. Figure 6 plots the intensity versus energy of the X-ray radiation typically given off by a synchrotron. The integrated energy output of a synchrotron is mostly at the soft end of the spectrum, but is several orders of magnitude greater than that of the most powerful rotating anode.

Synchrotron radiation also has the advantage of being very well collimated, since the electrons are traveling at a relativistic speed. When viewed from the laboratory frame of reference, the radiation from the accelerated electrons looks like a narrow cone emitted in the direction of the electrons' instantaneous velocity. In fact, the beam could be compared to a searchlight sweeping around a circle. However, though the extreme collimation of the beam means there are virtually no penumbral or geometric distortions, it does cause a problem when a large area like a wafer must be exposed. The beam can expose only 0.5-cm-high strips of wafer, and thus the exposure must be done in a scanning mode, strip by strip.

With such an intense source of radiation, one would expect the exposure times to be very short. However, the exposure time is highly dependent on the system design. Using no beryllium vacuum window and a 4-μm Mylar X-ray mask, the soft radiation is very effective. On the other hand, when a beryllium vacuum window is used, the soft radiation is not as effective and the exposure times are increased by a factor of five.

However, the cost of a synchrotron facility—$2 million after initial design—has by and large deterred industry from working with it as a production X-ray source rather than in its present research and development applications.

X-ray masks

Many different approaches have been taken in fabricating X-ray lithography masks. The primary problem is producing a thin substrate that is transparent to X rays. This generally requires a membrane that is 1 μm to 12 μm thick, for soft and hard X rays respectively. For aluminum X rays, a membrane thinner than 5 μm is typically desirable.

Two basic types of membranes have been tried—organic and inorganic films. Organic materials include Mylar, Kapton, Pyrolene, and polyimide. Inorganic types include silicon, silicon oxide, silicon metals, aluminum oxide, and silicon carbide. In general, inorganic membranes are very difficult to fabricate and very fragile (although SiC is reported to be very durable), whereas organic films are durable and easy to make but sometimes have an undesirably rough surface.

A primary question with both types of substrates is the dimensional stability of the masks with respect to temperature, stretching, and exposure to humidity. If superposition from one mask to another is to be within 0.1 μm, then the mask stability has to be better than 0.1 μm over 10 cm, or 1 part per million. (For the sake of comparison, low-expansion glass has a thermal expansion of 3.7 ppm/°C.) It is generally believed (although not proven) that the inorganic masks will be dimensionally stable enough, despite suffering from thermal expansion. Thick Kapton masks used with hard X rays have been shown to be stable to better than 1 ppm; and the thin polyimide masks, which are currently still under investigation, are at least as good as 10 ppm.

X-ray masks are similar to standard IC masks, except that the materials and orders are changed. In general, the thin film is either stretched across a frame, as is the case with many of the organic masks, or deposited on a flat substrate. At this point, either the substrate can be etched away to leave a blank mask substrate, or the X-ray absorber pattern can be created on the substrate, which is then etched away.

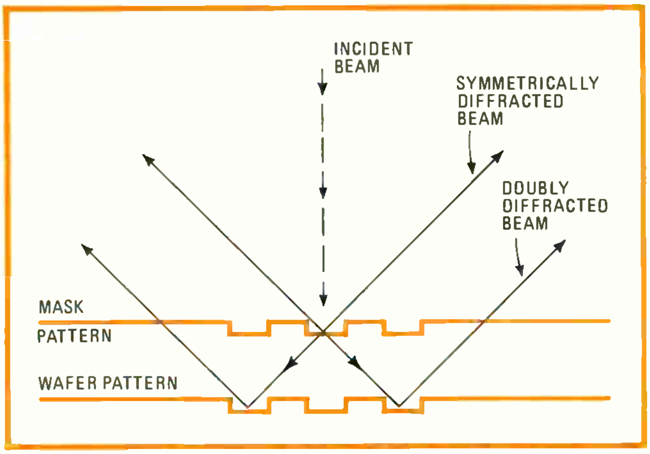
The X-ray absorber pattern can be created in a number of ways. Typically, it consists of two metal layers, first a thin layer of chromium for adhesion to the substrate and then a layer of gold. The thickness of the gold layer depends on the type of X rays and the contrast of the photoresist. For aluminum X rays, 5,000 Å of gold is typically used; for a softer X ray like copper, only 2,000 Å of gold is required, but for a hard X ray like palladium, 7,000 Å of gold will provide the same absorption. Patterns are created in the gold by one of four processes; ion-beam etching, electroplating, sputter etching, or liftoff.

X-ray resists

The field of X-ray resists is very new. When researchers started to work with X rays as an exposure source, they used a resist of polymethyl methacrylate (PMMA) that had been popular with electron-beam patterning. This was not a bad beginning. The basic mechanism for X-ray exposure is to absorb X rays by exciting electrons, which then have the energy of the incident X rays. Thus, a resist that is sensitive to electron radiation should be sensitive to X rays.

Since then, a number of good electron-beam resists have been developed for mask making, including Bell Laboratories' polybutene sulfone (PBS), which is a positive resist, and poly(glycidyl methacrylate)-co-ethylacrylate (PGMA-EA), which is a negative resist. These resists are relatively sensitive to X rays, but they are marginal from a direct wafer-processing point of view. Only recently have researchers begun to address the problem of producing a good X-ray resist.

The first successful X-ray resist, poly(2,3-dichloro-1-propylacrylate) was designed for harder X rays like palladium. The chlorine in DCPA increases its absorption of hard X rays. Most electron resists absorb 2% of the palladium X rays, but 1 μm of DCPA absorbs 12% and is 10 times more sensitive than PGMA-EA. Recently, two other X-ray resists have also been fabricated successfully



7. Interferometric alignment. In the diagram shown, the mask grating splits the incident beam into a transmitted beam incident upon the wafer and a diffracted beam that goes to the detector. The wafer grating then diffracts the incident beam to the detector, where it interferes with the beam diffracted from the mask.

for use specifically with the aluminum X ray.

Table 2 summarizes the characteristics of the various resists that have been used in X-ray lithography. Note that, with the new X-ray resists produced by Hunt/GI and Texas Instruments, exposure time for a 15-kW rotating anode system is well under 1 minute even when the distance from source to wafer is 30 cm. This will allow throughputs of better than 60 wafers per hour, a rate that is comparable to those of current UV contact and projection systems.

X-ray alignment

If X-ray lithography is to be used to manufacture a device requiring more than one precision mask, then precision alignment systems must be considered. Five approaches have basically been used in multiple-mask alignment systems. They are optical manual alignment, photoelectric reflection and transmission methods, the use of moiré patterns, and the interferometric technique.

The optical technique of aligning an image on the wafer with another on the mask works well, except when the magnification of the microscope system needs to be increased. This increase reduces the depth of field, making it hard to align a mask and wafer separated by a finite gap.

The photoelectric reflection technique is usually more accurate because it uses a photoelectric edge detector that has a greater depth of field and lets the system be automated. The detector and alignment system adjust the wafer so that the alignment marks on wafer and mask coincide. The limiting factor is the contrast of the image on the wafer. The photoelectric transmission method corrects this limitation by using a hole that has been etched into the wafer as the alignment mark. It has extreme contrast and has been demonstrated to be accurate to within 0.05 μm, or 500 Å.

The moiré pattern has often been suggested as an accurate method of alignment. To automate such a system, however, computer pattern recognition is needed. An outgrowth of this method is the simpler interferometric alignment system developed at Massa-

TABLE 3: EXISTING X-RAY SYSTEMS						
Builder	Electron-beam power (kW)	Source-to-wafer drain (cm)	Resist	Throughput (chips/hr)	Devices reported produced	Source
Bell Laboratories	4.5	50	DCPA	15	charge-coupled devices	palladium
General Instrument Corp.	1.0	20	PGMA	2	MOS EE-PROM	aluminum
Hughes Research Laboratories	10	24	PGMA	5	C-MOS on sapphire	aluminum
IBM Corp.	2.5	10	PMMA	1	bubble devices	aluminum
Nippon Telegraph and Telephone	25	50	FPM	4		silicon (7.1 Å)
Sperry Univac	7	16	PBS	12	64-kilobit bubble circuit	aluminum
Texas Instruments Inc.	18	43	XR79	70	bubble memories	aluminum

chusetts Institute of Technology's Lincoln Laboratories. The basic idea here is that a monochromatic light beam can be diffracted into symmetric beams by a grating. If the mask and the wafer both have a grating, then two sets of diffracted beams occur and will interfere with each other. The interference is dependent on the phase relationship between the two patterns and causes an intensity difference in the symmetric beams except when the patterns are aligned with each other. This method has been demonstrated to be accurate to within 1% of the gratings' line width and has been used to superimpose one pattern on top of another to within better than 0.02 μm, or 200 Å (Fig. 7).

Existing X-ray systems

Although X-ray lithography alignment systems are not commerically available, many companies have built their own. All of these systems use the basic electron-beam–generated X-ray source but have different targets and power levels. Some are used for single-mask devices like bubble memories and thus do not require good alignment. The other systems have been used in a wide range of processes, from prototype fabrication of standard devices and to production of small test devices with line widths ranging from 1 to 2 μm.

A system at Bell Laboratories is at the pilot-line stage. With DCPA resist and only a 4.5-kw source, throughputs on the order of 15 per hour are reported. Bell Labs is producing a device of standard size at present to prove that X-ray lithography is at least competitive with conventional optical lithography.

A summary of the X-ray systems that have been described in the literature is given in Table 3. Most of these systems have high flux generated by rotating anodes.

The three main fine-line lithography processes that seem viable for very large-scale integration in the immediate future are electron-beam, direct-step-on-wafer, and X ray. Each of these processes is a radical change for today's typical wafer fabrication facility and thus will undergo a substantial learning curve.

The direct-step-on-wafer process will provide for small geometries of approximately 1 μm in pilot-line production. Because it allows for traditional geometries in the reticle, it will be particularly useful for manufacturers who do not have electron-beam masking equipment. The system is commercially available today and thus will allow development of processes that are compatible with 1-μm geometries.

Electron-beam lithography has already established a market in mask making. It is also starting to be used to write patterns directly on wafers—a process that will always maintain a market of its own, since it gives quick turnaround on prototype devices. The defect density of the method will probably always be the lowest of all three. This makes it well suited for optical devices where large areas of zero defects are required. It will also dominate the market in low-volume high-cost parts where mass production is not required.

X-ray lithography is now in the process of demonstrating itself as economically and technically viable not only for single-level mask devices but also for multimask devices of all types. Although X-ray lithography equipment is not commercially available today, it is nearly at a point of being so. Companies are already working on fabricating commercial equipment and commercial X-ray photoresists; interest has also been expressed in making commercial X-ray masks.

X-ray lithography will require costly masks made by electron-beam patterning, so that it will not have the fast turnaround time needed for prototype device development. But, once a working device pattern is generated, X-ray lithography will be able to replicate the pattern at low cost and high throughput. Thus, the X-ray approach produces the one kind of system that keeps the cost of lithography down, thus allowing for the high-volume, low-cost production of complex VLSI circuits with very small geometries. □

Bit-slice parts approach ECL speeds with TTL power levels

Schottky-coupled logic puts emitter-coupled and transistor-transistor logic on the same chip, making pipeline prediction techniques possible

by Dale Mrazek, *National Semiconductor Corp., Santa Clara, Calif.*

☐ The dream of the computer designer is a system that operates at the high speeds allowed by emitter-coupled logic, yet has the low power consumption of standard, low-power Schottky transistor-transistor-logic parts. A technique called Schottky-coupled logic comes close to making that dream real. With this approach, bit-slice devices have been fabricated that are 30% to 50% faster than comparable LS 2900 family designs now available. At the same time, power consumption is slightly less than that used by present LS designs and only one third that required by ECL.

The substantially increased system throughput made possible by the IDM2900 family, built with Schottky-coupled logic, or SCL, means a number of advanced computer designs can be considered that were impossible before. For example, advanced, pipeline prediction techniques of microprogram control design can be used to reduce microcycle times significantly.

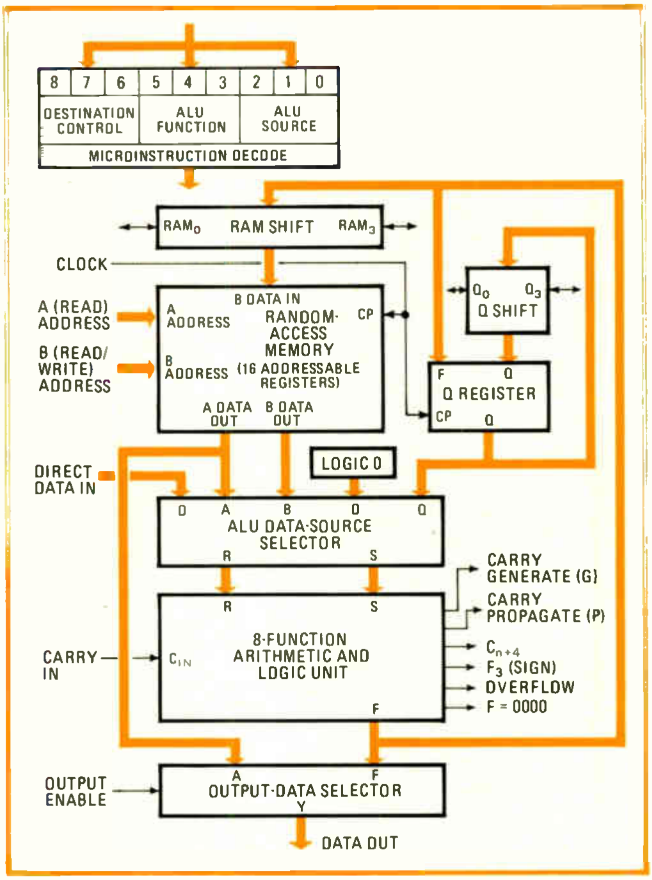
A bonus of this approach is that this is the first ECL-based 4-bit-slice family to meet military temperature requirements. The new series shows even less performance degradation over the military temperature range than some of the standard LS parts now available.

A 60-ns slice

Process and circuit improvements using SCL are most apparent in the IDM2901A, which boasts an average microcycle time of only 60 to 70 nanoseconds, a 100% improvement over existing LS designs. The device's power consumption, however, is about the same—only 800 milliwatts. Also available is an even faster version, the IDM2901A-1, with a microcycle time of only 50 to 60 ns—again, with no increase in power consumption.

Designed as a high-speed cascadable element intended for use in central processing units, peripheral controllers, programmable microprocessors, and numerous other applications, the IDM2901A consists of a 16-word-by-4-bit two-port random-access memory, a high-speed arithmetic and logic unit, and associated shifting, decoding, and multiplexing circuitry (Fig. 1).

Except for the most important parameter, speed, the IDM2901A is plug-compatible with any LS implementation of the same architecture now on the market. But plug-in replacement and raw speed improvements are just part of the story. The IDM2901A's read-modify-write cycle is 42% shorter than that of an LS 2901A. The



1. IDM2901A. A block diagram of the IDM2901A bit-slice processor is shown above. Inside is a 16-by-4-bit RAM, a high-speed ALU, and shifting, decoding, and multiplexing circuits. It boasts an average microcycle time of only 60 to 70 ns and consumes only 800 mW.

maximum clock frequency is 68% greater. Execution time for a typical operation, such as an add-and-shift (multiply) is 95 ns maximum and 60 ns typical, a significant gain over previous 2900 implementations. In a typical application, system microcycle time is 100 to 150 ns, about one half to two thirds that of previous LS bit-slice designs.

In addition to the IDM2901A, 14 other standard parts have been introduced, as well as 2 proprietary parts that allow system designers to take full advantage of the increased speed (tinted gray in the table). With the

IDM2900 FAMILY OF BIT-SLICE PARTS		
	Description	Typical uses
IDM2901A IDM2901A-1	4-bit-slice microprocessor with two-port 4-by-16-bit RAM, arithmetic/logic unit, and shift, decoding, and multiplexing circuits	in computer central-processing units, high-speed controllers, and programmable microprocessors
IDM2902	high-speed carry-look-ahead generator that anticipates a carry across four adders or groups of adders	to propagate carry terms to the most significant package when multiple 2901As are used
IDM2909A IDM2911A	4-bit-wide address controllers. 09A–input word can be masked, 11A–input word cannot be masked	to sequence through a series of micro-instructions in ROM or PROM
IDM29702 IDM29703	16-by-4-bit RAM, fully decoded with chip-enable input. 702 has three-state outputs, 703 has open-collector outputs	as a file-extension register or memory stack
IDM29704A IDM29705A	16-by-4-bit dual-port register file. 704A has open-collector outputs, 705A has three-state outputs	for register file expansion or as a general-purpose register file
IDM29750 IDM29751	32-by-8-bit field-programmable ROM with on-chip decoding of a 5-bit binary address. 750 has open-collector outputs, 751 has three-state outputs	for logic replacement or extension or as an external multiplexer
IDM29760 IDM29761	field-programmable 1,024-bit PROM. 760 has open-collector outputs, 761 has three-state outputs	for logic replacement, gate matrixes, or multiplexers
IDM29803	branch controller with 16 instructions to branch 2, 4, 8, or 16 ways in one microcycle; uses variable input mask for systems employing the 2909A or 2911A address controllers	in complex processors, controller systems, and address controllers
IDM29811	next-state controller	for microprogram control with the 2909A or 2911A
IDM29901	octal, edge-triggered flip-flop with three-state outputs	as a utilitity register or for temporary data storage
IDM29902	8-to-3-line priority encoder	in interrupt-driven systems
IDM29903	16-by-4-bit clocked RAM organized as an addressable D-type register file	mainly for file extension

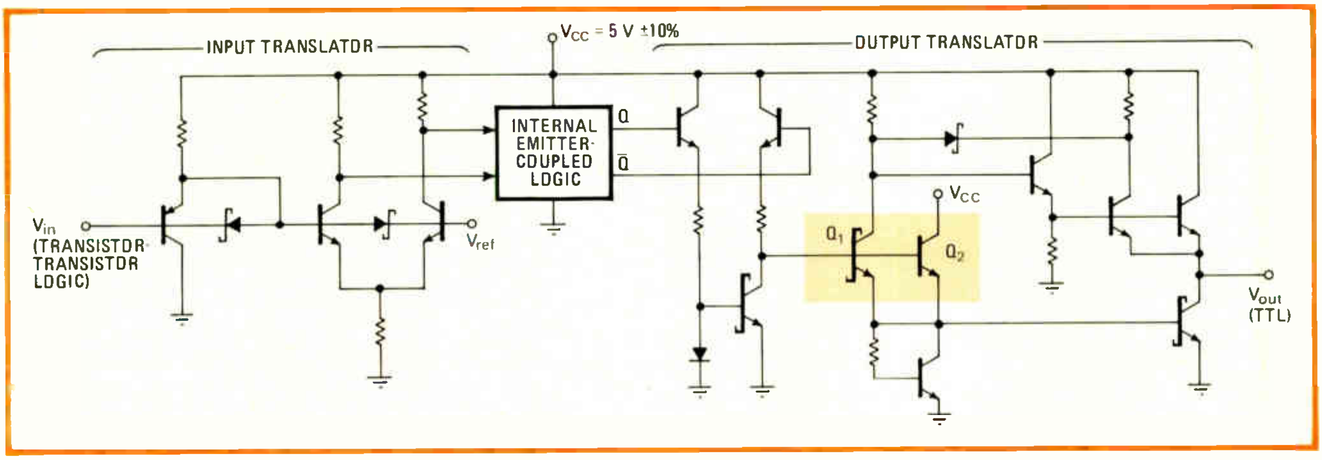
IDM2900 family, a typical 16-bit controller can be constructed having a system microcycle time of about 140 ns. This represents about a 30% improvement over that possible with LS devices. With the high-speed IDM2901A-1, the microcycle time can be reduced further to about 120 ns. Moreover, if the 29901 and 29903 are used as well, the same operations can be done in even less time—about 120 to 100 ns.

LS + ECL = SCL

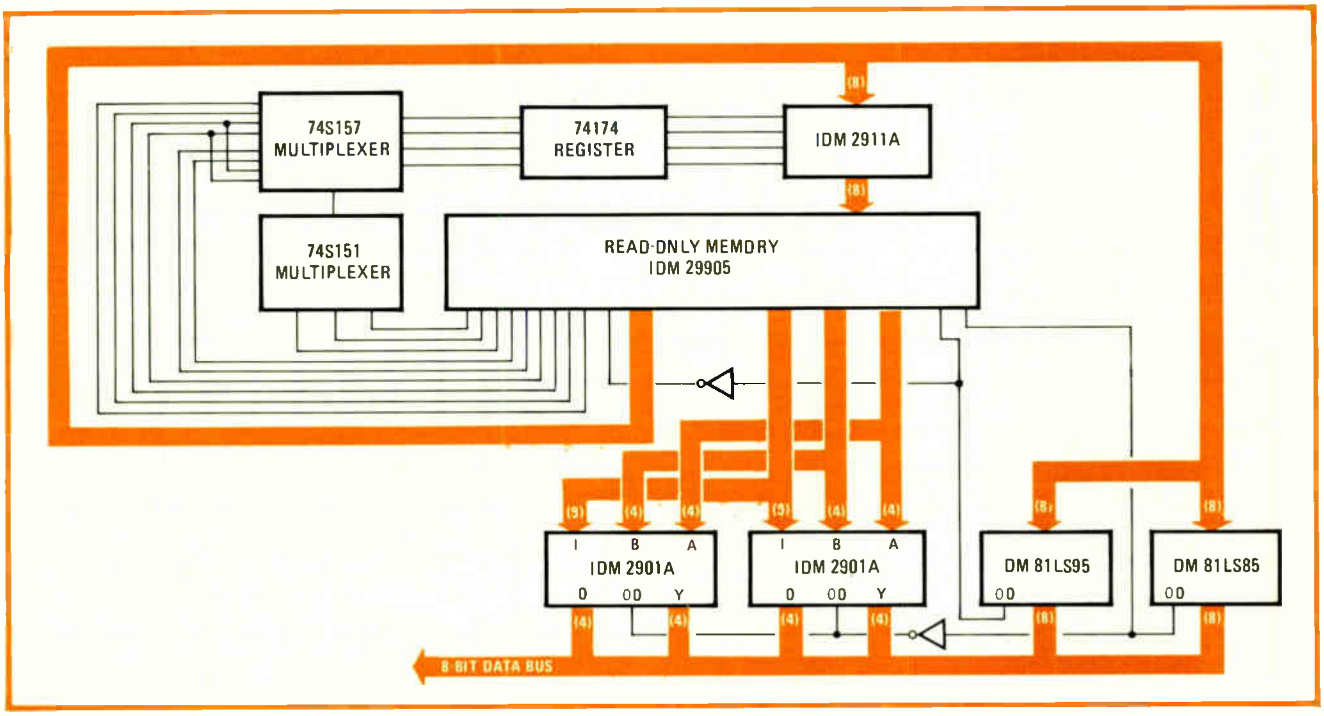
To combine ECL speeds with LS power consumption, several techniques are employed. One is the use of low-power Schottky circuitry at the periphery of the chip to interface the internal ECL circuitry with the external TTL world (Fig. 2), a technique commonly used in some bipolar memories. The input translators not only shift TTL levels to differential-ECL signals, they also enhance input-level sensitivity. As can be seen in the figure, the input translator is similar to a differential amplifier whose internal reference is stable. The result is very abrupt transfer characteristics on all input signals. Hence, very fast switching speeds ensue.

Even more responsible for the performance of SCL devices are the output translators. Traditional ECL-to-TTL translators are slow unless considerable power is applied. With IDM2900 parts, however, ECL speeds are retained, yet no additional power is consumed, thanks to an improved three-state translator circuit that transforms the 0.7-volt ECL levels into 5-V Schottky-TTL levels. This technique eliminates the slow and power-hungry buffer transistors that usually do the job. The translators can also drop down to one third their active power with no loss in speed. With them, an extra 60% to 65% of the power that would have been consumed is instead pumped into the portions of the device that require it—the ECL-core circuitry.

The output translators use both linear and digital techniques. Differential-ECL signals are translated by means of a differential-current amplifier. The differential output voltage is changed to a differential current and then back to an output voltage. The output voltage drives a phase-splitting transistor (Q_1 in Fig. 2), which, in turn, drives the peripheral output circuitry. The three-stage logic-buffer circuit is characterized by a current-mirror transistor (Q_2) having its base and emitter connected, respectively, to the base and emitter of the



2. TTL to ECL and back. In the IDM2900 family, translators interface internal ECL with the TTL world. The output translators have a phase splitter (Q_1) and current mirror (Q_2) with bases and emitters tied together. This considerably reduces power consumption.



3. Controller. The IDM2900 family can be used to build central processing units, programmable microprocessors, and controllers, like the one above. This state-sequencer uses the IDM2901A for its ALU data storage and the IDM2911A for sequencing through the states.

phase-splitter transistor. The current mirror's collector is connected to the voltage supply terminal, and its emitter is about twice that of the phase-splitter transistor.

The current mirror supplements the drive current provided by the phase splitter. This arrangement permits a higher resistance to be connected between the voltage-supply terminal and the collector of the phase-splitter transistor without diminishing the drive current to the pull-down transistor at the output. By connecting a higher resistance, the output impedance of the circuit is increased when the circuit is in its disabled state, and thus the current flow through the phase-splitter transistor and the resultant power consumption are reduced. (If the ratio of emitter sizes is increased significantly beyond the present 2:1 for this device's output specification, the dynamic response of the pull-up transistor might be slower.)

An additional advantage of this current-mirror arrangement is a faster dynamic response in the conduction state of the pull-down–output transistor to a change in the input signal. The faster response results from selective use of the Miller feedback effect, in which the voltage gain of a bipolar transistor circuit falls at high frequencies as a result of a corresponding increase in base-collector capacitance. Miller feedback occurs on the phase-splitter transistor because its collector is coupled to the voltage supply through a resistance. But it is absent on the current-mirror transistor because its collector is directly connected to the voltage supply. Consequently, when the input switches, the current ratio between the current mirror and the phase splitter is even greater than the ratio of their respective emitter sizes.

Figure 3 shows a versatile state-sequencing controller. It uses the IDM2901A for its data storage and arithmet-

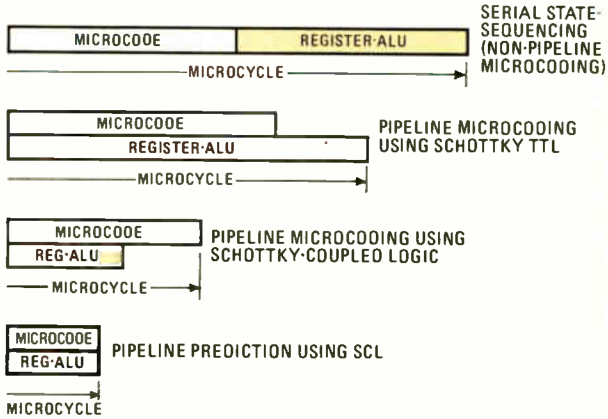
The history of the microcycle

In the very earliest use of state sequencing—in microcomputers and larger systems—operations were performed in series, one after the other, and the microcycle was defined as the sum of the operations.

In the first such technique, now called "non-pipeline microcoding" and still used today, a sequencer increments or branches to the next state, depending on the logic level of a test input. The controller timing is measured from the clock edge of the controller-register counter, through microcontrol storage (read-only memory) and the processing elements, then back through the next-state decision tree to the controller-register counter.

When it was discovered that the time required to obtain the microcode from ROM and the time required to perform an operation in the arithmetic and logic unit could be made to overlap, serial approaches were abandoned for concurrent ones.

Pipeline microcoding, the first of the new techniques, is commonly used in bit-slice systems such as those built with standard low-power Schottky transistor-transistor-logic parts. The microcontroller-loop timing operates in parallel with the execution of the processing section. While an arithmetic operation is being performed, the next microcontrol word is being set up for use by the microcode. A register between the output of the microcontrol store and the 2901 central processing units allows overlapped functioning of the two sections. The result is a faster machine cycle time than with the totally serial mode of operation. However, pipelining requires absolute knowledge of the next state, one cycle before the execution of the 2901A cycle. Therefore, it is difficult to implement several successive conditional next-state decisions.



Using Schottky-coupled-logic components instead of LS bit-slice devices for pipelining reduces the register and ALU portion of the microcycle 65% to 75%. However, total microcycle time may only be reduced 40% to 50%, since the microcycle time is determined by the length of the longest operation, which in this case may be the delay in the microcode portion.

To get the full benefit of the high speeds inherent in the SCL family therefore means abandoning the traditional approach to pipelining. Instead, a different technique—pipeline prediction—allows a reduction in the microcode portion of the microcycle so that it is equal to or less than the register-and-ALU setup time. The figure gives a rough timing comparison of the four schemes.

ic and logic generation and the IDM2911A as the state sequencer, with the latter's speed and subroutine stack an added benefit.

There are a number of factors to be considered when using IDM2900 devices in more complex processor systems. The IDM2901A's registers and ALU are usually insufficient when data and address word lengths grow from 8 to 16 bits and beyond. Special functional elements are generally added, like input- and output-data or addressing registers or components for sign extenstion of data, instruction decoding, shift and rotation control, and multiplication functions. Also, special processor-status registers are frequently needed, and these often require their own control elements. Some special thought to these additional circuits can reduce the parts count considerably and improve processor performance when using IDM2900 components.

Performing a multiplication

Usually, the emphasis in computer processor design is on speed, and nowhere is this element more crucial than when a multiplication is to be performed. This operation determines the longest cycle time if performed in the normal manner, because more than one path through the 2901A is taken. Also, several external components are usually required and their delays must be added to the solution time. However, using the high-speed components in the IDM2900 family, many of the paths may be circumvented and the multiplication time shortened.

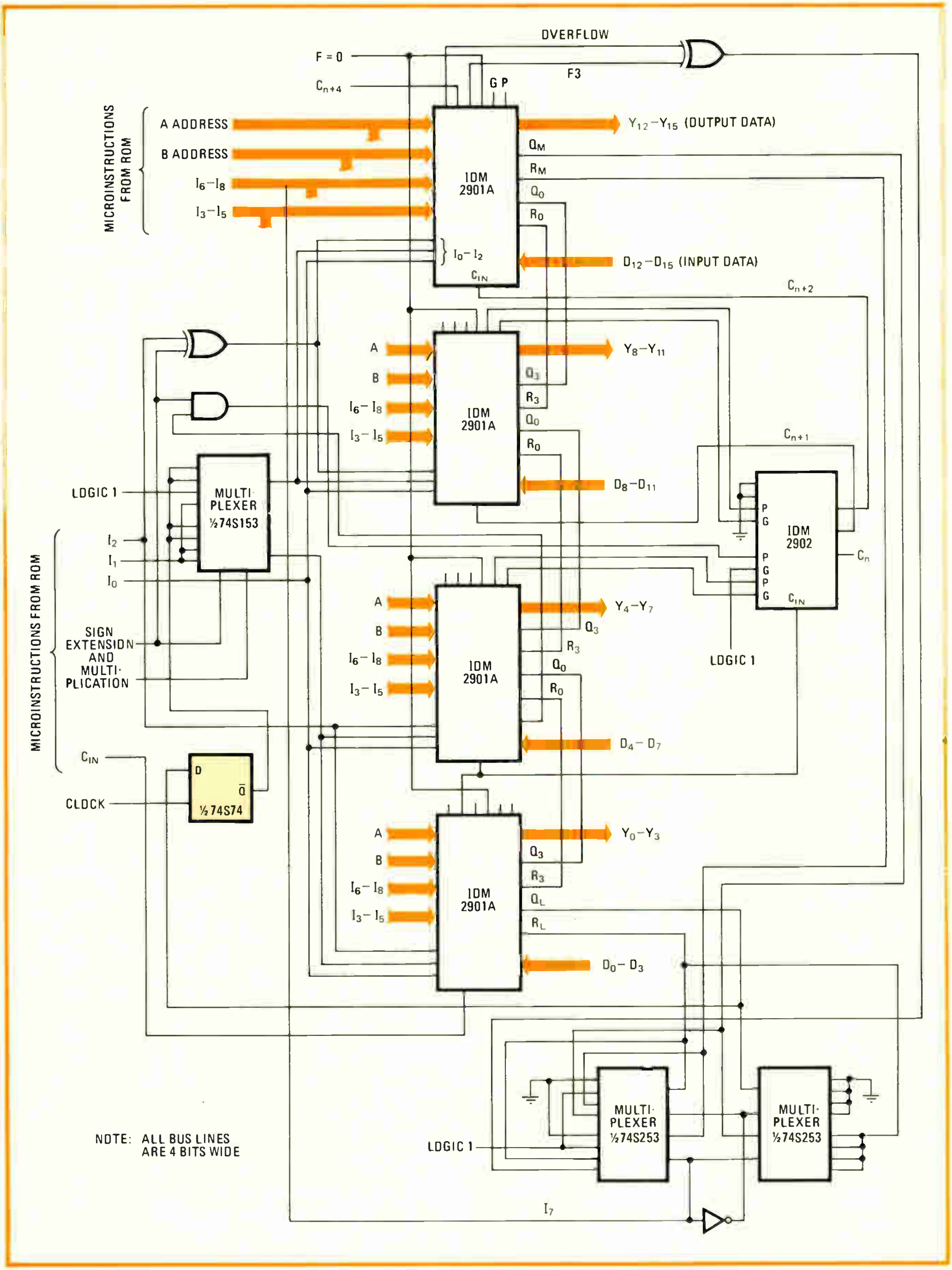
Assume the problem is to perform a multiplication of two signed 16-bit values. Figure 4 shows a circuit using IDM2900 devices plus two multiplexers (a 74S153 and a 74S253) and a D-type flip-flop (74S74). This circuit performs the multiplication 30 to 70 nanoseconds faster per cycle than do standard LS bit-slice parts, for a total speed improvement of 480 to 1,120 ns. In addition, the design eliminates a special interval for the multiplication cycle. The result is a processor or controller with a less complicated clock-control circuit.

Extra flip-flop

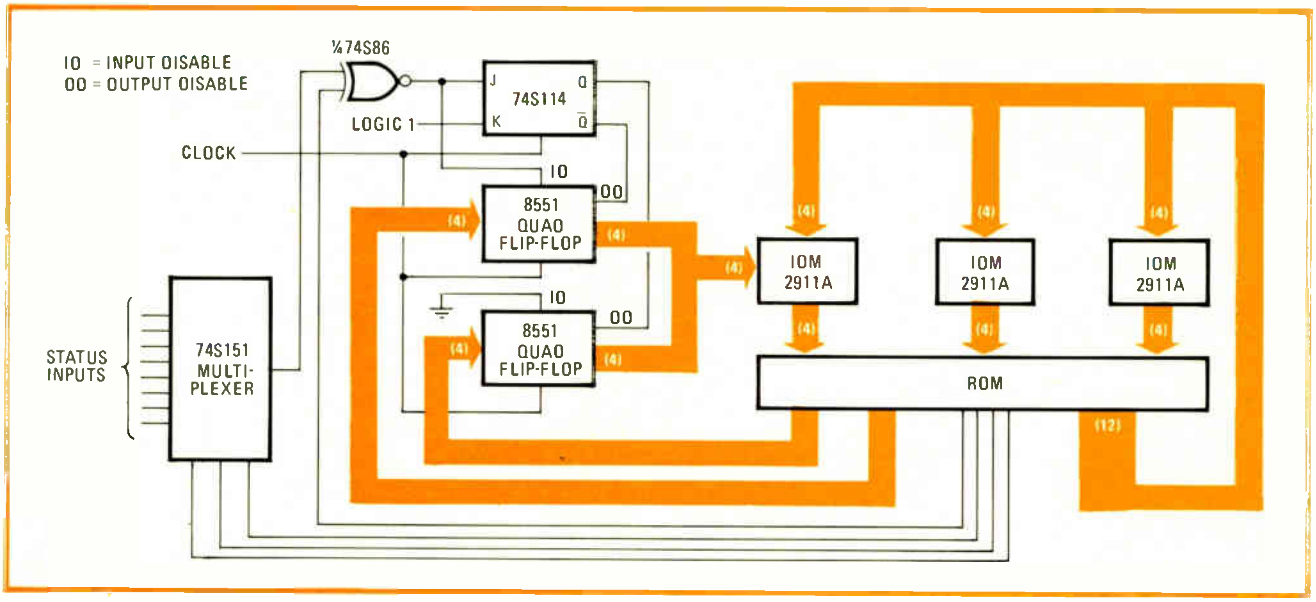
Note, though, that there is an extra stage of register storage in the Q register, in the form of a D flip-flop (colored in the figure). As a result, Q is shifted one time without shifting the file register, since the partial-product register has to be cleared.

The Q register is shifted first so as to get the least significant bit into the extra storage location. After the shift, the A and B register-file addresses do not change and therefore do not enter into the timing equations. The faster response resulting from the added D register saves a great deal of time in each microcycle of the multiplication's add and shift operations.

Since the A and B inputs do not change, the critical path is from the D register output into the I_0–I_2 inputs of the IDM2901As, which in turn perform a normal add-



4. Multiplier. This circuit multiplies two signed 16-bit values in 2's complement notation. It performs the multiplication 30 to 70 nanoseconds faster per cycle than if standard low-power Schottky parts were used, for an overall speed improvement of 480 to 1,120 ns.



5. Predictor. The high speed of Schottky-coupled logic allows pipeline prediction controllers to be built. This technique uses shorter microcycle times than standard pipeline microcoding techniques, because during any microcycle, the most probable next state is set up.

and-shift operation. Using the D flip-flop saves 20 ns, and using the I_0–I_2 inputs saves 10 ns in each of the 16 cycles of the 16-by-16-bit multiplication. This is all the hardware necessary for a positive-signed multiplicand.

If a negative result is required, an additional path must be added. Two are possible in the most significant IDM2901A package. One is from C_n to the RAM_0 output. The other is from C_n to the overflow or to F_3 (whichever is longer) and then through the additional exclusive-OR gate and multiplexer and back to the most significant RAM_3 input. The maximum time delay is 20 ns, from the overflow and F_3 outputs back to the RAM_3 input.

With techniques standard to previous 2900 designs, 15 conditional additions, followed by a shift, one conditional subtraction, and another shift are required to do a signed multiplication in 2's complement notation. The resulting data paths for this solution would take 141 microseconds. with the IDM2901A.

Faster yet

If IDM2901A-1s are used in the circuit, and if the A and B address lines are set up one cycle ahead of the multiplication sequence, the 16-by-16-bit signed multiplication takes only 116 μs, and a net savings of 25 μs per microcycle is thus achieved. Therefore it sometimes pays to add a flip-flop in certain locations to achieve higher performance and a simpler solution. Here, the multiplication cycle time was reduced 20% compared with standard techniques using LS bipolar components.

The pipeline prediction controller functions in much the same way as the controller in a standard pipeline configuration except that it can also accept any number of successive conditional next-state decisions in a row (see "The history of the microcycle"). But shorter microcycles can be obtained, because during any microcycle the most predictable next cycle is being set up. Should the test of the next-state decision be different from the one predicted, the alternate state is set up and the microcontroller and the data system pass through a correction interval. This design makes next-state decisions within the same cycle as the microcontrol portion of the IDM2901A.

Figure 5 shows a pipeline prediction technique in which the next state is a choice between two states. This means that one state is predicted, and if incorrect, the second choice is used. The microcycle is either delayed or an additional cycle is inserted.

There is no real reason why the design must be limited to only two next-state conditions—any number may exist. It is necessary only to predict the most probable next state and correct it if required, and most next-state decisions are known to a high probability of occurrence. The extra cycle time added for the few times an incorrect prediction is made is extremely small compared with the total microcycle time saved. Moreover, since this technique minimizes the number of states through a control sequence, further time is saved. Finally, pipeline prediction requires no additional components to achieve these increases in speed.

For the future

The present components in National's IDM2900 SCL family are built with exceedingly liberal design rules. In spite of that, the chip area of the IDM2901A, for example, is equal to or less than that of some of its LS counterparts. This means that inherent in the SCL technique is the possibility of further improving density and integration—combining many bit-slice functions onto fewer and fewer chips—while maintaining speed.

What's more, speeds of SCL-type bit-slice 2901A parts of 40 to 50 ns and system throughput of 80 to 90 ns may be expected by 1980. Even though SCL microcycle times at the component level may not match those of pure ECL parts, the system improvements allowed by the lower power consumption may ultimately result in systems with far faster throughputs than are possible with emitter-coupled logic—at much lower cost. □

Zero-sensing counter yields data's magnitude and sign

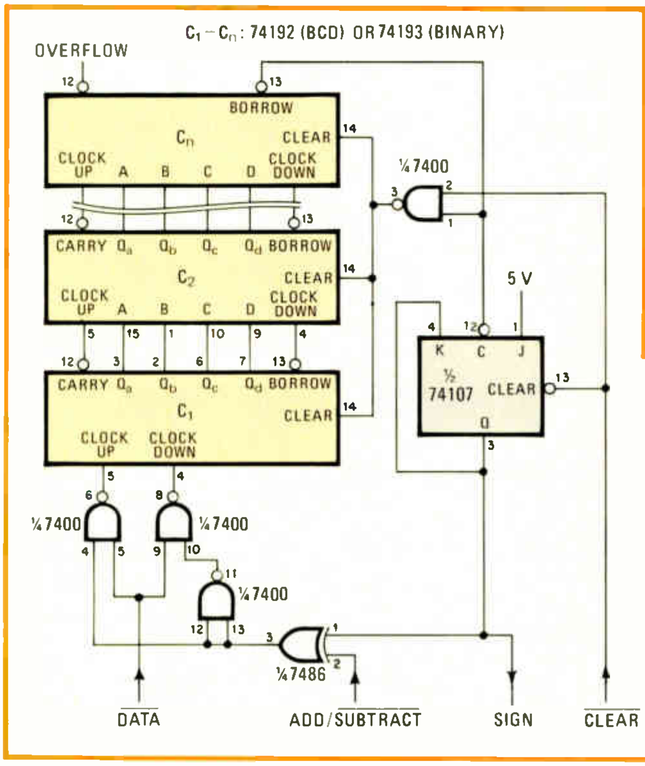
by Gary A. Frazier
Richardson, Texas

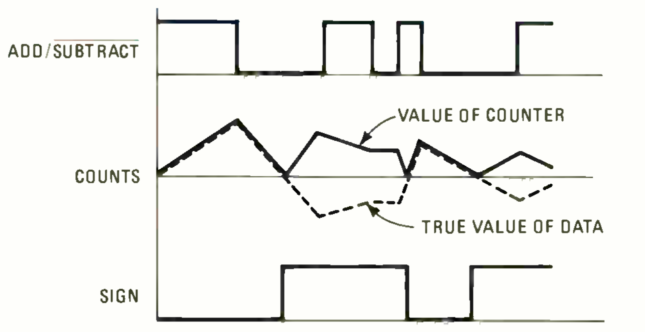
Upon sensing when an ordinary up-down counter is about to count down through zero, this circuit reverses the direction of the count to enable it to express a negative number by its magnitude and sign, instead of by the more usual but less convenient 2's complement. The circuit similarly represents positive integers, making it easy for any stored value to be handled directly by such data-system devices as digital-to-analog converters or microprocessors.

The unit shown in the figure has been found particularly useful in a digital-averaging application. Data is sampled during an interval in which the ADD/$\overline{\text{SUB}}$ line is toggled at some frequency, which in this case varies with time, as shown. Any data in phase with the ADD/$\overline{\text{SUB}}$ signal will accumulate in the n-stage counter (count-up mode), and digital noise will be averaged out (subtracted). The output of the counter is sampled at the end of the data-collection interval.

If the contents of the counter should ever decrease to zero, a borrow pulse is generated by the most significant counter, C_n, and toggles the flip-flop. In turn, the NAND gate connected to the clock-up port of C_1 is enabled. In this way, the output of the counter is mirrored about 0, as shown in the timing diagram, and is equal to the absolute value of the difference between the number of the add-to and the subtract-from counts. The sign bit is set each time the data actually drops below zero.

Note that when using the up-down counter, it is necessary to keep the counter cleared while the $\overline{\text{BORROW}}$ is low to avoid difficulties should the clock-up line suddenly become disabled while the clock-down line is activated. Otherwise, a decrement will take place. The frequency and symmetry of the ADD/$\overline{\text{SUB}}$ waveform is arbitrary so long as the counter does not overflow on any half cycle of a sampling interval. □



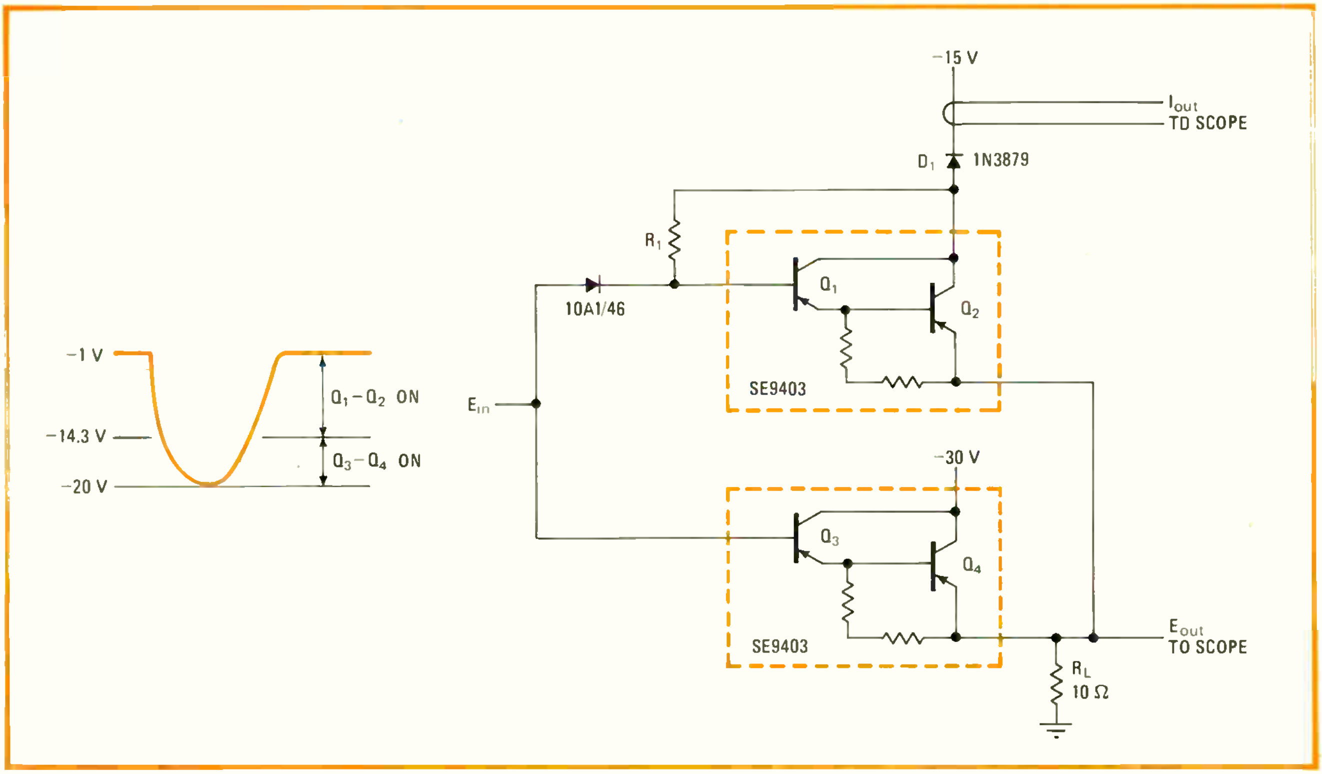


About face. Circuit inhibits up-down counters C_1–C_n from decrementing below zero, instead forcing them to count up and mirror the result of a negative-number addition in binary form. A negative-sign bit is also generated. Thus, all numbers are suitable for direct handling by a d-a converter or other data-system device.

Demand-switched supply boosts amplifier efficiency

by Jerome Leiner
Loral Electronic Systems, Yonkers, N. Y.

The efficiency of high-power audio amplifiers operating in class B will be improved by up to 80% at low power levels if the supply voltage can be switched from a low to a high value as the power demands on the amplifier increase. Using the automatic-switching circuit described here ensures a lower heat dissipation than would be possible with an amplifier that delivers a low-power output from a single high-voltage supply, which is the



High efficiency. Audio power amplifier switches from Darlington pair Q_1–Q_2 and low-voltage supply to Q_3–Q_4 and high-voltage supply only when power output demands increase. Circuit thereby eliminates the need for amplifier to dissipate excessive heat, a condition that occurs when an amp with a single high-voltage supply is used to process a low-amplitude input signal.

most common situation. The increased efficiency of this power amplifier can produce considerable savings in its weight and size and also reduces the amplifier's heat sink requirements.

The amplifier is designed to switch from the low- to the high-voltage supply as the audio signal level passes up through the low-voltage supply level. The switchover is made with virtually no perturbation in the output current up to as high as 25 kilohertz. At higher speeds, any waveshape distortion can be reduced by implementing negative feedback around the amplifier. Both supply voltages can be derived from one source, with the low voltage taken from a selected tap on the power transformer.

Several circuit configurations were tried, among them a cascaded emitter follower, a series transistor configuration, and the parallel transistor arrangement shown in the figure. The cascaded emitter follower and the series configuration performed adequately below 10 kHz. At higher frequencies, however, the effects of carrier storage produced by the first two arrangements caused large perturbations in the output current. The parallel arrangement finally adopted has virtually no storage problem and appears to be the most useful at higher frequencies.

For simplicity, the operation of one half of a complementary-output stage (see figure) is described. A half-sine wave that swings from −1 to −20 volts is the input-signal source in this case.

When the input level is at −1 V, current flows through D_2, R_1, and D_1. Thus the input base of Darlington pair Q_1–Q_2 is one diode drop lower than the base of Q_3–Q_4. As a result, Q_1–Q_2, which uses the −15-V supply, is on and Q_3–Q_4 is off.

When the input signal reaches within one diode drop of the low-voltage power supply, D_2 begins to turn off and Q_3–Q_4, which uses the −30-V supply, starts to turn on. As Q_3–Q_4 moves into the linear region, Q_1–Q_2 begins to turn off, so there is a smooth transition of current in the load. Q_3–Q_4 stays on until the signal polarity reverses; when the signal passes through the low-voltage supply level, Q_1–Q_2 goes on and Q_3–Q_4 goes off. □

Fast-acting voltage detector protects high-current supplies

by Jorges S. Lucas
Engeletro, Belo Horizonte, Brazil

Protecting a regulated, nonswitching power supply against both short circuits and overvoltages can be difficult, especially if the supply is to deliver high currents. Should either condition occur, this circuit will act quickly to protect the supply, and its load as well, by deactivating the series or shunt pass element in the regulator and thus forcing the output current and voltage to zero.

A typical high-current power supply (5 volts at 5

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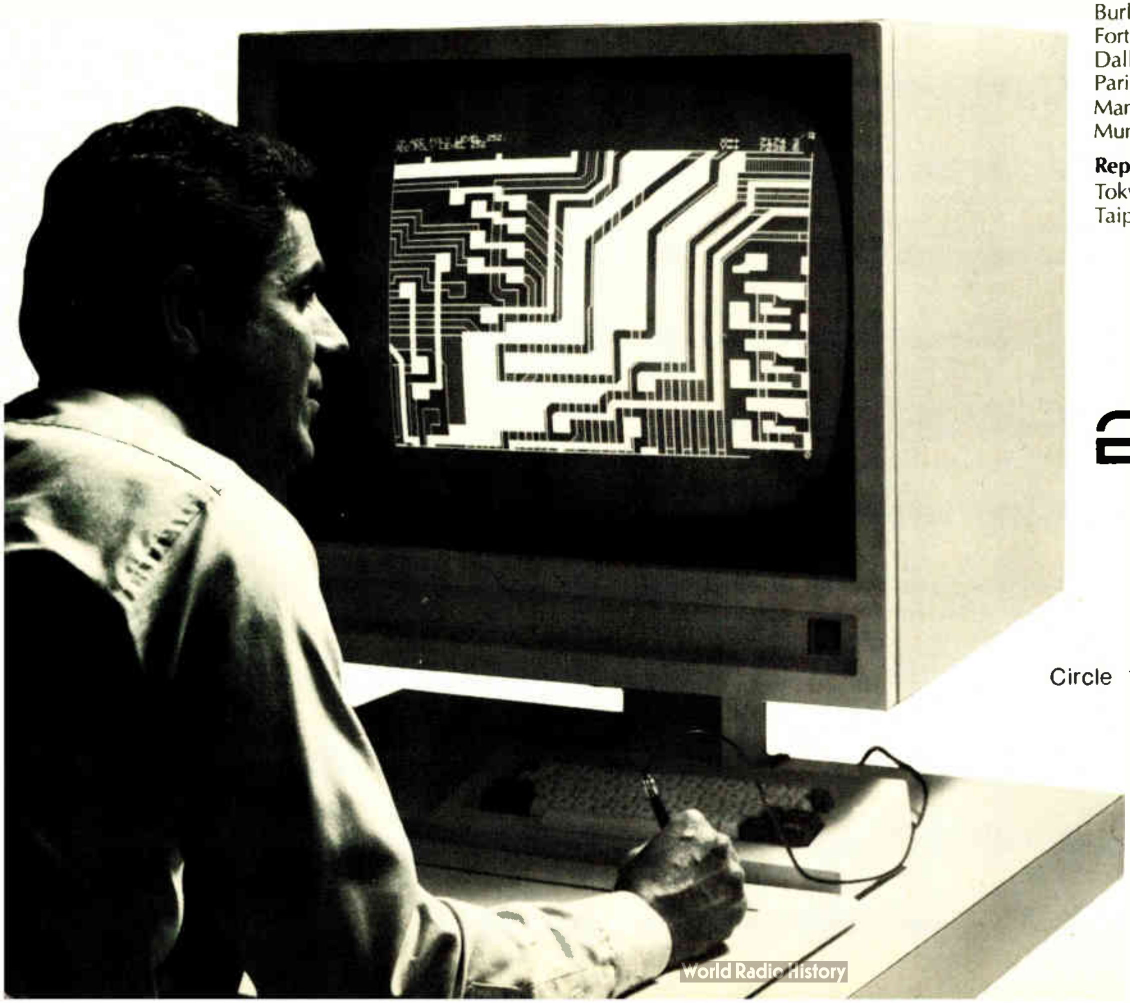

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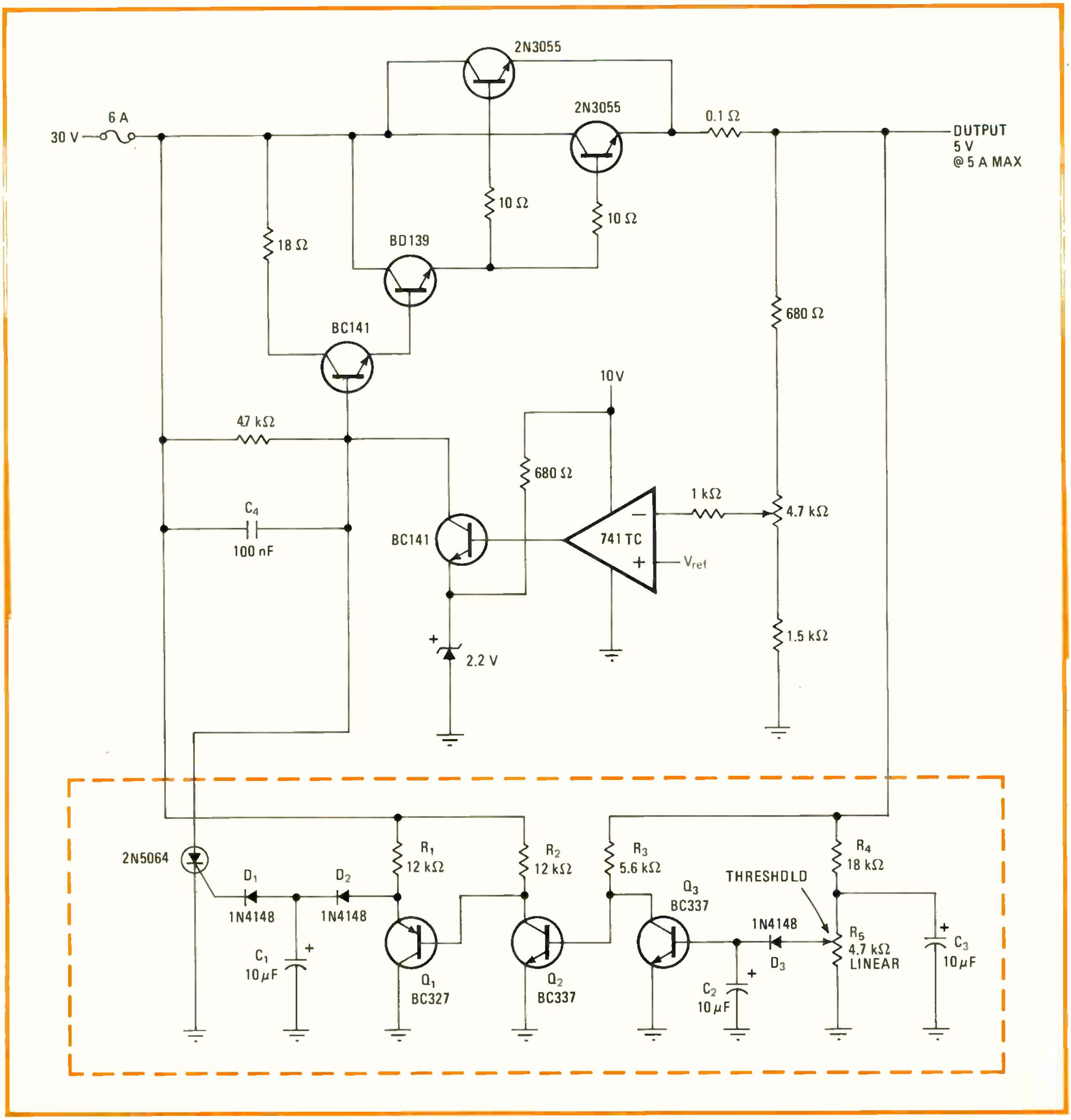
Circle 116 on reader service card



Power guard. Transistors Q_1–Q_3 and SCR (within dotted lines) protect high-current power supply from short circuits and excessive output voltage. On occurrence of either event, Q_2 turns on, disabling Q_1 and enabling SCR to fire, shutting down supply's regulator.

amperes), which is modified slightly to accommodate the protection circuitry (dotted lines), is shown in the figure. When a short circuit occurs at the output, Q_2 turns on, which in turn disables Q_1. The voltage at the gate of the silicon controlled rectifier then rises at a rate determined by the time constant of elements R_1, D_1, D_2, and C_1. This delay prevents the SCR from triggering when power is first applied to the circuit. The SCR then fires, disabling the BC141/BC139 transistors in the power supply and shutting down the regulator.

Q_3, on the other hand, detects when the output voltage climbs above a user-set threshold. Once the threshold is exceeded, Q_3's base voltage rises at a rate determined by the time constant of elements C_2, R_4, D_3, and threshold potentiometer R_5 (delay must be provided for the reason discussed previously).

Q_3 then turns on. Q_2 and Q_1 react accordingly, and the SCR fires, as it did for the short circuit. Normal circuit operation may be restored simply by turning the power supply off and removing the abnormal condition, then switching on the supply again. □

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

The much-publicized fiber-optics revolution is indeed here—but publicity notwithstanding, it will not put the traditional competition out of business for a long time. As experienced observers of electronics have learned, many new developments make their mark as ooze-throughs rather than breakthroughs, the only difference being in the ooze rate. Fiber is turning out to be no exception, and only sound engineering analysis will determine how quickly and where in particular it will be applied in new systems.

Data links appear to be the first area in the industry at large on which fiber optics is having an appreciable impact. This is most probably because the links can be put together without a great deal of effort in house or purchased in varying degrees of ready-to-plug-in formats from more than a dozen or so suppliers. But even so, many first-time users of fiber-optic data links undoubtedly suffer from new product inertia. Who wants to risk specifying a strange and unfamiliar gadget? Ultimately they overcome their fears, but the process is usually painful and time-consuming.

The following article is the first of a series that should help the readers of Electronics *come to grip with this situation. The goal of these articles is to give engineers enough background to be able to make intelligent decisions on the usefulness and impact of fiber-optic data links in particular applications or systems.*

It has been said that, because a fiber-optic communications system has so many advantages over a conventional electronic one and by now is also cost-competitive with it, any system that is not designed to use optical fiber is obsolete before it has even been built.

The only way to prove or disprove such a statement is with numbers, and the first article in the series (see below) addresses this question. By calculating the "value in use" of a particular system, the prospective user of fiber optics can put a numerical value on both its tangible and intangible

Estimating when fiber optics will offer greater 'value in use'

Kicking off a series on designing with fiber optics, this article tells how to calculate the economic advantage (or not) of using optical instead of wire cable in a system

by Jay Uradnisheck
E. I. du Pont de Nemours & Co., Wilmington, Del.

□ If it's no longer a question that fiber optics will become big business, it is still uncertain just which particular applications it will turn up in—except that they will be the ones in which its benefits compare most favorably with its costs. The engineer thinking of using the technology therefore needs to be able to evaluate more than just the cost of using it in a product. He must determine the value of its unique assets to the customer.

He (or she) can do so by listing the various as-yet intangible benefits of fiber optics in a specific application, placing a dollar value on each in terms of either total system investment or annual operating costs (whichever the customer prefers), and combining these figures with the costs of manufacture into a value-in-use factor. The VIU figure will help him determine where and when optical fiber is economically feasible.

Of course, the technology opens up some entirely new applications, but more often it will displace a conventional method of transmitting information, such as microwave transmission through air or electric-pulse transmission through wires. Thus a system's VIU will vary, not just with the application and the unique assets of fiber optics, but also with what alternative conventional equipment is available. The most successful applications, in short, will be where its value in use to the customer furthest exceeds its selling price.

To repeat, VIU calculations are based on the fundamental reality of the business world: that customers ultimately judge the worth of new products. It is their economic criteria that measure product worth, and they judge the new product by comparing it with the best *benefits. He can then compare it with conventional systems in terms of both the investment cost and cash flow. The result is a decision based on engineering economics as to whether or not fiber is feasible for a given application.*

The next article, which will appear on Nov. 23, shows how—once the decision has been made in principle to go to fiber—to check quickly that fiber optics can in practice satisfy specific design requirements and then choose the most applicable, lowest-cost components. All the key concepts are covered in a series of easily used design charts that do not require an extensive knowledge of details.

Finally, to help decide whether to build or buy, a special report in the Dec. 21 issue will compare and contrast the various do-it-yourself fiber-optic data links that have become available in many forms from numerous manufacturers anxious to tap a growing market. A feature of the special report will be a detailed table of the specifications and capabilities of available products.

conventional product they know about.

The first step in calculating a VIU is to draw a schematic diagram of the application using conventional technology. It may be as simple as a single wire connecting the origin and destination of information that has to be transferred. Next, draw a boundary around the portions of the application that might be changed or replaced by fiber optics. Then diagram the fiber-optic solution for the application.

Do not let the technical constraints of the conventional technology unnecessarily limit using fiber optics to its full advantage. Conventional auxiliary equipment, such as that needed to filter out interference, may be completely unnecessary with fiber-optic cables. Signals that are conventionally transferred with parallel channels might be multiplexed and transferred with only one fiber-optic channel.

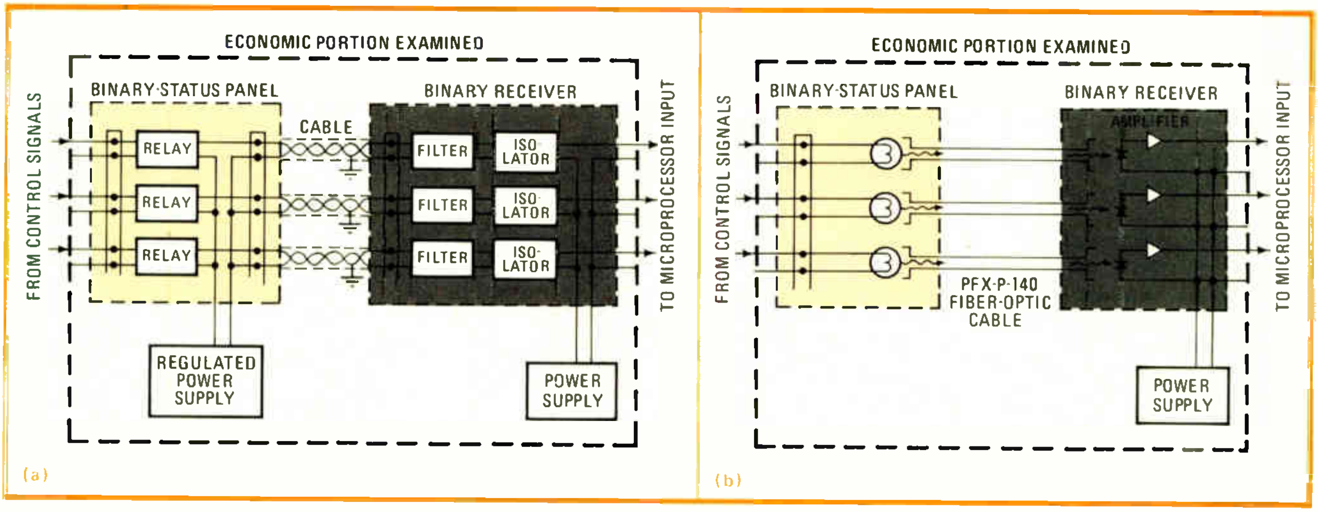
Compare and contrast

When VIU calculations are made, the economics of everything inside the two diagrams is examined. Remember, a lower-priced product need not mean it is better than the conventional product. A less expensive fiber-optic cable may require more expensive terminations, connectors, or electronics equipment. Therefore, the overall economic diagrams should account for all of those that result from using fiber optics.

One of the benefits of the VIU calculation is that it forces one to assign dollar values to the advantages of a new product so that they can be related to other economic considerations. Some of the advantages of fiber-optic

TABLE 1: SOME INVESTMENT ITEMS ASSOCIATED WITH INFORMATION TRANSFER EQUIPMENT

Cost item	Type	Consideration
Cable cost	variable	The type of wire cable will depend on the degree and intensity of interference as well as the rate of data transfer and transmission distance. The type of fiber-optic cable will depend on the data rate and the transmission distance.
Conduit	variable	The need for a conduit for wires depends on the building codes, explosive or corrosive environment, and amount of external interference. Fiber-optic cables may not require conduits except in severe environments.
Grounding cable	variable	Fiber-optic cables usually do not require the transmitter and receiver to be interconnected with gounding cables.
Spacers	variable	These are needed to minimize cross talk between some wire cables. Fiber-optic cables would not require spacers.
Floor shielding	variable	This may be needed to minimize noise pickup by wire cables, not by fiber-optic cables.
Raised flooring	fixed	A smaller-diameter cable might not be a tripping hazard and so would not require raised flooring.
Connectors	fixed	Costs depend on whether military specifications are required and on type of cable.
Electronics	fixed	Driver/electro-optics/opto-electronics/receiver is required for fiber-optic cables. Driver/receiver only is required by wire cables.
Labor	variable	This includes the cost of handling the cables, splicing, laying them out, etc. Fiber-optic cables may have a different installation cost because of their smaller weight.
Cable inventory	variable	If attaching connectors to cables is extremely time-consuming, it may be advisable to have an inventory of preconnectored cable. Frequently changing transmission distances may also require a larger inventory.
Connector inventory	fixed	Frequently changing distances may increase this item.
Engineering	fixed	Large, difficult-to-handle cables may require pre-engineering so that the cables can be connected in the plant before the system is laid out in the field.

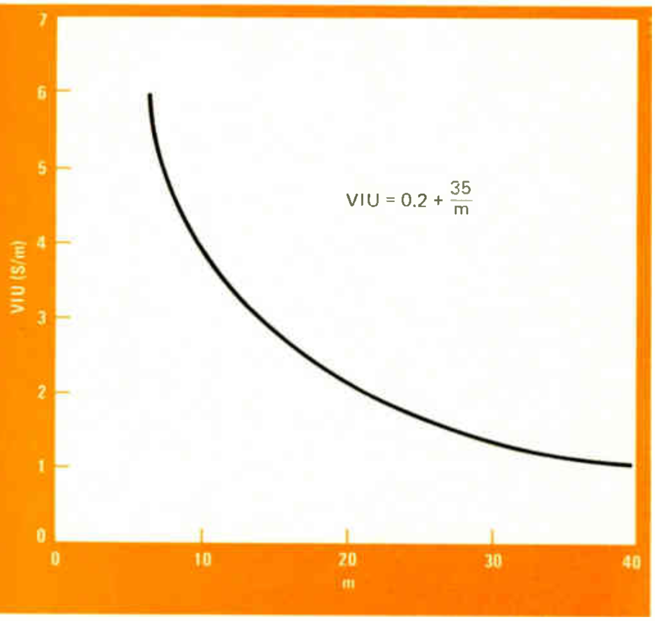


1. Clear case. To keep emi-induced transients from damaging microprocessors controlling a laser system, conventional cable link would need filters, amplifiers, even photo-optic isolators (a). Needing none of these, fiber-optic cable (b) would have a better VIU.

TABLE 2: INVESTMENT ESTIMATES FOR INFORMATION TRANSFER THROUGH SEVERE EMI ENVIRONMENTS

Cost item	Investment ($S)	
	Conventional	Fiber optics
Photo-optic relays	32 x 18	–
Cable	2 x 3 x m*	VIU** x m x 32
Cable ties	–	0.05 x m
Regulated power supply	2 x 60	60
Connectors	4 x 7.5	32 x 2.5
Filters	32 x 20	–
Isolators	32 x 4.5	–
P-i-n diode-amplifiers	–	32 x 9
Conduit	3 x m	3 x m
Back panel	200	100
Labor (electronics)	96 x 1	64 x 1
Labor (connectors)	64 x 1	64 x 1
Soldering tools, crimp tools, splicers, etc.	0.1 x 100	0.1 x 100
Electronic inventory	158	30
Cable inventory	0.2 x 2 x 3 x m	0.2 x VIU x 32 x m
Total investment	2,038 + 10.2 x m	696 + (38.4 x VIU + 3) x m

*m = transmission distance in meters
**VIU = value in use of the fiber-optic cable in dollars per meter



cables, such as to immunity to electromagnetic interference, dielectric isolation, improved safety, and increased bandwidth, have been given an indirect dollar value by being considered in the schematic diagram. But the others are taken into account when the overall economics is considered.

A new product's VIU is defined as the price that will cause no change in the end user's overall economics relative to the best competitive product. Thus if fiber-optic cables are priced consistently with the application's VIU, the end user will see no change in his overall economics as a result of switching to this new product. If they are priced below the application's VIU, there should be a strong economic reason to switch.

Moreover, if fiber-optic cables are priced below the application's VIU for one end user, they may be priced above their VIU for another. This is because a product's value in use depends not only on the specific applications, but also on who is using the system.

In calculating a VIU, the economics to be considered should be the user's favorite criteria. These may be total investment, percent return on investment, cash flow, percent profit margin, and so on. Most commonly used are total investment and operating cost.

Total investment method

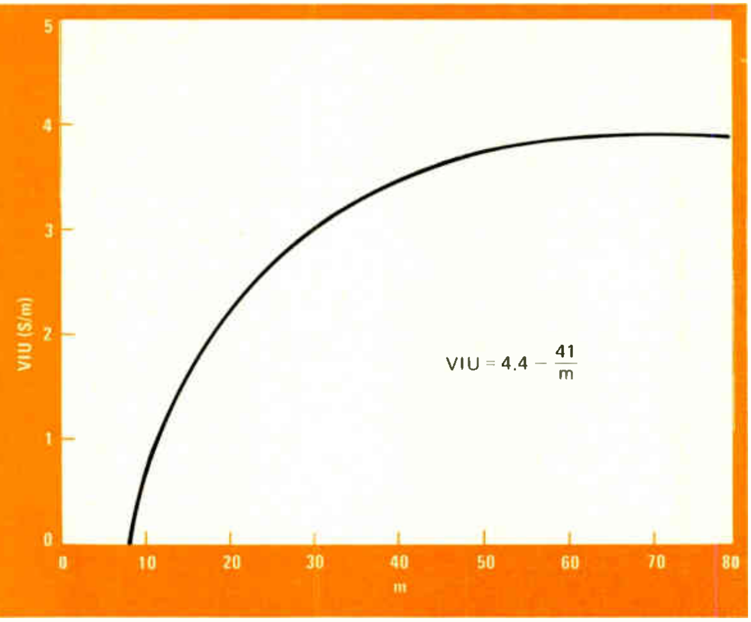
Often the most important design variable that makes or breaks the economic incentive to use a fiber-optic system is the transmission distance and the environment between the sender and receiver of information. This involves two types of investment cost items. The first, fixed investment cost, shows little or no dependence on the transmission distance. Cable connectors are a good example, since in a point-to-point system, no matter how short or long the transmission distance, the number of connectors is usually constant.

Variable costs are strongly dependent on distance. The cost of the cable itself, for example, is variable. This is included in Table 1, which lists some investment-cost items to consider in calculating the fiber-optic cable's

TABLE 3: INVESTMENT ESTIMATES FOR CPU AND PERIPHERAL INFORMATION TRANSFER

Cost item	Investment ($$)	
	17 individually shielded twisted wire pairs	Fiber optics
Connectors	4 x 10	4 x 2
Cable	2 x 3.5 x m*	2 x VIU** x m
Reference cable	0.3 x m	–
Multiplexers/ demultiplexers	–	2 x 50
Optoelectronics	–	2 x 50
Labor (connectors)	68 x 1	4 x 1
Connectored cable inventory	0.2 x (2 x 3.5 x m + 4 x 10 + 68 x 1)	–
Total investment	130 + 8.7 x m	212 + 2 x VIU x m

*m = transmission distance in meters
**VIU = value in use of the fiber-optic cable in dollars per meter



VIU. This list should be expanded as necessary for a particular application.

When setting up a comparison table, the would-be user of fiber-optics should list all the investment cost items for the conventional and fiber-optic solutions for the specific application (Table 2). The first step is to consider the cost of the equipment itself. In the fiber-optic version, a dollar value for the cable will not be available and an unknown variable, VIU, should be used in its place.

To the equipment cost should be added shipping and other delivery costs, as well as the cost of all auxiliary equipment not directly involved in the application but required to support the main equipment, such as power supplies, conduits for the optical cable, or shielding for copper cable. Also, do not forget the cost of such tools as splicers or polishing equipment.

Then add in labor costs, both for installation and testing. For instance, the cost of attaching connectors to fiber-optic cable varies with different types of cable and sometimes is more than the cost of the connector itself. Also necessary may be the additional labor costs required for testing the equipment before it is handed over to the end user, as well as the costs of supervision and material required for support.

Spare costs

Inventory is one of the more obscure items of investment cost. For each piece of equipment being used to transmit information, there is usually spare equipment on the site that could be put into action should portions of the original equipment malfunction. Estimate the inventory of equipment by finding out how many installations in the field might need to be replaced by a spare over a year's period. The number of dollars to put into inventory is not the entire investment for the spares, but the fraction of this investment that is actually being used to support just one of the installations.

The best course here is to split up the inventory into electronics and cable categories. For example, some installations will involve constant changes in the data transmission distances. These will require proportionally more cable to be in inventory than electronic equipment. Of course, inventory costs should be tabulated with other investment costs.

When all the cost items are tabulated, add the investments, including inventory, for the competitive system and do the same for the fiber-optic system. Then equate the two summations and solve for the unknown VIU. If cable costs are kept in dollars per meter and meters of transmission distance is used as the variable m, the resulting equation looks like:

$$\text{VIU} = V_c + \Delta V_I + \Delta F_I/m$$

where:

VIU = the value in use of the fiber-optic cable in dollars per meter

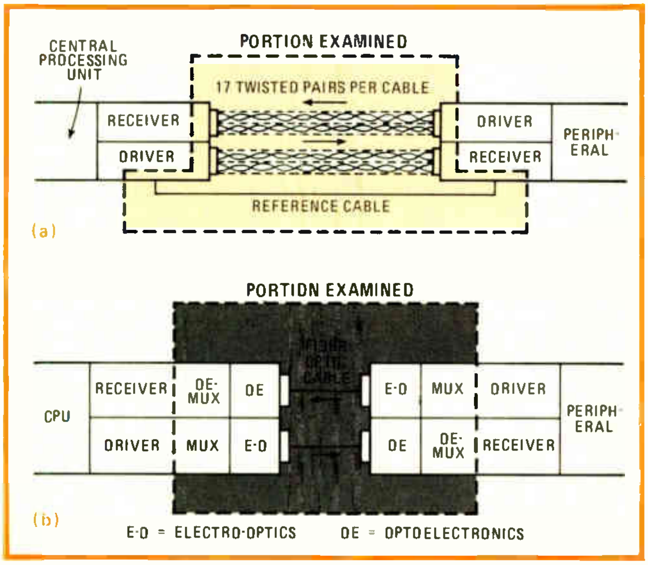
V_c = the selling price of conventional cable ($/m)

ΔV_I = the difference in dollars between all the variable-investment cost of the conventional cable and the fiber-optic cable

ΔF_I = the difference in dollars between all the fixed investment costs of the two kinds of cable.

For very long transmission distances, the VIU of the fiber-optic cable approaches the selling price of the conventional cable, plus whatever differences there are between the costs of laying down the cable, adding conduits, and so forth. In other words, VIU = $V_c + \Delta V_I$.

The equation also indicates that for applications where the fiber-optic system has reduced the cost of the electronics, there will be an especially high VIU for shorter transmission. For example, a carbon-dioxide laser system dubbed Antares is being built for fusion research at the Los Alamos Scientific Laboratory and will have to operate amid severe electromagnetic interference. The laser amplifiers are pulsed with megampere electric discharges, and the laser control signals must traverse environments containing electromagnetic interference of up to 50 kiloamperes and 1.8 megavolts/m. Also, control information must be received with low error rates by

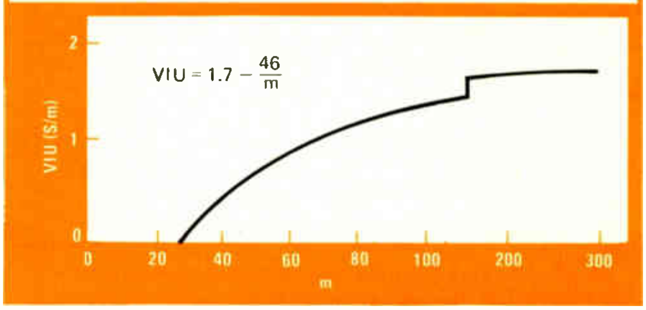


2. Talking peripherally. Instead of communicating with peripherals over two cables of 17 twisted-wire pairs each, a computer could use one fiber-optic cable with 17 time-multiplexed channels. Best VIU, though, might belong to time-multiplexed conventional cable.

TABLE 4: INVESTMENT ESTIMATES FOR CPU AND PERIPHERAL INFORMATION TRANSFER

Cost item	Investment ($$)	
	Shielded twisted pair	Fiber-optics
Connectors	4 x 4	4 x 2
Cable	2 x 1.5 x m*	2 x VIU** x m
Reference cable	0.3 x m	—
Multiplexers/ demultiplexers	2 x 50	2 x 50
Optoelectronics	—	2 x 50
Labor (connectors)	8 x 1	4 x 1
Total investment	124 + 3.3 x m	212 + 2 x VIU x m

*m = transmission distance in meters
**VIU = value in use of the fiber-optic cable in dollars per meter



microprocessors in shielded enclosures, and the computer interfaces must be protected from damage by voltage induced in ground loops and conducted interference.

The essence of this application involves transferring a control signal over a distance of 5 to 20 m to a microprocessor parallel input. A conventional system (Fig. 1a) might transmit control information to the binary receiver over individually shielded, twisted-wire pairs. Unwanted voltages of a broad frequency range could be induced in the cable by electromagnetic pulses from the laser amplifiers. To prevent these voltages from being interpreted as control signals, a lowpass filter would attenuate alternating-current signals above 100 kilohertz. Only the direct-current control signal remains.

The main problem

The electromagnetic pulses are so intense, however, that low-frequency voltages passing through the filter could possibly damage the microprocessors. Therefore, photo-optic isolators might be used to reject these transients. Also, extra precautions might be needed to minimize control errors from low-frequency induced voltages. The currents from the signal source that control system status might be isolated from each other and from the cables by a photo-optic relay on each channel. In addition, a regulated dc power supply might be needed to operate the relays and deliver a clean signal to the cable.

A fiber-optic system can readily accomplish the same control signal transmission (Fig. 1b). A large-diameter fiber-optic cable with a high numerical aperture would couple efficiently to an incandescent bulb. Since fiber-optic cable is a dielectric, there would be negligible induced voltages. Filters, relays, and isolators would no longer be needed, and the control signal would drive the lamps directly. Their wattage would be too high to be illuminated by incoming induced voltages in the control channels. Optical signals reaching the binary receiver would be converted by a diode-amplifier/comparator circuit to a logic-level signal for the microprocessor.

The investment estimates for the two systems shown in Table 2 are for transferring 32 separate control signals. Two cables containing individually shielded, twisted pairs are replaced by 32 plastic-core fiber-optic cables that require conduits. It is assumed that for every 10 electronic units, one is put aside for inventory. The labor required to splice and solder 64 wire cables to the connector is assumed to be the same as that required to connect 64 separate plastic-core fiber-optic cables. It is also assumed that for every 10 m of cable, 2 m are in inventory. The equating of total investments yields a curve for the VIU versus transmission distance like the one plotted in Table 2. According to it, the VIU of the fiber-optic cable declines toward the price of the conventional cable as the transmission distance is increased.

For this application, it was actually found that the environment was so severe that the shielding and isolation used for the conventional system was not enough to maintain the information error rate at an acceptably low level. More shielding, filtering, or extra isolators were required. This means the VIU of the fiber-optic cable was actually higher than calculated. To be truly rigorous, the VIU calculation should have compared conventional versus new technology for identical error rates in alternative systems.

A different application

A value in use that increases with transmission distance is possible when many information channels are replaced by a few fiber-optic channels. Consider a computer manufacturer who wants to transmit information between a central processing unit and peripheral units. The conventional method requires two cables to complete the information loop, each containing 17 individually shielded, twisted-wire pairs. A reference cable prevents potential differences between the devices from transmitting voltages into the data cables (Fig. 2).

Because of past experience, the manufacturer has discovered it beneficial to have about a two-month inventory of cables already equipped with connectors for emergency replacement for customers' computer systems.

The fiber-optic system would replace each cable of 17 pairs with one fiber-optic channel. The 17 driver channels would be time-multiplexed and processed through an electro-optic converter. The received optical signal would have to be converted to an electrical pulse by a detector/amplifier/comparator circuit and demultiplexed for the receiver.

If the VIU calculation is based on the 17-pair wire cable as the best conventional system, the curve in Table 3 results. However, the fiber-optic cable itself is not competing against the wire bundle. The best competition might be a well-shielded twisted pair for carrying the multiplexed signal. In this case, the schematic for the twisted pair would look very similar to the fiber-optic schematic except it would have no optoelectronics circuits, and the VIU curve is lowered throughout the ranges of transmission distances (Table 4). It is necessary to calculate the VIU based on the truly best competition, for the prevailing conventional solution to an application is not always the best competition for fiber optics.

Operating cost method

The economics of a product over its lifetime is not just a function of the total investment. Economics associated with the annual cash flow that results from the use of the product can sometimes be more important than the initial investment. For example, a customer would have considerable economic incentive to purchase an expensive data transmission system if it would save him enough money each year to pay back the entire original investment. Similarly, the VIU of fiber-optic cables may not describe the entire economic picture accurately unless cash flow is included.

To determine when to start using cash flow in a VIU calculation, estimate the investment and operating costs in the schematic for the conventional fiber-optic systems. If the annual operating cost differences between the two are more than a tenth the initial investment, include the cash flow in the VIU calculations.

VIU analyses based on cash flow employ economic criteria entirely different from those of total investment. A few of the more common are operating cost, annual cash flow, cash flow over the product's life, return on investment, and investor's method return on investment.

Cash flow is the difference between the operating costs of a process and any income generated as a result of the operation. Return on investment is cash flow that has been normalized with respect to the investment. The user's accounting preference determines which method he should use.

Just as for the total investment method of VIU analysis, the operating cost methods require that schematics be drawn of the best competitive system whose operating costs or investment would be altered should fiber optics be used.

The next step is to set up a chart for both systems and list all the costs associated with the total investment. Once again, the actual selling price of the fiber-optic cable is replaced by an unknown-parameter VIU.

TABLE 5: SOME OPERATING COST ITEMS ASSOCIATED WITH INFORMATION TRANSFER EQUIPMENT

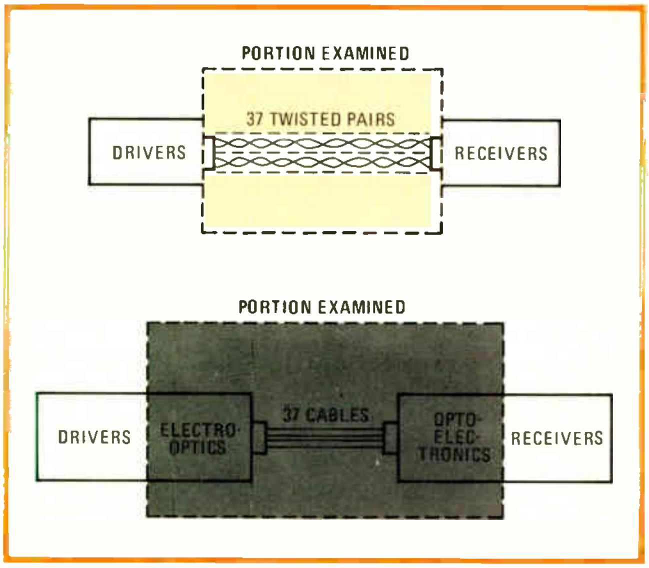
Cost item	Consideration
Utilities	Electricity for power supplies.
Maintenance	This cost refers to the labor associated with maintaining the system in good working order. When calculating this item, include not just the labor costs but also materials costs and overheads. Try to determine if the cable may require special care such as splicing breakages.
Insurance	This may change as a result of a sparkproof cable.
Weight	Aircraft can realize a fuel savings with lighter payloads.
Space	Consider additional benefits such as a larger cargo-carrying capacity.
Error rate	Data transmission systems can be analyzed statistically for the number of errors per total transmitted (this is called the bit error rate, BER). Once the BER is known, determine the total bits per year transferred. Next analyze the dollar value an error would cause to the overall system. The dollar value of an error may come from lost time on a production line or the cost of a maintenance call. The product of the dollar value of an error and the errors per year gives the dollar-per-year operating costs of errors.
	V_I = difference between all the variable investment costs of the conventional and fiber-optic systems (\$/m) F_I = difference between all the fixed investment costs of the conventional and fiber-optic systems (\$) m = data transmission distance (m) V_O = difference between all the variable operating costs of the conventional and fiber-optic systems (\$/hr x m) F_O = difference between all the fixed operating costs of the conventional and fiber-optic systems (\$/yr)

The operating costs can be determined by making another chart for both systems. This requires entering two types of annual costs. Depreciation is first. This will be the total investment divided by the operating life of the data transmission system—typically 10 years. Since the total investments from the first step contain unknowns as variables, equations instead of dollars per year are now entered. The second group of operating cost items, such as research and development, fuel, and procurement, should be entered only if they have different values for the different systems.

Table 5 lists some operating cost items that might be considered. In using these costs, the overall effect of the data transmission system on the economics of the entire process in which it is integrated must be examined.

Adding it up

Finally, the depreciation and other operating costs in Table 5 should be summed for both systems. Equate these summations and solve for the VIU parameter. If only unknowns were entered in the charts, the resulting



3. In flight. Heavily shielded 37-channel wire cable could weigh 4 kg/m as against 0.4 kg/m for same number of fiber-optic channels. Calculating VIU would show whether new fiber-optic system for aircraft would pay for itself within a year by reducing fuel costs.

TABLE 6: INVESTMENT AND OPERATING COST ESTIMATES OF AIRCRAFT DATA-TRANSFER SYSTEMS

Cost item	Total investment ($$) Competitive	Fiber optics
Connectors	2 x 50	37 x 2 x 3
Cable	7.7 x m	37 x VIU x m
Back panel	–	850
Labor (connectors)	74 x 1	74 x 1
Total investment	174 + 7.7 x m	1,146 + 37 x VIU x m
	Operating cost ($$/year)	
Fuel, procurement, R&D	200 x 5.7 x m	200 x (1 + 0.4 x m)
Depreciation	17.4 + 0.77 x m	114.6 + 3.7 x VIU x m
Operating cost	17.4 + 1,140.8 x m VIU = 295 – 80/m	314.6 + 50 x m + 3.7 x VIU x m

equation for the value in use would then be:

$$\text{VIU} = L_f(\Delta V_o + \Delta F_o/m) - F_{If}/m - V_{If} + (L_f/L_c)(V_c + V_{Ic} + F_{Ic}/m)$$

where:

VIU = the fiber-optic cable VIU in dollars per meter

L_f, L_c = life expectancy of the fiber-optic and conventional system in years

ΔV_o = the difference between all the variable operating costs of the conventional and fiber-optic system in dollars per meter per year

ΔF_o = the difference between all the fixed operating costs of the conventional and fiber-optic systems in dollars per year

m = data transmission distance in meters

F_{If},V_{If} = fixed and variable investment costs of fiber-optic systems in dollars and in dollars per meter

F_{Ic},V_{Ic} = fixed and variable investment costs of the conventional systems in dollars and dollars per meter.

This is the simplest form of the VIU equation. It holds for some applications, not all. Unfortunately, the first entry in the operating cost chart is often not as simple as dividing the entire total investment by one number. Should the fiber-optic emitter have a different operating life from that of the cable, the emitter's investment must be divided by its life expectancy. The cable's investment may be divided by still another number. Despite this complicating factor, the same procedure would still hold for calculating the VIU—once all the operating costs are added for the two systems, equate the costs and solve.

The principle of value-in-use calculation based on operating costs is used on an aircraft application in Table 6. Assume there is a need to transmit 37 separate data signals through the interior of the plane with very low (10^{-6}) bit error rates, despite electromagnetic, radio-frequency, lightning, and nuclear interference.

The conventional system might use individually shielded, twisted-wire pairs to transmit the data (Fig. 3) between the drivers and receivers. The fiber-optic counterpart might also use 37 separate channels. However, additional electronics would be needed on the front ends of the receivers and drivers. A value-in-use calculation that neglects the difference in operating costs between the two systems requires equating the total investment (Table 6) and solving for VIU. The result is:

$$\text{VIU} = 0.21 - 26/m$$

Unfortunately, a heavily shielded wire cable containing 37 channels could weigh as much as 4 kilograms per meter while the fiber-optic cable with the same number of channels could weigh 0.4 kg/m. Also, the cost of operating aircraft per unit weight varies greatly, depending on the physical dimensions of the aircraft and its operating characteristics.

In the light of previous studies, the total annual operating, procurement, and R&D costs per unit weight might be about $200/kg. Since the operating cost of the competitive system for all conceivable lengths is much less than a tenth the total investment, the VIU calculation for fiber-optic cables should also be analyzed according to operating cost.

The operating cost components could be the sum of the fuel, procurement, and R&D plus depreciation. If the life expectancy of both the fiber-optic and wire cable systems is 10 years, the depreciation is a tenth of the total investment. By equating the operating costs (Table 6) and solving for VIU, the alternative equation results:

$$\text{VIU} = 295 - 80/m$$

Either of these VIU equations could be correct. The choice of one over the other depends on the user's individual economics. If capital is tight, he may not want to spend more now to save money in later years, and the first equation is valid. But if enough money could be saved in one year to pay back the entire investment, the latter equation would have more meaning. □

Replacing hardwired logic with microcode

Microprogramming a computer adds to its power but requires familiarity with its structure as well as software experience

by Thomas M. Hedges,* *Georgia Institute of Technology, Atlanta, Ga.*

☐ Interest in designing microprogrammed computers has flared as rapidly as the price of read-only memory has dropped. As an alternative to hardwired control, the approach has many advantages: it significantly reduces the parts count and hence cost of the machinery, it simplifies control structures and maintenance, and above all, it makes the instruction set more flexible—so much so that it is a popular means of allowing one computer to emulate another. Moreover, if used exclusively for program control, microcode can replace hardwired logic altogether in disk controllers, radar signal processors, high-speed telecommmunications processors, and minicomputer front ends, to name just a few possibilities.

However, microprogramming is not easy. Though conceptually microprograms are no harder to write than assembly-language routines, in practice they also demand an intimate familiarity with the structure and timing considerations of the machine involved. The microprogrammer therefore requires an understanding of both hardware and software and how they interrelate. (Incidentally, microprograms are not to be confused either with techniques for programming microprocessors or with assembly-language applications programs.)

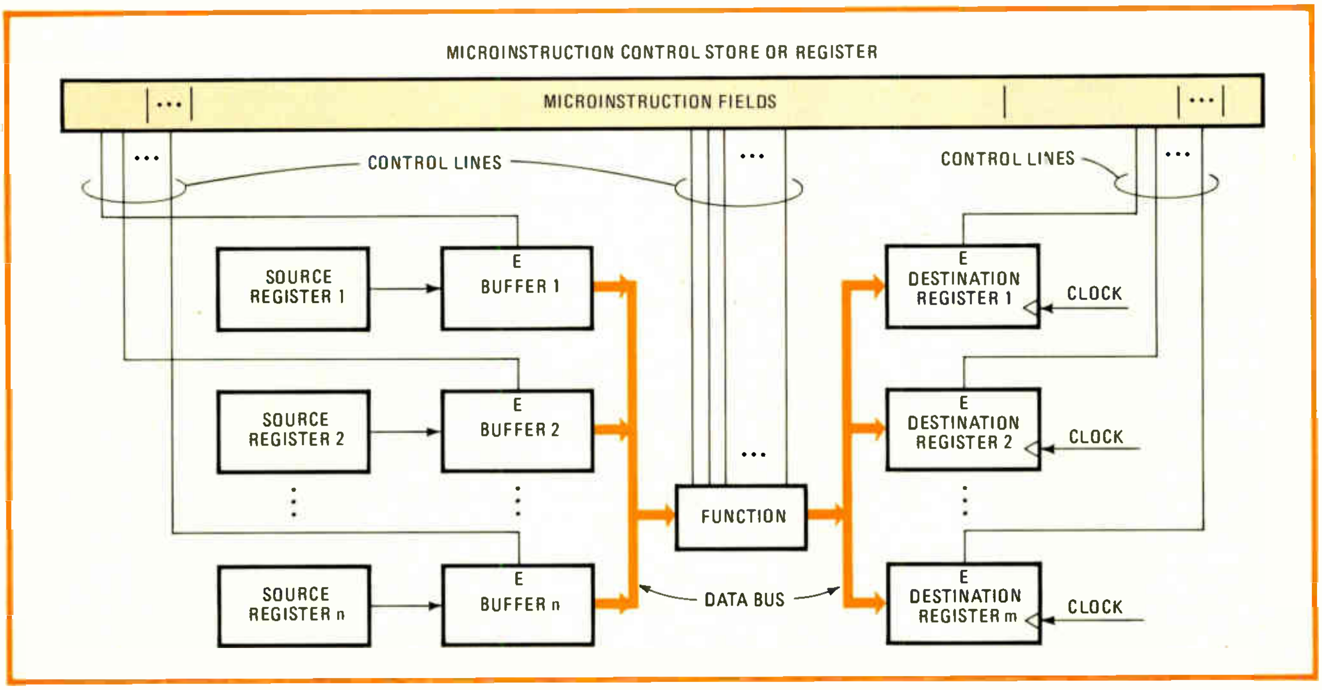
*Now at SRI International, Menlo Park, Calif.

The overall picture

Computer hardware generally has four functions: arithmetic and logic, memory, input/output, and control. Instead of hardwired logic, the control unit can have microprograms stored in the memory that is part of it. The other three functions are then controlled by the microinstructions.

With such a microprogrammed computer, the user tells the control unit what to do through the applications program. Then the control unit, performing almost like a computer within a computer, tells the rest of the machine how to do it.

This job the unit does by fetching assembly-language instructions (or op codes) from the computer's main



1. The means. The microinstruction, typically over 50 bits wide, is placed in a microinstruction register. Divided into fields that designate the source and destination registers as well as the desired function, the microinstruction organizes the flow of data through the computer.

How microprogramming started

Credit for the original microprogramming concept is generally given to Britisher M. V. Wilkes of Cambridge University's Mathematical Laboratory. In a paper he presented at Manchester University's Computer Conference in July 1951, Wilkes discussed "The Best Way to Design an Automatic Calculating Machine." Wilkes' intention, ironically enough, was to simplify the design of a hardwired machine. Today microprogramming is used to replace hardwired logic altogether.

As Samir Husson notes in his book "Microprogramming: Principles and Practices," the technique attracted little attention before the 1960s because it was too expensive to implement. The first commercial microprogrammed computer was IBM's 7950, introduced in 1961. Other early appearances of microprogramming were in such machines as the IBM System/360, the RCA Spectra/70, and the Honeywell H4200.

A variety of memory technologies were used for the read-only memories needed for the microinstruction store. Among these were traditional ferrite cores, cores cut into an E-shape to create a transformer memory, and arrays of diodes or capacitors. A novel approach was taken by IBM, which devised a card capacitor ROM for several of its System/360 models. The same size as the traditional IBM punch card, the card is printed with horizontal lines of silver ink and placed next to a copper-clad epoxy-glass sheet with vertical lines etched in it. Capacitive coupling occurs between the vertical copper lines on the sheet and horizontal silver lines on the card, except where the silver ink has previously been removed by punching out locations on the card. The presence or absence of this capacitive coupling is what indicates either the presence or absence of a data bit.

Microprogramming came to minicomputers early in the 1970s in units such as Microdata's Micro 800, which used diode arrays as ROMs, and the later 3200, Hewlett-Packard's 2100 family, and Digital Equipment's PDP-11 line. The increasing availability of low-cost and fast semiconductor ROMs, however, has recently caused the technique to boom in popularity.

Virtually all mainframes and minicomputers today are microprogrammed. Many of the machines now use random-access memory to store the microinstructions, making it easier for the user or the manufacturer to change the machine. Also, the ease with which microprogramming allows one machine to emulate another has resulted in its widespread use in the IBM-compatible computer area. **Anthony Durniak**

memory one at a time and decoding (or cracking) each one for execution by the arithmetic/logic unit. If the machine is hardwired, each instruction decodes into several machine states; in its microprogrammed counterpart, each instruction is decoded into several microinstruction statements.

With a hardwired control section, however, the instruction set is rather inflexible, whereas a microprogrammed system, having all the intrinsic advantages of software, is more flexible. Changing the microcode is enough to change the instruction set. Moreover, frequently used instruction sequences, or subroutines, can be placed in microcode and labeled with a single assembly-language instruction. This speeds up execution of the subroutine because it eliminates the need for repetitive fetching and cracking of op codes.

It is also possible to microcode an entire application program. In this case the main memory would contain no program steps.

The question of timing

All data manipulation operations in a microprogrammed computer are measured in terms of basic timing elements called microcycles. These are normally synonymous with and define system clock cycles. They can also be considered states of the machine. A microcycle is the time it takes to transfer information from one shift register to another and also, if desired, perform some function on the data during the transfer. The source and destination registers and the optional asynchronous or combinatorial function are selected by a microinstruction stored in the programmable control unit's memory.

A microinstruction is the microcode for a single microcycle. In today's minicomputers, it is typically over 50 bits wide and divided into fields, each of which controls a different piece of the hardware that is activated during the microcycle (see Fig. 1).

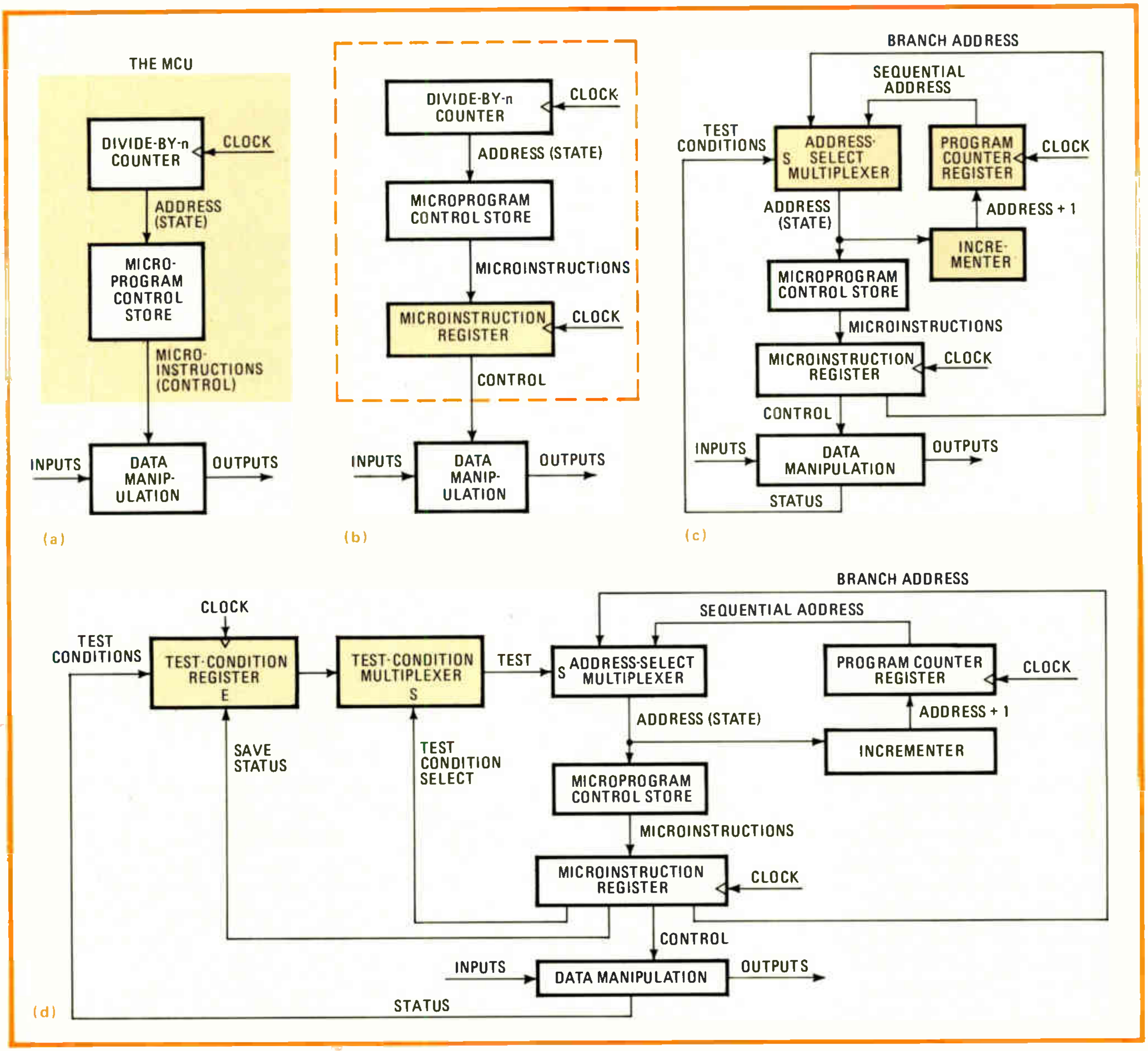
From these definitions it follows that the basic microcycle involves six events:

- Selection of the source register.
- Selection of the destination register.
- Selection of the function to be performed.
- Application of the data in the source register to the input of the function.
- Performing the function.
- Saving the output of the function in the destination register.

Thus selecting the minimum system clock cycle time requires adding the maximum duration of each event in a microcycle.

The first three events occur simultaneously as the current microinstruction is presented to the system. The delay associated with them is the delay through the microinstruction store or register. The fourth event requires a time period long enough for the data to propagate through the source register and for the associated buffer to turn on and drive the data bus leading to the function. However, since the entire system is clocked synchronously, the delay through the source register occurs in parallel with the delay through the microinstruction register. Therefore, delays associated with the first three events can be subtracted from the time required for the fourth if the delay through the source register is greater than the delay through the microinstruction store. The duration of the fifth event must be long enough for the longest asynchronous function to be performed. Finally, for the sixth, the set-up time for the destination register must be taken into account.

In a 5-megahertz microprogrammed processor built at



2. Software control. The basic microprogrammable control unit (a) uses a counter to generate the address of the current microinstruction. By adding a microinstruction register (b), the data manipulation can be performed in parallel with the generation of the next microinstruction. Incorporating test conditions and the ability to do branch addressing makes the MCU even more flexible (c). The test-condition register once again allows address generation and data manipulation to occur in parallel, while the multiplexer permits multiple test conditions (d).

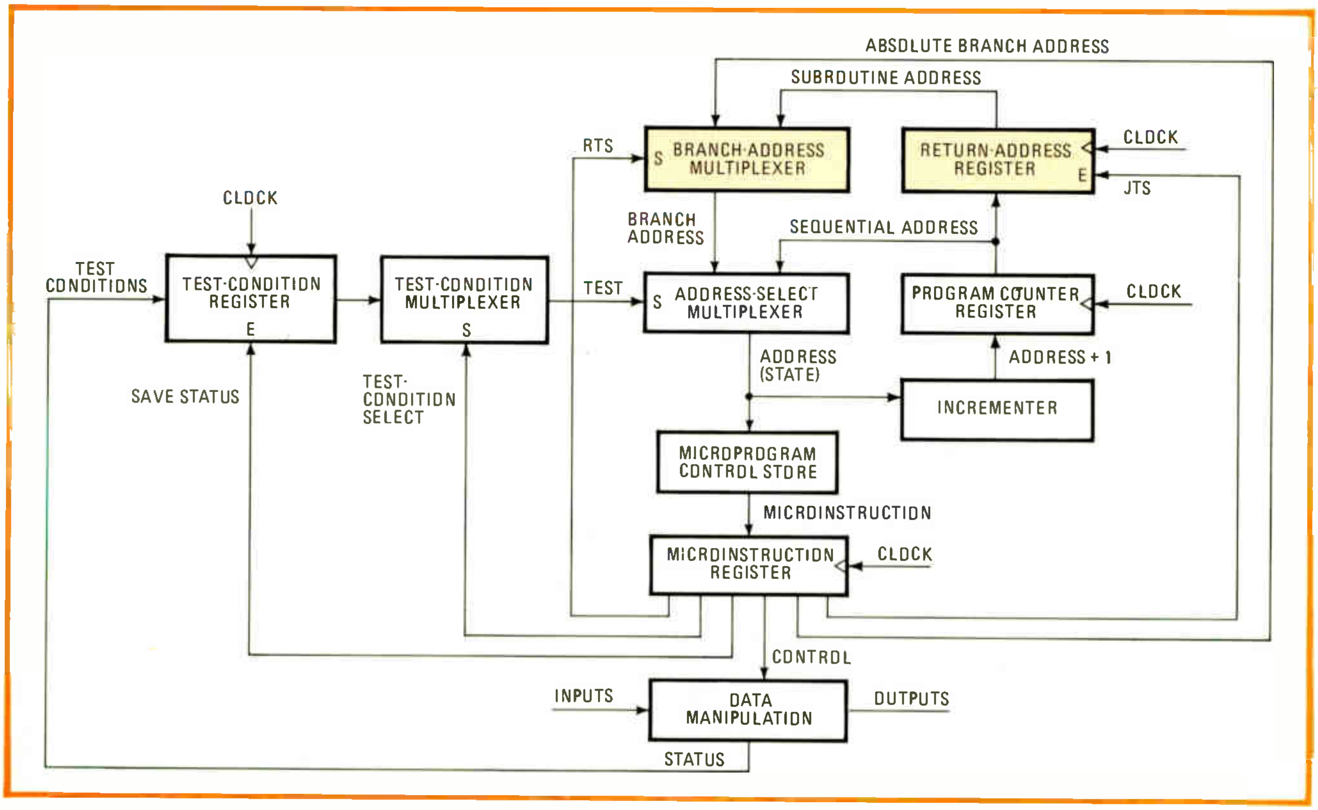
the Georgia Institute of Technology, for instance, these six events last 197 nanoseconds, or less than the system cycle time of 200 ns. In this case, the microinstruction register has an 18-ns delay that overlaps completely with the 57-ns delay before the data is ready to be manipulated (see "RAIL timing" for timing diagram and more details about the processor).

Controlling purpose

The purpose of the control portion of the machine is to generate a particular sequence of microinstructions. Thus it needs another subsystem to generate addresses, called microprogram addresses or states, which the memory subsystem decodes by generating microinstructions. This address, or state, calculator plus the microprogram control store are the elements that together make up a complete microprogram control unit.

The most basic MCU is a control store in receipt of the output of a divide-by-n counter (Fig. 2a). This MCU has n states and steps through them sequentially, decoding them into microinstructions. The microinstructions are used to control the data manipulations of the overall computer system inputs, producing the system outputs.

From a timing standpoint, this basic MCU has three delays associated with it: the delay from the active clock transition to the output of the counter; the delay through the microprogram control store; and the time associated with the performance of the data manipulation. In most systems, the sum of the two delays associated with microinstruction generation is about equal to the time of the data manipulation. Thus, if the microinstruction generation can be performed in parallel with the data



3. Jump to. The length of microprograms can be reduced by adding the subroutine capability to a microprogram control unit. To implement this operation, a branch-address multiplexer and return-address register are added to the basic control unit.

manipulation, the cycle time for the machine can be about halved. This is done by placing a microinstruction register, which is sometimes called a pipeline register, between the microprogram control store and the hardware for data manipulation (Fig. 2b). With the addition of this register, the MCU becomes a next-address calculator instead of a current-address calculator—in other words, the MCU is one instruction ahead of the data manipulation of the machine.

Test conditions

This basic MCU is still inflexible, however, because it cannot handle the test conditions implicit in conditional, or branching, instructions. To interpret these test conditions, the unit must be able to apply one of two addresses to the microprogram control store. One of the addresses will be used if the test condition is true or 1 and the other if the test condition is false or 0. Two convenient addresses to use are the next address in sequence and a branch address specified in the microinstruction. Then in the MCU, the branch address will be forced onto the control store if the test condition is true; if the test condition is false, the addressing will be sequential. As shown in Fig. 3c, this means replacing the divide-by-n counter by an incrementer, program counter register, and address-select multiplexer that can select one of two inputs. The program counter has changed in character because the next address should always be equal to the current address applied to the control store plus one, no matter whether the branch address or the program counter was selected as the current address.

The controller shown in Fig. 2c does, however, have a disadvantage. The data manipulation and next-address calculation portions of the machine are once again coupled. This occurs because the address applied to the control store is dependent upon the status of the data manipulation. To solve this problem, the test condition is saved in a register that is clocked on the system clock.

It is now necessary to wait at least one microinstruction before examining the appropriate test condition. But what if it is desirable to wait several microinstructions before checking a particular test condition? Then a register with a clock enable is used. Thereafter, if the status of the machine at the end of the current microcycle is to be saved, the register to be clocked is enabled, capturing the current status.

The technique of changing states described here should be familiar to any engineer who has programmed a computer. In most general-purpose computers, if a branch such as JUMP, GO TO, or WHILE, is not specified, the next instruction executed is the one following the current one. If either a conditional or unconditional branch is specified, the branch address must be specified; if the branch is not taken, the next instruction in the sequence is executed. This technique can also be used with commercially available microprogram sequencers, such as Advanced Micro Devices' Am2909, Am2910, Am2911, Signetics' 8X02, Monolithic Memories' 67110, and Texas Instruments' 74S482.

Now that the MCU has the ability to perform conditional addressing through the use of test conditions, a "real world" situation will be examined. In most systems based upon a register/arithmetic/logic unit, there are at least four test conditions: result = 0, overflow, sign, and

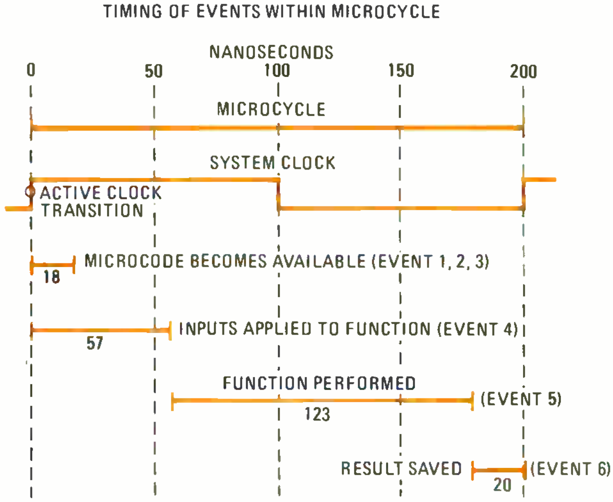
RAIL timing

A representative general-purpose microprogrammable processor is the Radar and Instrumentation Laboratory Processor (RAIL) developed at the Engineering Experiment Station at the Georgia Institute of Technology, Atlanta, Ga. Designed to process signals at 5-megahertz rates, the two-board-type processor can execute five million instructions a second—some five times faster than commercially available 16-bit minicomputers.

The RAIL processor is designed around the 2900 series of large-scale integrated circuits introduced initially by Advanced Micro Devices and including parts like the Am2901A register/arithmetic/logic unit. The four Am2901A RALUs used obey the processor's writable control store, as do the 74S374s serving as the microinstruction register, 74LS377s serving as the microinstructions' source and destination registers, and 4LS244s serving as buffers. It is the maximum delays through all these elements that determine the 200-nanosecond microcycle time of RAIL's microinstructions. Thus the microinstruction register has an 18-ns delay, data timing leaves the source register and buffer 29 ns later, the longest asynchronous function performed by the RALU takes 120 ns, and the destination register a 20-ns set-up time, for a total of altogether 197 ns (see timing diagram).

RAIL's writable control store and/or high-speed memory sits on one 7.5-by-10.3-inch printed-circuit board, and the central processing unit sits on the other. Each board holds 63 18-pin integrated circuits and has 110 edge connections.

Four Am2901A RALUs are used for common arithmetic functions. Each of these devices contains an eight-function ALU and 16 general-purpose register accumulators. They also contain an additional general-purpose register for use in conjunction with the others to perform double-length shifts.



carry-out. To these, the system designer will probably want to add other test conditions he considers pertinent. Obviously these multiple test conditions must be taken into account. The test-condition circuitry is thus completed with the addition of a multiplexer between the test-condition register and the select line of the address-select multiplexer (Fig. 2d). Each microinstruction must then specify the proper test condition to query.

The final feature that will be added to this simplified microprogram control unit is subroutine capability. This capability is useful for implementing complex functions. Suppose a designer has to implement a state diagram with three complex states, each of which is made up of eight simple states. To implement it directly would require 56 states, or 56 microinstructions. But if it were possible to store the three distinct complex states as subroutines, the size of the control store could be reduced. In this example it would require a main microprogram of 7 microinstructions and three subroutines of altogether 24 microinstructions to represent the three complex states. This totals 31 statements instead of 56.

When using subroutines, the main microprogram branches to the complex states or subroutines in the order desired. But since each subroutine is branched to more than once, the branch back to the main microprogram becomes ambiguous. The normal way to avoid this ambiguity is to assume that the subroutine will branch back to the address following the one that called it. Therefore when a subroutine is called, the next address in the main microprogram is saved in the return-address register shown in Fig. 3. When the subroutine is finished, the microprogram counter is loaded with the saved address and branches correctly back.

When hardwired logic is used, the control portion of a machine is documented through the use of schematics, timing diagrams, state diagrams, and state tables. With a microprogrammed system, however, the operation is described by the microinstructions. As can be seen from the previous description of the elements of the microprogrammed control unit, however, every microinstruction controls two or more registers and sometimes also a function simultaneously. While this is what contributes to the power of microprogramming, it is also part of what makes it complicated.

The job can be made simpler by dividing the microinstruction into fields and giving each a mnemonic. Each field describes a function or a source register or a destination register. Programs called assemblers can then be written to take statements made up of mnemonics and generate the appropriate bit patterns.

Better self-diagnostics

Finally, a microprogramming bonus not mentioned so far is that the technique improves a computer's self-diagnostic capability. Diagnostic programs have to assume that all the hardware that decodes and executes the instructions is in true working order. But for his diagnostics to be meaningful in a microcoded machine, the programmer must make assumptions about only a subset of hardware, namely the control portion. This subset, however, is much smaller than that required in a general-purpose computer and should allow microdiagnostics to isolate faults at least to the board level, and at times to the chip level. □

Chip cuts parts count in error correction networks

8-byte parity matrix implemented with LSI devices provides single-bit correction, double-bit error detection

by Reinhard Schürba, *Siemens AG, Data Processing Systems, Munich, West Germany*

☐ Moving data around in large memory banks at high speed can lead to bit errors. Circuits that constantly monitor chunks of data and correct inverted bits on the fly are used in mainframe computers for implementing high-speed error correction networks in the main memory control logic. Until now, such networks have consisted of many discrete logic devices in cumbersome and unreliable configurations. An error correction circuit has now been built using large-scale integration to minimize the number of devices needed. As a result of these improvements, error correction can now be applied even to relatively small systems.

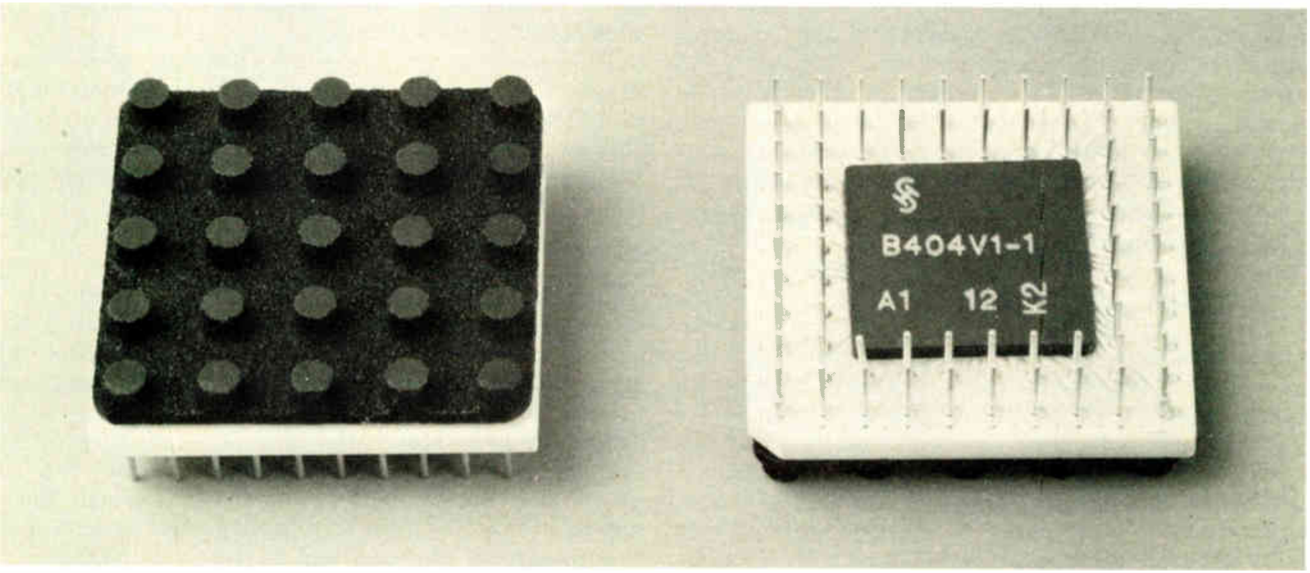
From the outset, the Heccs-LSI (shown in Fig. 1) was designed by Siemens AG to be an integral part of a network based on an 8-byte parity matrix with single-bit error-correcting and double-bit error-detecting capabilities. The parity matrix, shown in Fig. 2, allows partitioning of the overall correction network into eight 8-bit slices of uniform logic construction. Configured as an 8-bit–byte device, the Heccs-LSI replaces some 25 medium-scale integrated circuit packages. Since each chip incorporates all logic functions needed for 1 byte, a complete 8-byte error-correction network can now be implemented with less than 20 ICs, using 8 Heccs-LSIs and from 8 to 10MSI chips from the 100K family of emitter-coupled logic devices.

The additional MSI chips are required to form a superordinate section that combines the error and syndrome signals from the eight byte slices. This section generates a central parity-error message from the byte-individual error lines for write operations and the no-error, single-bit-error, or double-bit-error message from the resulting syndrome bit pattern for read operations. In the case of a correctable error, it generates a signal that selects the byte with the incorrect data bit and enables the correction circuit in that byte slice.

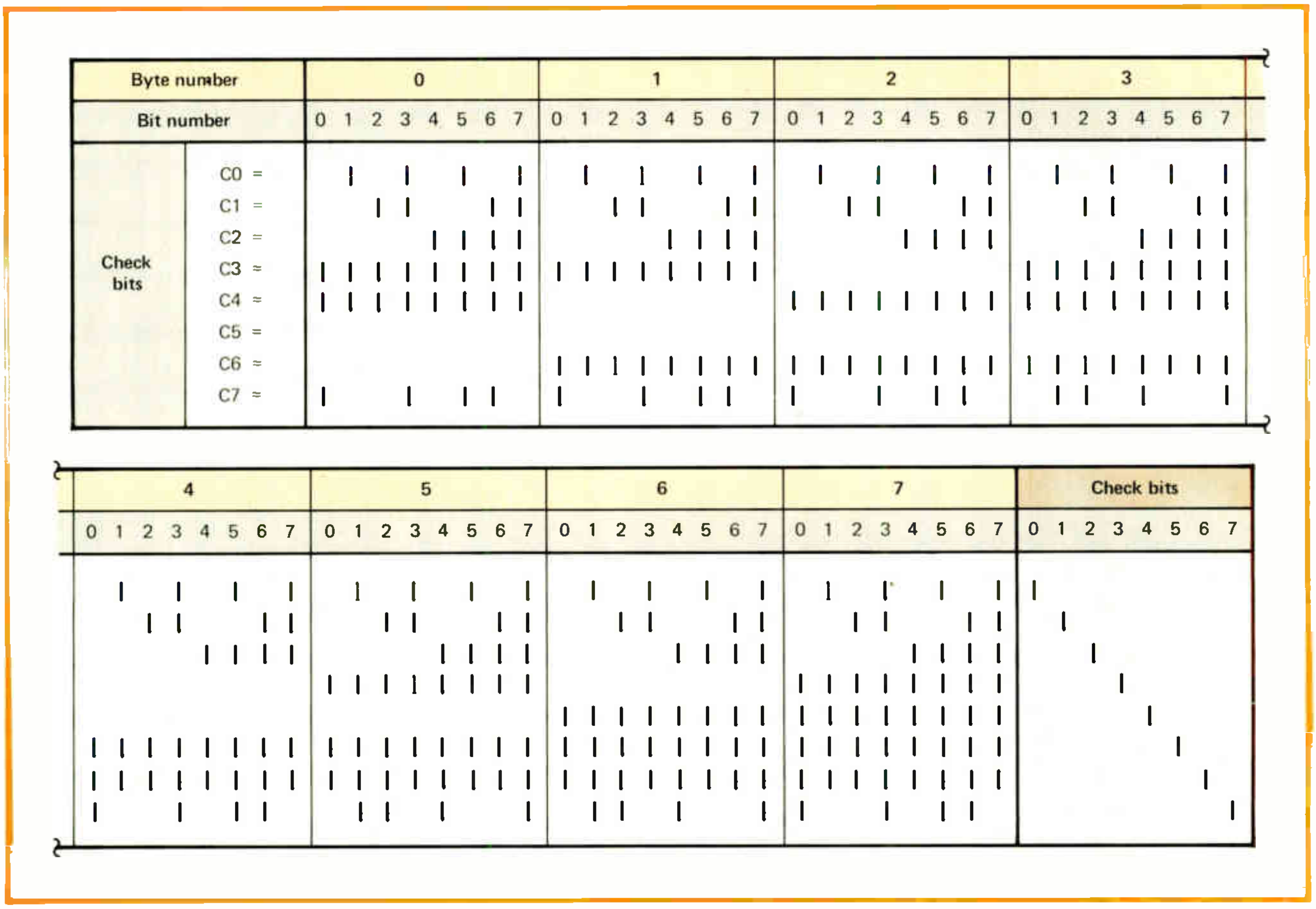
The 8-byte network will have a total power consumption of 30 W and take the same space as 37 standard 100K packages. This compares favorably with a network implemented by approximately 210 100K MSI circuits, which would consume about 120 W and almost 5.5 times the space. In addition, the network's simple wiring and greatly reduced number of devices assure substantially increased reliability over conventional MSI solutions.

Byte slice—close-up

The Heccs-LSI is designed to minimize the device count in 8-byte correction networks, but it is suitable for error correction networks with other than 8-byte data path widths. It is a member of the new Siemens Masterslice LSI family[1] and is built using bipolar subnanosecond emitter-coupled-logic technology. It operates from a



1. Packed. This 64-pin Pinpack ceramic package contains all circuitry for single-bit error correction, double-bit error detection for 1 byte of an 8-byte network. A standard 68-pin Jedec ceramic package is being considered for the future.



2. Matrix. The Heccs-LSI was planned to be an integral part of an 8-byte correction network. The network is governed by this parity matrix for check bit and syndrome bit generation. Dashes in the bit number column indicate positions of parity check bits.

−4.5-v supply and is compatible with the 100K family of ECL parts. In addition to the correction circuitry, the chip includes four registers, a data multiplexer for single-byte write operations, and circuitry for parity-error detection and various test and diagnostic operations. All of this is housed in a 64-pin ceramic package called Pinpack (Fig. 1). The on-chip logic requires 57 signal pins, of which 40 are for input and 17 for output. Another 6 pins are for power supply and ground. A 68-pin Jedec ceramic package is being considered for the future and Siemens plans to market the device in the U. S. Samples will be available within a few months.

The circuit provides two separate data-input registers for 9-bit write- and read-data inputs (WD_{IN}, RD_{IN}) and one output register for 9-bit data outputs, (D_{OUT}). A central multiplexer allows the selection either of the write or read data from the input registers or of the output data from the output register. In accordance with the selected data, an on-chip parity-bit/partial-check-bit generator generates the byte parity and six partial check bits, which are applied to the outputs, PC_{OUT}.

Each byte generates one parity check bit in an assigned position indicated by the dashes in Fig. 2. These check bits are stored in the main memory for write operations and read from the memory for read operations. For write operations, the byte parity is compared with the parity bit via the ninth write-data input bit, and the result is applied to the error output.

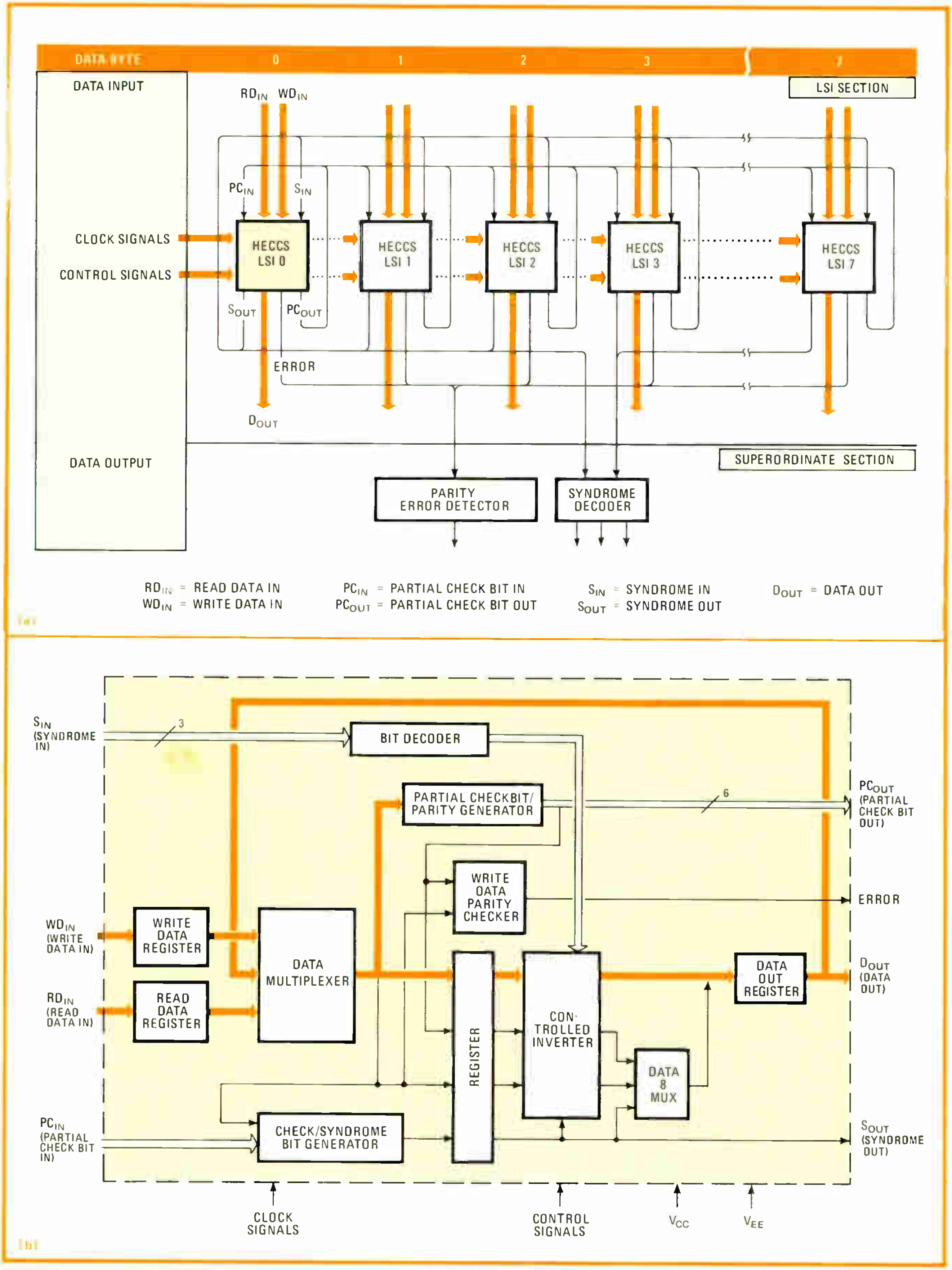
The check-syndrome-bit generator uses the partial check bits at PC_{IN} to generate a final check bit for write operations or a syndrome bit that appears at the output S_{OUT} for read operations. Depending on the mode of operation, the output multiplexer (Data 8 mux) presents one of three possibilities to the appropriate data output for the ninth bit: a check bit, a chip-generated parity bit, or the ninth input-data bit or its inverse. The bit decoder is designed to decode a 3-bit input word from S_{IN} to a one-of-eight-line output. The selected line will apply the appropriate data bit inverted to the data output.

8-byte correction network

The division of the 8-byte correction network on a byte basis is shown in Fig. 3a. Seven control signals are provided for the write and read operations involved in transferring the bytes on WD_{IN} and RD_{IN} to the data outputs, D_{OUT}.

For write operations, the byte-parity-protected write-data lines (WD_{IN}) are checked for odd parity. They are provided with check bits in place of parity bits according to the error-correction-code parity matrix and then applied to the data outputs, D_{OUT}.

For read operations, check-bit–protected read data is applied to the RD_{IN} inputs. Comparison of the applied check bits with newly generated check bits yields a syndrome byte, which is instrumental in correcting single-bit errors and detecting double-bit errors. Correc-



3. Inside. An 8-byte error correction network is implemented with eight Heccs-LSIs (a) and some additional MSI chips that make up a superordinate section. Each Heccs-LSI (b) handles error detection and correction for 1 byte in the network.

tion is done by inverting the incorrect data bit. In case of a single-bit error, syndrome bits 3 to 6 identify the incorrect byte by way of select signals, while the syndrome bits 0, 1, and 2 identify the incorrect bit within that byte. The resulting read data is transferred with odd parity protection to the D_{OUT} outputs of all eight slices.

The check bit is generated in two steps. The first step is to subtotal all bytes via the data information. Thus each Heccs-LSI slice generates six different byte-specific partial check bits (PC_{OUT}). In the second step, each slice takes account of the full data path width by combining selected partial check bits of all the assigned bytes into a final check bit, via the inputs PC_{IN}.

The error correction network detects and reports write-data parity errors when the supplied parity does not match the newly generated parity bit.

A test operation allows the byte-specific parity-error message to be checked via the signal output error. The Heccs-LSI processes the write-data bits 0 through 8.

Modes of operation

Each Heccs-LSI performs three groups of operations: write, read, and test. Four control signals determine the mode of operation. Besides the basic write-normal and read-normal operations, it is also possible through modification to select diagnostic operations such as write direct, read direct, etc., without additional logic circuitry. Altogether, the device is capable of performing 10 different operations.

The various functions are best explained with reference to the block diagrams of the 8-byte correction network and of the Heccs-LSI (Fig. 3a and b).

In all write operations each byte slice processes either a new write-data byte applied to the data inputs, WD_{IN}, or an old data byte already stored in its output register. The selection is made by a byte-select control signal. If new data information is desired at the data outputs, all byte-select signals are active (write-all-byte operation). If a mix of old and new data information is selected, only some byte-select signals are generated (write-single-byte operation).

The various modifications of the write operation differ with respect to the significance of the ninth data-output signal, D_{OUT8}. Normally, the D_{OUT8} output of each byte slice in the correction network supplies a respective check bit that has been formed according to the parity matrix from the selected 8-byte data information (write-normal operation). For diagnosis, however, the ninth data bits of the 8-byte data information can be directly applied, normally or inverted, to the devices' D_{OUT8} outputs (write-direct/write-direct-inverted operation)

For write-normal operations the new data bytes are checked for correct parity. If incorrect parity is detected, an error message will be sent out via the error outputs of the devices.

Read operations

Each slice in the correction network processes the read data applied to inputs RD_{IN}. The various modifications of the read operation, like those of the write operation, differ with respect to the significance of the data output signal D_{OUT8}.

TYPICAL DELAY TIMES OF THE HECCS-LSI		
Signal		Delay time (ns)
From	To	
WD_{IN}, RD_{IN}	PC_{OUT}	8.4
PC_{IN}	D_{OUT8} (check bit)	7.8
	S_{OUT} (syndrome bit)	6.3
S_{IN}	D_{OUT8} (parity bit)	4.7
WD_{IN}	ERROR (parity error)	10.2

For the read-normal operation, each slice supplies the corrected/uncorrected read data to the data outputs D_{OUT0} through D_{OUT7} and generates the associated parity bit in D_{OUT8}. To this end the slice compares an externally applied check bit from external control circuits via RD_{IN8} with an internally generated check bit and delivers a syndrome bit, S_{OUT}. If all syndrome bits equal 0, no error is present, and the slice applies the read data directly to the data outputs. If the syndrome-bit pattern indicates a correctable error, the syndrome decoder in the superordinate section (see Fig. 3a) generates a byte-selective signal that enables the error correction circuitry in the respective byte slice. From three input S_{IN} bits, this correction circuitry decodes the data bit to be corrected (that is, inverted) in the selected byte.

For a complete read cycle, each slice has three operations to perform: 1. accept data inputs and generate partial check bits, 2. generate a syndrome bit, 3. correct the error if necessary and output the data.

For a read-direct operation each slice applies the input read data RD_{IN0} through RD_{IN8} directly to the data outputs D_{OUT0} through D_{OUT8}.

Furthermore, a read-direct-corrected operation applies a corrected check bit to the data output D_{OUT8} in the case of an incorrect check bit.

8-byte network—how fast?

The table lists some typical delay times of the Heccs-LSI device. Accordingly, an 8-byte error correction network realized with Heccs devices will operate with typical delay times of about 22 ns for error detection and 30 ns for error correction.

To increase the repetition rate for chained operations and allow single-byte write operations, an additional latch stage between the data-input and data-output registers buffers all data bits and relevant partial results within the device. The data of the next cycle can be processed as soon as the syndrome bit of the current cycle is available. Thus it is possible to realize cycle times on the order of the error-detection delay time. This eliminates additional timing-compensation circuits used to align the delay and cycle times. □

References

1. W. Bräckelmann, H. Fritzsche, F.-K. Kroos, W. Trinkl, and W. Wilhelm, "A Masterslice LSI for Subnanosecond Random Logic," IEEE ISSCC Digital Technical Paper, 1977, pp. 108–109.

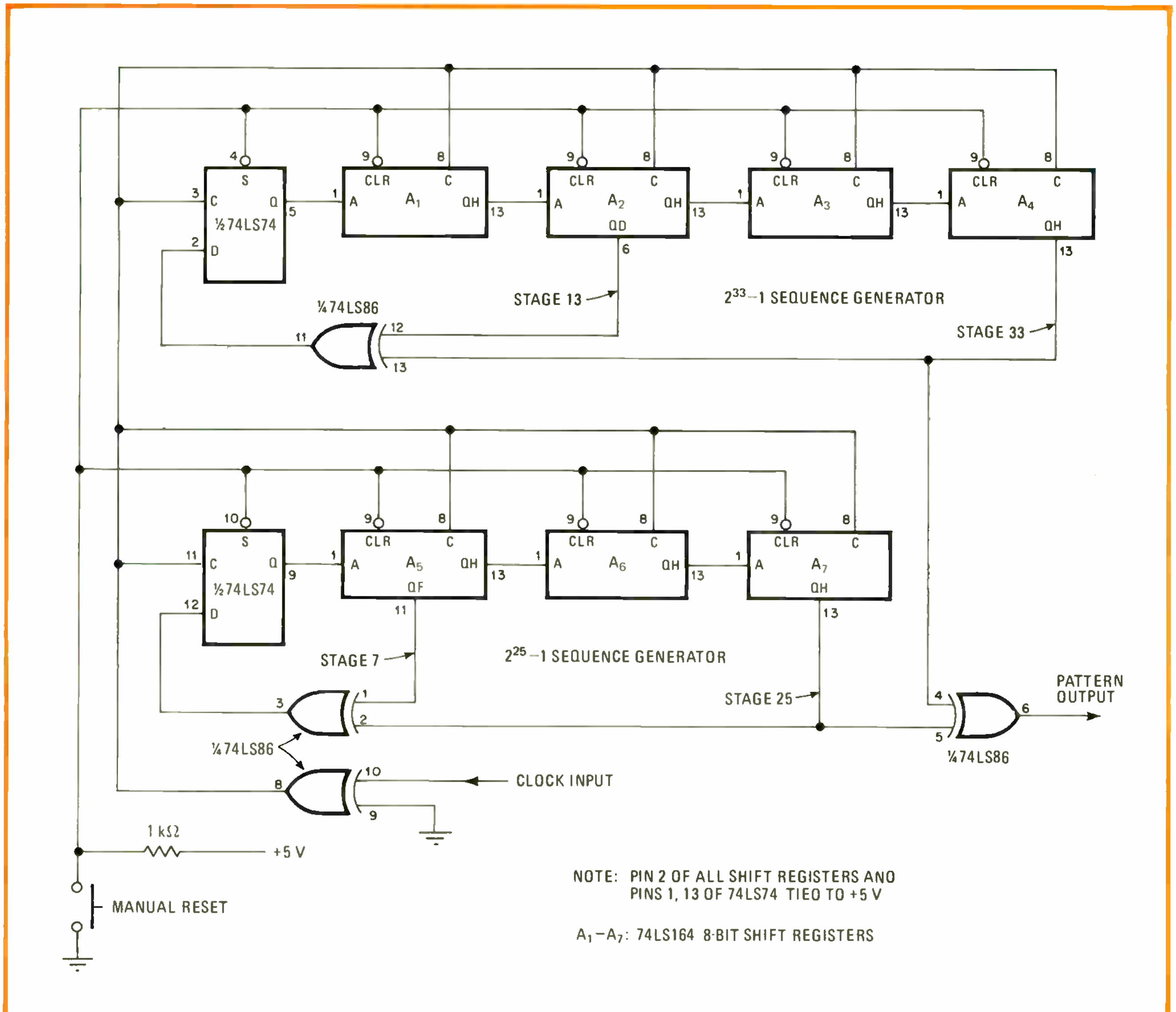
Uniting number generators for long bit patterns

by Leonard H. Anderson
Sun Valley, Calif.

The length of a pseudo-random bit pattern can be predictably extended if the rules for combining two or more available sequence generators of given length are known and applied. Fortunately, the interface required for combining number generators is extremely simple, often consisting of no more than one logic gate.

Maximal-length sequence generators that use shift registers normally have periods of $2^n - 1$, where n represents the number of registers used. Every such sequence has a numerical length that is odd, but few lengths are prime (that is, most often the number can be factored). It is a property of the register to have recurring factors that depend on the n^{th} multiple. The table shows the maximum length for any n and the factors common to every n^{th} multiple from 2 to 47.

These factors enable the designer to determine whether combining two or more generators of given length will increase the total sequence length: two generators having common factors tend to generate similar patterns during



Extension. Nine-package circuit combines 33-stage and 25-stage pseudo-random sequence generators in order to extend pattern length to 2.88×10^{17} clock periods. Generators' outputs are merged with one exclusive-OR gate. Combining generators of any length for long bit patterns is possible, provided rules for applying bit-pattern data (see table) to n-stage registers are known.

portions of their individual cycles, causing a departure from the pseudo-random output expected.

The factors for all sequence lengths have been found by first factoring n, then finding all the possible products of any and all factors, and finally consulting the table for the n^{th}-multiple sequence length. For a $2^{24}-1$ generator, n = 24 = 2·2·2·3. The n-factor combinations of 2·2·2·3 are 2, 3, 4, 6, 8, 12, and 24; thus, sequence length factors are 3, 7, 5, 3, 17, 13, and 241, respectively.

Now, if a $2^{24}-1$ generator is connected in series (cas-

BIT-PATTERN DATA – n-STAGE PSEUDO-RANDOM GENERATORS

n	Sequence length	Sequence length factors common to every n^{th} multiple
2	3	3
3	7	7
4	15	5
5	31	31
6	63	3
7	127	127
8	255	17
9	511	73
10	1023	11
11	2047	23 89
12	4095	13
13	8191	8191
14	16,383	43
15	32,767	151
16	65,535	257
17	131,071	131,071
18	262,143	19
19	524,287	524,287
20	1,048,575	5 41
21	2,097,151	7 337
22	4,194,303	683
23	8,388,607	47 178,481
24	16,777,215	241
25	33,554,431	601 1801
26	67,108,863	2731
27	134,217,727	262,657
28	268,435,455	29 113
29	536,870,911	233 1103 2089
30	1,073,741,823	331
31	2,147,483,647	2,147,483,647
32	4,294,967,295	65,537
33	8,589,934,591	599,479
34	17,179,869,183	43,691
35	34,359,738,367	71 122,921
36	68,719,476,735	3 37 109
37	137,438,953,471	223 616,318,177
38	274,877,906,943	174,763
39	549,755,813,887	79 121,369
40	1,099,511,627,775	61,681
41	2,199,023,255,551	13,367 164,511,353
42	4,398,046,511,103	5419
43	8,796,093,022,207	431 9719 2,099,863
44	17,592,186,044,415	397 2113
45	35,184,372,088,831	631 23,311
46	70,368,744,177,663	2,796,203
47	140,737,488,355,327	2351 4513 13,264,529

caded) with a 2^6-1 generator, a $2^{30}-1$ generator will result. Most often, the feedback connections between generators will not be known, so the method used to combine these generators (to be described shortly) might prove handy. However, in this case, combining the generators in the manner to be shown will not increase total sequence length either, because all factors of the 2^6-1 generator (that is, 3, 3, 7) are common to the $2^{24}-1$ generator previously analyzed.

Replacing the 2^6-1 generator with one that delivers a 2^9-1 bit stream will increase the total sequence length by only 73, as shown in the table, since the sequence length is 511 = 73·7, and 7 is still common to a factor of the $2^{24}-1$ generator. A generator having a higher order of n is thus needed to effect a significant increase in sequence length. Combining even-n generators should be avoided, however, because of the recurrence of the factor 3 at n multiples of 6 and 18, and a recurrence of factor 5 at multiples of 20. Factor 7 occurs at n = 21, also.

Only nine chips are required for a pseudo-random generator circuit that combines a $2^{33}-1$ bit stream with a $2^{25}-1$ one, as shown in the example in the figure, where the circuit arrangements for both generators are individually known. Note that both generators are merged via only one exclusive-OR gate.

The total pattern length is 2.88×10^{17} clock periods. Using a 10-megahertz clock, the pattern does not repeat for 333,600 days, or 913.347 years. □

Optically isolated scope probe eliminates ground loops

by Yishay Netzer
Haifa, Israel

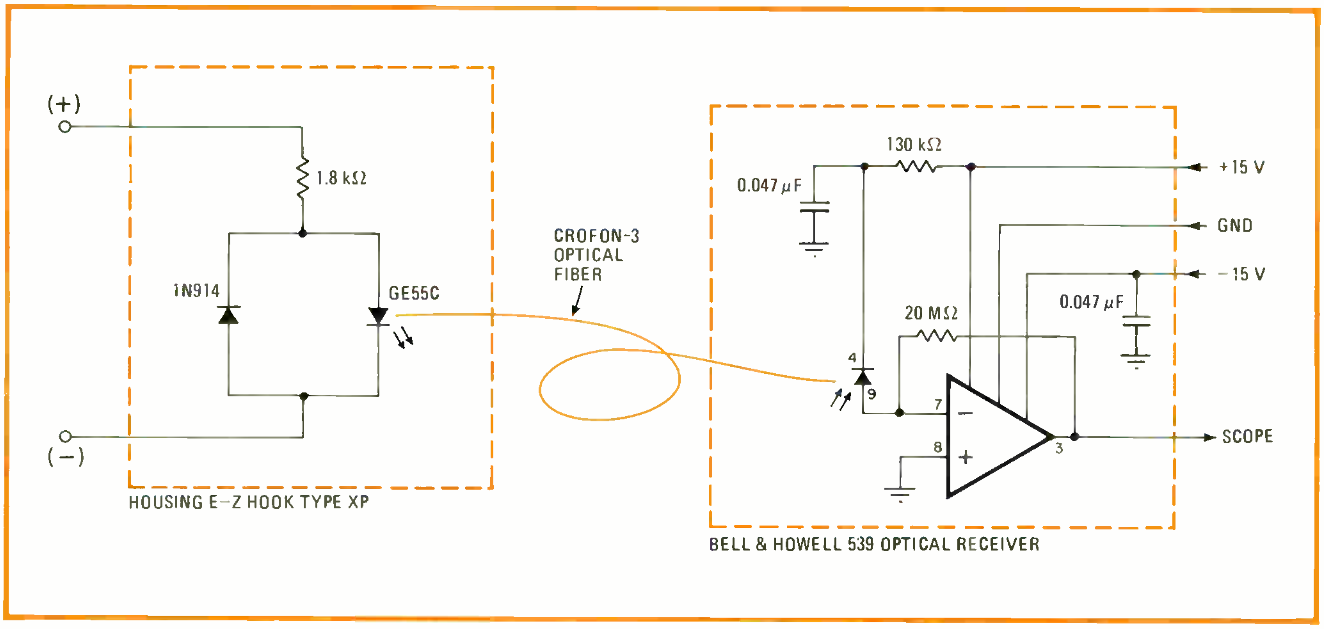
The infrared-light-emitting diode and optical receiver in this oscilloscope probe can detect an input signal while keeping the scope galvanically isolated from the circuit under measurement. In this way the probe eliminates any electrical interference caused by ground loops and by stray energy transmitted through supply lines. The probe has reasonable bandwidth and sensitivity, but is most useful for transferring signals in the audio range to the scope.

As shown in the figure, the head of the probe contains the LED, plus a series resistor that determines the sensitivity. Unipolar input signals generate a current through the GE55C LED, causing it to emit light of an intensity that is linearly proportional for signals greater than 1.6 volts (the LED's voltage drop). If the measured signal has no dc component, an offset (bias provided by a battery) must be applied at the input, and the composite signal should be capacitively coupled to the LED. The LED's output is then coupled by a plastic fiber-optic bundle to the 539 receiver located at the scope end, where the light is converted back into a voltage and coupled to the scope.

The probe's input impedance is understandably low. However, if a battery can be fitted into the probe head, it can serve as a supply for an active optical transmitter having high input resistance, high sensitivity, and wide bandwidth as well.

The packaged unit is lightweight and on first glance appears to be an ordinary scope probe. The probe has a bandwidth of 10 kilohertz. Voltage gain for the unit is 1 for input signals exceeding 1.6 V. □

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



On the beam. Optically isolated probe transfers input signals to scope using light-emitting diode and light-sensitive receiver, thereby eliminating most electrical interference. Probe works over 10-kHz bandwidth, has linear response for input signals exceeding 1.6 V.

World Radio History

Engineer's newsletter

Spinning the bobbin— part II

A spokesman for Eugen Beyer Elektrotechnische Fabrik points out that the transformer core-winding technique described by C. W. T. McLyman of Jet Propulsion Laboratory, Pasadena, Calif., [*Electronics*, July 20, p. 148] has been used by his company since 1959, when the West German firm obtained a patent.

In Beyer's process, the laminations are held stationary while a round bobbin of wire is wound onto a coil form. The form is friction-driven by a rubber wheel. When winding is complete, the bobbin is fixed by means of special plastic wedges. **The technique, which uses an unbroken core, makes it possible to supply high-quality input transformers with very small dimensions.** For further information, contact Eugen Beyer Elektrotechnische Fabrik, Postf. 1320, 7100 Heilbronn, or the company's sales representatives in the U. S., Hammond Industries, 155 Michael Drive, Syosset, N.Y. 11791.

Getting chips into leadless chip-carriers

At present, most IC companies will not supply their LSI products in the leadless ceramic chip-carrier packages made by 3M and Kyocera. Now Sertech Laboratories will package LSI chips in the chip-carriers and test them for interested firms. **Sertech will bond the chips into the carriers, hermetically seal the package, fully test the packaged chips** to the manufacturer's specs on a Sentry 7 test system, and then screen the units in accordance with MIL-STD-883. For additional information, write to G. J. Estep at Sertech Laboratories Inc., One Peabody St., Salem, Mass. 01970, or call (617) 745-2450.

Calculator program generates scope waveforms

Would you like to simulate the waveforms of an ideal oscilloscope? Wayne Hope of the Northern Alberta Institute of Technology has designed a program for the HP 9830A calculator and its peripherals to synthesize the operation of a dual-trace, delayed-sweep laboratory oscilloscope. **The output provides a computer-plotted graticule and waveform in response to software-generated commands** corresponding to the setting of each control found on this type of scope. The synthetic oscilloscope can be used in programmed learning of instrument operation. Copies of the 1,250-step program are available free; send an 8½-by-11-inch self-addressed, stamped envelope (Canadian stamps) to the author at Northern Alberta Institute of Technology, 11762 106 St., Edmonton, Alberta, Canada T5G2R1.

Glass cuts alpha particle emission

Alpha particles emitted by minute amounts of radioactive material found in chip packages can cause nondestructive soft errors in random-access memories [*Electronics*, June 8, p. 42]. In an effort to prevent this complication, Ferro Corp., working with Coors Porcelain Co., has developed a sealing glass with lower alpha emission for ceramic-glass dual in-line packages. **The new glass has alpha emission of 0.7 count/cm²/hour or less,** which compares favorably with those of sealing glasses in current use, running as high as 68 counts/cm²/hour.

In addition to low alpha emission, another objective was the development of a low-temperature (410°C) Cerdip and glass-lid sealing. Coors will supply glazed Cerdip, and Ferro glass ink samples of the low alpha-emitting sealing glass. For further information, write Bob White at Coors Porcelain Co., Golden, Colo. 80401, or Fran Merti, Ferro Corp., 60 Greenway Drive, Pittsburgh, Pa. 15204. **Jerry Lyman**

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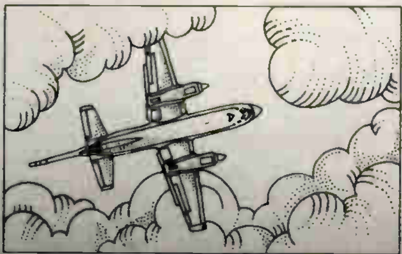
MOTOROLA MAKES A TREASURE

Nigeria has more people than any other nation in Africa. Indeed, it's one of the ten largest nations on earth.

Yet, incredibly, vast stretches of its 357,000 square miles had yet to be adequately mapped.

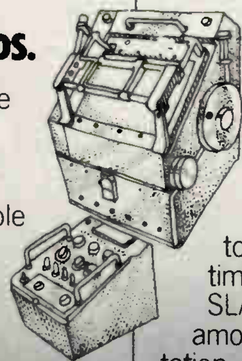
For years, the government of Nigeria tried to get the job done with conventional aerial photography.



But much of this part of the world swelters under an almost continuous cloud cover. And in northern Nigeria, near the Sahara, a dust cloud twelve thousand feet high obscures the earth for months at a time.

They turned the problem over to Motorola—and got the job done in only five months.

ELECTRONICS SEE THROUGH CLOUDS.



The equipment that made the difference was Motorola's Side-Looking Airborne Radar: SLAR.

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It can see through the cloud cover, day or night.

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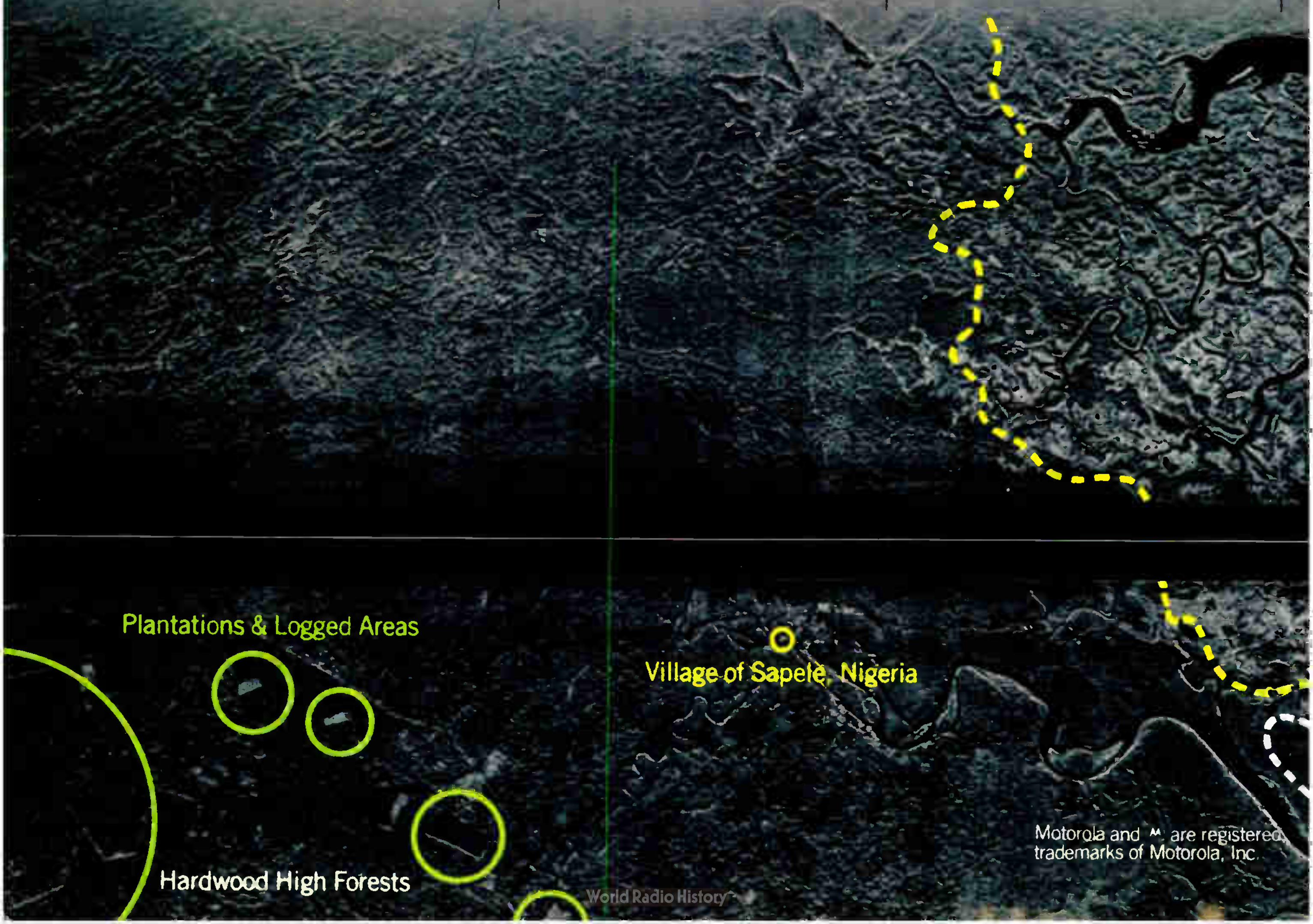
And SLAR displays its images instantly to the sensor engineer aboard the aircraft. Instead of having to wait for pictures to be developed, he knows immediately whether or not he has to make another pass over the same terrain.

ELECTRONIC EYES FIND TREASURES.

SLAR mapping gave Nigeria a new assessment of her natural treasures.

For instance, an inventory of her farmland and timber resources. Since SLAR can actually differentiate among several types of vegetation, it helped identify forests containing ebony, mahogany and rubber trees.

And it helped identify geological structures that could mean

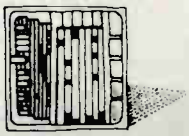


MAP OF NIGERIA.

the presence of unexploited oil, gas and mineral deposits.

THE ELECTRONIC MIRACLE: A MICROCOMPUTER.

Further developments have been made on this remarkable system. At the heart of Motorola's most advanced SLAR is a tiny electronic miracle: a Motorola microcomputer.



A microcomputer, drawn larger than life.

The microcomputer is one of the latest demonstrations of Motorola's fifty years of electronics expertise. And you'll find the technology that made it possible in many of the things we make today.

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Nor are we just the company that put popular-priced TV sets into American homes—in fact, we no longer make home TV sets here at all.

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Now, Motorola is not only one of the world's largest manufacturers dedicated exclusively to electronics, but also one of its foremost designers of custom and standard semiconductors. And Motorola microelectronics are working in a remarkable array of products.

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A Digital Voice Protection system that keeps criminals from tuning in on police radio communications.

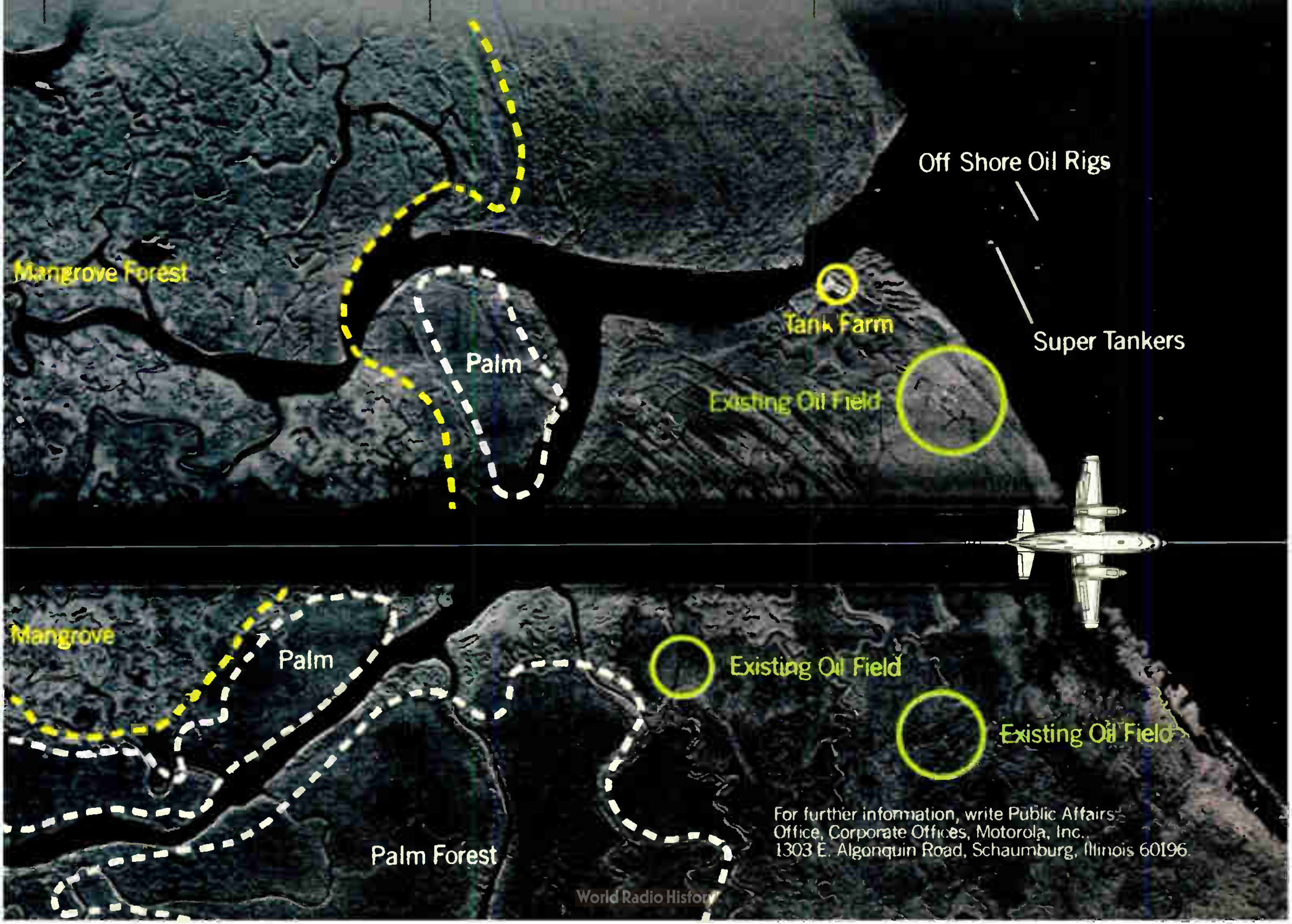
Even lightweight pagers that help busy people keep in touch while they're on the go.

And, of course, a device that's helping a nation like Nigeria take a realistic inventory of hidden natural resources.

MOTOROLA

Making electronics history since 1928.

Circle 141 on reader service card



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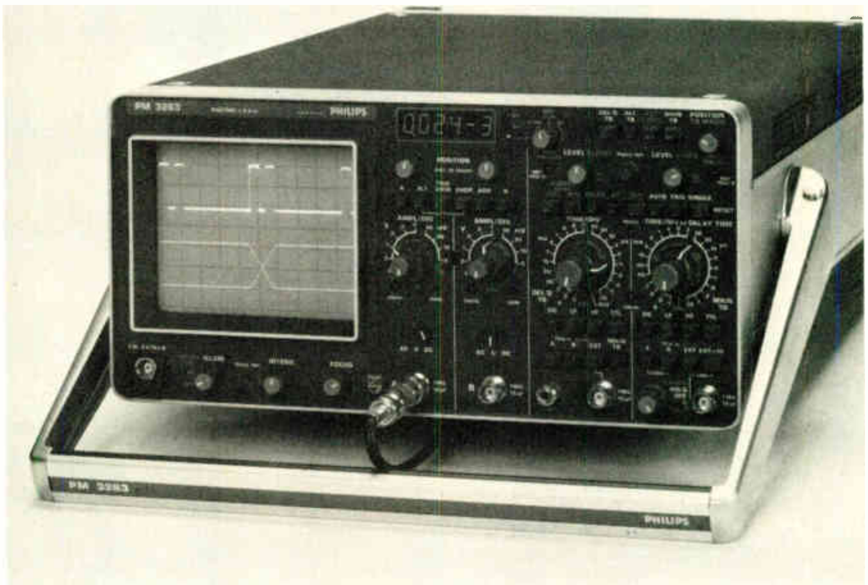
GENERAL ELECTRIC

Scopes tailored for digital signals

Philips introduces two 100-MHz units: an instrument with delay-by-event and time-interval capabilities, and a high-speed storage scope

by John Gosch, Frankfurt bureau manager

Suppose you have a stream of pulses of the kind often encountered in communications or data-processing equipment and want to examine a specific pulse. Or maybe it's necessary to measure, and possibly photograph, a single-shot signal or a spike such as may occur in, say, a nondestructive-testing or a digital application. For both tasks, instrument makers can offer a variety of oscilloscopes. But none, says Philips in the Netherlands, can handle those jobs as conveniently and accurately as can the two scopes that its Test and Measuring group is now introducing.



One is the microprocessor-equipped, 100-MHz PM3263 "whose prime feature is the combination of time interval measurement and delay-by-event facilities," says Gerard Imbens, product manager for oscilloscopes at the Eindhoven-based group. This, Imbens explains, means that users can measure a certain pulse or event after any number of pulses or events—up to 99,999—have passed. The measurement is thus independent of any previous jitter or clock pulse instability, the Philips man says.

The other instrument is the PM3266, a 100-MHz storage oscilloscope that can write at speeds up to 1,000 divisions per microsecond, with one division measuring 0.9 cm. Unlike competitive scopes that write only over a reduced area of the screen, the Philips scope writes at full speed over the screen's entire useful area. This enhances the accuracy with which a stored signal can be read.

Both new instruments evolved from Philips' dual-channel 100-MHz PM3262 [*Electronics*, Feb. 2, p. 132], which has become something of a hit on the market in the brief time since its introduction because of its combination of trigger-view mode and alternate time-base mode. The two successors will be shown in public for the first time at the Electronica components show in Munich, West Germany. They are slated for delivery in the U.S. and elsewhere next March or April.

The PM3263 is a portable dual-trace instrument with a dual-delay time base, a digital delay capability, and automatic triggering on transistor-transistor logic levels. Its sensitivity is 2 mv/division up to 35 MHz and 5 mv/div up to the full 100-MHz bandwidth.

In addition to measuring time intervals and frequencies, the scope can count events before the delayed or main time base starts. And, like its predecessor, the new model boasts an alternate display of the main and delayed sweeps to allow direct comparisons of the displayed signals. It also has a trigger-view facility that can serve as a third display channel.

One significant detail Imbens points to is the built-in six-digit red light-emitting-diode display. It indicates the delay, the time interval, the frequency, and the number of events, with time and frequency measurements shown in engineering notation (for example, −3 is milliseconds, ′′3 may be kilohertz, etc.).

To facilitate using the equipment, Philips has added a feature that tells the operator when he has made an error. For example, if the user is measuring frequencies with too small a resolution, the LED display will read "uncal" (meaning "uncalibrated").

To incorporate all of these measuring and fault-monitoring func-

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Elec-Trol now offers its Blue Boy Reed Relays in both an instrument and a commercial grade. The instrument grade provides low and stable contact resistance over a large number of operations, for use in such applications as ATE systems, data acquisition and telecommunications.

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ELEC-TROL

Circle 144 on reader service card

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Elec-Trol's new commercial grade Blue Boy Reed Relays are now offered in production quantities for as low as 59¢, and both commercial and instrument-grade units are available from distributor stock. Although completely sealed against hazardous environments, production cleaning solvents, and rough handling, these Blue Boys cost far less than standard sealed units. For pricing and product information, contact your local distributor.

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Circle 216 on reader service card

tions in a 23-lb unit about 12 by 6 by 18 in. in size would not be possible without a microprocessor, Imbens says. "It replaces a whole lot of hardware that would otherwise be needed." Besides keeping tabs on faulty operation and on all measuring functions, the microprocessor—an 8085 from Intel—checks its own peripheral circuitry as well as the LED display. Incorporated in the computer's memory is a set of service routines to simplify maintenance. The scope's power consumption is only 50 w.

Philips' other new entry at Electronica, the PM3266 storage oscilloscope, uses an image-transfer storage tube developed in house. The tube's scan magnification in the vertical direction makes possible the 900-cm/μs writing rate—a speed that allows storage of single-shot events and voltage spikes in the nanosecond range.

At the maximum write speed, the storage time ranges from 15 seconds at full intensity to an hour at minimum intensity. Making observations of continuous signals easy is the scope's auto-erase capability, which can be set to erase the display at time intervals ranging from 3 to 8 s. This ensures that the signal is continuously refreshed and displayed against a high-contrast background for optimum viewing.

Like its companion, the PM3266 is a compact, portable instrument. It weighs only 24 lb and consumes 55 w. The sensitivity ratings are the same as for the PM3263.

Both scopes operate from two ac supply ranges—90 to 140 v and 180 to 260 v—and from one dc range, which extends from 240 to 300 v. A battery pack for field use is available as an option.

The PM3263 will sell in the U. S. for $3,500, while the PM3266 will carry a price tag of $5,245. The battery pack adds $695 to the price of either scope.

Philips Gloeilampenfabrieken, Science and Industry Division, TQ III, Eindhoven, The Netherlands [338]

Philips Test and Measuring Instruments, 85 McKee Dr., Mahwah, N. J. 07430. Phone (201) 529-3800 [340]

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One-chip computer is bus-oriented

8-bit machine for RAM-intensive applications features fast hardware multiply and divide

by William F. Arnold, San Francisco regional bureau manager

With the plethora of microcontrollers and microprocessors entering the marketplace, design engineers might feel they have enough to work with. But National Semiconductor Corp. says it has found a useful niche for one more device configuration. At the Electronica exhibition, which begins in Munich, West Germany, today, the company is unveiling a family of single-chip, 8-bit microcomputers that are targeted for low-end processing applications but have features equaling those of mid-range and high-end performers.

Called the INS8070 series, the microcomputers are unique in the marketplace because unlike other single chippers, which are input/output-oriented, they have a bus-oriented architecture, according to Philip Hughes, microprocessor marketing product manager. Consequently, National is aiming the chips toward applications that need the economy of single-chip operation and the high flexibility of a multiprocessing bus architecture, he says.

Moreover, National packs some 16-bit power into the 8070 series by including a comprehensive set of directly executed 16-bit arithmetic operations. Also, the 8070 devices communicate with external memory and peripheral devices over a 16-bit dedicated address bus and an 8-bit bidirectional data bus.

Overall, designers should find the instruction set well suited for control system applications and high-level languages. The multiprocessing bus architecture should prove useful in direct-memory-access applications such as terminals, home-computer and work-processing systems, and intelligent peripheral controllers, Hughes says. These applications would include dumb and smart terminals, as well as small business computers, cash registers, television controllers, or "anything with lots of RAM," adds Thomas D. Dugan, senior product engineer, low-end marketing group.

Dugan places the 8070 family "between the I/O-oriented microprocessor like the [Intel] 8048 and [Mostek] 3870 and the mid-range byte-oriented products like the [Zilog] Z80." However, as an example of its 16-bit power, he says the 8070 performs a hardware multiply and divide faster than other 8-bit devices and as fast as any 16-bit chip. Especially designed for very fast arithmetic operations, the 8070 executes a 16-by-16 multiply operation in less than 37 microseconds, for example. Operating from an on-chip 4-MHz clock, the devices execute an average instruction in 7μs from an internal read-only memory.

First members of the family, made with n-channel, silicon-gate, depletion-load technology, are: the 8070, a minimum system containing 64 bytes of random-access memory and no on-chip ROM; the 8072, having 64 bytes of RAM and 2.5 kilobytes, or 20,000 bits, of ROM; and the 8074, containing 64 bytes of RAM and 4 kilobytes, or 32 kilobits, of ROM. The instruction set is mask-programmable in high-volume applications only. This means that an operating system could be programmed onto the chip; if it were for a home computer, "you could put Basic in there," Dugan explains.

Samples of the devices are due out in December and production is slated for the first quarter of 1979. When they appear, designers will find the 8070 members marshalling some flexible and easy-to-use features. For example, National aims at simplified programming, with multiple addressing modes including counter-relative, immediate data, indexed, auto-indexed, and implied functions. They also include stack operation, with a comprehensive set of 16-bit instructions, including load, store, add, multiply, divide, exchange, shift, and stack push or pop.

For system flexibility, the devices can handle up to 64 kilobytes of memory and will interface with memories or peripherals of any speed. In addition, they have on-chip control of handshake bus access. Also on the chip are the clock generator, two interrupt-sense inputs, and three control flag outputs accessible by the user.

The 8070 devices have separate strobe inputs to indicate when valid input/output, memory, or peripheral data are present on the 8-bit data bus. The rest of the input/output signals are dedicated to such general-purpose control and status functions as initialization, bus management, microprocessor halt, interrupt request, I/O cycle extension, and functions specified by the user.

Housed in standard 40-pin dual in-line packages, the devices have 16 address and 8 data lines and use a single +5-V supply.

Price of the minimum 8070, in 1,000-piece lots, will be $9.90 each. Price of the 8074, in 1,000-piece lots, is expected to be no more than $15.

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051 [339]

New products

Instruments

5½-digit meter is easy to use

Microprocessor-based unit employs digital measurement to reduce complexity, price

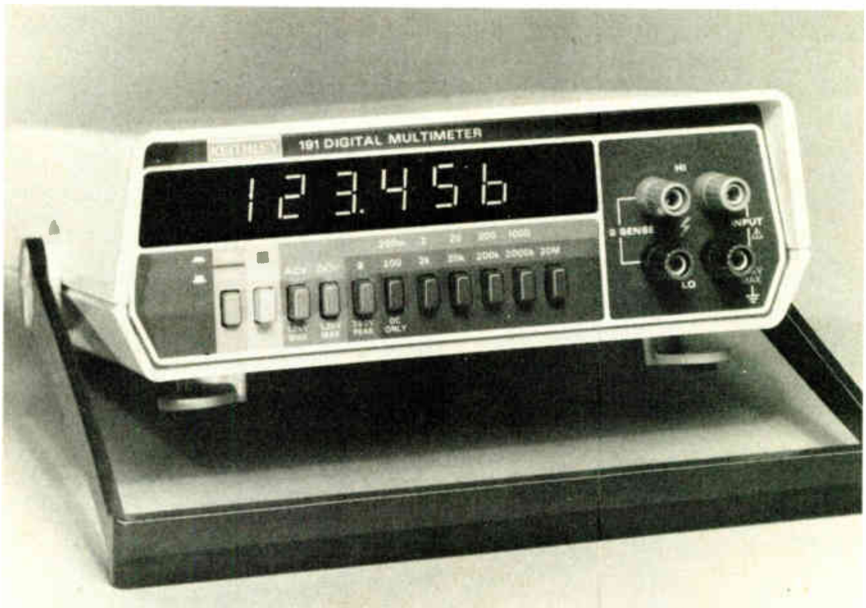
Mentioning microprocessor-based, 5½-digit multimeters usually conjures up images of front panels like the bridge instrumentation on board the Battlestar *Galactica*, not to mention astronomical prices. Such DMMs, usually destined for automatic test systems, feature more bells and whistles than the average bench jockey wants or needs. Addressing that potential user, Keithley Instruments has produced a 6802-based bench meter, the model 191, designed not for full programmability but for simplicity of operation.

The 200,000-count, manual-ranging unit performs many analog measurements using digital conversion and clever microprocessor manipulation, thus eliminating many costly components, simplifying maintenance, and keeping the unit's basic price to a low $499. The DMM has five dc voltage ranges, spanning 200 mV to 1.2 kV, and six resistance ranges, from 200 Ω to 20 MΩ. Accuracy varies with function, range, temperature, and interval between calibrations. A representative specification is a maximum error of 0.01% of reading plus 2 counts for the 20-V dc range from 18° to 28° C for one year.

By combining charge-balance and single-slope-conversion techniques, the combination of analog-to-digital converter and microprocessor makes it possible to take five readings per second in the dc voltage mode. Resistance measurements may be taken from two input terminals or changed to four-terminal readings by simply connecting an additional set of leads to the extra two terminals: no terminal links or settings need be changed.

An optional, field-installable ac voltage card provides average response readings calibrated in rms for an additional $175. It adds four ranges, from 2 V to 1 kV full scale, accepting signals in the 20-Hz-to-100-kHz band. An optional radio-frequency probe lets readings range to 100 MHz.

The microprocessor uses digitally stored autozero and autocalibrate values after each measurement to compute corrected values for display. It also performs nonlinear digital filtering automatically on the



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Now, for the first time, you don't need an expansion box or special back planes. DMAX/16 consists of two hex boards which install easily into standard SPC slots units and connect to the current loop or EIA/RS-232 panel by separate flat-ribbon cable. As many as 16 can be placed on a single PDP-11 for a total of up to 256 lines. A DMUX/16™ option allows modem control for 16 channels.

DMAX/16 provides complete program control of the lines, each of which operates with several individually programmable parameters, such as character length and number of stop bits. Parity generation and detection are odd, even or none. The operating mode is half duplex or full duplex. Fifteen software programmable baud rates: 0 to 9600 baud — plus 19,200 baud — and an external baud rate. Breaks may be generated or detected on each line and the unit can echo received characters without software intervention.

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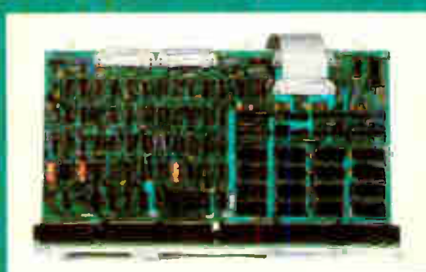

Able, the computer experts

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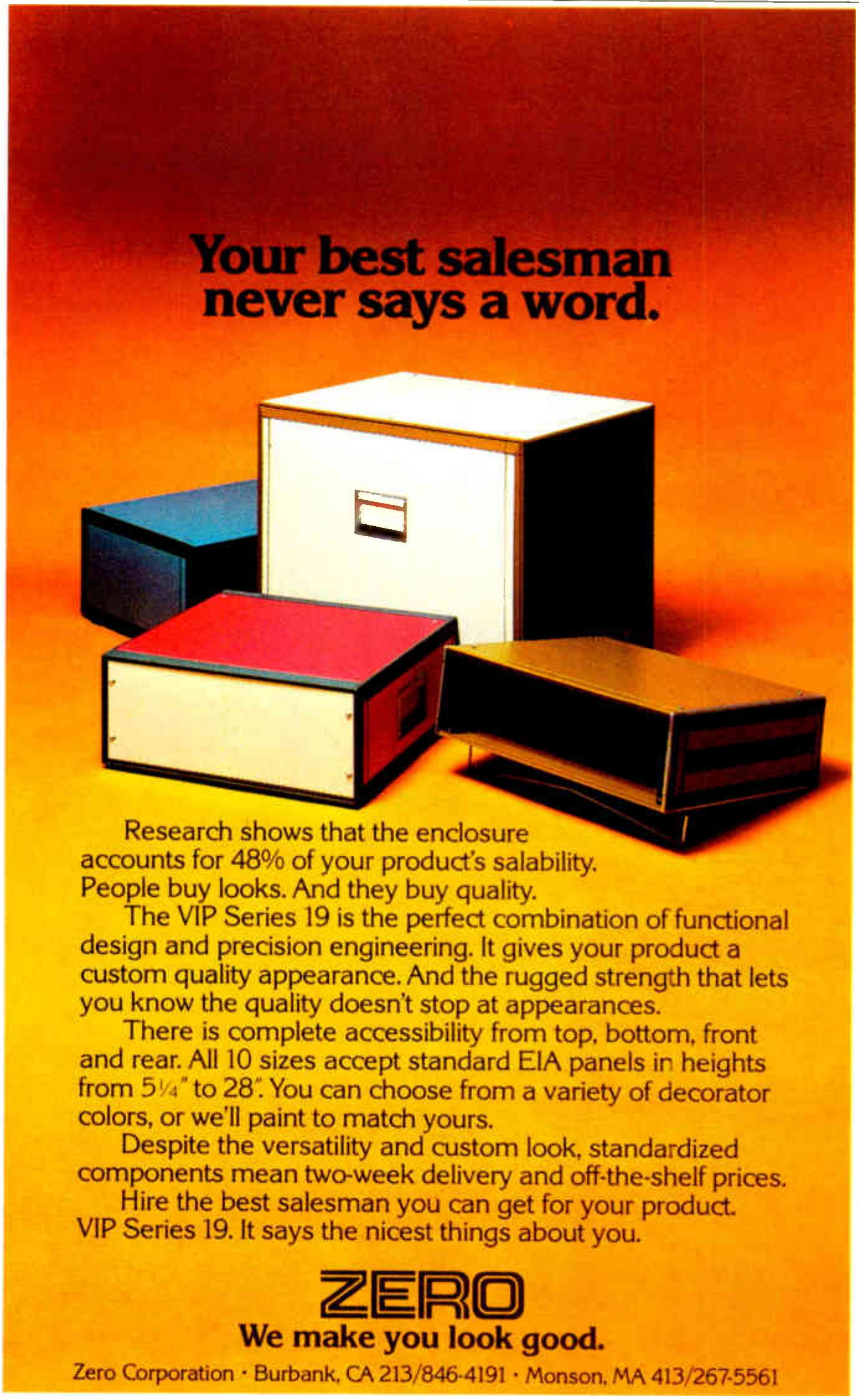
Circle 151 on reader service card

200-mv and 200-Ω ranges so that noise is suppressed to the microvolt level using continuous averaging.

Should an improper function-range combination be selected or an overload occur, an error message is displayed. The meter's push-button–null feature permits instant nulling of external input offsets on any scale reading. When the button is pushed, the displayed reading is stored in memory; thereafter, readings are displayed as deviations from that reading.

Optional accessories include a 50-A shunt, a 200-A clamp-on current probe, and a 40-kv probe.

Keithley Instruments Inc., 28775 Aurora Rd., Cleveland, Ohio 44159. Phone (216) 248-0400 [351]



Phase-angle voltmeter needs no filters over wide band

The model 321 wideband phase-angle voltmeter is remarkable for what it does not have: vacuum tubes or plug-in modules. The solid-state instrument measures phase angle in four ranges that cover the bandwidth from 10 Hz to 100 kHz without the need to change filters; it maintains accuracy to within 0.5°

Voltage measurements can be

made in four different modes: total, fundamental, in-phase, and quadrature; thirteen ranges from 300 μv to 300 v, full scale, are provided. The reference signal's voltage can vary from 150 mv to 150 v without any need for recalibration or adjustment.

The model 321 is priced at $3,598.

North Atlantic Industries Inc., 60 Plant Ave., Hauppauge, N. Y. 11787. Phone (516) 582-6500 [355]

Instrument monitors, analyzes IEEE-488 bus operations

The model 488 is intended for use with the IEEE-488 bus, but how it is so used is largely up to the individual designer. It may be employed as an ordinary bus monitor for trouble-shooting minicomputer- or calculator-based systems. But it may also be used to evaluate compatibility and characterize instruments or subsystems, as a bus exerciser for use in development, or as a low-cost bus controller in small systems.

The programmable instrument is capable of driving up to 14 devices simultaneously at data transfer rates of up to 250 kHz. It can be

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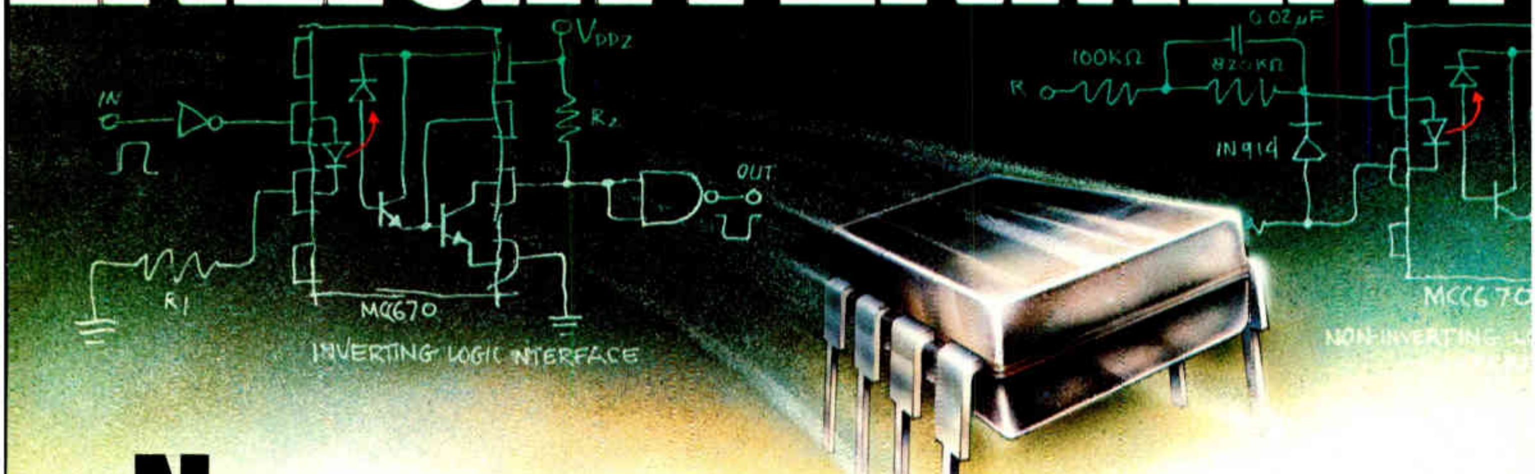

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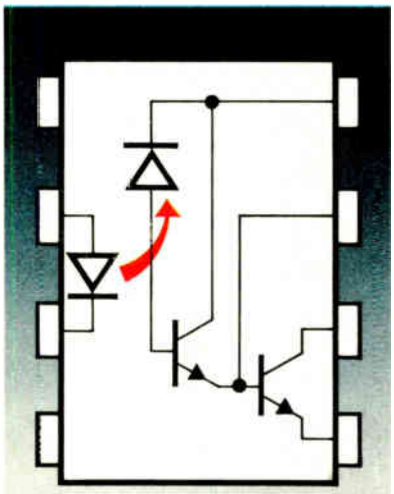

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For more technical data or price information, contact Monsanto Commercial Products Co., Electronics Division, 3400 Hillview Avenue, Palo Alto, CA 94303.

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Circle 153 on reader service card

programmed from the front panel in its machine code or in IEEE bus language, or by plugging an erasable programmable read-only memory programmed in the machine code into a ROM slot. In addition to its 255-byte program storage capability, the unit can store 511 bytes of data.

Error messages, recorded data, and run state can be shown on a 16-character light-emitting-diode display. Prompting guides the operator through all the step sequences needed to activate the model 488's various modes. The instrument is priced at $3,500 and is available now.

Interface Technology, 852 N. Cummings Rd., Covina, Calif. 91724. Phone Stan Kuboda at (213) 966-1718 [354]

Voltage standard resolves 7 digits from 0.1 to 1,000 V

Call it a dc voltage standard and calibrator or a portable ultrastable source, what the model 1030A does is provide a highly stable voltage output in four ranges—1,000 V, 100 V, 10 V, and 100 mV—with a resolution of 0.1 ppm. Calibration accuracy is within 0.002% of the setting plus 0.0005% of full scale plus 5 μV.

The standard can provide currents of up to 50 mA and is stable to within 0.00075% over an 8-hr period. Worst-case accuracy is within 0.003% of setting plus 0.001% of range plus 5 μV.

Weighing 13 lb and measuring 5.22 by 17 by 14.5 in., the model 1030A can be powered from a 115 or 230 V ac source. It costs $2,095. Delivery is within 45 days.

Electronic Development Corp., 11 Hamlin St., Boston, Mass. 02127. Phone Bob Ross at (617) 268-9696 [356]

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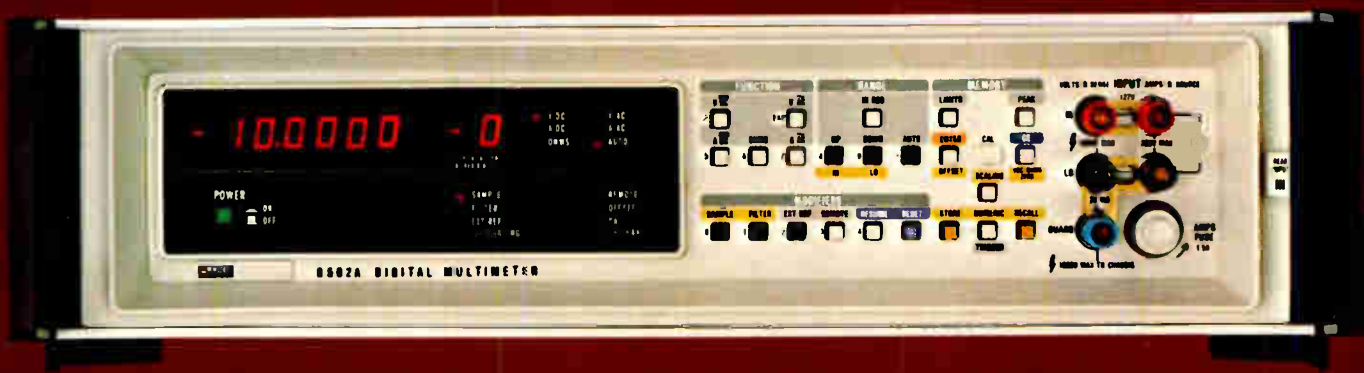

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Error C

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Circle 156 on reader service card

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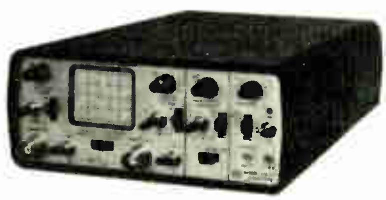

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Circle 253 on reader service card

Semiconductors

Chip tunes radios, TVs

Microprocessor-oriented phase-locked-loop circuit is almost a complete tuner

Like switches and relays, mechanical tuners are prime candidates for replacement by all-electronic alternatives wherever it is economical and practical. The use of varactors to replace mechanically variable capacitors in radio and television tuners is growing, and now Fairchild has developed a chip that simplifies the linking of varactor-based tuners with complex microprocessor-based receivers.

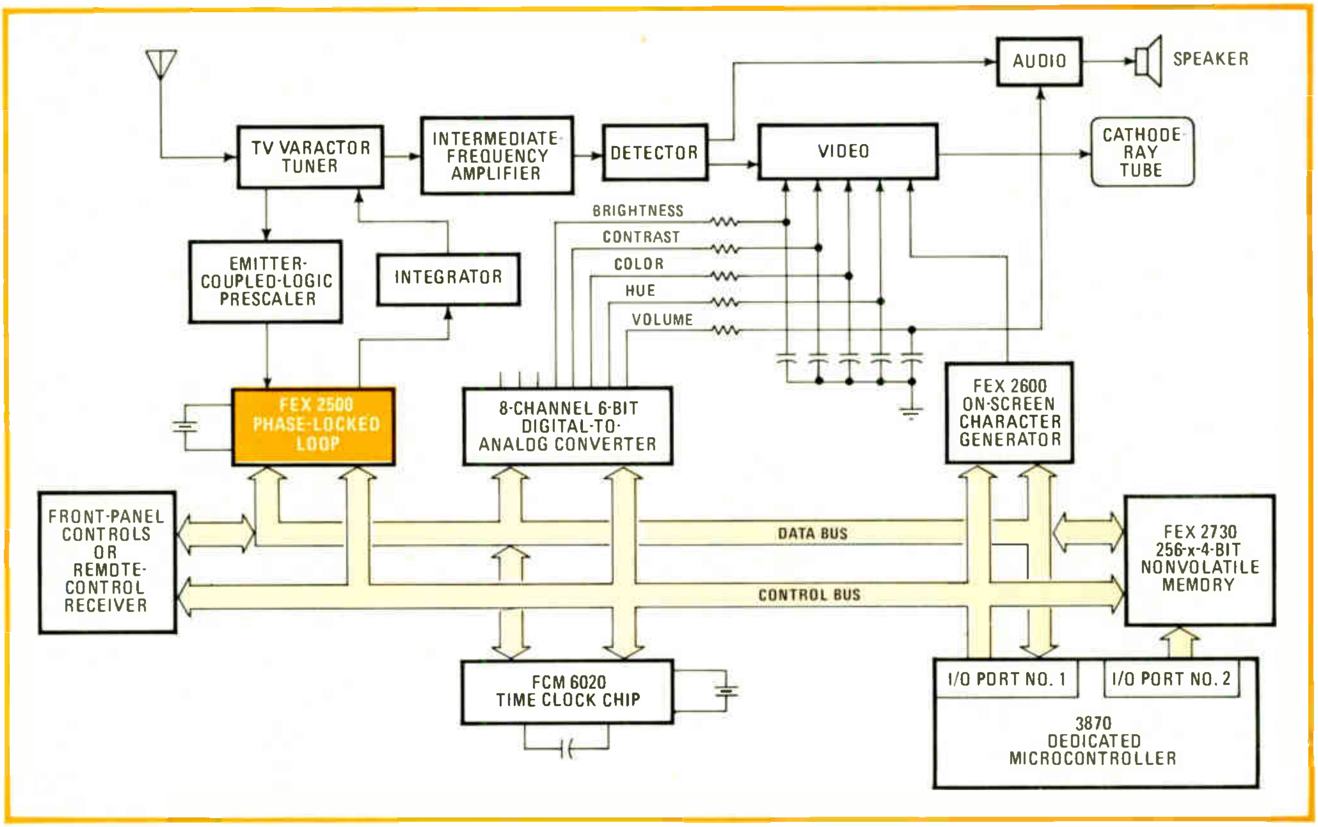
Called the FEX 2500, the chip provides nearly all the subsystems required for a processor-controlled phase-locked-loop tuning system. "An external varactor tuner, integrator, and crystal are all that is needed to complete the entire loop," states Donald M. Staub, Fairchild's C-MOS products division marketing manager. The bus-oriented device can be used in simple tuners or in complex units that, in addition to tuning the receiver, control information display (time, date, and channel selection on a TV set, for example). The major difference between the two applications is software, explains Staub.

In a typical television-tuner application (see diagram), the FEX 2500 forms a loop with the TV's varactor tuner, a prescaler realized in emitter-coupled logic, and an integrator. Addressed to a selected channel by the microprocessor, the FEX 2500 adjusts the voltage on the varactor tuner until the tuner locks to the reference frequency established by the external crystal and the modulus of a divide-by-N counter built into the chip. The modulus, N, is determined by data words sent to the chip through the microprocessor's data bus and stored within the 2500.

The divide-by-N programmable counter is constructed in two sections—a program counter and a so-called swallow counter. This configuration serves a pulse-swallowing function that allows digital fine tuning of the receiver despite the inherently large steps associated with a phase-locked loop operating at radio frequencies.

The FEX 2500's standard coarse-tuning increments are 1 kHz for a-m broadcast receivers, 25 kHz for fm, and 62.5 kHz for TV. For frequencies from 100 kHz to 4 MHz, the varactor tuner can be connected to the 2500 directly. However, for higher frequencies, up to 1 GHz, the ECL prescaler is needed.

The 28-pin IC is made with complementary-metal-oxide-semiconductor technology and can operate from supply voltages between 7.8 and 12 V dc. Available now in sample quantities, the chip will sell for between $5 and $6 in large quantities (50,000 pieces), according to Staub. Evaluation kits containing the FEX 2500, a 3870 microprocessor, a 11C82 prescaler, a nonvolatile memory, and miscellaneous display



drivers, among other things, are being offered for $15 each in large quantities, he adds.

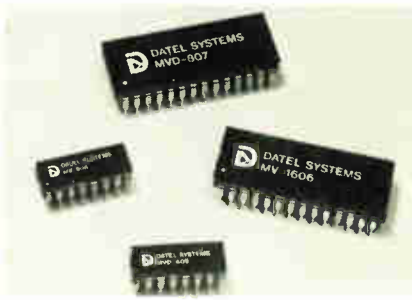
Fairchild Camera and Instrument Corp., Integrated Circuits Group, 464 Ellis St., Mountain View, Calif. 94042 [411]

Analog multiplexers lower channel resistance to 270 Ω

The MV series of analog multiplexers consists of four devices: 4- and 8-channel differential input models and 8- and 16-channel single-ended input models. All members of the series have typical resistances of 270 Ω or less in the on state. Individual channels are addressed with a 2-, 3-, or 4-bit word, depending on the model, and each device has an inhibit input that allows users to connect several devices in parallel and address each one separately.

With complementary-metal-oxide-semiconductor switches that are dielectrically isolated, channel switching is performed in a break-before-make mode so that no two channels are ever momentarily shorted together. When switching from channel to channel, the output settles to within 0.1% of final value within 1.2 μs and to within 0.01% within 2.8 μs. Break-before-make delay is 100 ns or less, turn-off typically 250 ns, and turn-on 350 ns.

When the units are used with a high-impedance load, such as the input of an operational amplifier, transfer accuracies of 0.01% can be achieved at channel sampling rates up to 350 kHz. The devices accept analog inputs in the ±15-V range and digital address and inhibit inputs are compatible with C-MOS and TTL levels.



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New products

The 8-channel differential and the 16-channel single-ended devices operate from ±15-v supplies and are priced at $19.50 in small quantities. The 4-channel differential and the 8-channel single-ended devices require an extra +5-v supply and cost $16.00.

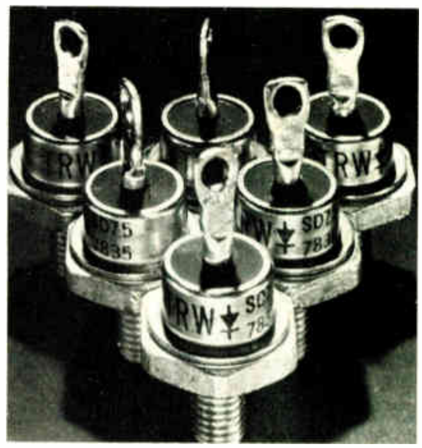
Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021 [413]

Schottky diode passes high current even when hot

Intended for use in high-power switching and linear power supplies, the SD-75 is a Schottky-barrier power diode that offers low forward voltage at high currents. At a junction temperature of 125°C, the device exhibits a forward voltage of 0.60 v with a forward current of 60 A. The diode, which can operate at junction temperatures of up to 150°C, handles 75 A with a forward voltage of 0.70 v at 25°C.

The SD-75 is rated for a peak reverse voltage of 45 v and has a thermal impedance of only 0.8°C/w, allowing it to be operated at full rated load up to 150°C. Packaged in a standard DO-203AB can (formerly referred to as DO-5), the device is priced at $6.75 in original-equipment-manufacturer quantities and is deliverable two weeks after receipt of order.

TRW Power Semiconductors Division, TRW Inc., 14520 Aviation Blvd., Lawndale, Calif. 90260. Phone Don Penn at (213) 679-4561 [414]



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The 3420 saves power, too. Typically it draws less than 30 watts in standby, less than 40 watts in operate mode. System design is very simple, as the static RAMs require no charge pump or refresh circuitry. And they don't generate soft-bit errors, so reliability is much higher than with dynamic RAM systems.

Other versions of the MICRORAM 3400 Series are available in 13 to 22 bit configurations, 8 to 32K capacities, and access times as low as 130 nsec.

Transform your system from sluggish dynamic to reliable high speed static NMOS memory. Call or write today for full technical details as well as price and delivery information.

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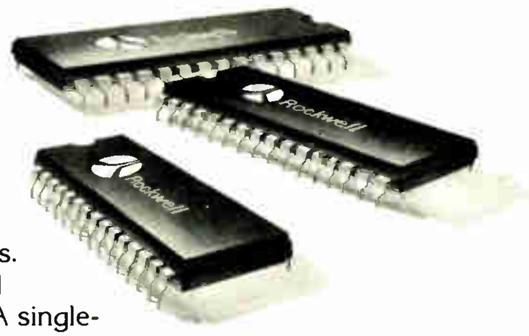

Don't pay the premium for CMOS controller microcomputers before comparing them power-for-power and price-for-price with Rockwell's PPS 4/1.

Often, for less than one third the cost, you can use one of 10 PMOS one-chip microcomputers from Rockwell to meet your low power specs.

Of course, designers choose Rockwell one-chip computers for other reasons. A single-byte instruction set provides ROM efficiencies of typically 2-to-1 over other microcomputers. Bidirectional ports, counters and other features increase options and eliminate costly interface circuitry. Vacuum-fluorescent displays, for example, can be driven directly.

Saving power, and money. That's Rockwell Micropower. For more information contact D/727-F3, Microelectronic Devices, Rockwell International, P.O. Box 3669. Anaheim, CA 92803 or phone (714) 632-3729.

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Packaging & production

Programmer sells for $995

Dedicated unit for 2758 and 2516/2716 PROMs makes eight copies in 2 minutes

There are basically three routes to take when the development of a microprocessor-based product reaches the point at which programmable read-only memories must be programmed: use the development system as a production tool, make a special-purpose PROM duplicator, or purchase a general-purpose programmer plus any necessary personality cards. Now Kaye Instruments is offering an inexpensive, dedicated programmer that can handle PROMS of the Intel 2716 and 2758 and Texas Instruments 2516 types.

Called the model PC16K PROM Cloner, the instrument sells for $995. The price is one third to one half that of most general-purpose machines, or about the price of a single personality card.

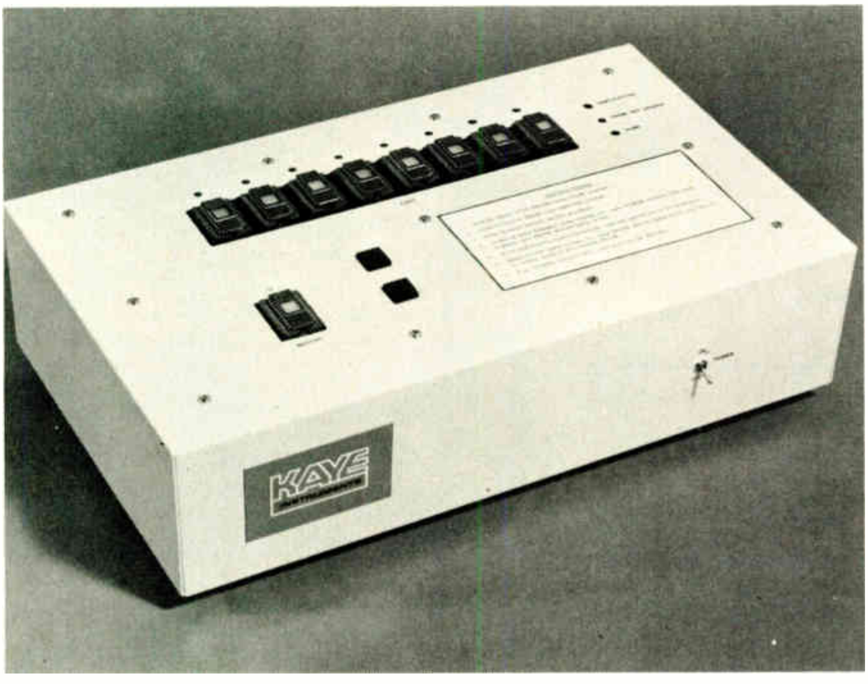
The unit's speed and simplicity of operation suit it well for the production line, with operator training completed in a matter of minutes. Besides the on-off switch, there are only two push-button controls—one for a full duplicating cycle, the other for a verification-only cycle.

The duplicating cycle, which takes only 2 minutes, checks blank PROMS for proper erasure, duplicates the master PROM on as many as eight other memories at a time, and verifies the copies. The verification cycle can be used simply to check a programmed PROM or ROM against a master PROM.

Three signal lights plus one above each copy PROM keep the operator informed about the stage of the cycle and about any problems that develop. Any memory whose lamp is lit at the end of the cycle has failed to be verified when checked against the master PROM.

The PC16K has a novel bit-test feature that automatically allows erased PROMS with single-bit faults to be used if the fault matches the corresponding bit on the master PROM. Normally, memories with such a single bit fault would fail on other units.

The programmer will be available from stock starting on Dec. 1. The



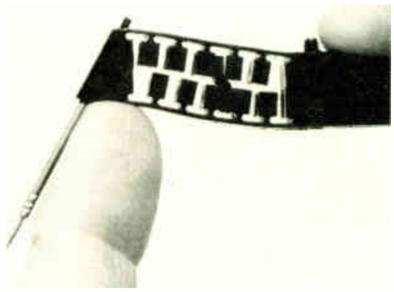
$995 price applies to quantities of 10 units or fewer.

Kaye Instruments Inc., 15 De Angelo Dr., Bedford, Mass. 01730 [391]

Flexible hybrid probe lessens contact pressure and tip wear

The IC-2000 variable-pressure probe is designed for high-volume production testing of both thick- and thin-film hybrid-circuit modules. By simply placing a small insert between the flex members of the probe, users can minimize contact pressure as well as horizontal travel.

The probe comes with a tungsten-carbide needle for greater tip life;



needle depth is screw-adjustable. Planarization screws adjust the probe for use with standard probe-card mountings. Vertical tolerances of up to 0.100 in. are achievable, while horizontal travel can be controlled to within 0.005 in. per 0.020 in. of lift.

In single quantities, the IC-2000 is priced at $19.90 and is available for delivery from stock.

I. C. Industries Inc., P. O. Box 104, Altamonte Springs, Fla. 32701. Phone (305) 339-8298 [395]

Self-supporting connector takes strain off LCDs

The self-supporting Zebra connector consists of a Zebra strip—a laminate of vertical conductive and nonconductive elements with 0.04-in. center-to-center spacings between conductive elements—to which noncon-

Introducing the OPEN-MINDED datalogger.

The new DigiTec Datalogger 3000 takes an open-minded approach to data acquisition. Open-minded because it is a comprehensive microcomputer system dedicated to data acquisition; not just a microprocessor based, hardware-oriented datalogger.

The Datalogger 3000 provides standard capabilities not even *optionally* available on other dataloggers; for example:

- a built-in CRT display prompts the user in programming and displays more information than possible with conventional dataloggers.
- a mini cassette loads the system program, provides absolute memory back-up, and records data.
- unique linearization capability. Six linearization tables; 4 preprogrammed and 2 completely open. You're free to define both open tables with *any* 16 points along *any* curve to linearize your specific inputs. And since the Datalogger 3000 is truly a computer, it actually interpolates measurements that fall between points you've entered. The result: the most accurate measurements possible.
- the 3000 can be programmed from the front-panel, a remote CRT terminal or even a host computer.
- and of course an alphanumeric printer, alarm limits with relay outputs and English messages, scaling & offset factors, engineering units, composite video output and other features also come standard on the Datalogger 3000.

So, if you're open-minded and interested in a revolutionary approach to data acquisition, contact us. Find out how the Datalogger 3000 can take an open-minded approach to your application.

Call Daryl Barnaby, (513) 254-6251 collect

Circle 165 on reader service card

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DIGITEC: Precision measurements to count on.

Circle 225 on reader service card

ductive silicon sponges are applied on one or both sides.

When the connector is placed between a printed-circuit board and a liquid-crystal display or between two pc boards, it provides a conductive path between the contacts of the two units. A small amount of pressure holds the compressible device in place, ensures good contact, and minimizes stress.

Individual conductive elements in the connector have nominal resistances between 1 and 6 kΩ, depending on the thickness of the unit. Three standard models are available in lengths from 0.5 to 4 in. and in various thicknesses (board spacings) and widths. A connector 1 in. long and 0.085 in. wide and thick is priced at 20¢ in quantities of 5,000. Delivery is about two weeks.

Technical Wire Products Inc., 129 Dermody St., Cranford, N. J. 07016 [394]

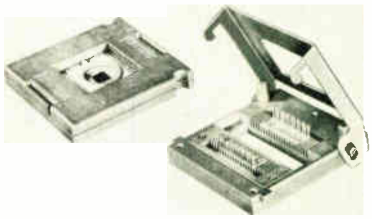
Socket-carrier systems take 24- to 44-lead flat-packs

Designed to test most nonstandard integrated-circuit packages, a series of adjustable flat-pack carrier and socket systems introduced by Textool accepts packages with from 24 to 44 flat or formed leads.

The carrier design includes wiping contacts to provide firm nondamaging connection. The socket's lid will not short against the contacts.

Flat-pack systems are available from stock at prices that vary according to the number of contacts and systems required. A 24-contact socket and a carrier, for example, are priced at $12.82 and 80¢ respectively, in quantities of 100 or more.

Textool Products Inc., 1410 W. Pioneer Dr., Irving, Texas 75061 [396]



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Circle 167 on reader service card

Industrial

Amplifier-filter replaces relays

Unit's high isolation makes relays unnecessary in low-level systems

Multichannel data-acquisition systems that have to handle low-level inputs, like those generated by thermocouples and strain gages, typically employ front-end multiplexers made up of mercury-wetted relays. These relays are not only expensive, they are also often the least reliable part of the system. Now Analogic is offering a combination isolation amplifier and filter that allows these low-level relays to be replaced by a cheap and reliable high-level solid-state multiplexer.

Designated the MP227, the amplifier is intended to be used on a one-amplifier-per-channel basis. Matthew V. Mahoney, group manager for a-d-a modular products, explains that "it's desirable to put the amplifier-filter near the input of each channel." In this position, the chopper-stabilized unit eliminates almost all common-mode interference. Also, because it puts the gain at a point in the system where the bandwidth is lowest—before the multiplexer—it reduces total system noise.

The MP227's isolation specifications are particularly impressive. They include a minimum common-mode rejection ratio of 166 dB (176 dB typical) from 50 to 800 Hz at gains of 50 to 1,000 and for source imbalances up to 1 kΩ. Common-mode voltage rating is 1,000 V dc or 750 V rms. Common-mode input impedance is 10^{10} Ω in parallel with 80 pF. The differential-mode input impedance is 100 MΩ shunted by 22 kΩ and 1.5 μF in series.

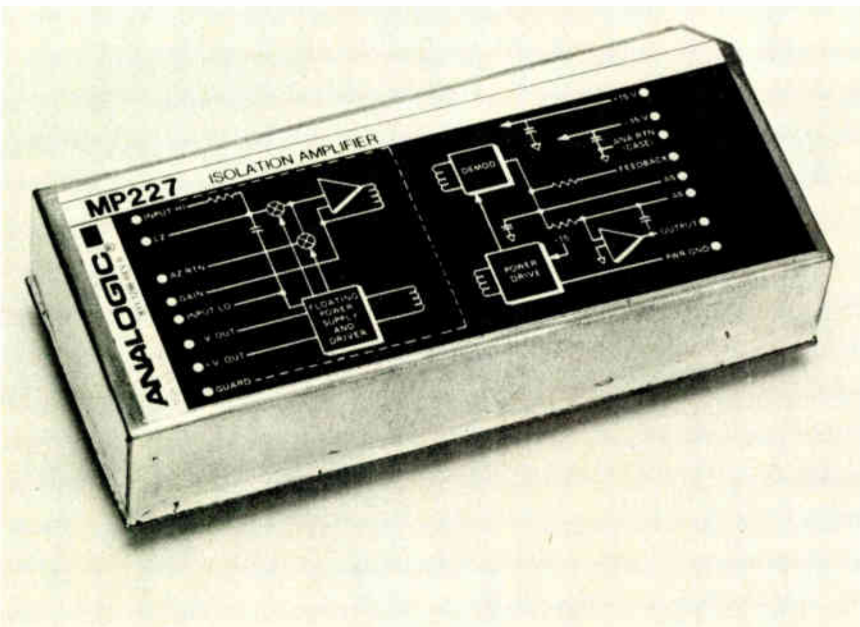
The unit's temperature coefficient of gain is a maximum of ±20 parts per million of full scale per °C for gains between 10 and 500; at a gain of 1,000, it is 30 ppm/°C.

The standard filter is a low-pass unit with a 6-dB frequency of 5 Hz; however, other cutoff frequencies between dc and 100 Hz can also be supplied. Two filters are employed in the MP227: a one-pole RC input filter and a two-pole Butterworth output filter. Between them they provide a roll-off rate of 60 dB per decade. The standard 5-Hz response is 60 dB down at 50 Hz. The filter nodes are externally accessible so that the user can modify the frequency-response characteristics.

Completely self-contained, the amplifier needs no external drivers. It has an internal power oscillator and an isolated power supply. The isolated supply, which can be used for open-thermocouple indication, supplies a nominal ±4 V dc with respect to the low input terminal and can deliver 3 mA.

Power requirements are +15 V at 5 mA and −15 V at 3 mA. Housed in a package with dimensions of 1.2 by 2.8 by 0.5 in., the MP227 operates from 0° to 70°C. It sells for $39 in original-equipment quantities and has a delivery time of four to eight weeks.

Analogic Corp., Audubon Road, Wakefield, Mass. 01880. Phone Dick Ferrero at (617) 246-0300 [371]



Piezoelectric unit measures speed, acceleration directly

The model 1018 piezoelectric sensor provides acceleration and velocity information directly and simultaneously. The unit has no moving parts and can measure acceleration or deceleration of up to 14 g and velocity up to 500 in./s.

When used to take measurements at 70°F and at a rate of 100 Hz, the unit provides an output of 100 mV/g±10% for acceleration measurements and one of 10 mV rms/in./s peak ±11% for velocity measurements. Maximum sensitivity temperature coefficients are 0.03%/°F and 0.06%/°F for acceleration and velocity measurements, respectively, and 3-dB pass bands are 0.3 to 7,000 Hz and 0.4 to 7,000 Hz, respectively. The unit can survive shocks of up to 5,000 g.

The 1018 has a maximum dynamic output impedance of 50Ω and works from a 15-V dc supply with a maximum ripple of 1 mV for specified response. It measures 2 in. in length, has a 1-in.-wide hex head, and a body diameter of 0.88 in. In single quantities, the model 1018 is priced at $450; delivery is approxi-

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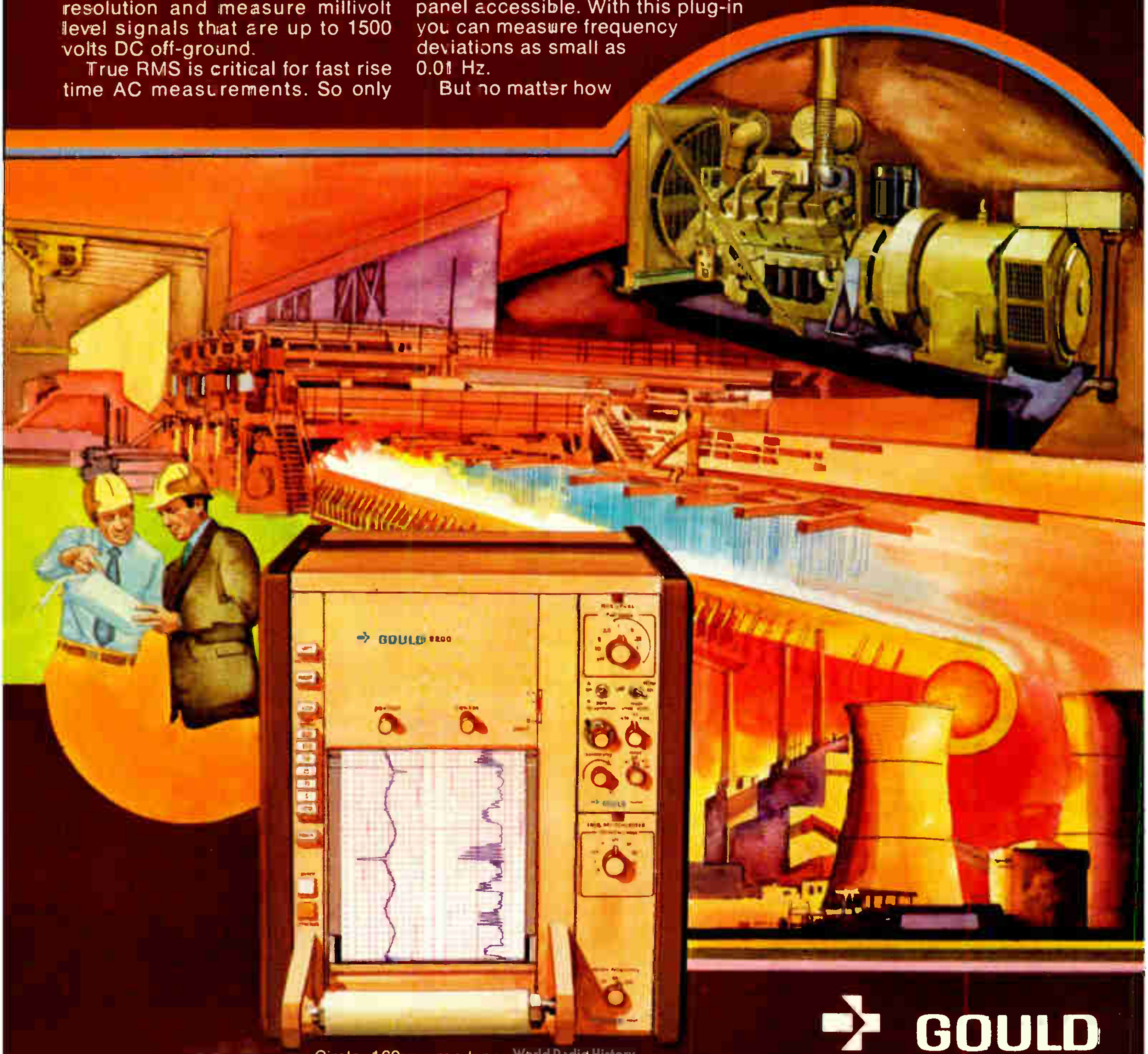

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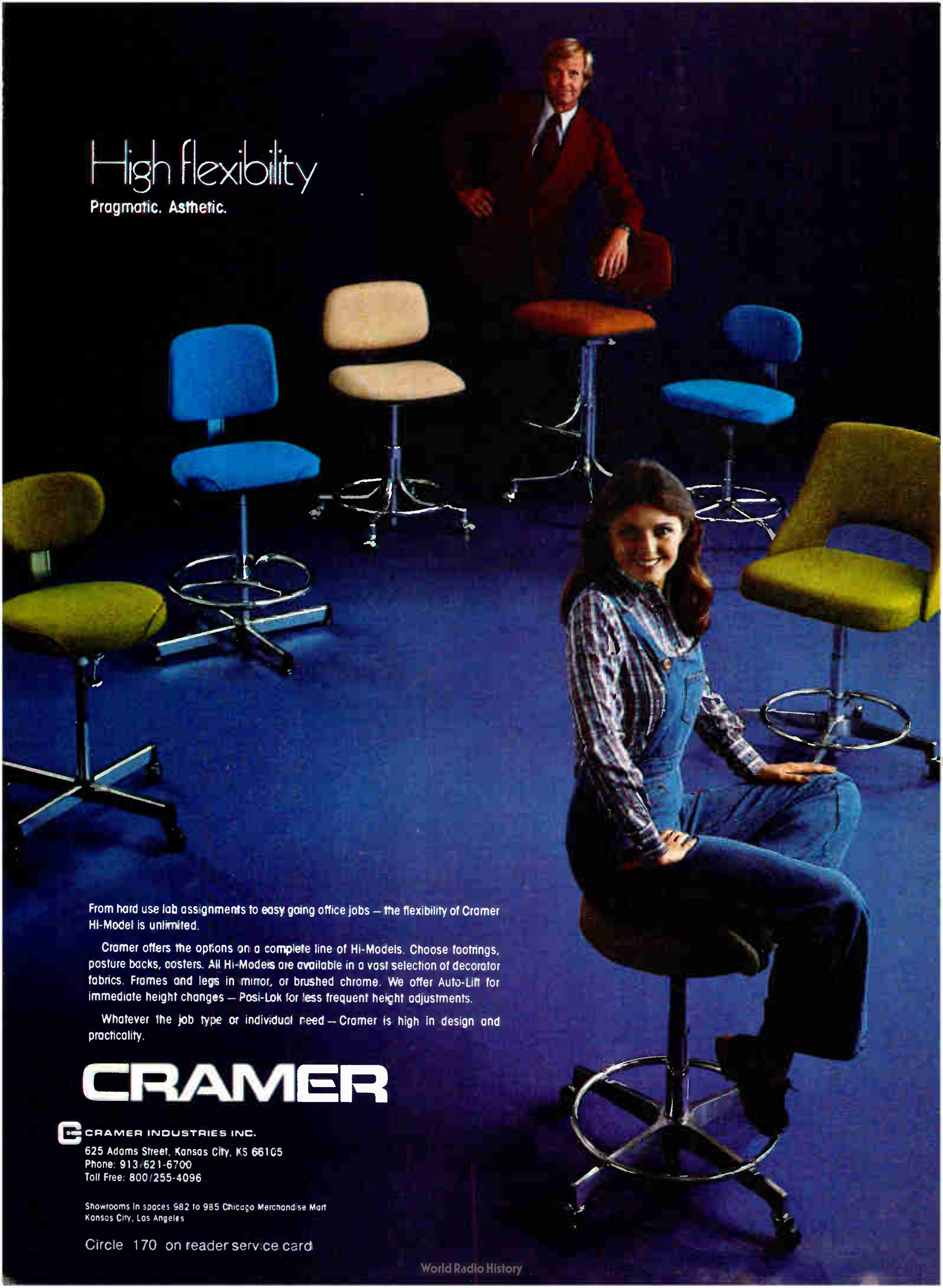
Circle 169 on reader service card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BBN Instruments Co., 50 Moulton St., Cambridge, Mass. 02138. Phone Thomas Glynn at (617) 491-0091 [379]

Tachometer generator tells slow-speed tale directly

Developed for measuring slow speeds in commercial and industrial operations, the Classic series of permanent-magnet dc tachometer generators deliver outputs of up to 60 v per thousand revolutions per minute, making direct meter readings of very slow rates possible.

The continuous-duty device requires no excitation current, connects directly to a dc motor, and can be calibrated for any rotational surface speed or volume measurement required. Its maximum power output is 15 w at 3,600 rpm and it can operate to either 10,000 rpm or 200 v with a capacitor filter.

At 25°C, output is linear to within 1% in one direction, 3% in either direction.

Carter Motor Co., 2711 W. George St., Chicago, Ill. 60618 [374]

Proximity sensors react quickly to all metals

The FY series of cylindrical two-wire proximity sensors responds to all types of metals at rates up to 330 operations per minute. The sensors are available with diameters of 18 or 30 mm in shielded and unshielded versions. An individual device's sensing range varies from 5 to 15 mm depending on its diameter and whether or not it is shielded.

The units operate with a nominal supply voltage of 120 v at 50 to 60 Hz. Load current is 0.23 A continuous, 3 A maximum inrush, and 20 mA minimum.

Priced at approximately $50 in 100-piece quantities, the units are available from stock.

Micro Switch Division, Honeywell Inc., 11 W. Spring St., Freeport, Ill. 61032. Phone (815) 235-6600 [376]

Berg Quickie Connectors are the logical cable interface for Digital minicomputers

Berg Quickie™ Connectors rapidly, reliably terminate multi-lead, flat, round conductor cable—without pre-stripping. Quickie designs allow for visual inspection before and after assembly.

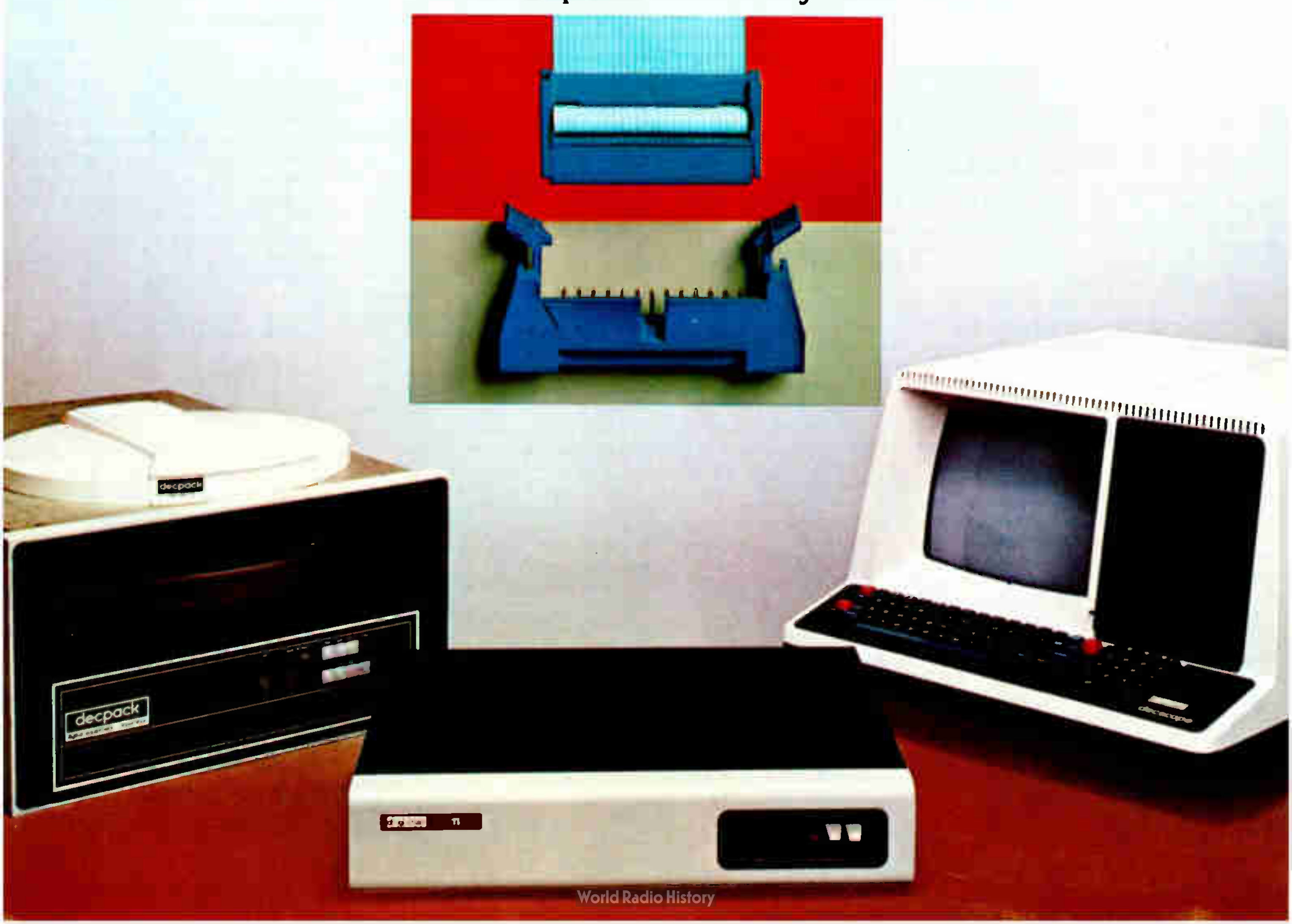
Digital Equipment Corporation likes the Quickie connector's ease of termination and how its askewed tines strip away insulation to assure positive electrical contact. They like the way Quickie Headers latch to maintain connection integrity through vibration and impact. Digital has found it can rely on Berg . . . to supply the products and the application machines that precisely meet its demanding interconnection needs.

Berg is experienced. We read interconnection needs like Digital computers read data. We have the products, the background, and the back-up to do the job. Your job. Let's work on it, together. Berg Electronics, Division E. I. du Pont de Nemours & Co., New Cumberland, Pa. 17070—Phone (717) 938-6711.

DU PONT **BERG ELECTRONICS**

Circle 172 on readerservice card

We serve special interests—yours!



New products

Computers & peripherals

Graphics unit made for PDP-11

High-resolution 16-bit processor has 65,536-word refresh memory

The number of suppliers of graphics processors for PDP-11 minicomputers has just increased by one. Computer Design & Applications Inc. is offering a programmable processor on two hex-size boards that slide into the PDP-11 chassis.

The MDP-3 is tailored to driving both black-and-white and color monitors to display data derived from systems such as radars, sonars, and computerized axial-tomography scanners. The processor board is a general-purpose 16-bit computer microprogrammed with an instruction set "similar to that of a popular minicomputer," says CD & A president Robert Caspe. The graphics processor is built with the bipolar 2903 bit slice.

The refresh memory, on a separate board, consists of 65,536 words by 17 bits. Sixteen bits of each word contain the images to be displayed on the cathode-ray-tube monitor; the 17th bit is for graphic overlays, such as lines for highlighting certain data. Two formats are provided: 512 by 512 interlaced picture elements (pixels) or 256 by 256 noninterlaced pixels. In the former format, 4 bits per pixel are available; in the latter, 16 bits per pixel.

Interfacing between the MDP-3 and the host PDP-11 is by means of a programmed input/output interface and a direct-memory-access interface. In the programmed I/O mode, one of two switch-selectable I/O device codes emulates the host's teletypewriter controller to gain access to the host. The DMA interface, Caspe says, provides a "window" for the graphics processor into the host's memory. This allows substantial expansion of the graphics processor memory, but at some cost in memory-accessing speed. Other features of the MDP-3 include an ASCII character generator, memory for 1,024 characters, and zoom capability.

Caspe points out that the MDP-3 is part of a family that also includes the recently introduced MIP-3/A, a dual-port, intelligent 12-bit analog-to-digital-converter input processor that can perform conversions without interrupting the PDP-11's central processor. Combined with an earlier product—the MSP-1 floating-point array processor—the input and display processors yield a line of building blocks for data acquisition, processing, enhancement, and display applications.

The MDP-3's price is $14,500 in single quantities, dropping to $7,800 each in lots of 50 to 99. Delivery time is 30 days after receipt of order.

Computer Design & Applications Inc., 377 Elliot St., Newton, Mass. 02164. Phone Dennis Fennelly at (617) 964-4320 [361]

Commercial mini halves entry price

First-time buyers of minicomputers for commercial data-processing application will probably be interested in the Eclipse C/150 system. The newest entry in Data General Corp.'s commercial data systems series, the C/150 lowers the entry-level price tag from the $100,000 neighborhood to about $54,000.

That price buys a small C/150 system, including 128 kilobytes of main metal-oxide-semiconductor memory; a 10-megabyte cartridge disk; an 800-b/in., 75-in./s magnet-

WE WIN!

87% of all low-voltage switching power supplies use Schottkys instead of ordinary P-N Diodes.

TRW's high power Schottky diodes automatically boost power-conversion efficiency by 10% to 15%. This is because they feature only half the forward voltage drop of ordinary p-n diodes and thus dissipate only half the power for the same amount of forward current. You get less heat, which provides more reliability, less maintenance, and lower overall cost... that's why Schottky diodes are favored eight-to-one over ordinary p-n diodes.

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Our Schottkys have accumulated over **25 billion (25×10^9) device-hours in the field,** with less than .018% field unit failures for all causes combined—not bad for a product that some people consider as being frail.

And to top that, we're the first Schottky diode supplier to specify the reverse energy capability of our products. With the recent introduction of our 75 amp Schottky diode, the SD-75, we have established yet a higher standard of quality for the industry, which extends to our entire product line. Nobody specifies Schottky diode tolerance to inductive spikes as we do. Before shipping we drive each part into avalanche thousands of times with the reverse energy test. It's your assurance of added design margin.

But don't just take our word for it—see for yourself. When you clip and send us the attached coupon, we'll include our application note number 131 which gives all the facts on our reliability and design considerations.

TRW Schottky Diodes

Part No.	I_F Rating	V_R	T_J	Package
SD-75	75	45	150°C	DO-5
SD-51	60	45	150°C	DO-5
SD-5171	60	45	150°C	DO-5*
SD-41	30	45	150°C	DO-4
SD-241 (Dual)	30	45	150°C	TO-3
1N6098	50	40	150°C	DO-5
1N6097	50	30	150°C	DO-5
1N6096	25	40	150°C	DO-4
1N6095	25	30	150°C	DO-4

*With flex lead

For immediate information on TRW Schottky diodes, call John Power at (213) 679-4561.

TRW Power Semiconductors
An Electronic Components Division of TRW Inc.
14520 Aviation Boulevard, Lawndale, California 90260

☐ **Please send me data sheets on TRW's Schottky diodes.**

☐ **Please send sample.**
Current requirement_______________amps.

Name _______________ Position _______________

Company Name _______________

Address _______________

City _______________ State _______________ Zip _______________ E

TRW *POWER SEMICONDUCTORS*

ANOTHER PRODUCT OF A COMPANY CALLED TRW

ic-tape drive; a 60-character-per-second printer; and the company's real-time disk operating system (RDOS), and Infos and RPG II software packages. For larger configurations, the price ranges up to about $150,000, depending upon the amounts of main and mass storage and upon the peripherals added.

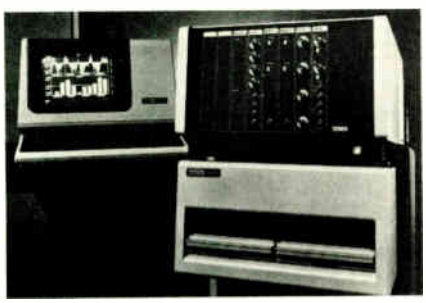
In introducing the C/150, Robert Kiburz, manager for Eclipse data systems, strongly emphasizes the unit's compatibility with other Data General minicomputers. He says this means optimum use in distributed data-processing applications, such as inventory control, product distribution, and credit management. Deliveries will begin in January.

Data General Corp., Rte. 9, Westboro, Mass. 01581. Phone (617) 366-8911 [362]

Function modules tailor computers for laboratory

Designed for the researcher who is not a computer expert, the MINC modular computer system performs engineering and scientific computation, laboratory data acquisition, and general-purpose computation. Up to eight function modules of seven different types can be combined: analog-to-digital converter, digital-to-analog converter, digital input, digital output, multiplexer, preamplifier, and programmable clock. To move the system to different lab locations, the user can mount it on an instrument cart.

In addition to these modules, MINC employs the RX02 double-density dual-diskette unit for program and data storage and the VT105, a video graphic terminal with full alphanumeric capabilities



and a graphic facility of 512 horizontal by 190 vertical positions. Also standard for all MINC configurations is a PDP-11/03 processor with 30 kiloword memory capacity, extended and floating-point instruction sets, three serial-line channels, and an IEEE-488 standard interface that can support as many as 14 laboratory instruments.

Software used is MINC Basic, an extension of PDP-11 Basic. The system is priced from $12,500, and deliveries are to begin next month.

Digital Equipment Corp. Maynard, Mass. 01754 [364]

Military display terminal designed for tight spaces

Designed for use in small, harsh areas such as submarine compartments and mobile gun platforms, the PD 3500 is a bulkhead-mountable computer terminal with a 6-in.-thick plasma-display head that contains a plasma panel, panel driver-electronics module, driver timing, and a control-logic module. A separate control unit contains the display processor and power-supply modules; a third unit houses the rugged

terminal's keyboard assembly.

Standard features of the $14,400 PD 3500 include seven-by-nine-dot and five-by-seven-dot character fonts with an alpha cursor and complete incremental and vector graphics capability. The unit has 5400J integrated circuits or optimal screened parts and includes an RS-232-C serial-communications port and a full alphanumeric, solid-state keyboard. Also included is a 16-bit parallel high-speed microprocessor with a 330-nanosecond execution time that enables the terminal to write a worst-case (that is, longest) vector in 10 milliseconds. On a 512-by-512-element display, the graphics address rate is 50,000 dots/s.

Interstate Electronics Corp., P. O. Box 3117, Anaheim, Calif., 92803. [366]

Add-in unit puts 256-K bytes in a single PDP-11 slot

A single-card memory designed specifically for use with PDP-11/04 and PDP-11/34 minicomputers, the NS11/34Q supplies up to a full 128-K by 18 bits of storage. The dynamic n-MOS random-access memory has a read access time of 300 ns.

Depending on memory capacity, options, and quantity ordered, the cards are priced from $2,895 to $7,995 each. Delivery is four weeks.

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051 [368]

Display terminal emulates other popular emulators

To help original-equipment manufacturers fill user needs regardless of existing equipment configurations, the new I-100 display terminal uses a Z80 microprocessor and programmable read-only memories to emulate the control code sets of other replacement terminals.

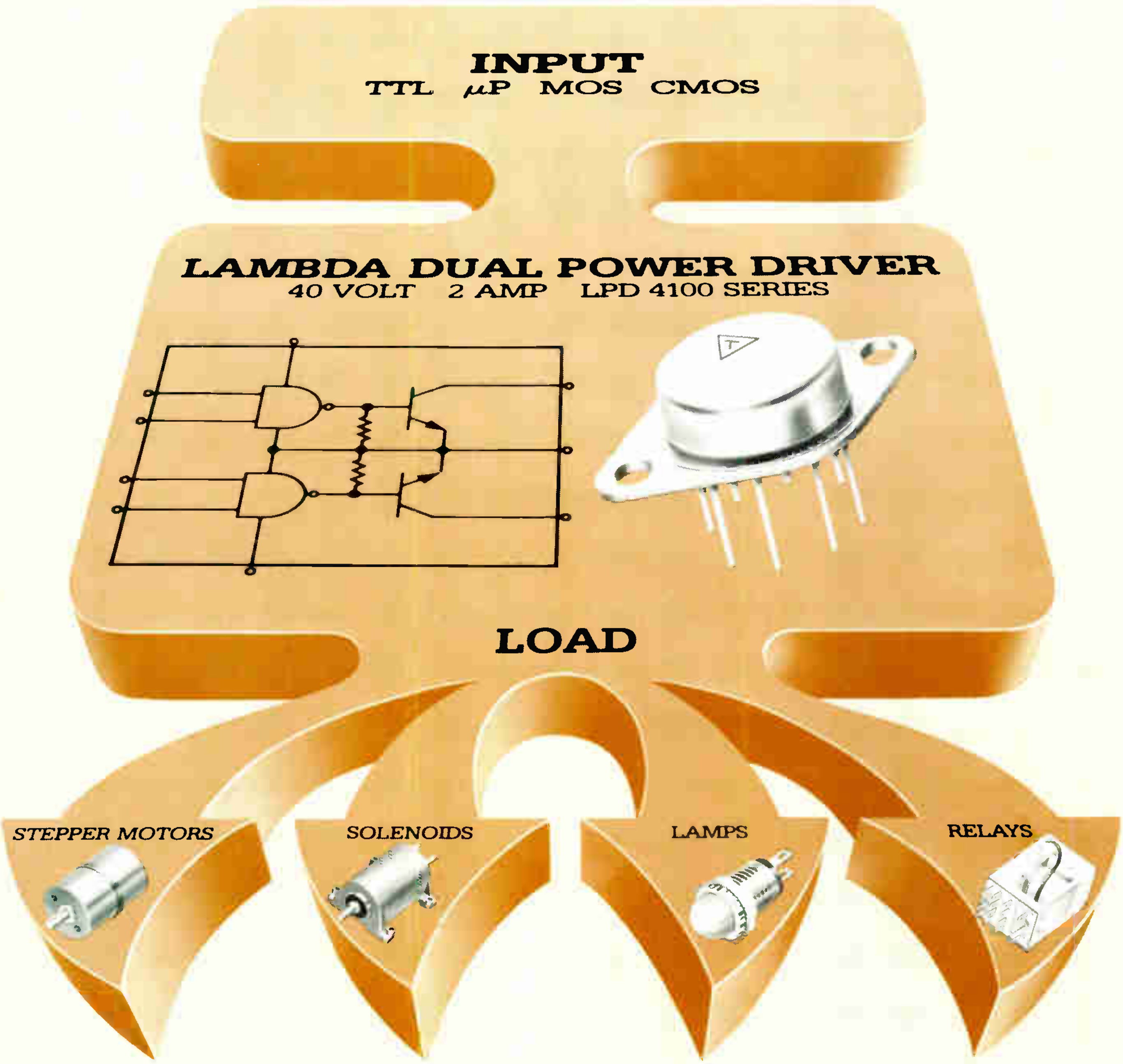
Priced at $849, the I-100 offers users a wide range of operating features that include computer control of keyboard scanning, screen formatting and editing, paging, and line drawing with a 32-character set. A 1,920-character screen (80 characters/line) offers a 25th line for status displays, as well as a full 96-character ASCII set, switch-selectable baud rates up to 19,200 bits/s, block-mode transmission with protected/unprotected fields, and up to 8 programmable function keys and a 15-key numeric cluster.

Infoton Inc., Second Avenue, Burlington, Mass. 01803. Phone (617) 272-6660 [365]

L99

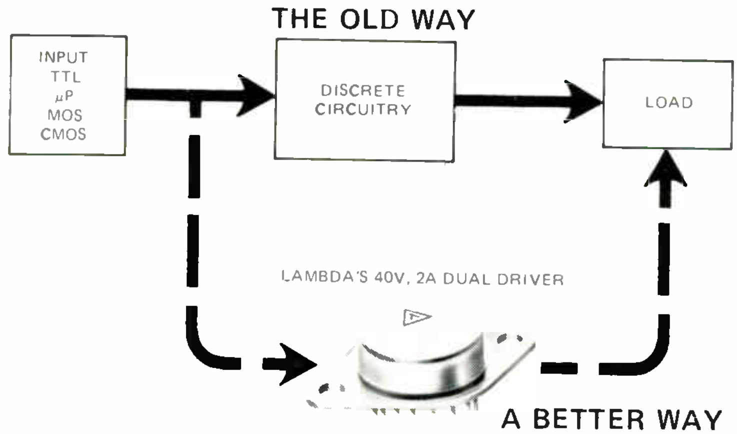
New 40 volt, 2 amp monolithic dual power driver.

It can drive a relay in a control system. A solenoid in a printer. And light the lamps on a pinball machine.



Δ LAMBDA SEMICONDUCTORS

LET LAMBDA'S 4100 SERIES MONOLITHIC DUAL POWER DRIVER SOLVE YOUR HIGH CURRENT INTERFACE PROBLEMS



BETTER BECAUSE:

- Two Drivers Per Package
- Three Functions—AND, OR, BUFFER—Eliminate External Logic Functions
- Two Amps Per Driver Output
- Non Darlington Output Transistor For Low V_{SAT}
- 100% Compatible With TTL, Low Power Schottky, CMOS.
- Duty Cycle Up To 100% (D.C.)—Both Outputs
- Hermetic TO-3 Type 8 Pin Package

DESCRIPTION:

The LPD 4100 Series of Dual Power Drivers are Monolithic bipolar integrated circuits capable of switching load currents of up to two (2) Amperes. The input characteristics of these power drivers are fully compatible with TTL, Low Power Schottky TTL, and CMOS operated at an appropriate power supply level. The functions available in the 4100 series include Dual 2 input AND a Dual 2 input OR, and a Dual buffer. The output of each power driver consists of an open collector transistor which is capable of sustaining 40 volts. The devices are assembled in a hermetic 8-pin TO3 package for low thermal resistance and high reliability. The device is specifically designed to interface TTL logic levels to high current drive requirements, such as relay drivers, lamp drivers, solenoid drivers and stepper motors.

ABSOLUTE MAX RATINGS:

Supply Voltage — (VCC)	10V
Input Voltge — (VIN)	30V
Output Voltage — Output High (VOH)	40V
Output Current — Output Low (IOL)	2 Amps
Operating Free Air Junction Temperature	-55°C to +150°C
Storage Temperature	-55°C to +200°C
Power Dissipation (TOTAL)	6 Watts
Power Dissipation (Each Driver)	3 Watts
Thermal Resistance-Junction to Case (θ JC)	3.5°C/Watt
Derating Factor	285MW/°C (From Tc of +104°C)

RECOMMENDED OPERATING CONDITIONS:

Supply Voltage Maximum (VCC MAX)	+5.5 Volts
Supply Voltage Nominal (VCCN)	+5.0 Volts
Supply Voltage Minimum (VCC MIN)	+4.5 Volts

ORDERING INFORMATION

MODEL	LOGIC FUNCTION	PRICE QTY. 1	100	1000	2500
LPD4101	AND	6.00	4.00	3.50	3.25
LPD4104	OR	6.00	4.00	3.50	3.25
LPD4106	BUFFER	6.00	4.00	3.50	3.25

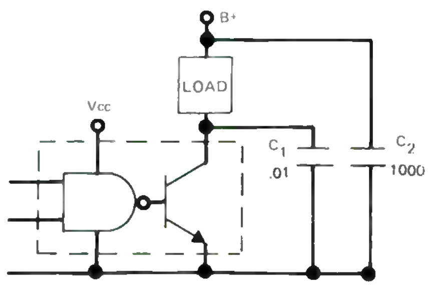
ELECTRICAL CHARACTERISTICS, 4100 SERIES DUAL AND, OR, BUFFER

CHARACTERISTIC	SYMBOL	JUNCTION TEMPER-ATURE	VCC	DRIVEN INPUT	OUTPUT	LIMITS MIN.,	MAX.	UNITS.,	OTHER INPUT LPD 4101 DUAL AND GATE	LPD 4104 DUAL OR GATE	LPD 4106 DUAL BUFFER GATE
"1" INPUT VOLTAGE	VIH	0 – 125° C	MIN			2.0	–				NA
"0" INPUT VOLTAGE	VIL	0 – 125° C	MIN			–	0.8	V			NA
"1" INPUT CURRENT	IIH	0 – 125° C	MAX	2.7V			20	μA	OV	OV	NA
"0" INPUT CURRENT	IIL	0 – 125° C	MAX	0.4V			-50	μA	OV	OV	NA
INPUT CLAMP DIODE VOLTAGE	VCD	0 – 125° C	MIN	-12mA			-1.5	V			NA
"1" OUTPUT REVERSE CURRENT	IOH	o – 125° C	MIN	2.0V	40V	–	100	μA	2.0V	OV	NA
"0" OUTPUT VOLTAGE	VOL	+25° C	MIN	0.8V	0.5A	–	0.5	V	VCC	0.8V	NA
"0" OUTPUT VOLTAGE	VOL	+25° C	MIN	0.8V	1.0A	–	0.8	V	VCC	0.8V	NA
"0" OUTPUT VOLTAGE	VOL	+25° C	MIN	0.8V	2.0A	–	1.5	V	VCC	0.8V	NA
"1" OUTPUT LEVEL SUPPLY CURRENT	ICCH	0 – 125° C	MAX	VCCN			30	mA	VCCN	VCCN	NA
"0" OUTPUT LEVEL SUPPLY CURRENT	ICCL	0 – 125° C	MAX	OV			400	mA	OV	OV	NA
TURN-ON DELAY	tPD-	+25° C	VCCN	SEE TEST FIGURE			350	n Sec			
TURN-OFF DELAY	tPd+	+25° C	VCCN	SEE TEST FIGURE			2.0	μ Sec			

* PRICES AND SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

APPLICATIONS DATA

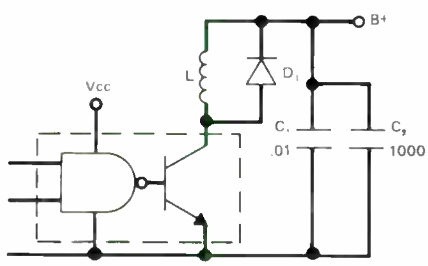
Basic Driving Circuit



C_1 may be necessary to slow the 4100 slew rate during turn off to prevent overvoltages due to stray inductance. C_2 should be added to prevent ringing in applications where long B+ lines are used or when the B+ supply has poor transient load regulation

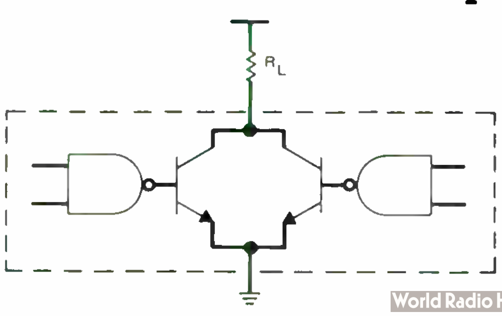
Inductive Drive Circuit

L is an inductive load such as a relay, solenoid or DC motor



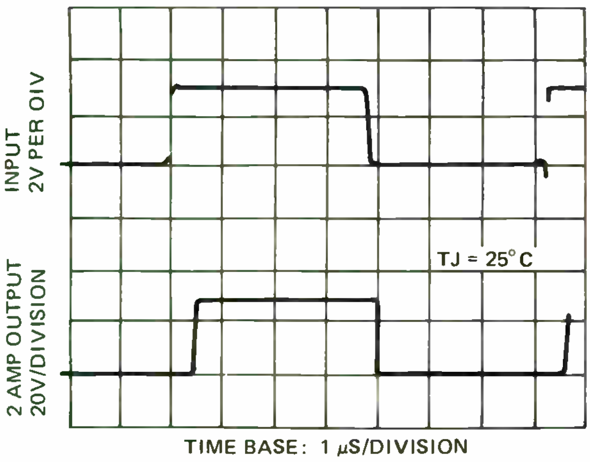
Diode D_1 is necessary to protect the 4100 output transistor from overvoltage switching transients during turnoff. D_1 should be a fast switching diode.

Parallel Connection of Driver Outputs

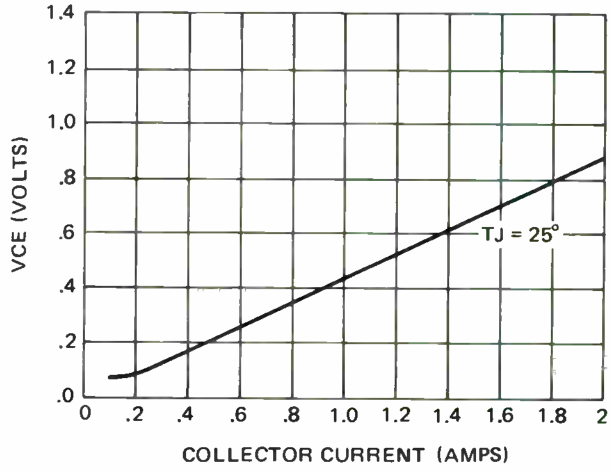


Outputs from each driver may be connected in parallel to increase load current to 4 amps.

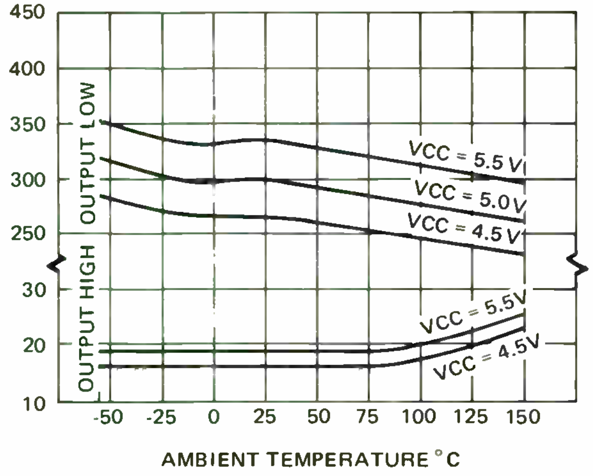
OPERATIONAL DATA



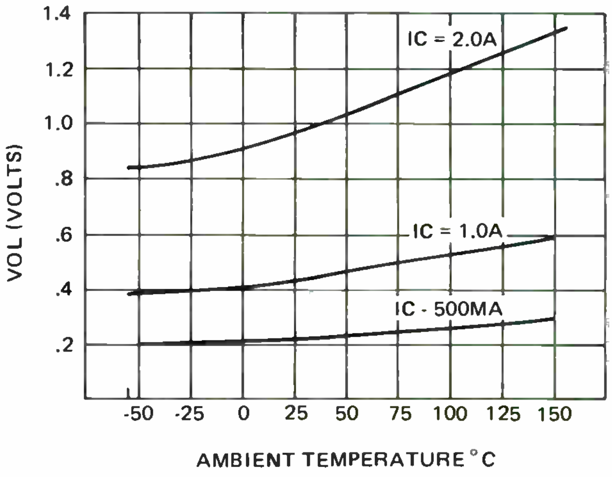
TYPICAL SWITCHING SPEED WAVEFORMS



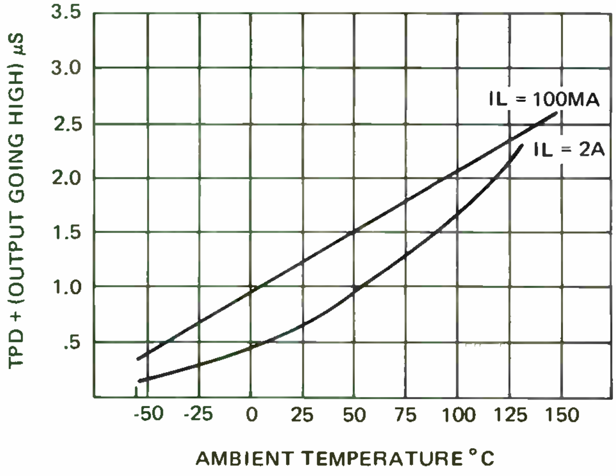
TYPICAL COLLECTOR EMITTER SATURATION VOLTAGE VS COLLECTOR CURRENT (VOL)



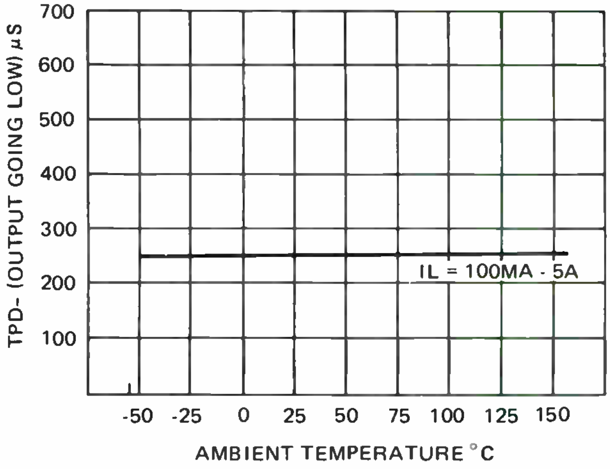
TYPICAL SUPPLY CURRENT VS AMBIENT TEMPERATURE



TYPICAL COLLECTOR-EMITTER SATURATION VOLTAGE VS AMBIENT TEMPERATURE (VOL)



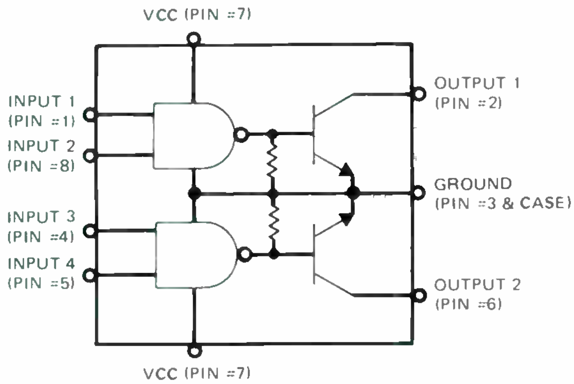
TYPICAL PROPAGATION DELAY VS TEMPERATURE



TYPICAL PROPAGATION DELAY VS TEMPERATURE

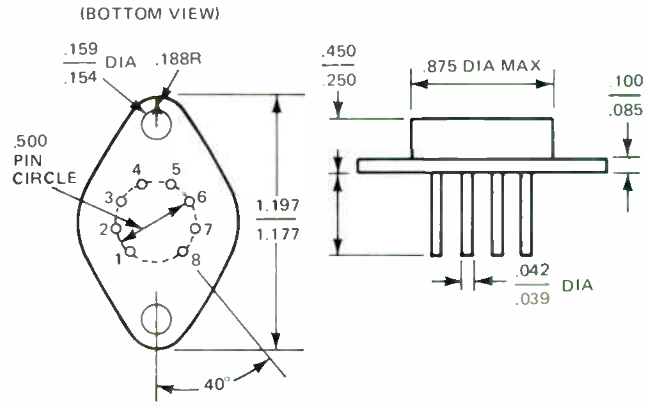
PACKAGE CONFIGURATIONS

LPD 4101 DUAL AND DRIVER

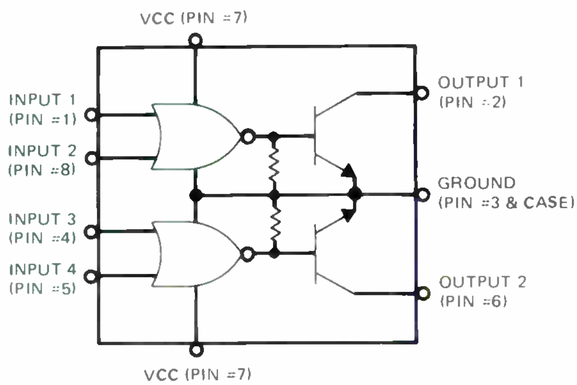


POSITIVE LOGIC: OUTPUT 1 - INPUT 1 INPUT 2

8 PIN TO 3 TYPE PACKAGE

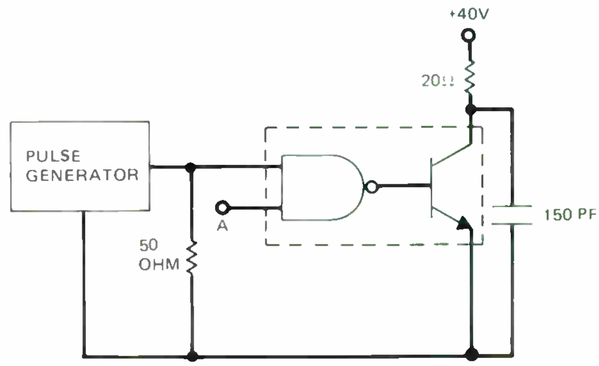


LPD 4104 DUAL OR DRIVER



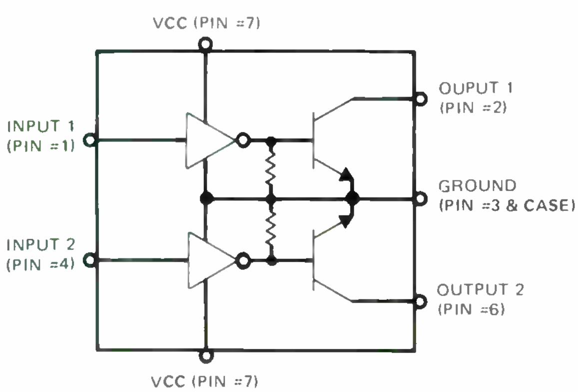
POSITIVE LOGIC OUTPUT 1 - INPUT 1 & INPUT 2

SWITCHING TEST CIRCUIT



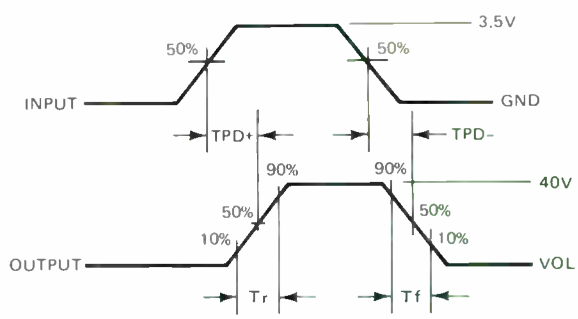
NODE A — + 5 VOLTS FOR 4101 AND DRIVER
0.0 VOLTS FOR 4104 OR DRIVER

LPD 4106 DUAL BUFFER



POSITIVE LOGIC: OUTPUT 1 - INPUT 1

SWITCHING WAVEFORMS

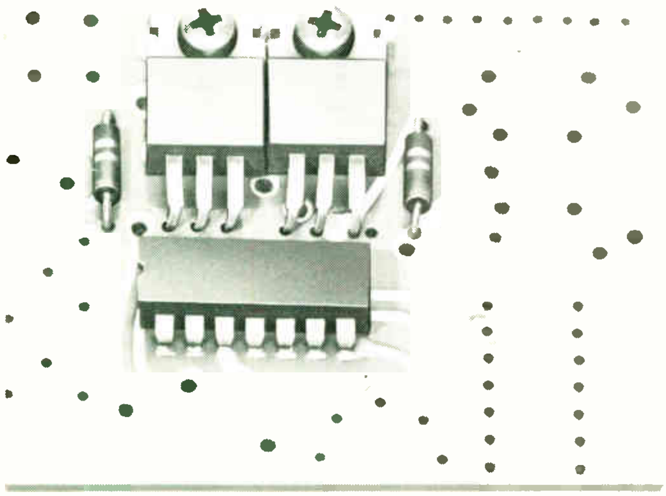


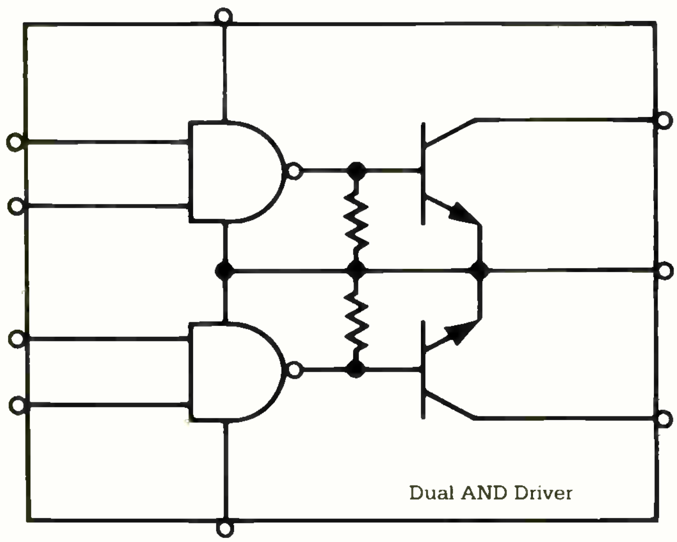
INPUT WAVEFORM: Tr = Tf ≤ 100 ns
Duty Cycle = 10%

New 2 amp monolithic dual power driver replaces 5 circuit components.

Input compatible with TTL, μP, MOS and CMOS.

This...
instead of this:





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599 N. Mathilda Ave..
Tel. 408-245-0380
TWX. 910-339-9243

LAMBDA ELECTRONICS

Microcomputers & systems

Development unit works alone or with computer

Bit-slice microprocessors are used for their versatility and high speed: their word lengths and instruction sets can be tailored by the designer and, because they are made from bipolar logic, they can operate at clock speeds in excess of those used by metal-oxide-semiconductor microprocessors. Although these devices are fast and flexible, all too often the hardware and software development that is required to incorporate these parts into systems is slow and constraining.

To aid designers working on high-speed processors and controllers, the Bipolar Development System acts as a stand-alone, real-time firmware test and integration station, interfacing with a central computer or a development system for code generation. Compatible with all major bit-slice processors and sequencers, the BDS lets users work with their existing software bases.

The basic system, which sells for $4,950, includes 32 kilobits of high-speed memory, an object-code editor, and a communications interface. The memory works at cycle rates of up to 20 MHz and can be switch-configured for word widths of 8 to 32 bits. Real-time breakpoints and triggers can be set on the unit's front panel.

Instruction modification, problem location, and patching are performed by the BDS editor, which displays words in octal or hexadecimal, while showing selected fields in binary code. A fill command initializes the memory, and an enter command examines or modifies it on a word or bit basis. Other commands initiate scanning of memory sections for a specified bit pattern and duplicate subroutines prior to modification.

To simplify system testing, the BDS uses read-only-memory simulation modules that plug directly into the socket of the user's programmable-read-only-memory. Standard organizations include 512, 1-K, or 2-K depths by 4- or 8-bit widths for latching and non-latching memories. The ROM simulation modules are priced at $500 to $1,000 depending on quantity and type.

The computer used to generate code interfaces with the BDS in a half- or full-duplex mode, with parity, baud rate, and code format selected at the BDS. The 20-mA current-loop or optional RS-232-C interface eliminates the need for tape or other storage and transfer media.

Software for use with an Intel development system is offered for $800, including the price of a meta-assembler, and a Fortran-based meta-assembler costs $1,200. Also

for $1,200, an Advanced Communications/Processor Control package will provide RS-232-C, modem, and PROM programmer interfaces, as well as the following additional programming controls: run, step, halt, halt or breakpoint, and cycle. Delivery of complete BDS systems is 30 to 45 days after receipt of order.

Step Engineering Inc., P. O. Box 61166, 714 Palomar Ave., Sunnyvale, Calif. 94086. Phone Steve Drucker at (408) 733-7837 [341]

Desk-top computer built with printer and drive

Since desk-top computers are most frequently used with peripheral line printers and floppy-disk drives, designers of the 625 Mark II decided to wrap those components up with their computer in a compact 9.5-by-20-by-28.5-in. package. The Z80-based unit is offered with an extended Basic-language operating system and up to 60 kilobytes of internal random-access memory.

The unit's dual floppy-disk drives can be used to store up to 630 kilobytes of program information or processing data. A number of software packages (including a word-processing and text-editing module) are offered on flexible disks. Data can be entered on the standard "qwert" keyboard, or a 15-key numerical keypad, or a set of 20 keys that can be defined for any of 60 functions.

Information can be read from the Mark II's 80-character-by-16-line cathode-ray tube and copied on the integral 40-column line printer. The CRT's 64 graphic characters give the microcomputer a limited graphics capability, and the printer's character sizes can be varied.

Five internal board slots accept optional boards that provide interfaces to the IEEE-488 bus, dual serial communications links, and the S100 bus, to name a few. Prices for the 625 Mark II start at $8,000 and delivery takes approximately 60 days.

Compucorp, 1901 S. Bundy Dr., Los Angeles, Calif. 90025. Phone (213) 820-2503 [343]

Software adds 9900 support to Intel development systems

The first in a line of software development products that will link Intel Corp.'s Microprocessor Development Systems and Texas Instruments Inc.'s 9900 16-bit microprocessor family, Pivot 9900 software provides cross support for the TMS 9900 and the SBP 9900. The software runs on any Intel MDS-800 or Series II system with 48-kilobyte memory and ISIS-II software.

The Pivot software provides the ability to create and assemble source

code, link and locate machine code, simulate and debug programs, and create firmware. It also provides a quantitative measurement of the 9900's performance and, since all editing, file management, and PROM programming remain functions of ISIS-II, it is not necessary for users to learn a new operating system to employ the package.

Pivot 9900 is available in single- or double-density floppy-disk versions and comes with complete documentation, including installation and user's manual, assembly language programming manual, and simulator programming manual. Priced at $1,500, the package is available immediately. After purchase, software updates will be provided free for one year.

Processor Innovations Corp., 118 Oakland St., Red Bank, N. J. 07701. Phone (201) 842-8110 [344]

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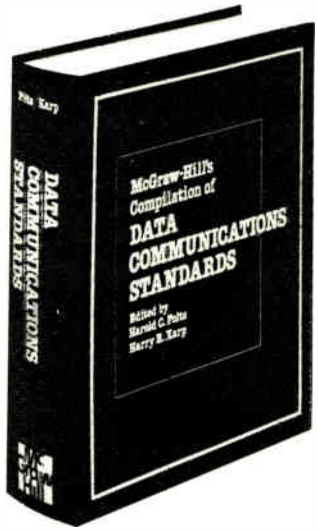

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Products newsletter

Du Pont slashes fiber-optic prices

The realization of large-quantity production orders, coupled with anticipation of even higher volumes, has led the Du Pont Co. of Wilmington, Del., to make substantial price reductions on its plastic- and silica-core fiber-optic cables. **In effect immediately, the reductions average approximately 35% on orders of 50,000 meters and up,** with smaller reductions available on lower-quantity orders. The firm's single- and double-channel standard plastic-core cables, PFX-P140 and PFX-P240, are reduced 17% to $1.25 per meter and $2.50/m, respectively. Also, lower-attenuation plastic-core, single-channel cable PFX-PIR140; is lowered 22% to $1.75/m; single-channel PFX-S120 and two-channel PFX-S220 silica-core cables are reduced 40% to $1.35/m and 48% to $2.70/m, respectively.

Hughes adds to C-MOS line

Hughes Aircraft Co., Newport Beach, Calif., is beefing up support for its 1800 microprocessor family with the addition of three new complementary-metal-oxide-semiconductor circuits: a read-only memory, a universal asynchronous receiver/transmitter, and an input/output decoder. **All three units are compatible with the HCMP 1802 microprocessor.** Organized as 2,048 by 8 bits, the HCMP 1835 ROM typically draws less than 2 mA at 5 V. Its 16-bit address is time-multiplexed into two banks of 8 bits; access time is about 750 ns. The UART has two modes—one for operating with such standard UARTs as the TR1602, the other for compatibility with the 1802. The HCMP 1853 decoder provides control for up to 14 I/O devices.

DEC rounds out printer line

With an announcement early last week, Digital Equipment Corp., Maynard, Mass., rounded out its line of printers to include table-top and tractor-feed models. **Two DECwriter IV models—the LA34 and LA38—have a baud rate of 300 (or 110), print using a nine-by-seven dot matrix, and have a full 128-character ASCII set.** The LA34—a table-top unit with roll-type feed—will sell for $975 in quantities of 100. The table-top LA38, which offers tractor and roll-type feeds, has a separate 18-key pad for fast entry of numbers; it will be sold as part of digital systems starting late next spring for $1,700 in single units. **At the top of the DECwriter line is the bidirectional LA120, with its 180-character-per-second printing rate and baud rates of 50 to 9,600.** The tractor-feed DECwriter III will sell for $1,830 in hundreds starting in January.

Intel's 32-kilobit EPROM draws little power

Although Intel Corp. is behind Texas Instruments in launching a 32,768-bit ultraviolet-light–erasable programmable read-only memory, the Santa Clara, Calif., firm is expected to unveil, at Electronica in Munich, its 2732 device whose singular pinout [*Electronics*, Sept. 14, p. 85] gives it a chip-enable function to power it down for standby operation. **In the standby mode, power consumption is cut from 24 to 4 μW per bit.** The memory operates from a single 5-V power supply. Maximum access time is 450 ns. The U. S. price will be $147.30 for single units; in lots of 100 or more, the part will sell for $91.65 each.

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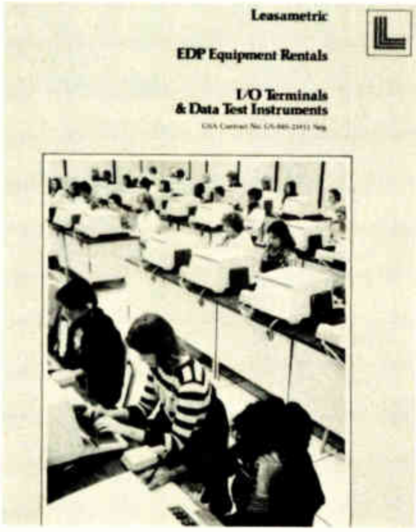
New literature

Rentals. "I/O Terminals and Data Test Instruments," an eight-page brochure, lists a wide range of data communications equipment with the manufacturers, model numbers, descriptions, and rental rates. Some of the devices offered include calculator systems, acoustic couplers/modems, protocol monitors, and line-disturbance monitors. All equipment listed is in inventory, serviced, and ready for immediate delivery. Leasametric, Division of Metric Resources Corp., 1164 Triton Dr., Foster City, Calif. 94404. Circle reader service number 421.



Semiconductor selection. Presented in an eight-page brochure are typical applications for Schottky, p-i-n, silicon step recovery, and limiter diodes, along with specifications and package recommendations. The "Semiconductor Selection Guide" can be obtained from Aertech Industries, 825 Steward Dr., Sunnyvale, Calif. 94086 [422]

Molecular-beam epitaxy system. Described in a 12-page brochure is the MBE-360 molecular-beam epitaxy process and its applications. The parts that make up the system are explained thoroughly—the vacuum system, the work chamber, the epitaxy equipment, and the specimen load lock. Two types of analytical instruments are offered with the MBE-360: those for use simultaneously with the growth process (real-time process monitoring), including the reflection electron diffraction system and the quadruple mass spectrometer; and those for use sequentially with growth, including the auger electron spectrometer. Varian Palo Alto Vacuum Division, 611 Hansen Way, Palo Alto, Calif. 94303 [423]

Solar power products. Seven data sheets provide information on the electrical characteristics, typical performance curves, dimensions, environmental performance, and applications of a terrestrial solar power product line. The Concentrator solar power module is suited for low-power remote-battery trickle-charging applications, while the 20-watt solar module is ideally suited to charge 12-volt batteries and may be interconnected in series-parallel configurations to meet high-power requirements. OCLI Photoelectronics Division, Marketing Department, 15251 E. Don Julian Rd., City of Industry, Calif. 91746 [424]

Microwave. "Microwave Transistor Designer's Guide," a 136-page booklet, is meant for the circuit designer working with the complex problems of this technology. It provides information on amplifier and oscillator design characteristics—specifically, S-parameters, gain, stability, noise figure, and noise-figure measurement. In addition, a section on reliability profiles processing sequences, failure rates versus time, and conditions of operation. This guide can be obtained from Microwave Associates Inc., South Avenue, Burlington, Mass. [430]

Buy and rent. The "Continental Equipment Sales Catalog Summer 1978" lists over 500 electronic test

instruments for sale, rent, or lease by manufacturer and model number along with the price. Specifications are also given. Continental Resources Inc., 175 Middlesex Turnpike, Bedford, Mass. 01730 [425]

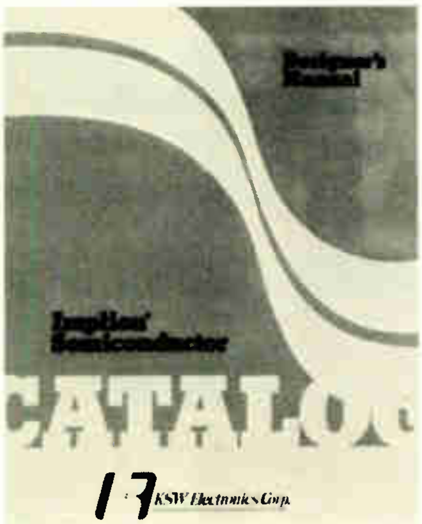
Electronic switches. Three types of electronic switches that cover the range from 0.5 to 1,000 MHz are described in a 12-page catalog. One type has a balanced design without integral drivers, the second has integral TTL-compatible drivers, and the third integral TTL drivers. Specifications and diagrams of each type of switch are provided. Order catalog ES-788 from Lorch Electronics Corp., 105 Cedar Lane, Englewood, N. J. 07631 [426]

Metals, materials, and processes. Designed for those who use precious metals in components, films, and electroplating processes, this 23-page booklet describes electrical contact materials for switches, thermostats, appliances, telephone relays, voltage regulators and circuit breakers. It also discusses thick-film conductor materials and systems for use on conductors, capacitors, resistors, and hybrid circuits. Engelhard Industries Customer Service, 2655 U. S. 22, Union, N. J. 07083 [427]

Ac and dc motors. Specifications and information for a line of precision miniature ac and dc motors, gearmotors and blowers are given in a 24-page catalog. It is available from TRW Globe Motor Division, 2275 Stanley Ave., Dayton, Ohio 45404 [428]

Tachometers. Presented in a 12-page brochure is a line of Zero-Max tachometers that can be used to measure any production value that depends on rotary or continuous-linear motion. "Tachometers" discusses the features, operational characteristics, specifications, and dimensions of fixed and portable analog tachometers and the Maxi-Tach digital tachometer. The units are designed to indicate speed accurately from 0 to 2,000 revolutions per minute, as well as such rate functions as parts per hour, percent of capacity, and gallons per minute. Zero-Max Industries Inc., 2845 Harriet Ave., Minneapolis, Minn. 55408 [429]

Ion-implanted diodes. A 24-page catalog gives information on a line of diodes that includes: ion-implanted, hyper-abrupt- and abrupt-junction; p-i-n; and low-voltage zener diodes.



The "Implion Semiconductor Catalog" provides selection guides and electrical characteristics for each diode series. KSW Electronics Corp., South Bedford Street, Burlington, Mass. 01803 [431]

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The Electrical Engineering Department, University of Utah, has a faculty position opening January 1, 1979, for a person with a Ph.D. and a strong digital hardware background. The successful candidate will receive an Assistant Professor rank, and will be responsible for the undergraduate and graduate programs in the digital area. Opportunity exists for generation of new courses in both areas and research will be strongly encouraged. Also, there will be job opportunity for interaction with an outstanding computer science department and a new facility and staff capable of fabricating large-scale digital integrated circuits. Send resume to Dr. Carl H. Durney, Chairman, Department of Electrical Engineering, University of Utah is an equal opportunity employer.

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- To design software/hardware for mincomputer-based automatic test equipment: Requires experience on digital systems. H.F. 21MK/RTE experience highly desirable.

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to perform developmental test of missiles at systems/subsystems level; plan tests and evaluate results. Experience desired in guided missiles, avionics, or airborne radar technology. Digital hardware and software helpful. BSEE desired.

Circuits Design Engineers

With recent relevant experience in the design and development of RF/IF, digital, or analog circuits for missile guidance systems. MSEE, software/hardware integration experience also desirable. Must be familiar with applicable state-of-the-art components—phase and frequency lock loops, wide and narrow receivers, use of microprocessors.

Systems Engineers

These positions require system engineering for missile systems using radar and electro-optical technologies. This includes defining design characteristics, interfaces, test requirements, and performing trade studies. Weapons experience not required, but previous systems engineering, servo analysis, or circuit or logic design experience in the above technologies is desirable.

Systems Analysts

To perform design and analysis for state-of-the-art electro-optical missile seekers. Job assignments require ability to develop mathematical models for missile guidance systems performance evaluation. Proficiency in advanced one and two-dimensional signal processing techniques desired.

Digital Systems Design Engineer

To participate in digital systems analysis and designer trade offs on RF components, subsystems and systems. Write design requirements, specifications and test requirements. Do RF modeling, hybrid missile flight simulation. Knowledge of Machine Languages, Basic and Fortran. Familiarity with microprocessor use in analytical and control systems. Interface equipment to systems.

Automatic Test Equipment (ATE) Systems Engineers

Several openings inour ROLAND Division for system test engineers with a background or interest in computer based automatic test equipment, for testing L band and K band radar units. Must be familiar with Basic or Atlas programming. Will be responsible for unit application software development, maintenance, and tasks related to production test stations.

Product Engineers

Experienced in CAD, including interactive graphics; ability to do product design for high-rated production and knowledge of hybrid microelectronics and circuit partitioning required. Design experience in hybrids and electronic subassemblies desirable.

Microwave Engineers

Growth in microwave and in microwave product development requirements for radar missiles has created immediate openings in:

- Microwave Antennas
- Solid State Transmitter
- Microwave Sources and Receivers
- Missile Radomes
- RF/Microwave Mechanical Systems Engineering

PLATFORM DESIGN ENGINEERS

To perform design analysis and/or development test of components/subassemblies in gyro stabilized platforms (i.e. motors, bearings, pickoffs, mechanisms). Background in CAD of devices, finite element analysis, and mass properties desired. Openings for both senior and junior-level candidates.

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- LSI Design Engineers needed for analog and digital circuit design for MOS/CCD and bipolar custom LSI. Positions require complete design responsibility including partitioning, establishing design requirements and directing layout and evaluation testing.

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- Automated Artwork Generation and Checking. You'll develop and maintain artwork design rule checking and mask level circuit regeneration software. Responsibilities will include algorithmic development, software implementation and user interface design, as well as user assistance.
- Semiconductor Modeling and Analysis. You'll develop and maintain circuit-level semiconductor models, and use those models to determine process design rules and standard LSI cells. Responsibilities will include model development, model parameter determination, software implementation and circuit analysis, as well as Design Engineer one-to-one assistance.
- Scientific Programmers with background in high level languages, structural programming and data structures. You will develop new programs in the areas of interfaces including graphics as well as design and implement automation hardware.

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Electronic Digital Field Engineer

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The field engineers should have a B.S. in electrical engineering or equivalent and prior experience in their fields. It is desirable that the digital engineer have experience with the operation and interfacing of Data General mini-computers. Salaries will depend upon experience. Reply to: **Staff Employment Center, 1717 East Speedway, Tucson, Arizona 85721. Or call: Dr. W. F. Hoffmann at (602) 626-1558.** An Equal Opportunity, Affirmative Action, Title IX, Section 504 Employer.

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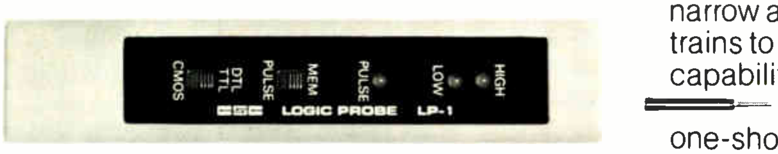

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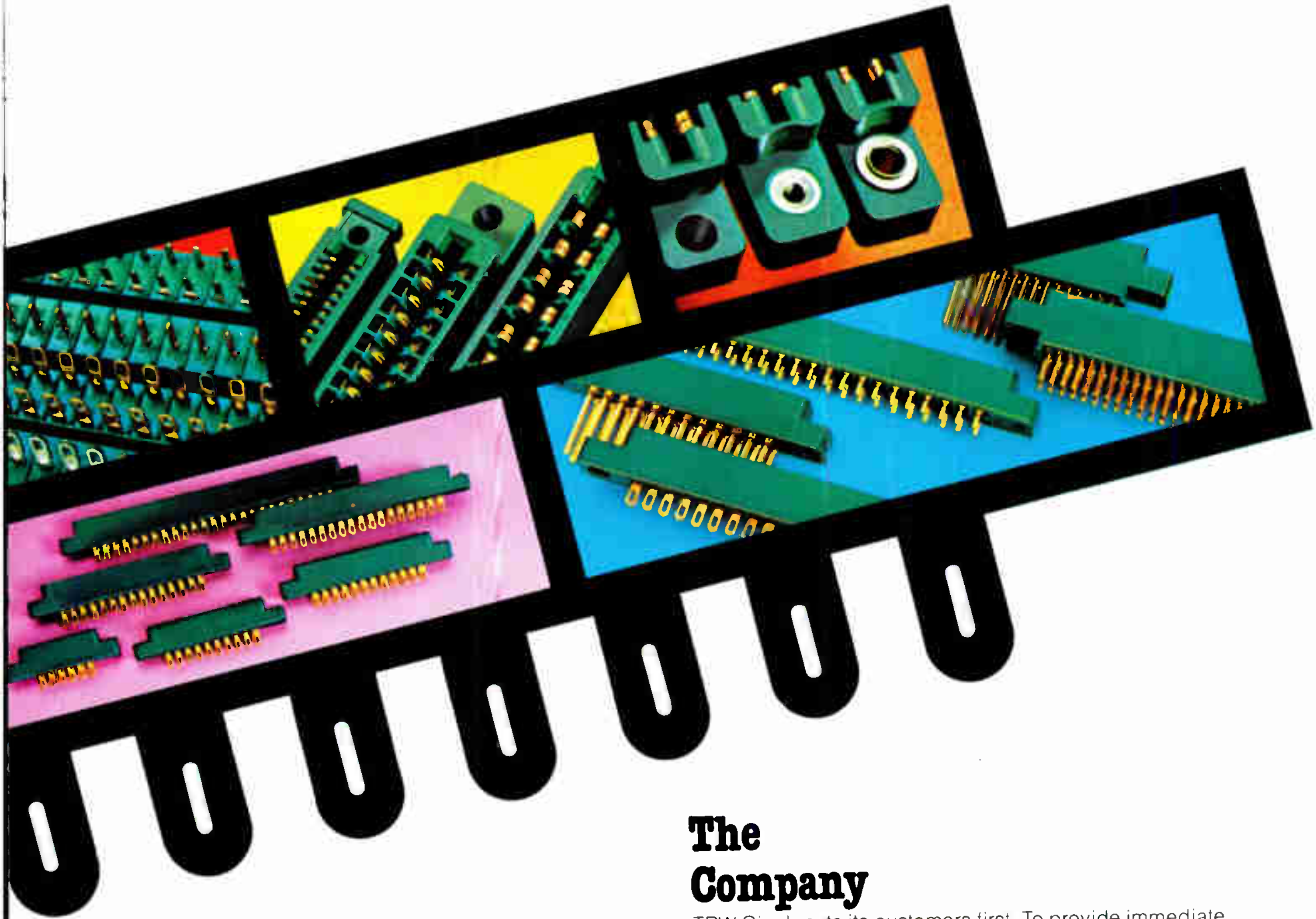

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